Diversity and Vegetation Analysis of Plant species Associated with Prickly Pear (*Opuntia ficus indica* L. Mill.) in Nile Delta, Egypt

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Abstract

The present work aimed to study the floristic diversity and vegetation analysis of weeds associated with *Opuntia ficus indica* (L.) Mill. in three Nile Delta governorates. Ninety nine stands (10m X 10m) were surveyed in autumn and spring (2015-2016). Seventy one species belonging to 61 genera and 27 families were recorded associated with Prickly Pear. Poaceae, Asteraceae, Chenopodiaceae and Brassicaceae, were the most dominant families. Annuals recorded the highest number of species (45 species) while perennials were represented by 26 species. Therophytes were the dominant life form represented by 43 species while monoregional represented the dominant floristic category (22 species). The application of TWINSPAN on the cover estimates of 71 associated species recorded in the 99 sampled stands of Prickly Pear, led to the recognition of 8 vegetation groups: The names of these groups are: A: *Boerhavia Coccinea*, B: *Cynodon dactylon*, C: *Cyperus rotundus*, D: *Psidium guajava*, E: *Amaranthus lividus*, F: *Malva parviflora*, G: *Phragmites australi* and H: *Imperata cylindrical*. *M. parviflora* group had the highest value of species richness (21.6 species/stand) and relative evenness (0.63), while the highest species turnover (8.2) was recorded in *Boerhavia coccenea* VG A and the highest relative concentration of dominance (2.43) was recorded in *Amaranthus lividus* VG E. Some of the recorded species are invasive and negatively impact Prickly Pear cover, these species need control. Some other species provides many ecological and human services, these species need management and conservation.

Key Words: *Opuntia ficus indica* - Floristic Diversity - Vegetation Analysis - Nile Delta - TWINSPAN

1. Introduction

Recently biodiversity in agriculture has become a worldwide political issue. The United Nations General Assembly defined the time span of 2011-2020 as the Decade of Biodiversity. The reason for this international interest in biodiversity is the global change and losses of species resulted from industrialization. Biodiversity considerations apply to agriculture and they do not only refer to crops but to associated species also (**Kraehmer *et al.*, 2016**).

The plant community plays an important role in sustainable management by maintaining biodiversity and conserving the environment (**Kandi et al. 2011**). A major objective of most weed community ecology studies has been to identify the patterns of species composition and distribution and to interpret these patterns in relation to known or presumed gradients in the environment (**Fried et al. 2008**).

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Quantitative analysis, especially quantitative classification methods and ordination techniques, has been used widely to indicate the ecological relationships between vegetation and the environment (**Zhang & Zhang 2000**). Moreover, floristic studies are not only important in order to know the variety of plants that is present in an area, but because plants are socioeconomically significant. They provide shelter, food, medicine and everything for the human being and other species of that area.

Weeds are unwanted plant species emergent in the cultivated crops and grow where they are not needed. Out of 8000 only 250 weed species are important for agriculture world (**Holm *et al.*, 1979**). Weeds cause great destruction to crops as they increase the costs of different cultural practices, decrease the effectiveness of agricultural equipment and excellence of fertile lands, decrease the germination capability of crops seed due to the phytotoxins or allelochemicals (**Algandaby and Salama, 2016**).

In some circumstances, weeds and associated species to crops can reduce soil erosion, slow nutrient loss, increase soil organic matter, improve nitrogen levels and conserve soil water. Weeds that have proportionally deeper rooting systems relative to co-occurring crops may be capable of significant net transfer of nutrients from deep soil layers not available to such crops (**Patriquin, 1986**). In addition to their ecological value, many authors pointed out there importance in animal feeding, human consumption, medical uses, biological control, phytoremediation and phytoextraction (**Borgio *et al.*, 2007; Dkhil *et al.*, 2011; Shelef *et al.*, 2013; Golzardi *et al.*, 2015; Al-Snafi, 2015; Al-Oqai *et al.*, 2016; Biswas *et al.*, 2016**).

Native to Latin America, *Opuntia ficus indica* (L.) Mill. commonly named prickly pear, is a long-domesticated cactus crop that is important in agricultural systems throughout arid and semiarid parts of the world (**Anderson, 2001**). It has been introduced in the Mediterranean basin in the 15th century (**Donkin, 1977**). The species is well known for its ability to grow in dry and even desert conditions and its cultivation has been especially important in marginal and subsistence economies (**Feugang, 2006**). Commercial plantations are concentrated in Spain, Italy, Mexico, Brazil, Chile, Argentina, and USA (**Basile, 2001**). Prickly pear plants are used in a variety of ways, such as food and beverage, feed, medicinal and dyeing (**Pimienta and Muñoz-Urias, 1995**). Seed oil of prickly pear is exceptionally valuable because of its high content of essential fatty acids such as linoleic acid (omega-6), Vitamin E (around 1000 mg/kg) and sterols (around 10 g/kg) (**Ennouri et al, 2006**).

Vegetation Study of *Opuntia ficus indica* orchards in Egypt has not received suitable attention in respect to its importance. So, this work aimed to study the floristic composition and vegetation analysis of associated species with prickly pear (*Opuntia ficus indica*) in some habitats of Nile Delta region.

2. Materials and Methods
2.1. Floristic analysis

Twelve sites of *Opuntia ficus indica* located at three governorates (Qalyubiya represented by orchards, Minufiya along train Road of Cairo-Alexandria (Berket Al Saboa) and Buhayrah along the sides of Abo Mangug-Shobrakheet road] were selected to study vegetation associated with *Opuntia ficus indica* (fig. 1).

