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Factors affecting the distribution of *Pluchea dioscoridis* (L.) DC. and its associated species in Gharbia Governorate, Nile Delta, Egypt.

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Abstract

***Pluchea dioscoridis* is a perennial ruderal shrub. It has been classified as a weed controller due to its bushy growth, medicinal plant due to its strong antioxidant and anti-liver cancer activity and a phytoremediator plant. The present work aims to study the environmental factors affecting the distribution and common associated species of *P. dioscoridis* in Gharbia governorate, Nile Delta, Egypt. It aims also to assess the diversity and behavior of the common species along the different environmental factors. Seventy three stands, representing four common urban habitats (wastelands, railway sides, canal and drain banks), were selected. In each stand; the florisitic composition and cover of the studied species and its common associated species were estimated. Seventy-two species were recorded as being associated with *P. diosocridis*. Therophytes were the most represented, while parasites were the least. Mediterranean taxa had the highest chorological contribution. The highest coverage percentage of *P. dioscoridis* was recorded in the canal banks. TWINSPAN and DCA techniques led to the recognition of four vegetation groups; these groups were indicated by *Persicaria salicifolia* (A); *Echinochloa stagnina* and *Chenopodium album* (B); *Arundo donax* (C) and *P. dioscoridis* (D). Vegetation group D, which occupied wastelands, was the most diverse, while VG B occupied drain banks, was the least diverse. Soil analysis indicated that VG A occupied canal banks had the highest values of OM (7.7%) and P (41.2 mg100g^{-1}), but the lowest water holding capacity (20.8%), Cl (0.08%), CO_3 (0.07%) and HCO_3 (0.04%). Canonical Correspondence Analysis (CCA) showed that chloride, electrical conductivity, total nitrogen, carbonate, and calcium cations were the most effective environmental variables on the distribution of *P. dioscoridis* and its associated species in the study area. This study may be a beneficial tool to use *P. dioscoridis* as indicator of ecological change and to estimate the relationship between soil variables and wild communities of it.**

Keywords: Chorotype, habitat, Pluchea dioscoridis, species diversity, species cover, soil measurement

Introduction

The plant community has a vital role in affordable management by maintaining biodiversity and conserving the environment (Kandi et al. 2011). Communities of ruderal vegetation owe their existence to disturbance of their habitats (Grime 1979). Weeds are considered to be a main component of agro-ecosystems and have an influence on land diversity. Field experiments indicate that weeds can enhance species diversity of an ecosystem, lower pest density and conserve soil fertility (Chen et al. 2004). Most of weed communities help in featuring the patterns of species structure and distribution and then interpretation of these patterns with respect to environmental factors (Fried et al. 2008). Classification and ordination techniques have been applied to feature the ecological relationships between vegetation and the environmental factors (Zhang & Zhang 2000).

Urban areas are unique habitats; where large populations of humans build dense buildings; these areas have been significantly changed from their natural state into urban ecosystems. Urbanized lands have a very simple community structure and species composition (McKinney 2002, Lundholm & Marlin 2006, Jim & Chen, 2010). The urban ecosystem comprises plant species from the natural flora of ruderal habitats to the cultivated flora of reclaimed areas (Sukopp & Werner 1983). The relationship between urban vegetation and environmental factors was represented by few studies like those of Klotz (1990) and Pyšek (1993); these studies showed that species richness of plant is highly correlated to population size in cities. Gilbert (1989) reported that cities have high species richness due to their habitat diversity which offers a variety of ecological conditions for plant species.

New habitats have been introduced in Nile Delta by agriculture and by the permanent occupation of sites for habitation (Shaltout &

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Sharaf El-Din 1988). Different types of habitats have been supported by the Nile Delta region; some of which are natural and the others are human made; salt marshes, coastal dunes, and brackish shallow lakes were found to be the main natural habitats at the northern part of the Nile Delta; while irrigation, drainage canals, railways, railway yards, motor roads, abandoned fields, demolished houses, refuse areas and grave yards were the human made habitats (Shaltout & Sharaf El-Din 1988, Shaltout 1994).

Pluchea dioscoridis (L.) DC (Asteraceae); is an important perennial wild evergreen shrub. It had been recorded in eight habitats (rail ways, highways, wastelands, abandoned fields, orchards, canal and drain banks and Lake Mariut) in Nile Delta (Shaltout et al. 2010). The distribution and presence of *P. dioscoridis* had been affected by human activity, chiefly due to destructive manner (limiting canals and drains), resulting in the reduction of aquatic communities (Shaltout & El-Sheikh 2002). Herein, we investigated the distribution and associated species of the *P. dioscoridis* in the different habitats in Gharbia Governorate (middle of Nile Delta), Egypt. We also aimed at evaluating the most important environmental factors affecting its distribution in the different habitats, and assessing the diversity and behavior of the associated species along different environmental factors, which may be a good tool to use it as indicator of ecological change.

Materials and methods

1. Study area

Gharbia Governorate (Fig. 1) is located in the middle of Nile Delta (31°9'22" - 30°34'41"N; 31°18'22" -30°45'27"E). It covers about 25,400 km^2 (Abdel-Hamid et al. 2011); and comprises eight districts, which were selected to represent the distribution of *P. dioscoridis* population in different habitats. The main land use is agriculture; Nile Delta comprises about 63% of Egypt's fertile land (Abu Al-Izz 1971). This Delta lies in the arid belt of the southern Mediterranean region; its climate is rather arid to semi-arid (UNESCO 1977). The highest temperature is in July and August with an average of 38 °C, and its lowest temperature in December and January with an average of 7.7 °C, with an average rainfall of 42.8 mm year^{-1}. The relative humidity varies between 45% at the south in June and 76%, at middle region in August (NASA-POWER 2000-2017). The soil of Nile Delta is mostly heavy in texture and rather compact at the surface. The human status of the soils is fairly well. Thus, all soils with exception of the northern part are man-made and are regarded as anthropic variants of the Gleysols and Fluvisols (for more details see Shaltout et al. 2010).

2. Vegetation sampling

Seventy three stands (100 m^2 each) were selected to represent the different habitats of *P. dioscoridis* populations in the eight disrticts of Gharbia Governorate. The sampling processes of the study sites have been carried out during a year between March 2016 to Februaray 2017 through regular seasonal visits to the study area. These stands represent the distribution of *P. dioscoridis* population in four urban habitats (wastelands, railway sides, canal and drain banks); and were distributed as follow: 40 (1-40) in the wastelands, 12 (46 – 57) along the canal banks, 16 (58 – 73) along the drain banks, and 5 (41 – 45) along the railwaysides. In each stand, the floristic elements had been surveyed and the associated perennial and annual species were recorded seasonally indicating the first and second dominant species. Identification and nomenclature of the recorded species were according to Boulos (1999, 2000, 2002, 2005, 2009). The life form of each species was according to Raunkiaer (1937); and the actual and relative number of species belonging to each life form were calculated. The abundance of each species in each stand (visual estimate of coverage as a percentage of the stand area), was estimated according to the scheme of Braun-Blanquet (1932). Analysis of global geographical distribution of the recorded species was carried out according to Zohary (1966, 1972); Täckholm (1974); Abdel El-Ghani (1981, 1985); Hassan (1987). Voucher specimens were kept in Tanta University Herbarium (TANE).

3. Soil analysis

Three composite soil samples were collected as profiles for the soil depth (0-50 cm) from each stand. The sampled soil was brought to the laboratory in plastic bags directly after collection,

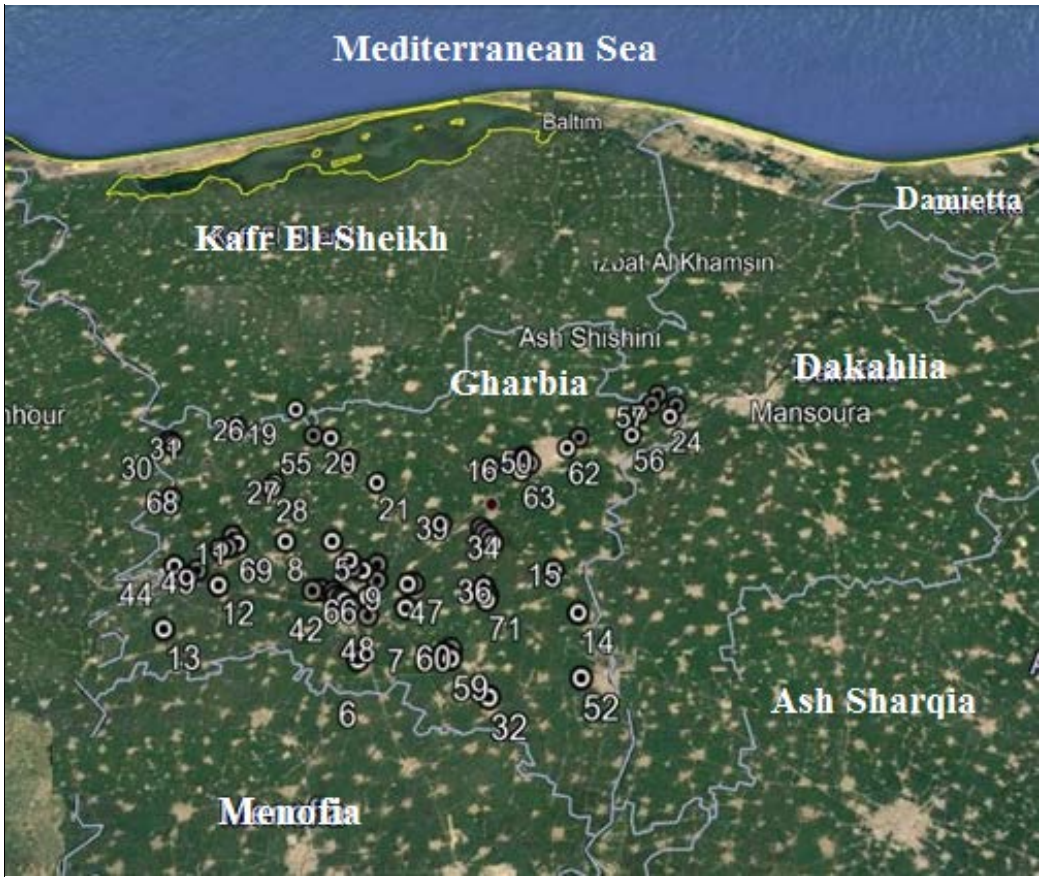

Fig. 1. Study area showing the selected stands (o) in Gharbia Governorate

spread over paper sheets, air dried and passed through a 2 mm sieve to remove gravels and debris. Prior to particle size analysis, the binding agents as carbonates and organic matter were removed by treating the soil with a few drops of 1M HCl, boiled with H_2O_2 and dispersed with sodium hexa-metaphosphate. Soil texture analysis was carried out by Bouyoucos hydrometer method (Piper 1947), whereby the percentages of sand, silt and clay were calculated. The porosity of soil and water-holding capacity were measured as reported by Piper (1947).

Soil-water extract of 1:5 *w/v* were prepared for the determination of pH values, electric conductivity (EC; as a measure of salinity), carbonates, bicarbonates, Cl, SO_4 and $CaCO_3$. Soil reaction (pH) and EC were measured using a glass electrode pH meter (Model 9107 BN, ORION type) and electrical conductivity meter (conductivity meter 60 Sensor Operating Instruction Corning), respectively. Determination of carbonates and bicarbonates was carried out by titration with 0.1N HCl using phenolphthalein and methyl orange as indicators. Chlorides were estimated by direct titration against N/ 35.5 silver nitrate and calcium carbonate was determined by titration against 1N NaOH (Jackson 1962). Sulphates were determined using the "gravimetric with ignition of residue method", where sulphates were precipitated in 1% HCL solution as barium sulphate (Piper 1947).

Total organic matter was determined by loss-on-ignition at 440 °C according to Piper (1947). Nutrients (N, P, K and Ca) content in the collected samples were determined after digestion using the mixed-acid digestion method (Parkinson & Allen 1975). Estimation of K and Ca in the soil solution was carried out by using flame photometer (CORNING M410). Determination of the total soluble nitrogen was achieved using Kjeldahl method (Pirie 1955). Molybdenum blue and indo-phenol blue methods were applied for the determination of P and N, respectively, using a spectrophotometer (CECIL CE 1021) set at 660 nm in case of N and 700 nm in case of P. All these procedures are according to APHA (1985) and Allen (1989).

4. Data analysis

Two-way indicator species analysis (TWINSPAN) and detrended correspondence analysis (DCA) were applied to the matrix of cover estimates of the associated species with *P. dioscoridis* in 73 stands (Hill 1979 a,b). The relationships between vegetation gradients and environmental variables were produced by canonical correspondence analysis (Ter Braak 1986, 1987) in which points represent the common species and arrows represent environmental variables. The significance of variation in the soil variables with respect to TWINSPAN vegetation types was evaluated using one-way analysis of variance (ANOVA) using SPSS (SPSS 2006). Duncan's new multiple range test was applied as a post-hoc test to the ANOVA to evaluate the significance of differences between each pair of means.

Species richness (alpha diversity) for each vegetation group (VG) was assessed as the average number of species per stand, and then the species average per TWINSPAN group was used for comparison between other vegetation groups. The relative evenness or equitability (Shannon-Wiener diversity index) of the importance value (relative coverage) of a species was calculated from the formula: $H' = -\sum P_i \log P_i$ (Harper 1999), where P_i is the relative importance value (relative coverage) of the species. The relative concentration of dominance (Simpson's diversity index) is the second group of heterogeneity indices and is expressed by Simpson's diversity index: $C = \sum P_i^2$ (Whittaker 1972, Pielou 1975), where P_i is the relative importance value (relative coverage) of the species.

Results

1. Floristic analysis

Seventy-two species belonged to 58 genera and 23 families were associated with *P. dioscoridis* populations in 73 stands in the study area (Table 1). Fifty-four species (61.1% of the total species) predominated in the wastelands, followed by 47species (65.3 %) in canal banks, 37 species (51.4 %) in drain banks and 18 species (25.0 %) in railway sides. Poaceae was the most represented family (25.0 % of the total recorded species), followed by Asteraceae (12.5 %), Fabaceae (8.3 %), Chenopodiaceae (7.0 %) and Brassicaceae (5.6 %). The most common species associated with *P. dioscoridis* were *Cynodon dactylon* (P = 73.0 %), *Phragmites australis* (P = 60.7%), *Cyperus rotundus* (P = 50.5%), *Imperata cylindrica* (P = 49.3%) and *Panicum repens* (P = 48.3%). Therophytes were the most frequent life-form (39 species = 54.1%), followed by Geophyte-Helophyte (13 species = 18.1%), Hemicryptophytes (7 species = 9.7 %), Phanerophytes (6 species = 8.3 %), while chamaephytes (4 species = 5.6 %) and Parasites (3 species = 4.1%) were the less represented (Table 1 and Fig. 2).

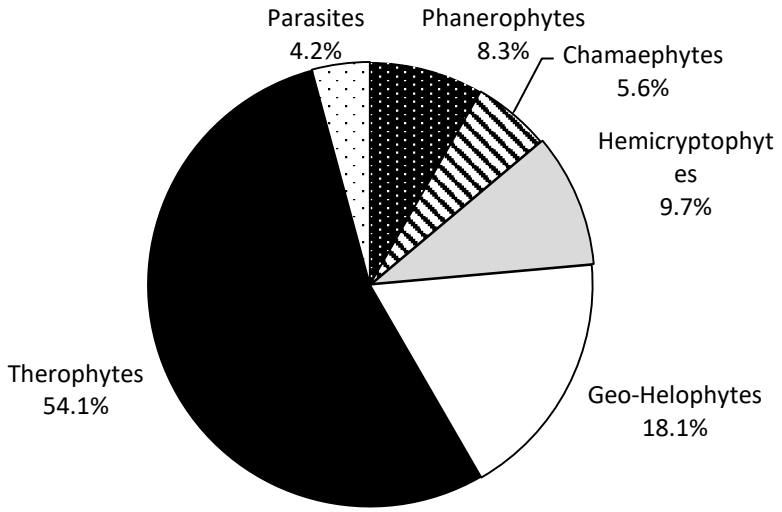

Fig. 2. Life form spectrum of the species associated with the distribution of *Pluchea dioscoridis* in Gharbia Goveronorate-Nile Delta, Egypt.

Table 1. Floristic composition, presence value (P %) of the wild species associated with *Pluchea dioscoridis* in Gharbia Governorae (Nile Delta, Egypt). Chorology is: ME: Mediterranean, COSM: Cosmopolitan, IR – TR: Irano-Turanian, SA-SI: Saharo-Sindian, ER – SR: Euro-Siberian, SA-AR: Saharo-Arabian, Temp: Temperate region, SU-ZA: Sudano-Zambezian, PAN: Pantropical, PAL: Palaeotropical, TR: Tropical, IT: Irano-Turanian, IN: Indian and NEO: Neotropical. **Habitats** are CB: canal banks, WL: wastelands, DB: drain banks and RS: Railways sides.