Vegetation data were collected during autumn and spring seasons at 2015 and 2016, respectively. Ninety nine (each 10×10 m) were selected randomly along the selected sites. A list of species of the orchard floor was made for each sampled stand. The cover of each species was visually estimated as a percentage using Réléve method (**Muller-Dombois and Ellenberg, 1974**). Identification and nomenclature were according to **Täckholm (1974), Boulos and El-Hadidi (1984)**, **El-Hadidi and Fayed (1994-1995)** and **Boulos (1999, 2000, 2002, 2005 and 2009)**. The voucher specimens were deposited in faculty of women, botany Department Herbarium Ain Shams University.
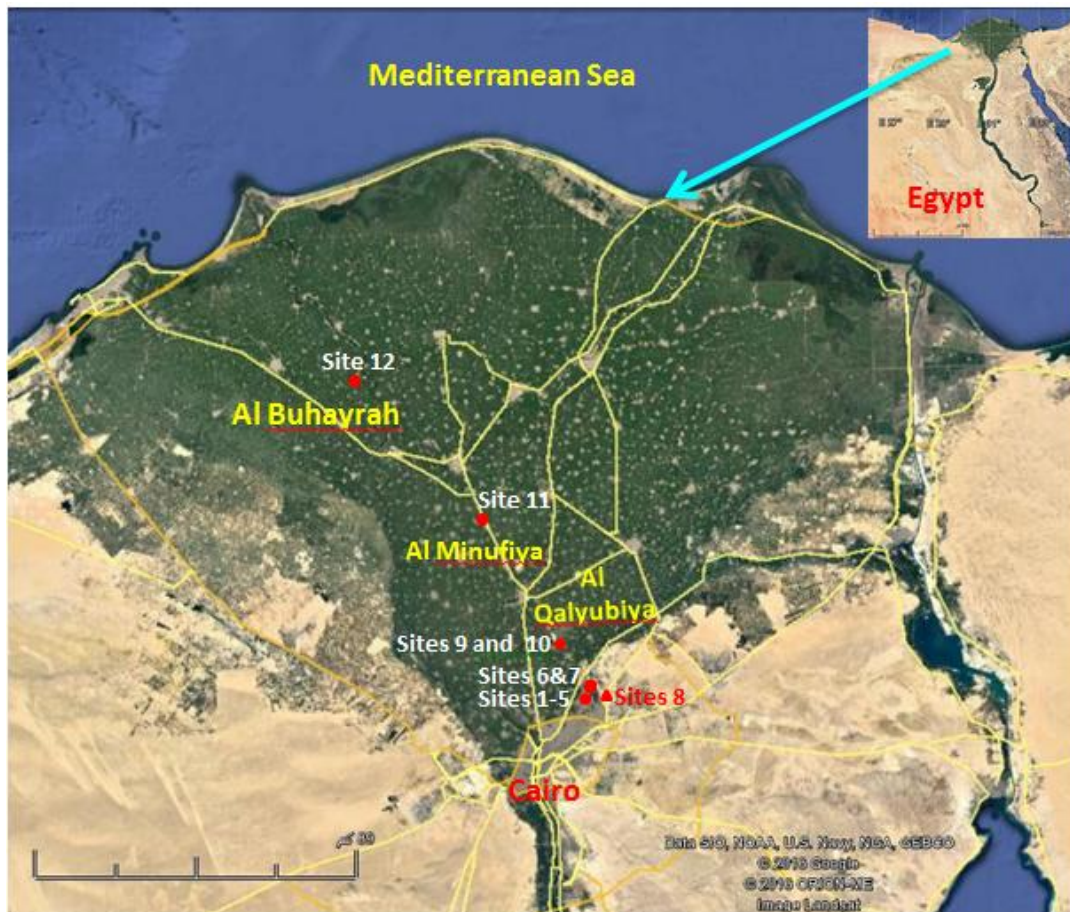

Fig. 1: Study sites (Google Earth map, 2015)

2.2. Multivariate analysis

Two-way indicator species analysis (TWINSPAN) as a classification technique and Detrended Correspondence Analysis (DCA) as an ordination technique were applied to the matrix of cover estimates of 71 species in 99 stands in *Opuntia ficus indica* farms. TWINSPAN is a two-way classification FORTRAN program that constructs a key to the sample classification by identifying one to several species that are particularly diagnostic of each division in the classification. The most significant new feature is that the program first constructs a classification of samples, and then uses this classification to obtain a classification of species according to their ecological preferences (**Hill, 1979a; Gauch, 1980; Gauch and Whittaker, 1981**). DCA is a FORTRAN program for detrended correspondence

analysis and reciprocal averaging. It was applied as a mean of axis construction to achieve a two-dimentional ordination of species and stands (**Hill, 1979b; Hill and Gauch, 1980**).

2.3. Diversity indices

Some diversity indices were calculated for the vegetation groups as derived from the multivariate analysis. Species richness (alpha-diversity) for each vegetation group was calculated as the average number of species per stands. Species turnover (beta-diversity) was calculated as a ratio between the total number of species recorded in a certain vegetation group and its alpha diversity (**Whittaker, 1972**). Relative evenness or equitability (Shannon-Wiener index) of the species cover was expressed as $\hat{H} = -\Sigma^s P_i (\log P_i)$, where S is the total number of species and P_i is the relative cover of the species. The relative concentration of dominance is the second group of heterogeneity indices and is expressed by Simpson's index: $D= 1/C \{C = \Sigma^s (P_i)^2\}$, where S is the total number of species and P_i is the relative cover of species (**Pielou, 1975; Magurran, 1988**).

3. Results

3.1. Flora and Vegetation

3.1.1 Floristic analysis

Seventy one species belonging to 61 genera and 27 families were recorded associated with *O. ficus indica* (**Table 1**). The most dominant family was Poaceae, represented by 16 species, Asteraceae (10 species), Chenopodiaceae (5 species), Brassicaceae (4 species) Solanaceae, Amaranthaceae, Euphorbiaceae and Fabaceae, (each 3 species, Apiaceae, Amaryllidaceae, Convolvulaceae and Polygonaceae (each 2 species), and each of the other families were represented by one species (**Fig 2**).

Habit of species

Annual plants represented the highest number of species (45 species) associated to *O. ficus indica*, while perennial plants represented by 26 species (**Fig. 3**).

Life forms

The life form spectra of the recorded species associated with *O. ficus indica* indicated the presence of eight life forms: therophytes, chamaephytes, hemicryptophytes, geophytes-helophtes, phanerophytes, geophytes, helophytes and Parasites (**Fig. 4**). It was found that, therophytes were the dominant life form represented by 43 species, while geophytes-helophtes were represented by 7 species, hemicryptophytes (6 species), phanerophytes and chamaephytes (5 species), geophytes (3 species), helophytes and Parasites each one were represented by a single species.

Chorological analysis

The spectrum of the global distribution of the recorded species associated with *O. ficus indica* indicated that monoregional taxa were the dominant elements; represented by 22 species followed by bi-oregional and pluri-regional (15 species), cosmopolitans (14 species) and 5 species of cultivated elements (**Fig. 5**).
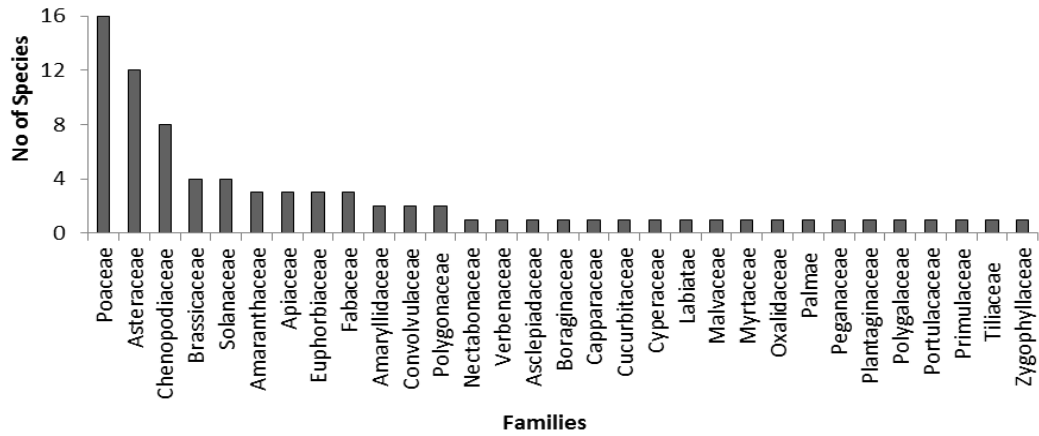
Fig. 2. Number of plant species belonging to the different families associated with *Opuntia sp.*
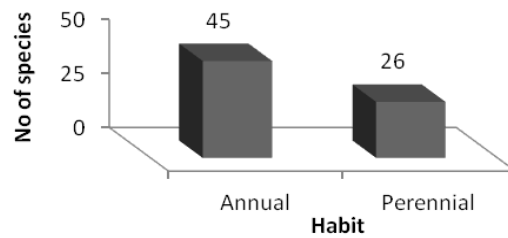

Fig. 3. Habit of the recorded species associated with *Opuntia sp.*
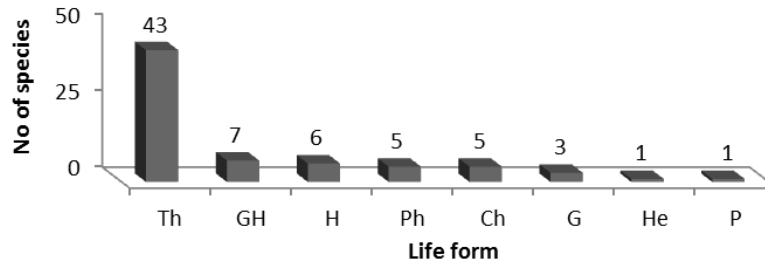

Fig. 4. Life form spectra of the recorded associated species in each of *Opuntia sp.* Th: therophytes, GH: geophyte – helophytes, H: hemicryptophytes, Ph: phanerophytes, Ch: chamaephytes, G: geophytes, He: helophytes and P: Parasite.
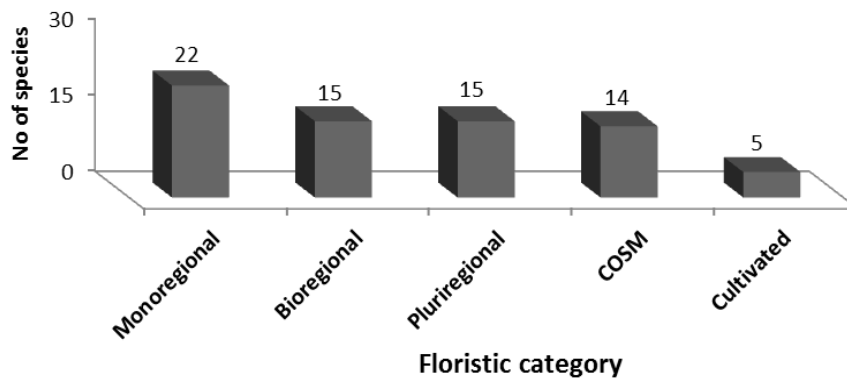

Fig. 5. Floristic category of the recorded species associated with *Opuntia* sp.

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Table 1. Floristic properties of the recorded species associated with *Opuntia ficus indica*