Species	Family	Chorology	Habitat	P (%)
Phanerphytes				
Salix tetrasperma Roxb.	Salicaceae	Temp	CB	6.0
Ricinus communis L.	Euphorbiaceae	SU-ZA	Wl,CB	27.1
Tamarix nilotica (Ehrenb.)Bunge	Tamaricaeae	SA-AR+IR-TR	Wl,CB	10.2
Sesbania sesban (L.) Mer.	Fabaceae	SU-ZA	Wl,CB,DB	5.1
Salix mucronata Thunb.	Salicaceae	Temp	Wl	5.0
Dalbergia sisso Roxb.	Fabaceae	West Asia+ IN	Wl,CB,DB	1.7
Chamaephytes				
Chenopodium ambrosioides L.	Chenopodiaceae	COSM	CB,DB	18.3
Solanum nigrum L.	Solanaceae	IR-TR+ER-SR+ME	All habitats	17.2
Symphyotrichum squamatum (Spreng)	Asteraceae	NEO	CB,DB	21.2
Withania somnifera (L.) Dunal	Solanaceae	ME+IR-TR+PAL	Wl,CB	3.3
Hemicryptophytes				
Convolvulus arevensis L.	Convolvulaceae	PAL	CB,DB,Wl	27.2
Cynanchum acutum L.	Asclepiadaceae	PAL	Wl,CB,DB	27.0
Lotus glaber Mill.	Fabaceae	ER-SR+ME+IR-TR	Wl,DB	18.3
Ipomoea cairica (L.) Sweet	Convolvulaceae	PAL	Wl	14.3
Plantago major L.	Plantaginaceae	ER-SR+ME+IR-TR	Wl,CB	6.2
Silybum marianum(L.)Gaertn.	Asteraceae	IR-TR+ER-SR+ME	Wl	15.3
Vigna luteola (Jacq.) Benth.	Fabaceae	SU-ZA	Wl,CB,DB	1.2
Geophytes-Helophytes				
Arundo donax L.	Poaceae	ME+IR-TR+ER-SR	Wl,CB,DB	26.2
Cynodon dactylon (L.) Pers.	Poaceae	PAL	All habitats	73
Cyperus alopecuroides Rottb.	Cyperaceae	PAL+NEO	Wl,CB,DB	47.3
Cyperus articulatus L.	Cyperaceae	TR	CB,Wl	24.4
Cyperus rotundus L.	Cyperaceae	IR-TR+PAL+NEO+ME	Wl,CB,DB	50.5
Imperata cylindrica (L.) Raeusch.	Poaceae	ME+IR-TR+SA-AR +PAL+NEO	CB,DB,RS	49.3
Panicum repens L.	Poaceae	PAL+NEO+ME	CB,DB,RS	48.3
Persicaria salicifolia (Willd.) Assenov	Polygonaceae	COSM	CB,DB	30.0
Persicaria senegalensis (Meisn). Soják.	polygonaceae	PAL+ME	CB	10.0
Phragmites australis (Cav) Trin. ex Steud.	Poaceae	ME+IR-TR+SA-AR+ PAL+NEO	All habitats	60.7
Saccharum spontaneum subsp. *aegyptiacun* (Willd) Hack.	Poaceae	ME+IR-TR+SA-AR +PAL	CB,DB,Wl	13.3
Sorghum virgatum (Hack.) Stapf	Poaceae	PAL	Wl,RS	3.3
Typha domingensis (Pers) Poir. ex Steud.	Typhaceae	ME+IR-TR+PAL	CB,DB	1.3
Therophytes				
Amaranthus viridis L.	Amaranthaceae	COSM	CB	20.3
Ammi majus L.	Apiaceae	IR-TR+ME	Wl,CB,DB	16.2
Anagallis arvensis L.	Primulaceae	ME+IR-TR+ER-SR	RS	15.4
Avena sativa L.	Poaceae	Temp	Wl,CB,DB	15.4
Bassia indica (Wight) A.J.Scott.	Chenopodiaceae	SU-ZA + IR-TR	RS,Wl	17.2
Beta vulgaris subsp *maritima* (L.) Arcang.	Chenopodiaceae	ME+ ER-SR + IR-TR	CB,DB	19.3
Brassica nigra (L.) Koch	Brassicaceae	ER-SR+ME	Wl	14.4
Brassica rapa L.	Brassicaceae	ER-SR+ME	Wl	7.0
Cenchrus incertus M. A. Curtis	Poaceae	NEO	Wl	3.3
Chenopodium album L.	Chenopodiaceae	COSM	DB	17.3
Cichorium endivia subsp. *divaricatum*	Asteraceae	ME+IR-TR	RS,CB	15.4
Conyza aegyptiaca (L.) Dryand.	Asteraceae	SU-ZA	Wl,CB,DB	9.2
Conyza bonariensis (L.) Cronquist.	Asteraceae	ME+NEO	Wl,CB	17.2
Corchorus olitorius L.	Tiliaceae	PAN	Wl	10.3
Coriandrum sativum L.	Apiaceae	IR-TR+ME	Wl	15.4
Dactyloctenium aegyptium (L.) Willd.	Poaceae	PAL+ME	WL,DB,CB	18.3
Desmostachya bipinnata (L.) Stapf.	Poaceae	SU-ZA+SA-AR+ ME+IR-TR	CB,RS	10.2

Table 1. Cont.1

Species	Family	Chorology	Habitat	P (%)
Echinochloa crusgalli (L.) P. Beauv.	Poaceae	ME+IR-TR+ER-SR	Wl	14.4
Echinochloa stagnina (Retz) P. Beauv.	Poaceae	PAL	CB,DB,Wl	46.3
Eruca sativa Mill.	Brassicaceae	ME+IR-TR+ER-SR	RS,Wl	14.4
Euphorbia indica Lam.	Euophorbiaceae	Temp+NEO	Wl,RS	12.2
Hibiscus sabdariffa L.	Malvaceae	PAL	Wl	8.2
Hibiscus trionum L.	Malvaceae	PAL	Wl	8.3
Malva parviflora L.	Malvaceae	ME+IR-TR	Wl,DB,CB	26.4
Melilotus indius (L.)All.	Fabaceae	ME +IR-TR+SA-AR	CB	16.3
Phalaris minor Retz.	Poaceae	ME+IR-TR	All habitats	15.4
Phalaris paradoxa L.	Poaceae	ME+IR-TR	RS	14.4
Polypogon monspeliensis (L) Desf..	Poaceae	ME+ IR-TR+SA-AR	CB,DB,Wl	33.8
Polypogon viridis (Gouan) Breistr.	Poaceae	ME-IR-TR	Wl,CB,DB	17.2
Portulaca oleracea L.	Portulacaceae	COSM	CB,DB,Wl	16.2
Rumex dentatus L.	Polygonaceae	ME+ IR-TR+ER-SR	CB,DB,Wl	40.2
Senecio glaucus subsp. *coronopifolius* (Maire)	Asteraceae	SA-AR+IR-TR	CB,DB	14.4
Sismbrium irio L.	Brassicaceae	ME +IR-TR+ER-SR + SA-AR	RS,CB,DB	17.2
Sonchus oleraceus L.	Asteraceae	ER-SR+ME+IR-TR	All habitats	29.2
Sorghum bicolor (L) Moench	Poaceae	PAL+NEO	Wl	3.3
Trifolium alexandrinum L.	Fabaceae	Temp+ME	CB	7.2
Urospermum picroides (L.) F. W. Schmidt	Asteraceae	IR-TR+ME	Wl	16.2
Urtica urens L.	Urticaceae	ER-SR+ME +IR-TR	Wl	10.3
Parasites				
Cuscuta pedicellata Ledeb.	Cuscutaceae	IR-TR+ME	Wl	2.2
Cuscuta planiflora Ten.	Cuscutaceae	PAL	Wl	1.1
Orobanche crenata Forssk.	Orobanchaceae	ME+IR-TR	CB	2.2

(P%) = the number of individuals of each species in all stands or habitats divided by the total number of all species (72).

The chorological analysis of the recorded species revealed that bi-regional taxa were the most frequent chorotype (24 species = 33.3 %), followed by pluri-regional (23 species = 23.0 %) and mono-regional (19 species = 26.4 %), while cosmopolitans were the less represented (6 species = 8.3 %) (Table 1). On a mono-regional scale, Mediterranean taxa were the most represented (39 species = 24.2 % of the total species), followed by Irano-Turanian (34 species = 47.2 %), Palaeotropical (22 species = 30.6 %) and Euro-Siberian (22 species = 30.6 %). *P. dioscoridis* showed Saharo-Sindian distribution intermingled with Sudano-Zambezian elements.

2. Multivariate analysis

The application of TWINSPAN based on the relative coverage estimates of 73 plant species, including *P. dioscoridis*, recorded in 73 stands along four habitats (canals, drains, railway sides and wastelands), led to the recognition of four vegetation groups at level 2 of the classification according to their habitat preferability (Table 2 and Fig. 3). On the same set of data the application of DCA showed a clear pattern of segregation among these groups along the ordination axes 1 and 2 (Fig. 4). The vegetation groups were named after the common species associated with *Pluchea dioscoridis* as follows: *Pluchea dioscoridis-Imperata cylindrica* group (**VG A**) which mainly occupied the canals banks; the indicator species was *Persicaria salicifolia* (RC = 14.2%). *Pluchea dioscoridis-Phragmites australis* group (**VG B**) mainly inhabited the drain banks; its indicator species were: *Echinochloa stagnina* (RC = 3.2%) and *Chenopodium album* (RC = 3.1%). In contrast, The *Arundo donax-Pluchea dioscoridis* group (**VG C**) inhabited the railwaysides and wastelands; with *Arundo donax* as indicator species (RC = 32.52%). Furthermore, *Cynodon dactylon-Pluchea dioscoridis* group (**VG D**) inhabited wastelands habitat; with *Pluchea dioscoridis* (RC = 49.0%) as indicator species.