Species	Family	Arabic name	Habit	Life form	Floristic category
Emex spinosa (L.) Campd	Polygonaceae	حنزاب	Annual	Th	ME + SA-SI
Portulace aleracea L.	Portulacaceae	رجله	Annual	Th	COSM
Beta vulgaris L.	Chenopodiaceae	سلق	Annual	Th	ME+ER-SR+IR-TR
Chenopodium album L.	Chenopodiaceae	سرمق ابيض - زربيح ابيض	Annual	Th	COSM
Chenopodium glaucum L.	Chenopodiaceae	سرمق - زربيح	Annual	Th	ME+ER-SR
Chenopodium murale L.	Chenopodiaceae	لسان الثور	Annual	Th	COSM
Bassia indica (Wight.) A.J.Scott.	Chenopodiaceae	كوخيا	Annual	Th	IR-TR+S-Z
Amaranthus hypridus L.	Amaranthaceae	رعاف	Annual	Th	COSM
Amaranthus lividus L.	Amaranthaceae	أمارنطون	Annual	Th	ME+IR-TR
Amaranthus viridis L.	Amaranthaceae	قطيفة مذنبه	Annual	Th	COSM
Gynandropsis gynandra (L.) Briq.	Cleomaceae	ابو قرن	Annual	Th	PAL
Sisymbrium irio L.	Brassicaceae	سمارة رثة	Annual	Th	ME+IR-TR+ER-SR
Brassica nigra (L.) Koch	Brassicaceae	خردل اسود	Annual	Th	COSM
Eruca sativa Mill.	Brassicaceae	جرجير	Annual	Th	CULT and NAT
Coronopus niIoticus (Delile) Spreng .	Brassicaceae	حارة	Annual	Th	S-Z
Melilotus indicus (L.) All.	Fabaceae	حندقوق هندي	Annual	Th	ME+IR-TR+SA-SI
Alhagi graecorum Boiss.	Fabaceae	عاقول	Perennial	Ch	ME+IR-TR+SA-AR+S-Z
Dalbergia sissoo Roxb.	Fabaceae	السرسوع	Perennial	Ph	Cultivated
Oxalis corniculata L.	Oxalidaceae	حميضة قرينية	Perennial	He	COSM
Tribulus terrestris L.	Zygophyllaceae	الحسك	Annual	Th	PAN
Ricinus communis L.	Euphorbiaceae	خروع	Perennial	Ph	PAN
Euphorbia heterophylla L.	Euphorbiaceae	فريبون - حلبلوب ارضي	Annual	Th	PAN
Euphorbia peplus L.	Euphorbiaceae	فريبون بيبلوس – فرفح	Annual	Th	ME+ER-SR+IR-TR
Polygala hohenackeriana Fisch. & c. A. Mey.	Polygalaceae	مغزرة	Perennial	H	SA-SR
Corchorus olitorius L.	Tiliaceae	ملوخيه	Annual	Th	PAN
Malva parviflora L.	Malvaceae	خبيزة	Annual	Th	ME+IR-TR
Cucumis prophetarum L. subsp. *dissectus* (Naudin) C. JetTrey	Cucurbitaceae	خيار الذيب	Perennial	H	SA + SZ
Ammi majus L.	Apiaceae	خلة ـ سدا	Annual	Th	ME+IR-TR
Apium graveolens L	Apiaceae	شبت	Annual	Th	Cultivated
AnagaIiis arvcnsis L.	Primulaceae	زغلنت ـ عين القط	Annual	Th	COSM
Cynanchum acutum L.	Asclepiadaceae	عليق مدبب ـ اللفلاف ـ مرخ	Perennial	Ch	ME+IR-TR
Convolvulus arvensis L.	Convolvulaceae	عليق بري	Perennial	H	Trop
Cuscuta planiflora Ten.	Cuscutaceae	حامول البرسيم – حامول	Annual	P	ME+SA-SR+IR-TR
Echium rauwolfii Delile.	Boraginaceae	زهرة الافعى ـ لسان الثور	Annual	Th	SA
Phyla nodiflora L.	Verbenaceae	ليبيا	Perennial	H	ME+IR-TR+Trop
Boerhavia coccennea L. Mill	Nectagonaceae		Perennial	Ch	SA-AR+S-Z

Table 1. continue

Species	Family	Arabic name	Habit	Life form	Floristic category
Solanum nigrum L.	Solanaceae	عنب الديب	Annual	Ch	ME+ER-SR+ IR-TR
Solanum lycopersicum L.	Solanaceae	طماطم	Annual	Th	Cultivated
Datura innoxia Mill	Solanaceae	داتوره- عين الجمل	Annual	Th	NEO
Plantago major L.	Plantaginaceae	لسان الحمل	Perennial	H	COSM
Pluchea dioscorides (L.) Desf.	Asteraceae	برنوف	Perennial	Ph	SA-AR+S-Z
Conyza bonariensis (L.) Cronquist	Asteraceae	خوع- نفلا	Annual	Th	NEO
Symphotrichum squamatum (Spreng.) Nesom	Asteraceae	غير معروف	Annual	Ch	Trop
Xanthium strumarium L.	Asteraceae	الشبيط ـ اللزيق	Annual	Th	PAN
Bidens pilosa L.	Asteraceae	ذو السِنَين ـ حُسيكة	Annual	Th	PAN
Verbesina encelioides (Cov.) Benth.	Asteraceae	القراص ـ المحرق	Annual	Th	PAN
Senecio glaucus L. subsp. *coronopifolius* (Maire) C. Alexander	Asteraceae	الشيخة الرمادية	Annual	Th	ME+SAAR+IR-TR
Cichorium endivia L. subsp *pumilum* Jacq.	Asteraceae	سريس ـ الكبر- شيكوريا كاسنبة	Annual	Th	ME+IR-TR
Launaea nudicaulis (L.) Hook.	Asteraceae	حوا	Perennial	H	SA-AR+IR-TR+S-Z
Sonchus oleraceus L.	Asteraceae	جعضيض	Annual	Th	COSM
Allium neapolitanum Cyr.	Amaryllidaceae	ثوم نابولي ـ ثوم ابيض	Perennial	Th	ME+SA-SR
Allium cepa L.	Amaryllidaceae	بصل	Perennial	GH	Cultivated
Phoenix dactylifera L.	Palmae	نخلة التمر	Perennial	Ph	Cult - SA-AR+S-Z
Avena fatua L.	Poaceae	شوفان	Annual	Th	COSM
Phalaris minor Retz.	Poaceae	ذيل القط	Annual	Th	ME+IR-TR
Bromus catharticus Vahl.	Poaceae		Annual	Th	ME+ER-SR+IR-TR +MA
Phragmites australis (Cav.)Trin.	Poaceae	بوص	Perennial	GH	COSM
Desmostachya bipinntata (L.) Stapf	Poaceae	حلفا ـ سخبر	Perennial	G	SA-SI+S-Z
Cynodon dactylon (L.) Pers.	Poaceae	نجيل بلدي	Perennial	G	COSM
Panicum repens L.	Poaceae	الثمام المنتفخ ـ الثمام الزاحف	Perennial	G	PAN
Echinochloa colona (L.) Link	Poaceae	ابو ركبه ـ دُنيبه	Annual	Th	ME+IRTR+Trop
Setaria verticillata (L.) Beauv.	Poaceae	ذيل الثعلب	Annual	Th	COSM
Setaria viridis (L.) Beauv	Poaceae	العشب الاخضر الخشن	Annual	Th	PAL
Paspalidium geminatum (Forssk.) Stapf	Poaceae	نسيله ـ أبو بيض	Perennial	GH	Trop
Digitaria sanguinalis (L.) Scop.	Poaceae	ابوركبة	Annual	Th	PAL
Cenchrus echinatus L.	Poaceae	سبط قَنفذي	Annual	Th	Trop
Imperata cylindrica (L.) Raeusch.	Poaceae	حلفا ـ حلف ـ ديس	Perennial	GH	ME+SA-AR+IR-TR
Dichanthium annulatum (Forssk.) Stapf.	Poaceae	عشب هندي ـ دياز	Perennial	GH	PAL
Vossia cuspidata (Roxb.) Griff.	Poaceae	غير معروف	perennial	GH	Trop
Cyperus rotundus L.	Cyperaceae	سعد	Perennial	GH	ME+IR-TR+Trop
Psidium guajava L.	Myrtaceae	جوافة	Perennial	Ph	Cultivated