It was observed that **VG D** was the most diverse group (Table 3), as it had the highest species number (34), richness (9.5 species stand^{-1}), relative evenness (1.0) and relative concentration of dominance (0.9). In contrast,

Table 2. Mean and coefficient of variation (value between brackets) of the relative coverage of species (%) in the different vegetation groups, resulting from TWINSPAN classification of the sampled stands of different habitats in Gharbia Governorate, (Nile Delta, Egypt) .*A:* canal banks, *B:* drain banks, *C:* railway sides and wastelands, *D:* wastelands

Classification level	Vegetation group			
Level 2	A	B	C	D
No. of stands	12	16	11	34
Amaranthus viridis	-	-	0.20 (2.44)	-
Ammi majus	-	0.56 (2.45)	5.4 (1.40)	0.92 (6.23)
Anagallis arvensis	0.09 (5.50)	-	0.10 (2.20)	-
Arundo donax	-	27.0 (0.33)	39.5 (0.45)	41.2 (0.55)
Avena sativa	3.1 (1.25)	-	1.7 (4.15)	-
Bassia indica	1.3 (3.45)	-	-	8.1 (1.64)
Beta vulgaris subsp *maritima*	0.43 (4.25)	-	1.0 (5.26)	0.35 (3.26)
Brassica nigra	-	-	5.2 (3.28)	3.2 (4.04)
Brassica rapa	-	-	2.1 (4.23)	1.7 (5.23)
Cenchrus incertus	1.2 (2.23)	-	-	1.7 (3.32)
Chenopodium album	2.7 (3.66)	3.4 (2.36)	11.5 (2.36)	12.7 (2.10)
Chenopodium ambrosioides	2.7 (5.36)	3.1 (1.25)	-	-
Chenopodium murale	-	0.2 (4.25)	-	3.2 (1.22)
Cichorium endivia subs. *divaricatum*	1.2 (6.43)	0.27 (3.25)	0.37 (5.36)	-
Convolvulus arevensis	-	4.2 (2.32)	-	1.5 (2.39)
Conyza aegyptiaca	2.7 (1.36)	-	-	3.6 (1.58)
Conyza bonariensis	-	0.32 (3.25)	-	0.97 (6.36)
Corchorus olitorius	-	-	2.5 (1.44)	3.1 (1.90)
Coriandrum sativum	-	-	0.31 (2.36)	1.7 (3.21)
Cuscuta pedicellata	-	-	-	0.09 (3.26)
Cuscuta planiflora	0.07 (5.25)	-	-	-
Cynanchum acutum	-	-	0.51 (2.26)	4.3 (1.00)
Cynodon dactylon	-	26.0 (1.36)	-	50.1 (0.9)
Cyperus alopecuroides	-	10.2 (1.36)	7.1 (2.22)	8.2 (3.21)
Cyperus articulates	7.1 (2.36)	-	2.0 (1.47)	3.0 (2.32)
Cyperus rotundus	15.2 (0.90)	20.2 (0.78)	-	17.7 (1.29)
Dactyloctenium aegyptium	3.1 (1.23)	-	1.7 (3.25)	6.1 (2.22)
Dalbergia sisso	-	2.7 (1.32)	-	1.0 (5.25)
Desmostachya bipinnata	-	2.1 (3.25)	5.2 (2.36)	3.1 (2.58)
Echinochloa crusgalli	-	-	-	4.3 (0.99)
Echinochloa stagnina	3.2 (1.66)	2.11 (2.97)	-	1.1 (3.58)
Eruca sativa	-	-	2.7 (3.25)	1.5 (5.25)
Euphorbia indica	-	-	2.52(2.00)	3.1 (3.10)
Hibiscus sabdariffa	-	-	0.07 (3.62)	-
Hibiscus trionum	-	-	0.09 (4.33)	0.08 (5.36)
Imperata cylindrica	30.2 (0.92)	20.2 (0.99)	-	27.2 (0.79)
Ipomoea cairica	-	-	-	1.8 (3.39)
Lotus glaber	-	0.36 (2.39)	-	-
Malva parviflora	24.5 (4.36)	-	20.1	33.2 (2.21)
Melilotus indius	0.52 (4.32)	2.1 (2.01)	-	-
Orobanche crenata	1.4 (3.65)	-	-	0.97 (4.39)

Table. 2. Cont.

Classification level	Vegetation group			
Level 2	A	B	C	D
No. of stands	12	16	9	36
Panicum repens	16.2 (2.11)	9.3 (0.92)	7.2 (2.14)	-
Persicaria salicifolia	14.2 (2.25)	7.5 (1.44)	-	-
Persicaria senegalensis	0.92 (2.89)	-	0.78	-
Phalaris minor	-	4.2 (2.36)	1.7 (3.55)	-
Phalaris paradoxa	0.71 (3.36)	-	5.2 (2.00)	-
Phragmites australis	-	30.3 (1.30)	19.3	37.2 (0.12)
Plantago major	1.6 (5.36)	-		-
Pluchea dioscoridis	50.4 (2.01)	35.2 (2.00)	30.2	47.0 (0.25)
Polypogon monspeliensis	-	12.8 (2.36)	1.3 (3.39)	2.7 (2.36)
Polypogon viridis	-	1.9 (5.21)	-	1.2 (3.45)
Portulaca oleracea	2.7 (1.11)	-	-	15.2 (1.58)
Ricinus communis	10.1 (3.33)	-	17.2	15.2 (3.96)
Rumex dentatus	-	13.2 (2.22)	10.3	9.1 (3.50)
Saccharum spontaneum subsp.	-	3.2 (2.31)	-	2.7
Salix mucronata	-	-	1.4 (3.58)	0.91 (2.54)
Salix tetrasperma	4.11 (1.25)	-	-	2.17 (1.00)
Senecio glaucus subsup.	3.21 (2.25)	1.8 (5.28)	-	-
Sesbania sesban	-	0.91 (3.21)	0.42	-
Silybum marianum	-	-	8.54	11.26 (0.79)
Sismbrium irio	0.31 (2.58)	3.4 (1.36)	0.45	-
Solanum nigrum	0.34 (3.25)	-	0.09	1.5 (1.52)
Sonchus oleraceus	0.21 (2.36)	-	7.1 (1.28)	6.2 (2.25)
Sorghum bicolor	-	0.91 (3.26)	0.42	2.7 (1.32)
Sorghum virgatum	-	-	1.2 (1.66)	1.4 (1.98)
Symphyotrichum squamatum	6.1 (1.54)	2.5 (1.44)	-	-
Tamarix nilotica	3.21 (1.11)	-	5.2 (2.26)	-
Trifolium alexandrinum	3.2 (2.36)	-	4.8 (2.25)	-
Typha domingensis	0.05 (3.36)	-	-	-
Urospermum picroides	-	-	-	0.09 (4.25)
Urtica urens	-	-	5.2 (1.28)	0.92 (2.77)
Vigna luteola	0.82 (3.69)	-	-	-
Withania somnifera	2.7 (1.25)	-	-	3.4 (1.47)

VG B had the lowest species richness (6.2 species stand^{-1}), and relative evenness (0.7), while VG C had the lowest relative concentration of dominance (0.4).

3. Soil analysis

Soil texture of the study area was clay loam, while pH values indicated that the soil reaction is neutral with a tendency to alkalinity in all groups (Table 4). VG A had the highest values of OM (7.7%) and P (41.2 mg100g^{-1}), but the lowest of water holding capacity (20.8%), Cl (0.08%), CO_3 (0.07%) and HCO_3 (0.04%), VG B had the highest values of N (224.3 mg100g^{-1}) and Ca (1900.1 mg100g^{-1}), while the lowest of porosity (27.7%), SO_4 (0.08%) and P (23.2 mg100g^{1}).VG C had the highest water holding capacity (28.4%), Cl (0.22%), SO_4 (0.32%) and CO_3 (0.19%); while the lowest of $CaCO_3$ (2.7%) and K (32.3 mg100g^{-1}). VG D had the highest values of porosity (44.3%), $CaCO_3$ (3.2%) and K (94.3 mg100g^{-1}), but had the lowest of OM (2.6%), N (114.3 mg100g^{-1}) and Ca (933.5 mg100g^{-1}).

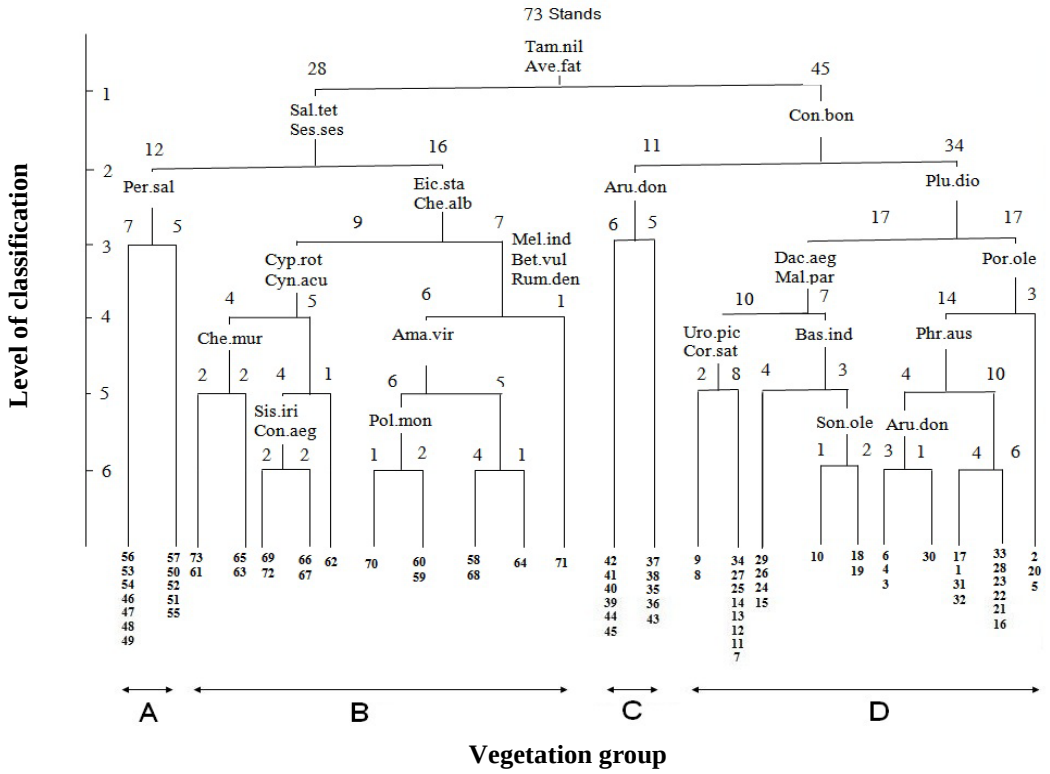

Fig. 3. The dendrogram resulting from the application of a two-way indicator species analysis on the coverage estimates of the 73 species that were recorded in the 73 stands in Gharbia Governorate, Nile Delta, Egypt. **A** canal banks, **B** drain banks, **C** railway sides and wastelands, **D** wastelands. The indicator species are abbreviated by the first three letters of genus and species, respectively; as ***Tam. Nil*** *Tamarix nilotica*, ***Ave. fat*** *Avena fatua*, ***Sal. tet*** *Salix tetrasperma*, ***Ses. ses*** *Sesbania sesban*, ***Con. bon*** *Conyza bonariensis*, ***Per. Sal*** *Persicaria salicifolia*, ***Che. alb*** *Chenopodium album*, ***Aru. don*** *Arundo donax*, ***Plu. dio*** *Pluchea dioscoridis*, ***Cyn. acu*** *Cynanchum acutum*, ***Cyp. rot*** *Cyperus rotundus*, ***Rum. den*** *Rumex dentatus*, ***Bet. vul*** *Beta vulgaris*, ***Mal. par*** *Malva parviflora*, ***Dac. aeg*** *Dactyloctenium aegyptium*, ***Son. ole*** *Sonchus oleraceus*, ***Che. mur*** *Chenopodium murale*, ***Mel. ind*** *Melilotus indius*, ***Che. alb*** *Chenopodium album*, ***Bas. ind*** *Bassia indica*,***Uro. Pic*** *Urospermum picroides*, ***Cor.sat*** *Coriandrum sativum*,***Con. aeg*** *Conyza aegyptiaca*, ***Sis. iri*** *Sismbrium irio*, ***Pol. mon*** *Polypogon monspeliensis* and ***Por. ole*** *Portulaca oleracea*

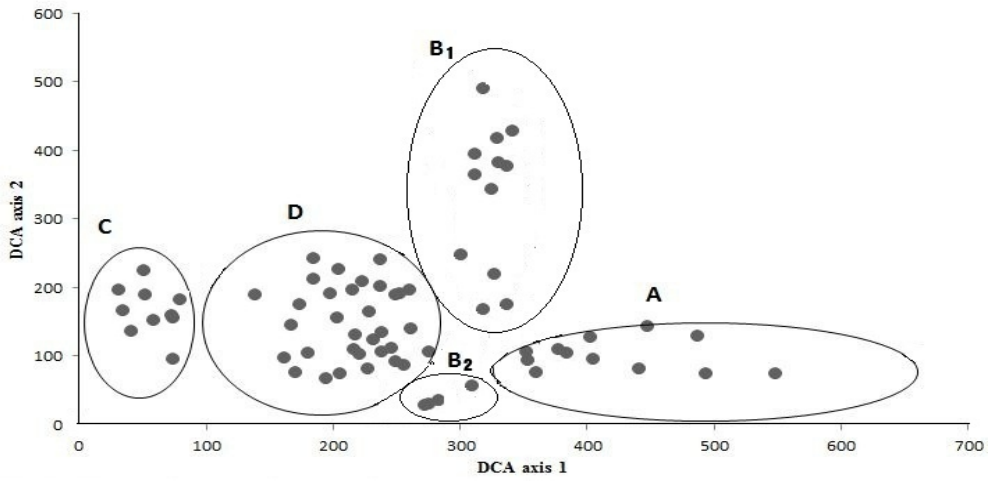

Fig. 4 Detrended correspondence analysis (DCA) ordination diagram of the vegetation groups that resulted from the application of the coverage estimates of the 73 species on the 73 sampled stands in Gharbia Governorate, Egypt. *A* canal banks, *B* (*B1*and *B2*) drain banks, *C* railway sides and wastelands, *D* wastelands.

Table 3. Characteristics of the four vegetation groups identified after application of TWINSPAN on the 73 stands of *Pluchea dioscoridis* in Gharbia Governorate, Nile Delta, Egypt .*A* canal banks, *B* drain banks, *C* railway sides and wastelands, *D* wastelands. P%: presence percentage, VG: vegetative groups and RC: relative cover.

VG	No. of Stands	P % stands	No. of species	P % of species	First dominant species	RC (%)	Second dominant species	RC (%)	Species richness	Shannon-Weiner index	Simpson's diversity index
A	12	16.4	42	57.5	*Pluchea dioscoridis*	50.4	*Imperata cylindrica*	30.2	9.0	0.8	0.7
B	16	21.9	33	45.2	*Pluchea dioscoridis*	35.2	*Phragmites australis*	30.3	6.2	0.7	0.5
C	11	15.1	40	54.8	*Arundo donax*	39.5	*Pluchea dioscoridis*	30.2	9.1	0.8	0.4
D	34	46.6	50	68.5	*Cynodon dactylon*	50.1	*Pluchea dioscorid*	47.0	9.5	1.0	0.9

Table 4. Mean and standard error (±SE) of soil variables of the four vegetational groups (A-D) obtained by TWINSPAN classification of different habitat types supporting the 73 stands of *Pluchea dioscoridis* in Gharbia Governorate (Nile Delta, Egypt).*A* canal banks, *B* drain banks, *C* railway sides and wastelands, *D* wastelands.

Soil variable		Vegetation group				F-values
		A	B	C	D	
Clay	(%)	42.44 ± 2.70^{a}	49.33 ± 0.89^{b}	53.67 ± 1.07^{d}	44.60 ± 0.40^{c}	60.42^{***}
Sand		41.87 ± 0.67^{a}	26.41 ± 1.22^{c}	31.12 ± 0.49^{a}	31.49 ± 0.35^{a}	0.52^{ns}
Silt		15.69 ± 2.38^{a}	24.26 ± 0.61^{a}	15.21 ± 0.58^{c}	23.91 ± 0.25^{a}	57.92^{***}
Porosity		30.80 ± 0.49^{a}	27.66 ± 0.48^{b}	38.37 ± 0.52^{cd}	44.33 ± 2.60^{c}	55.79^{***}
WHC		20.82 ± 0.24^{ab}	23.24 ± 0.56^{c}	28.37 ± 0.62^{bc}	25.52 ± 0.39^{a}	54.77^{***}
$CaCO_3$		3.11 ± 0.32^{a}	2.99 ± 0.15^{c}	2.65 ± 0.19^{e}	3.22 ± 0.26^{e}	251.28^{***}
OM		7.69 ± 0.19^{a}	5.26 ± 0.23^{b}	3.69 ± 0.24^{c}	2.58 ± 0.25^{c}	83.38^{***}
Cl^-		0.08 ± 0.02^{c}	0.17 ± 0.02^{a}	0.22 ± 0.01^{ab}	0.15 ± 0.01^{b}	18.29^{***}
SO_4^{--}		0.09 ± 0.01^{b}	0.08 ± 0.01^{a}	0.32 ± 0.01^{bc}	0.30 ± 0.05^{a}	20.45^{***}
CO_3^{--}		0.07 ± 0.02^{cd}	0.09 ± 0.02^{a}	0.19 ± 0.03^{bc}	0.12 ± 0.01^{b}	47.96^{***}
HCO_3^-		0.04 ± 0.01^{a}	0.07 ± 0.02^{c}	0.27 ± 0.02^{ab}	0.32 ± 0.01^{b}	344.01^{***}
pH		6.72 ± 0.24^{ab}	7.03 ± 0.11^{ab}	7.18 ± 0.01^{a}	7.25 ± 0.03^{a}	3.26^{*}
EC (mS/cm)		2.11 ± 0.02^{b}	3.21 ± 1.04^{a}	4.05 ± 0.01^{d}	9.25 ± 0.18^{d}	88.50^{***}
TN	($mg\ 100g^{-1}$)	217.21 ± 1.21^{a}	224.25 ± 2.06^{d}	165.73 ± 1.35^{b}	114.30 ± 1.92^{b}	3924.39^{***}
TP		41.16 ± 1.01^{b}	23.23 ± 0.96^{b}	31.35 ± 1.29^{ab}	31.25 ± 0.89^{a}	248.15^{***}
K		55.48 ± 1.18^{bc}	42.97 ± 2.14^{e}	32.32 ± 1.00^{b}	94.27 ± 0.98^{ab}	1172.62^{***}
Ca		1501.36 ± 255.23^{ef}	1900.99 ± 230.36^{d}	1126.08 ± 115.36^{bc}	933.48 ± 60.22^{d}	3329.79^{***}

P< 0.05, **:*P*< 0.01, ***: *P*< 0.001, ns = not significant. Means in the same columns followed by different letters are significantly different at P<0.05 according to Duncan's multiple range test ($LSR_{0.05}$).