3.2. Vegetation Analysis

The application of TWINSPAN on the cover estimates of 71 associated species recorded in the 99 sampled stands of *O. ficus indica* led to the recognition of 8 vegetation groups (Fig. 6). These groups showed a reasonable segregation along the ordination plane axes 1 and 2 of DECORANA (Fig. 7). It is noticed that the first six vegetation groups represents the sites located at Al Qalyubiya governorates, while the 7th group contains the stands along the sides of Cairo-Alexandria train road (Berkat Al-Saboa site, Minufiya) and the 8th group contains the stands along the sides of Abo Mangug-Shobrakheet road (Buhayrah). The vegetation groups are named after the first dominant species associated with *O. ficus indica* (the species that have the highest presence percentage and/or the highest cover). The presence of *O. ficus indica* was 100% in all vegetation groups, while cover varied from one group to another. The description of these vegetation groups was indicated as follows:

A: **Boerhavia coccenea**, it includes 43 stands and 34 species, *Opuntia Ficus-indica* covered 62.9% in this group where *Cynodon dactylon* represented by 7.6% cover and 100% presence and *Boerhavia coccenea* represented by 1.4% cover and 46.5% presence. *Cynanchum acutum, Verbesina encelioides, Launaea nudicaulis, Panicum repens, Setaria viridis* and *Chenopodium album* are common associated weeds. On the other hand, *Gynandropsis gynandra, Polygala hohenackeriana, Allium neapolitanum and Cucumis prophetarum* are recorded only in this vegetation group of the ten groups.

B: **Cynodon dactylon**, it includes 10 stands and 32 species. In this group *Opuntia Ficus-indica* represented by 37.9% cover, *Cynodon dactylon* (29.0%) 100%, the common associated weeds to this vegetation group are *Cynanchum acutum, Alhagi graecorum, Avena fatua, Amaranthus viridis, Ricinus communis, Cyperus rotundus*, while *Dalbergia sissoo*, and *Xanthium strumarium* are recorded only this vegetation group.

C: **Cyperus rotundus**, this group contains 11 stands and 26 species. In this group *Opuntia Ficus-indica* covered 65.0%, *Cynodon dactylon* covered 5.7% and presented by 100% and *Cyperus rotundus* cover 1.3% and presented by 81.8%. The common associated weeds are *Amaranthus lividus, Amaranthus viridis, Avena fatua* and *Boerhavia coccenea*.

D: **Psidium guajava**, it contains 8 stand and 31 species. In this stand *Opuntia ficus-indica* represented by 71.3% cover, while *Cynodon dactylon* represented by 3.8% cover and 100 % presence and *Psidium guajava* represented by 2.0% cover and 100% presence. *Paspalidium geminatum, Cyperus rotundus, Amaranthus viridis, Amaranthus viridis* and *Verbesina encelioides* are the common associated weeds, while *Echinochloa colona, Phoenix dactylifera* and *Psidium guajava* are foun in this vegetation group.

E*: Amaranthus lividus*, it contains 8 stands and 40 species. In this group *Opuntia Ficus-indica* represented by 50.6% cover, but *Cynodon dactylon* represented by 8.4% cover and 100% presence and *Amaranthus lividus* by 4.4% cover and 100% presence. The common associated groups to this group are *Cyperus rotundus, Amaranthus viridis, Chenopodium murale, Avena fatua, Sonchus oleraceus* and *Setaria verticillata*, while *Eruca sativa, Bromus catharticus, Beta vulgaris, Senecio glaucus* and *Phalaris minor* recorded only in this vegetation group.

F: **Malva parviflora**, it contains 9 species and 44 species. *Opuntia Ficus-indica* represented by 27.8% cover while *Cynodon dactylon* represented by 19.9% cover and 100% presence and

Malva parviflora represented by 1.2% cover and 100% presence. The common associated weeds to this vegetation group are *Amaranthus lividus*, *Amaranthus viridis, Avena fatua*, *Corchorus olitorius* and *Emex spinosa*. Six weeds were recorded only in this vegetation group (*Cichorium endivia*, *AnagaIiis arvcnsis*, *Anethum graveolens, Coronopus niIoticus*, *Melilotus indicus* and *Plantago major*)

G: *Phragmites australi*, it contains the 5 stand of site 12 (Abo Mangog road, Al- Baihara Governorate) and 8 species. In this group, *Opuntia Ficus-indica* represented by 54.0% cover while *Phragmites australis* represented by 7.0% cover and 100% presence and *Ricinus communis* represented by 2.2% cover and 100% presence. *Cynodon dactylon*, *Bassia indica*, *Amaranthus lividus* and *Cynanchum acutum* are the common associated weeds to this vegetation group.

H: *Imperata cylindrical*, it contains the 5 stands of site 11 (Berket Al-Saboa, Monefia Governorate) and 11 species. In this group, *Opuntia Ficus-indica* represented by 60.0% cover while *Phragmites australis* represented by 8.0% cover and 100% presence. *Cynodon dactylon*, *Pluchea dioscorides*, *Imperata cylindrical* and *Convolvulus arvensis*. *Phyla nodiflora* is the weed species which found in this vegetation group of the ten groups.