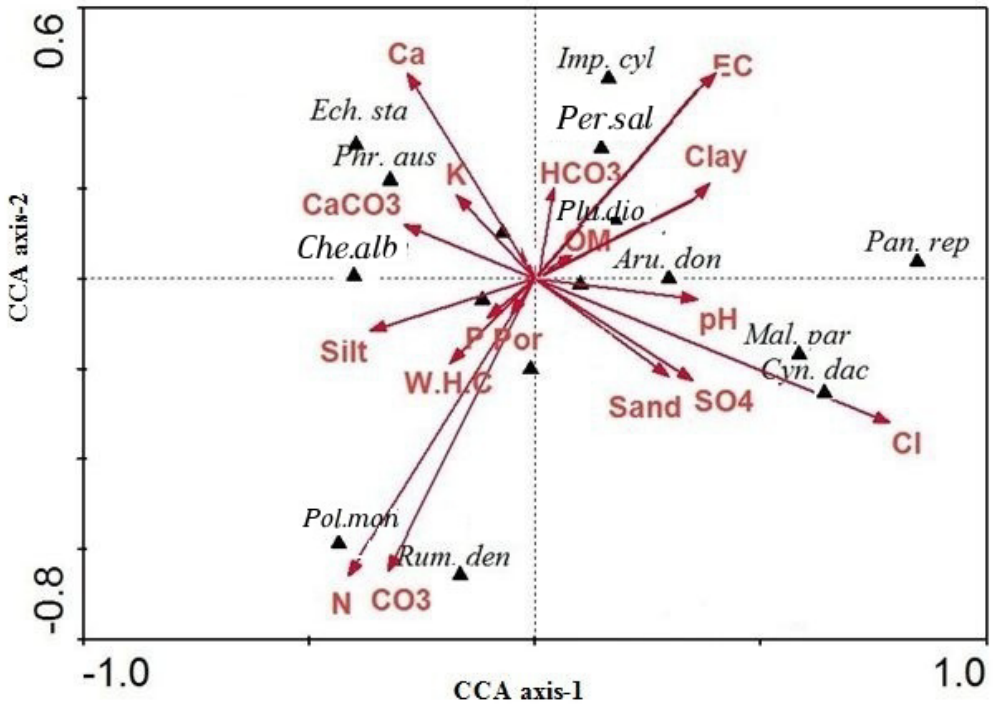

Fig. 5. Canonical correspondence analysis (CCA) ordination diagram of plant species along the gradient of environmental variables (arrow) in Gharbia Governorate. Eigen value for axis one is 0.69 and axis two is 0.06. The indicator and preferential species are indicated by first three letters of genus and species, respectively (The species codes are***: Ech. sta*** *Echinochloa stagnina****, Phr. aus*** *Phragmites australis****, Per. sal*** *Persicaria salicifolia****, Pol. mon*** *Polypogon monspeliensis*, ***Rum. den*** *Rumex dentatus****, Cyn. dac*** *Cynodon dactylon****, Mal. par*** *Malva parviflora****, Aru. don*** *Arundo donax****, Pan. rep*** *Panicum repens*, ***Plu. dio*** *Pluchea dioscoridis****, Che. alb*** *Chenopodium album****, Imp. cyl*** *Imperata cylindrica*).Soil variables codes as W.H.C: water-holding capacity, **OM:** organic matter, **N**: total nitrogen, **EC**: electrical conductivity, **Por**.: porosity.

4. Vegetation–environment relationship

The correlation between *P. dioscoridis* with its common associated species and the environmental characters was indicated on the bi-plot ordination diagram produced by CCA (Fig. 5). It was clear that the percentage of Cl^-, EC, N, CO_3^{--} and Ca^+ were the most effective environmental variables, which have high significant correlations with the first and second axes. *Pluchea dioscoridis*, *Imperata cylindrica* and *Persicaria salicifolia* (VG A) were greatly affected by the percentage of clay, EC and HCO_3; while clay percentage was the most effective variable on *Arundo donax* (VG C). On the other hand, *Phragmites australis*, *Echinochloa stagnina* and *Chenopodium album* (VG B) were influenced by K, Ca and $CaCO_3$. In addition, *Cynodon dactylon* and *Malva parviflora* (VG D) were affected by pH, Cl and SO_4, while *Polypogon monspeliensis* (VG B) and *Rumex dentatus* (VG B and C) were affected by N and CO_3.

Discussion

Seventy-two species were recorded as associated species with the distribution of *P. dioscoridis* in the different studied habitats in Gharbia Governorate. Poaceae, Asteraceae, Fabaceae, Chenopodiaceae and Brassicaceae were the leading families and are represented collectively by 42 species (53.9% of the total recorded species) forming the bulk of the flora in the study area. This is more or less in agreement with the study of (Mashaly & Awad 2003, Shaltout et al. 2005, Omar 2006, Ahmed 2014, Shehata & Galal 2015) in Nile Delta. The life form spectra provide information that could help in assessing the response of vegetation to variations in certain environmental factors (El-Ghareeb 1975). In the present study, therophytes were the most represented life form (50% of the total recorded species); this result coincides with studies of El-Kady et al. (1999), Ahmed (2014), Shehata & Galal (2015). This high contribution of therophytes can be referred to their short life cycles that permit them to resist the short life

cycle of crops (El-Kady et al. 2000). In addition, the adverse climatic conditions; moisture deficiency and substrate instability of the other habitats probably lead to the frequent occurrence of therophytes, associated with *P. dioscoridis* during the suitable seasons (El-Kady et al. 2000).

The chorology of the recorded species indicated that the bi-regional taxa had the highest percentage, followed by the pluri-regional, mono-regional and cosmopolitan. This may be due to that, Egypt is a meeting point of floristic elements belonging to at least four phyto-geographical regions: African Sudano-Zambesian, Asiatic Irano-Turanian, Afro-Asiatic Sahro-Sindian and Euro-Afro Asiatic Mediterranean (El-Hadidi 1993). Zohary (1973) explained that the inter-regional species (bi-, tri- and pluri-regionals) are dominant over mono-regional ones due to the presence of interzonal habitats, such as anthropogenic, hydro-, halo- and psammophilous sites. Thirty nine of the recorded species (50%) were Mediterranean taxa (pluri-, bi- and mono-regional). Irano-Turanian chorotypes, either pure or penetrated into other regions, comprised 34 species (43.6%) of the recorded flora; while the other floristic elements are represented by varying number of species, reflecting their different capability to penetrate the region, and this can be due to the influence of man and the history of agriculture in the study area (El-Ameir 2005).

Vegetation structure could be spilt through the classification and ordination analyses depending on indicator species and their correlation to environmental factors (Abd El-Ghani et al. 2013). The indicator species is of high importance because of their sensitivity to changes in environmental factors which may be beneficial or damaging (Seele et al. 2000; Thiebaut et al. 2002; Stelzer et al. 2005). The vegetation composition of *P. dioscoridis* along wastelands, railway sides, canal and drain banks was classified by TWINSPAN classification into four groups. *P. dioscoridis* was the first dominant in two groups (A and B); which occupies canal and drain banks. Shaltout & Slima (2007) reported that *P. dioscoridis* prefers inhabiting wetlands, while it was recorded as second dominant in two other groups (C and D); inhabiting railway sides and wastelands. Comparable results were reported by Shaltout and El-Sheikh (2002), Abu Ziada et al. (2008), El-Halawany et al. (2010), Shaltout et al. (2010), Abdel El-Ghani et al. (2012), El-Sherbeny et al. (2015) and Shehata & Galal (2015).