3.3. Diversity of the plant communities

The total number of species recorded in the 8 vegetation groups, identified according to TWINSPAN classification technique, varied from 44 species in *C. dactylon* and *M. parviflora* group (VG F) to 26 species in *Cyperus rotundus* group (VG C). *M. parviflora* group (VG F) had the highest value of species richness (21.6 species/stand), while VG A had the lowest values of species richness (4.2 species/stand). The highest species turnover (8.2) was recorded in VG A while the lowest in VG G. VG F had the highest value of relative evenness (0.63), while the highest relative concentration of dominance (2.43) were recorded in VG E (**Table. 2**).
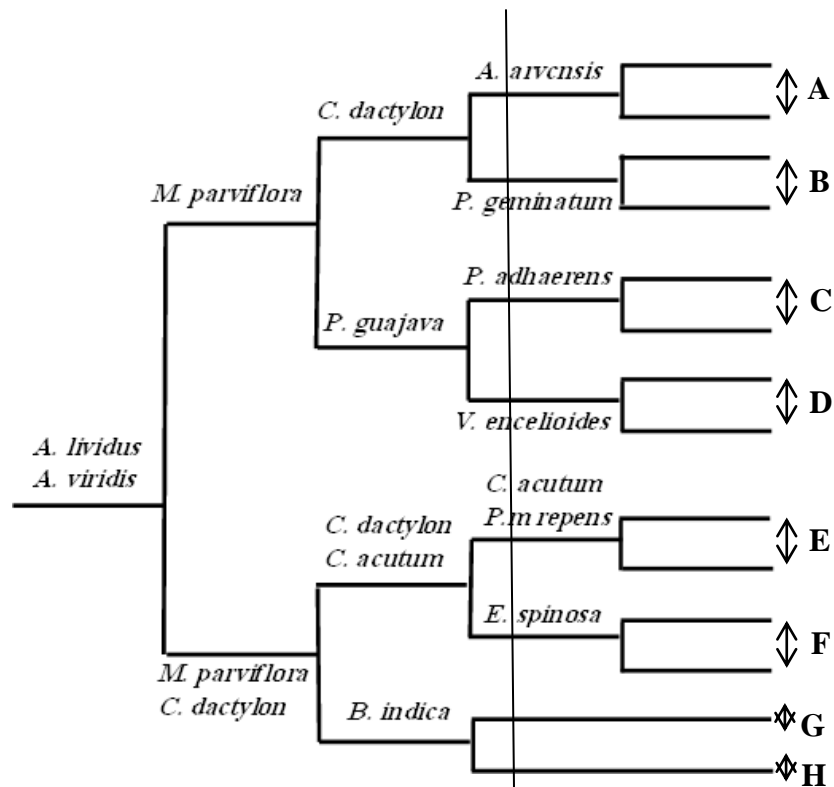
Fig. 6. The dendrogram resulting from the application of TWINSPAN on the 99 sampled stands. The names of these groups are: **A:** *Boerhavia coccenea*, **B:** *Cynodon dactylon*, **C:** *Cyperus rotundus*, **D:** *Psidium guajava*, **E:** *Amaranthus lividus*, **F:** *Malva parviflora*, **G:** *Phragmites australi* and **H:** *Imperata cylendrica*.
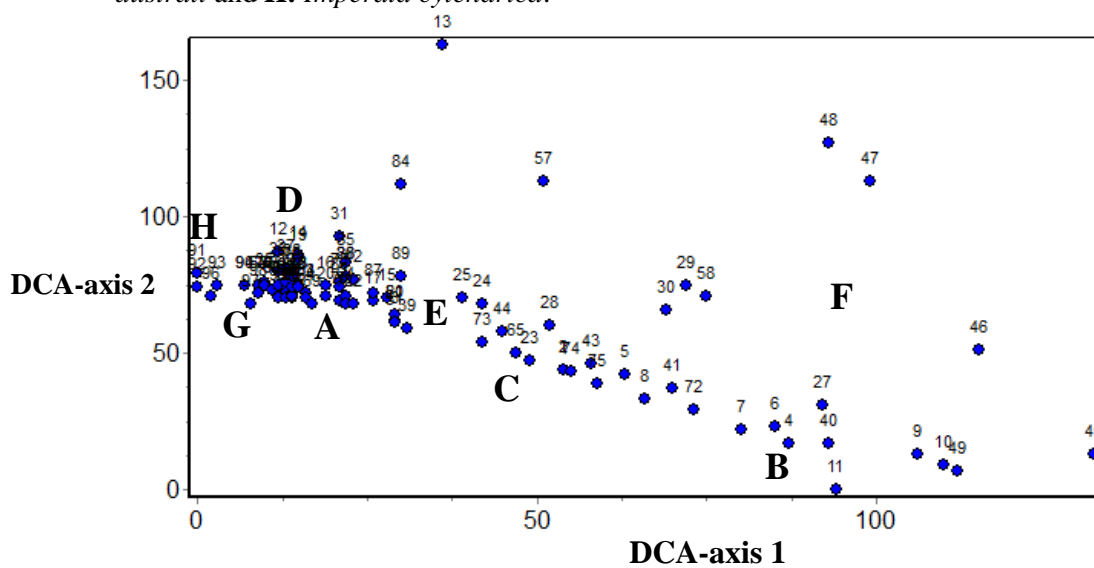

Fig. 7: DCA ordination of the 8 vegetation groups identified after the application of TWINSPAN on the 99 sampled stands. The names of these groups are: **A:** *Boerhavia coccenea*, **B:** *Cynodon dactylon*, **C:** *Cyperus rotundus*, **D:** *Psidium guajava*, **E:** *Amaranthus lividus*, **F:** *Malva parviflora*, **G:** *Phragmites australi* and **H:** *Imperata cylendrica s.*

Table 2: Diversity indices of the 8 vegetation groups produced from TWINSPAN. Maximum are bold and underlined and minimum values are italic and underlined. **A:** *Boerhavia coccenea*, **B:** *Cynodon dactylon*, **C:** *Cyperus rotundus*, **D:** *Psidium guajava*, **E:** *Amaranthus lividus*, **F:** *Malva parviflora*, **G:** *Phragmites australi* and **H:** *Imperata cylendrica*

Diversity idex	Veg A	Veg B	Veg C	Veg D	Veg E	Veg F	Veg G	Veg H
Number of species	34.0	32.0	26.0	31.0	40.0	**44.0**	*8.0*	11.0
Species richness	*4.2*	8.1	8.6	14.4	19.0	**21.6**	7.4	6.0
Species turnover	**8.2**	4.0	3.0	2.2	2.1	2.0	*1.1*	1.8
Relative evenness	0.44	0.55	0.37	0.40	0.55	**0.63**	*0.19*	0.28
Relative concentration of dominance	1.92	2.42	1.61	1.78	**2.43**	2.77	*0.83*	1.21

4. Discussion

Little database about associated species of *Opuntia ficus indica* populations in Egypt and worldwide are available. Flora of the study sites represented 71 species of the Egyptian flora where they are belonging to 61 genera and 27 families. Poaceae represented the most dominant plants associated with *O. ficus indica* communities, followed by Asteraceae, Chenopodiaceae, Brassicaceae and Fabaceae. These families constitute the main bulk of the flora of the study area in according to **Springuel (1990)**, **Speringuel et al. (1991)** and **Ali et al. (1995)** in the Nile Valley (Upper Egypt), **Al-Sodany (1992)** in various habitats in north Nile Delta, and **Khedr and Hegazy (1998)** in the north western part of Nile Delta and **Khalafallah et al. (2016)** middle Nile Delta.

The plant life form is usually understood to be a growth form which displays an obvious relationship to important environmental factors. The life form spectra of the recorded species associated with *O. ficus indica* showed that therophytes were the dominant life form where it represented by 60.6% of the total recorded species, followed by geophytes-helophytes (9.9%), hemicryptophytes (8.5%), phanerophytes and chamaephytes each life form represented by 7.0%, Geophytes (4.2%) and Helophytes and Parasite each life form represented by 1.4%. According to **Galal (2001)**, therophytes are the main life forms and most of them are weed species characteristic to the cultivated lands, coinciding with **Hassib (1951)** on the Egyptian flora. **Heneidy and Bidak (2001)** pointed out that the dominance of therophytes over the other life forms seems to be a response to the hot-dry climate, topographic variation and biotic influence. The present study indicated that annuals recorded 45 species (63.4% of the recorded species). **Khalafalla et al. (2016)** found that annuals associated with wheat and maize crops represented 89.7 and 73.9% of the total recorded species. **Gomaa (2012)** attributed the high contribution of annuals to their short life cycle that enables them to resist the instability of the agro-ecosystem. Annuals are generally characterized by high allocation of resources to the reproductive organs and the production of flowers early in their life-span to ensure some seed production even in a year when the growing season is cut short (**Sans and Masalles, 1995**). However, **Marshall (1989)** demonstrated that most perennial species are not adapted to successful establishment in arable crops.

The spectrum of the global distribution of the recorded species associated with *O. ficus indica* orchards appeared that monoregional taxa were the dominant species (30.99% of

the total recorded species), followed by bi-regionals and pluri-regional (each category recorded 21.13%), cosmopolitans (19.82%) and cultivated elements (7.04%). The present result is in consistent with the results of **Khalafallah *et al.* (2016),** where they found that mono-regional taxa were the dominant elements in maize crops in Middle Delta. According to **Mashaly (1987),** 50% of the species in the Deltaic sector are Mediterranean taxa, 32% are pluri-regionals, and 8% are Saharo-Sindian elements. In the present study, Mediterranean taxa were the main category (30.99%) in the study area, however presence of phytogeographical elements other than Mediterranean is believed to be a reflection of intense climatic changes and/or the degradation of the Mediterranean ecosystem which facilitated the invasion of some elements from the adjacent regions (**Mashaly, 1987; Madi *et al.*, 2002**).

In Egypt, phytosociological studies on weeds along the Nile valley are still limited. In fact, most of the studies that carried out on weed communities are mostly floristic (**Shaltout *et al.*, 1992**; **Galal, 2001**). Phytosociologists used ordination techniques to simplify distribution patterns along the gradients of environmental variables (**Springuel and Murphy, 1991**; **Spink, 1992**). The classification of vegetation associated with *O. ficus indica* orchards, using TWINSPAN analysis, resulted in identifies 8 vegetation groups. *C. dactylon* is a common community associated with *O. ficus indica*. This classification may indicate the significant effect of habitat type, management practices, seasonality and soil characteristics, these factors influence weed community composition (**Légere and Samson, 1999; Leeson *et al.*, 2000; Gomaa, 2012**).

C. dactylon and co-dominance between *C. dactylon* and other species dominated *O. ficus indica* orchards. This indicated that *C. dactylon* can tolerant and survive in different condition as pointed out by **Sieben *et al.* (2016)** that *C. dactylon* is the main vegetation group in their study to wetlands in inundated and non-inundated conditions. The grass *C. dactylon* is not only tolerant to inundation, but also to salinity (**Hameed and Ashraf, 2008**), which is important in the wetlands of arid regions (**Johns *et al.,* 2014**). *C. dactylon* and its co-dominants were represented by 6 communities distributed in 10 sites of *O. ficus indica* orchards located at Qalyubiya governorate. These sites had different practices for weed control and showed different coverage of *O. ficus indica*. *O. ficus indica* orchard of site 7 (Ezbet Shokry, Abo Za'able, Qalyubiya) subjected to application of herbicide (Herbazed 48%) additionally, they had high cover % of *O. ficus indica* (averaged 84%) these factors leads to reducing the number of weed species. On the other hand, the stands distributed in young *O. ficus indica* orchards (Ezbet Al-Abiad, Abo Za'able, Qalyubiya) and cultivated with *Alium cepa* crop characterized by wide spaces and regular irrigation showed high number and cover of weed species. The present results showed negative correlation between the cover percentage of *O. ficus indica* and the associated weeds. This correlation has reversible effect on the *Opuntia* cover and associated species. *Phragmites australis, C. dactylonm, I. cylendrica* and *C. acutum* showed harsh effect on the coverage area of *O. ficus indica*, while increasing in coverage area of *O. ficus indica* can decreased the cover and diversity of other weeds. Consequently the rhizomatous or climbing weeds are strong competitor reduced growth and spatial distribution of *Opuntia*, while *Opuntia* is strong competitor against sallow roots and annual weeds. *C. acutum*

From the field study and the knowledge from farmers it was noted that habitat type, season, soil type, weed management, agricultural practices, *Opuntia* cover and application of

herbicides had the most significant influence on species composition. It clear that low cover of *Opuntia* highly leads to increase in number of species, high species richness, high relative evenness and high relative concentration of dominance as recorded for *C. dactylon* and *M. parviflora* vegetation group. But high cover of *Opuntia* resulted in reducing diversity indices except species turnover increased as shown for *B. coccenea* vegetation group.