In the present study, it was clear that VG D, which characterizes wastelands, had the highest species richness and was the most diverse, while VG B which inhabited the drain banks was the least diverse; these results coincided with the study of Shaltout & Slima (2007). The lower species diversity in drain banks may be due to the bushy growth of the shrub preventing other species from colonizing the banks (Simpson 1932), and the dense canopy of tall growing associated species along canal and drain banks (e.g. *Cyperus alopecuroides*, *Phragmites australis* and *Persicaria senegalensis*) making more difficult, the germination and growth of other species leading to reduction of the species diversity (Shaltout & El-Sheikh 1993). It is well known that the aquatic weeds aggressively colonize disturbed canal or drain banks forming dense mono-dominant stand (Holzner 1978), which in turn increases their competitive ability and lower their species richness (Abdel El-Ghani et al. 2012). Diversity, species richness and evenness vary among different habitats due to dissimilarities in the soil characteristics, substrate discontinuities and the phytotoxic effects of one or more species, depending on their relative dominance among the other associated species (James et al. 2006).The highest coverage percentage for *P. dioscoridis* was recorded in canal and drain banks despite of its lower species diversity as a result of allelopathic effect of *P. dioscoridis* which offer phytotoxicity for some weeds by reducing their germination rates and seedling growth (Fahmy et al. 2012; Balah 2016).

The texture of soil has an influence on the soil or productivity through affecting the soil water-holding capacity, moisture availability and infiltration rate for plants (Sperry & Hacke, 2002).The soil analysis in the present study showed that canal and drain banks had the lowest salinity values, while wastelands had the highest salinity and this is in accordance with the study of Shaltout & Slima (2007) and

Ahmed (2014). Also, it was observed that the electrical conductivity (salinity) for all studied habitats was higher than those recorded by Shaltout (1994), Sharaf El-Din et al. (1999), El-Sheikh (2003)and Shaltout & El-Komi (2006) for the soil of *P. dioscoridis* and this may be related to the high ability of *P. dioscoridis* to sustain salinity.

Multivariate analysis of CCA indicated that, the most important soil variables with respect to the distribution of plants were soil fertility (phosphorus content and organic carbon), salinity, alkalinity, pH, soil texture, nitrogen and calcium carbonate (Shaltout & El-Sheikh 1993; Shaltout et al. 1994; Al-Sodany, 1998). Shaltout & El-Sheikh (1991) reported that the distribution of plants has either negative correlation with some soils parameters. In the present study, it was found that chloride, EC, total nitrogen, carbonate, and calcium cations were the most effective soil variables. The distribution of *P. dioscoridis* was positively correlated with EC, clay, organic matter and bicarbonate.

Conclusion

Seventy-two species were recorded as being associated with *P. dioscoridis* in the studied habitats in Gharbia Governorate. Poaceae, Asteraceae, Fabaceae, Chenopodiaceae and Brassicaceae were the leading families and are represented collectively by 42 species. Therophytes was the most represented life form (50%). Biregional and Mediterranean taxa were the most represented chorotype. Four vegetation groups (A-D) were identified after the application of TWINSPAN and DCA analysis. *P. dioscoridis* was the first dominant species in groups A and B, which inhabited the canal and drain banks (as *P. dioscoridis* prefers inhabiting wetlands). The same species was the second dominant in groups C and D, which occupied railway sides and wastelands. Group D had the highest species richness and was the most diverse, while VG B was the least diverse. The highest coverage percentage for *P. dioscoridis* was recorded in canal banks. The environmental variables such as chloride, electrical conductivity, nitrogen, carbonate, and calcium cations were the most effective environmental factors in the distribution of *P. dioscoridis* populations and its associated species. The distribution of this shrub was positively correlated by EC, clay, organic matter and bicarbonate.

References

Abd El-Ghani, M.M. 1981. Preliminary studies on the vegetation of Bahariya Oasis-Egypt. M.Sc.Thesis, Cairo Univ, Egypt.

Abd El-Ghani, M.M. 1985. Comparative study of the vegetation of Bahariya and Farafra Oases and the Faiyum region, Egypt. Ph.D. Thesis, Cairo Univ, Egypt.

Abd El-Ghani, M.M., Shehata, M.N., Mobarak, A. & Bakr, R. 2012. Factors affecting the diversity and distribution of synanthropic vegetation in urban habitats of the Nile Delta, Egypt. *Rendiconti Lincei.* **23(4)**: 327-337.

Abd El-Ghani, M.M., Soliman, A., Hamdy, R. & Bennoba, E. 2013. Weed Flora in the Reclaimed Lands along the Northern Sector of the Nile Valley in Egypt. *Turk. Jour. Bot.* **37**: 464-488.

Abd El-Hamid, Y.A., Mostafa, A.A., Allam, K.M. & Kenawy, M.A. 2011. Mosquitoes (Diptera: Culicidae) in El-Gharbia Governorate, Egypt: their spatial distribution, abundance and factors affecting their breeding related to the situation of lymphatic filariasis." Egypt. *Acad. J. Biol. Sci*. **3**: 9-16.

Abu Al-Izz, M.S. 1971. *Land Forms of Egypt*. The American University in Cairo Press. Dar Al-Maaref, Cairo.

Abu Ziada, M.A., Mashaly, I.A. & Torky, M. 2008. Ecological studies on the aquatic vegetation in North East Nile Delta, Egypt. *Intern. Jour. Bot*. **4(2)**: 151-163.

Ahmed, D. 2014. Distribution and antifungal activity of medicinal plant *Solanum nigrum* L. (Solanaceae) in the Nile Delta of Egypt. *Ecol. Med*. **40 (2)**: 29-39.

Allen, S.E. 1989. *Chemical analysis of ecological materials*. Blackwell Scientific Publications, London.

Al-Sodany, Y.M. 1998. Vegetation analysis of canals, drains and lakes of northern part of Nile Delta Region. Ph.D. Thesis, Tanta Univ., Egypt.

American Public Health Association (APHA) 1985 Standarad Methods for the Examination of Water and Waste Water, 17th ed. American Public Health Association, Washington, D. C.

Balah, M.A. 2016. Chemical and biological characterization of *Conyza dioscoridis* (L.) Desf. family (Compositae) in some perennial weeds control. *South African Journal of Botany*. **103**: 268-274.

Boulos, L. 1999. *Flora of Egypt*, Vol. 1. Azollaceae–Oxalidaceae.Al–Hadara Publishing, Cairo.

Boulos, L. 2000. *Flora of Egypt*, Vol. 2. Geraniaceae -Boraginaceae. Al– Hadara Publishing, Cairo.

Boulos, L. 2002. *Flora of Egypt*, Vol. 3. Verbenaceae-Compositae. Al-Hadara Publishing, Cairo.

Boulos, L. 2005. *Flora of Egypt*, Vol. 4. Monocotyledons (Alismatacae- Orchidaceae). Al-Hadara Publishing, Cairo.

Boulos, L. 2009. *Flora of Egypt, Checklist. Revised Annotated Edition*. Al-Hadara publishing, Cairo.

Braun-Blanquet, J. 1932. *Plant sociology*, 1st ed. McGraw Hill, NewYork.

Chen, X., Tang, J., Fang, Z. & Shimizu, K. 2004. Effects of weed communities with various species numbers on soil features in a subtropical orchard ecosystem. *Agriculture. Ecosystem & Environment Journal* **102**:377–388.

El-Ameir, Y.A. 2005. Eco-palynological studies of the plant life of the River Nile in Egypt. M. Sc. Thesis, Mansoura University, Egypt.

El-Ghareeb, R. 1975. A Study of the Vegetation Environmental Complex of Saline and Marshy Habitats on the Northern Coast of Egypt. Ph.D. Thesis, Alexandria Univ, Egypt.

El-Hadidi, M.N. 1993. *Natural Vegetation*. In G.M. In Craig (ed.). The Agriculture in Egypt, Oxford Univ. Press, Chapter 3: 39-62.

El-Halawany, E., Mashaly, I., Abu-Ziada, M. and Abd El-Aal, M. 2010. Habitat and Plant Life in El-Dakahlyia Governorate, Egypt. *Journal of Environmental Sciences* **39(1)**: 83-108.

El-Kady, H.F., Shaltout, K.H., Mousa, M.T. 1999. Diversity of Weed Communities in the Common Orchards of the Nile Delta. *Jour. Univ. Arab Bio*, Cairo. **9(13)**:149-168.

El-Kady, H.F., Shaltout, K.H., El-Shourbagy, M.N. & Al- Sodany, Y.M. 2000. Characterization of habitats in the North Western part of the Nile Delta. Proc. 1st Int. Conf. Biol. (ICBS) Fac. Sci., Tanta Univ. **1**: 144-157.

El-Sheikh, M. 2003. Plant succession on abandoned fields In Assiut, Egypt. Ass. Univ. Bull. *Environmental Research* **6 (1)**: 115-130.

El Sherbeny, G.A., El-Shehaby, O.A. & Mohsin, I.I. 2015. Ecological study and morphological variation of *Pistia stratiotes* in the northern eastern section of the Nile Delta, Egypt. *Jour. Envir. Sci*. **44(1)**: 31-45.

Fahmy, G.M., Al-Sawaf, N.A., Turki, H. & Ali, H.I. 2012. Allelopathic potential of *Pluchea dioscoridis* (L.) DC. *Jour. App. Sci. Res.*. **8(7)**: 3129-3142.

Fried, G., Norton, L.R. & Reboud, X. 2008. Environmental and management factors determining weed species composition and diversity in France. *Agr. Ecosys. Environ*.**128**: 68–76.

Gilbert, O.L. 1989. The ecology of urban habitats. Chapman and Hall, London.

Grime, J.P. 1979. *Plant Strategies and Vegetation Processes*. John Wiley and Sons. Chichester.

Harper, D.A. 1999. *Numerical palaeobiology: computer-based modelling and analysis of fossils and their distributions*. John Wiley & Sons Inc.

Hassan, L.M. 1987. Studies of the flora of Eastern Desert, Egypt. Ph.D. Thesis, Fac. Sci., Cairo Univ, Egypt.

Hill, M.O. 1979a. *DECORANA-a FORTRAN Program for Detrended Correspondence Analysis and Reciprocal Averaging*. Section of Ecology and Systematic, Cornell Univ., Ithaca, New York.

Hill, M.O. 1979b. *TWINSPAN-a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes*. Cornell University, Ithaca. New York.

Holzner, W. 1978. Weed species and weed communities. *Vegetatio* **38 (1)**:13–20.

Jackson, M.L. 1962. Soil Chemical Analysis. Constable and Co. LTD. London.

James, J.J., Caird, M.A., Drenovsky, R.E. & Sheley, R.L. 2006. Influence of resource pulses and perennial neighbors on the establishment of an invasive annual grass in the Mojave Desert. *Jour. Arid Environ.* **67**: 528–534.

Jim, C.Y. & Chen, W.Y. 2010. Habitat effect on vegetation ecology and occurrence on urban masonry walls. *Urban For Urban Gree*. **9**:169–178.

Kandi, B., Sahu, S.C., Dhal, N.K. & Mohanty, R.C. 2011. Species diversity of vascular plants of Sunabeda wildlife sanctuary, Odisha, India. *N.Y. Sci. J* **4**: 1–9.

Klotz, S. 1990. *Species-area and species-inhabitants relations in European cit*ies. In: Sukopp H, Hejny´ S, Kowarik I (eds) *Urban ecology: plants and plant communities in urban environments*. SPB Publishing, The Hague. pp 99–104.

Lundholm, J.T. & Marlin, A. 2006. Habitat origins and microhabitat preferences of urban plant species. *Urban Ecosystem*s **9**:139–159.

Mabberley, D.J. 1987. *The plant book, a portable dictionary of the higher plants*.Cambridge Univ. Press.

Mashaly, I.A. & Awad, E.R. 2003. Ecological Perspectives on the Weed Flora of Orchards in the Nile Delta, Egypt. *Journ. Envirn. Sci*. **25**:1-37.

McKinney, M.L. 2002. Urbanization, biodiversity, and conservation. *Bioscience*. **52**:883–890.

NASA-POWER. 2017. Climatology resource for agroclimatology. NASA prediction of worldwide energy. http://power.larc.nasa.gov/cgi-bin/cgiwrap/solar/agro.cgi.

Omar, G.M. 2006. Plant life of the Different Habitats in the North Nile Delta of Egypt: Ecology and Fodder Potentialities. Ph.D. Thesis, Fac. Sci., Mansoura. Univ., Egypt.

Parkinson, J. & Allen, S.E. 1975. A wet oxidation procedure suitable for the determination of nitrogen and mineral nutrients in biological material." *Communications in Soil Science & Plant Analysis* **6**: 1-11.

Pielou, E.C. 1975. *Ecological diversity*. Wiley, New York.

Piper, C.S. 1947. *Soil and Plant Analysis*. Interscience publishers, Inc. New York.

Pirie, N.W. 1955. *Protein. In: Modern Methods of Plant Analysis* IV, 23, Springer Verlage, Berlin.

Pyšek, P. 1993. Factors affecting the diversity of flora and vegetation in central European settlements. *Vegetatio* **106**:89–100.

Raunkiaer, C. 1937. *The Life Forms of Plants and Statistical Plant Geography*. Clarendon Press., Oxford.

Seele, J., Mayr, M., Staab, F. & Raeder, U. 2000. Combination of two indication systems in pre-alpine lakes diatom index and macrophyte index. *Ecol. Model***. 130**: 145-149.

Shaltout, K.H. 1994. Post-agricultural succession in the Nile Delta region. *Jour. Arid Envir.* **28**: 31-38.

Shaltout, K.H. & Sharaf El-Din, A. 1988. Habitat types and plant communities along a transect in the Nile Delta region. *Fedd. Repert.*. **99**: 153 – 162.

Shaltout, K.H. & El-Sheikh, M.A. 1991. Gradient analysis of canal vegetation in Nile Delta region. *Fedd. Repert.* **102**: 639-645.

Shaltout, K.H. & El-Sheikh, M.A. 1993. Vegetation-environment relations along water courses in the Nile Delta region. *Jour. Veget. Sci*. **4(4)**: 567−570.

Shaltout, K.H. & El-Sheikh, M.A. 2002. Vegetation of the urban habitats in the Nile Delta region, Egypt. *Urban Ecosystems. **6* (3)**: 205-221.

Shaltout, K.H., El-Din, A.S. & El-Sheikh, M.A. 1994. Species richness and phenology of vegetation along irrigation canals and drains in the Nile Delta, Egypt. *Vegetatio*. **112(1)**: 35−43.

Shaltout, K.H., Hassan, L.M. & Farahat, E.A. 2005. Vegetation-Environment Relationships in South Nile Delta, *Taeckholmia* **25**:15-46.

Shaltout, K. H. & El–Komi, T. M. 2006. Above-ground phytomass of *Pluchea dioscoridis* and *Tamarix nilotica* in the abandoned fields in Nile Delta, Egypt. Proc. 4th Int. Con. Biol.Sci.(Botany). pp. 59–64.

Shaltout, K. H. & Slima, D. F. 2007. The biology of Egyptian woody perennials. *Ass. Univ. Bull. Envir. Res*. **10(1)**: 85-103.

Shaltout, K.H., Sharaf El-Din, A. & Ahmed, D. 2010. *Plant life in the Nile Delta*: Tanta University Press, Tanta.

Shaltout, K.H., El-Beheiry, M.A., El-Kady, H.F. & Keshta, A.E. 2010. Distribution of the naturalized species *Dalbergia sisso* Roxb.ex DC. in Nile Delta, Egypt. *Taeckholmia*. **30**: 121-141.

Sharaf El-Din, A., Shaltout, K.H., E1-Kady, H.F. & El-Komi, T.M. 1999. Nutrient status of *Pluchea dioscoridis* and *Tamarix nilotica*

under pure and mixed situations in the Nile Delta region. *J. Union Arab. Biol*. **9 (B)**: 43-58.

Shehata, H.S. & Galal, T.M. 2015. Factors affecting the distribution and associated species of Malva parviflora in the Nile Delta, Egypt. *Weed biology and management*. **15(1)**: 42-52.

Simpson, N.D. 1932. A *Report on the Weed Flora of the Irrigation Channels in Egypt.* Ministry of Public Works, Government Press, Cairo.

Sperry, J.S. & Hacke, U.G. 2002. Desert shrub water relations with respect to soil characteristics and plant functional type. *Functional Ecology* **16**: 367–378.

SPSS. 2006. SPSS base 20.0 User's guide. SPSS inc., Chicago, USA

Stelzer, D., Schneider, S. & Melzer, A. 2005. Macrophyte – based assessment of lakes – a contribution to the implementation of the European water Frame work Directive in Germany. Intimate. Rev. *Hydrobiologyia*. **90**: 223 – 237

Sukopp, H. & Werner, P. 1983. *Urban environments and vegetation.* In:Holzner W, Werger MJA, Ikushima I (eds) Man's impact on vegetation. Dr W Junk Publishers, The Hague. pp. 247–260.

Täckholm, V. 1974. *Students' Flora of Egypt* 2nd ed. Cairo University.

Ter Braak, C.J. 1986. Canonical Correspondence Analysis: A New Eigenvector Technique for Multivariate Direct Gradient Analysis. *Ecology*. **67**: 1167-1179.

Ter Braak, C.J. 1987. The Analysis of Vegetation - Environment Relationships by Canonical Correspondence Analysis (CCA).*Vegetation*. **69**: 69-77.

Thiebaut, G., Guerold, F. & Muller, S. 2002. Are trophic and diversity indices based on macrophyte communities pertinent tools to monitor water quality? *Water Res*. **36**:3602–3610.

UNESCO. 1977. Map of the world distribution of arid regions. MAB Technical Notes, Paris.

Whittaker, R.I. 1972. Evolution and measurement of species diversity. *Taxon*. **21**:213–251

Zhang, F. & Zhang, J.T. 2000. Research progress of numerical classification and ordination of vegetation in China. *J. Shanxi Univ. (Nat. Sci. Educ.)* **23**: 278–282 (in Chinese with English abstract).

Zohary, M. 1966 & 1972. *Flora Palaestina*. Parts 1 & 2, Israel Academy of Sciences and Humanities. Jerusalem.

Zohary, M. 1973. *Geobotanical Foundations of the Middle East*, Gustav Fischer Verlag, Stuttgart, Germany.