Lawlor (2003), Douglass *et al.* (2009) and **Weston *et al.* (2005)** reported that the invasion of *Cynanchum* species and their waste conspicuously got to be ubiquitous through the farmlands, gardens (especially in perennial plants cultivation) and also in zero-tillage management system. Their higher invasive power due to; they can generate immense number of winged seeds to spread away by wind for many kilometers (**Lawlor, 2003; Douglass *et al.,* 2009; Blanchard *et al.*, 2010; Hotchkiss *et al.*, 2008**); The higher proportion of root to shoot (**Smith, 2006**); production and extraction of allelo-chemicals compositions (**Weston *et al.*, 2005; Cappuccino, 2004; DiTommaso *et al.*, 2005**).

The high species richness may be related to this environmental micro-heterogeneity that promotes diversity (**Palmer and Maurer, 1997**). The variations in species richness, diversity and evenness among the different community types may be attributed to differences in soil characteristics, substrate discontinuities and the allelopathic effects of one or more invasive species depending on their relative dominance among other associated species (**James *et al*., 2006; Galal and Shehata, 2015; Khalafallah *et al.,* 2016**)**. Moreover, the difference in field management practices may also be a factor that explains differences in weed species richness (**Stevenson *et al*., 1997; Sher and Al-Yemeni, 2011; Gomaa, 2012**). Although weeds are unwanted plants, increased their diversity may have other indirect beneficial effects on agro-ecosystems. For example, increased vegetation diversity can lead to suppression of pests via 'top-down' enhancement of natural enemy populations or by resource concentration and other 'bottom-up' effects acting directly on pests (**Tracy *et al*., 2004; Galal and Shehata, 2015**).

Average species richness of 8 vegetations groups in *O. ficus indica* (11.2) was higher than that recorded **by Khalafallah *et al.* (2016)** in wheat crop (10.9) and **Soliman (2016)** in maize (10.0), in orchards (olive and date palm) by **Gomaa (2012)** and in farms (8.0) by **El-Shiekh (2013)**. The high species richness of this study compared with crops and olive and date palm orchards and farms may be attributed to the fact that the land of *Opuntia* orchards rarely plowed a practice that reduces the richness of weeds (**Gomaa, 2012**).

The present study recorded 71 species associated with *O. ficus indica* orchards, most of these species have medicinal uses, phytoremediation and phytoextractions, cattle feeding, human foods and other uses (**Dkhil *et al.*, 2011; Borgio *et al.*, 2007; Shelef *et al.*, 2013; Golzardi *et al.*, 2015; Al-Snafi, 2015; Al-Oqai *et al.*, 2016; Biswas *et al.,* 2016**) . In addition to their drastic effects on the useful weeds and the main production of *Opuntia* (vegetative parts and fruits) and their poisoning threats to cattle (**Schmutz *et al.* 1968; Holm *et al.,* 1977; Lawlor, 2003; Douglass *et al.,* 2009**). Maximizing the use of weed and increased production of prickly pears must apply the natural methods to ameliorate the impact of harmful weeds and manage and conserve the useful species.

5. Conclusion

Seventy one species were recorded in 99 stand distributed in *O. ficus indica* L. Mill. populations. The recorded species are belonging to 61 genera and 27 families. Poaceae is the most dominant family, Therophytes were the dominant life form and the monoregional represented the dominant floristic category. Eight vegetation groups were recognized by application of TWINSPAN on the cover of 71 associated species recorded in 99 stands of Prickly Pear. Most of the recorded species have ecological and human uses, these species need management and conservation. While other species are invasive and have drastic effect on *Opuntia* Plants, these species need control.

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الملخص باللغة العربية

التنوع النباتى وتحليل الكساء الخضرى للنباتات المصاحبة للتين الشوكى فى دلتا النيل بمصر

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تهدف الدراسة الحالية إلى دراسة التنوع النباتى وتحليل الكساء الخضرى للنباتات المصاحبة للتين الشوكى فى ثلاثة محافظات تقع فى منطقة دلتا النيل (القليوبية – المنوفية – البحيرة). تم مسح 99 موقع (10م x 10م) فى فصلى الخريف والربيع. نتج عن المسح تسجيل 71 نوعاً من النباتات المصاحبة للتين الشوكى تنتمى إلى 61 جنس و 27 عائلة. تمثل العائلة النجيلية إلى جانب المركبة والزريحية والصليبية الأكثر سيادة من بين العائلات المسجلة. الحشائش الحولية تمثل العدد الأكبر (45 نوعاً) بينما النباتات المعمرة تمثل بـ 26 نوعاً. النباتات الحولية هى صاحبة السيادة بين صور الحياة الأخرى حيث مثلت بعدد 43 نوعاً كما تعتبر المجموعة الفلورية للنباتات ذات الانتشار المحدود بمنطقة فلورية أحادية هى السائدة من بين المجموعات الفلورية. وبتطبيق التحليل الدليلى ثنائى الاتجاه تم تسجيل 8 مجتمعات نباتية . وأوضحت الدراسة أن هناك علاقة ارتباط معنوية سلبية بين مساحة التغطية لأشجار التين الشوكى ومساحة التغطية للنباتات وعدد الأنواع ودلائل التنوع الحيوى. سجل فى هذه الدراسة عدد من الأنواع ذات التنافس القوى والضار لأشجار التين الشوكى وعلى رأسها العليق والبوص والحلفا لذلك يجب مقاومة انتشارها وسط الحدائق وكذلك سجل عدد كبير من أنواع الحشائش التى لها فوائد بيئية وطبية وليس لها تأثير ضار معنوى على أشجار التين الشوكى لذلك يجب دراسة كيفية إدارتها والاستفادة منها.