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Species distribution patterns of the weed flora in mango orchards of Ismailia Governorate, Egypt: implications for conservation

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Abstract

The present study deals with the analysis of the floristic composition including plant species, life span, life-form spectra and chorological affinities of weeds associated with mango orchards in Ismailia Governorate. A total of 102 weed species (79 annuals, 21 perennials and 2 biennials) related to 85 genera and grouped in 30 families were recorded. Out of the total species, 23 species monocots and 79 species dicots were recorded. Poaceae, Asteraceae, Brasicaceae and Fabaceae were the most species-rich families representing collectively about 50% of the total species. Therophytes were the predominant life form and constituted 73.53% of the total flora, followed by hemicryptophytes (12.75%), geophytes (4.9%), chamaephytes (3.92%), nanophanerophytes (2.94%) and helophytes (1.96%). The chorological analysis of the surveyed flora revealed that the Mediterranean elements constituted the main bulk (41.18%) of the total flora of the area. The other major chorotypes were cosmopolitan (24.51%), pantropical (13.73%) and palaeotropical (7.84%). Saharo-Sindian chorotype comprised 20 species (19.6%) of the recorded flora, while the other chorotypes were either poorly represented by few number of species or absent. Comparison between the present floristic composition of mango orchards in Ismailia with similar relevant studies either in Ismailia or in adjacent areas were included.

Key words: Mango orchard, weed flora , Ismailia, life-form, chorotype

Introduction

Mangifera indica L. (Mango) is universally considered one of the most important and nutritional fruit crop in tropical and subtropical areas of the world (Loay, 2005). There is a long tradition of mango cultivation in Egypt. It was first introduced to Egypt from Sri Lanka, whose fruit, in turn, is derived from Indian varieties. Then, Mohamed Ali Pasha planted the first shrubs in 1825 (Yahia, 1999; Haggag, 2010). Mango production is concentrated between Ismailia Governorate and the eastern part of Sharkia, both areas producing about 60% of the total amount of mango produced in the country annually (Yahia, 1999).

Ismailia Governorate is the most mango-growing region known for creating the finest mangoes in Egypt. The soil and climate of Ismailia are particularly favorable to the cultivation of Egyptian mango. The agriculture season in Egypt begins from July till November. Production area of mango in Ismailia is 23% of the total in the country (Yahia, 1999). Recently, the cultivated area of mango orchards in Ismailia Governorate expanded in area to 204694 Feddan (1 Feddan=4200 m^2) in 2018 according to data from Ismailia Agriculture Directorate.

Orchards are a traditional agroecosystem that is widely maintained worldwide and accounts for a considerable area (Rey, 2011). They have a high potential of multiple services; their perennial character and multi-strata habitat, as well as the opportunity of creating diversified hedgerows and cover crops in alleys, may contribute to a high level of biodiversity and related services. Groundcover in orchards also enhances biotic interactions responsible for pest control and pollination (Demestihas *et al.*, 2017). Arable weed species play an important role in supporting biological diversity, in particular as food resources of primary importance for birds and insects inhabiting farmlands (Marshall *et al.*, 2003; Gibbons *et al.*, 2006). A weed is defined as a plant that causes economic losses

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or ecological damage, creates health problems for people or animals, or is undesirable where it is developing (Zimdahl, 2018). However, weeds have numerous positive perspectives, even in orchards. They secure the soil against water and wind erosion where numerous orchards are planted, protect the soil against mechanical compaction, which is exceptionally imperative in modern orchards with narrow alleyways where machinery usually moves along the same paths(Zarnovican *et al.,* 2017). Moreover, weeds create a safe habitat for many beneficial organisms, have ornamental and medicinal value, used as indicators of the chemical or physical properties of the soil, used as human or domestic animal food, used as phytoremediants to collect and remove toxic heavy metals from the environment, prevent many of the problems associated with monoculture, which is now considered very important for environment protection and finally, promote biodiversity and preserve the biological balance in orchards (Lipecki*,* 2006; Zimdahl, 2018).

Weed species composition is strongly influenced by environmental heterogeneity, which is itself partly, related to crop type and management practices (tillage, fertilization and herbicide use) (Sandrine *et al.*, 2011). Existing vegetation is also an indicator of the climate, soil and anthropogenic influences occurring in a region (Sharma *et al.*, 2014). The major community description and its appearance depend upon the occurrence of life forms which are based on the position and degree of protection of regenerating parts with respect to the ground surface (Cain, 1950). The physical appearance of vegetation chiefly depends on the life form of dominant plant species (Hanson and Churchill, 1961).

Patterns of species life forms and its proportion in an area reflect a complete ecological picture of the community as well as provide a good indication of the climatic zone of the community (Cain, 1950; Kershaw, 1973). The plant species of any community can be classified in one or the other life forms. The ratio of the life forms of different species in terms of numbers or percentages in any floristic community is the biological or phytoclimatic spectrum. The biological spectrum is also regarded as the indicative of the prevailing environment as the life forms are related to the environment around the plants (Sudhakar Reddy *et al.,*2011).

In Egypt, the floristic studies on the orchards attracted the attention of many authors (Abd El-Ghani, 1994 &1998; El-Kady *et al*., 1999; Mashaly and Awad, 2003; Mashaly *et al*., 2016). During the last few years, mango orchards in Ismailia Governorate are affected by a several diseases. The chemical-based strategies have been so far dominating for management of mango diseases but it has caused serious imbalance in the agroecosystem, and may lead to destroying mango orchards (Haggag, 2010; El-Marzoky, 2014). Due to the economic importance of mango crop in Ismailia Governorate, this study was conducted. The present work, hence, aims at studying the floristic composition, distributional pattern, life- form spectra and chorological affinities of the associated weeds in mango orchards in Ismailia Governorate. Among the purposes of the study is to find out any possible changes in weed species composition of mango orchards in Ismailia Governorate and other adjacent areas in Egypt.

Study area

The present study was performed in Ismailia Governorate (Longitudes 31º 40′ - 32º 38′ E and Latitudes 30º 15′ - 30º 57′ N), which is a part of the East Nile Delta region (Fig. 1). This region has a number of geomorphological features directly affecting the agricultural activities and land use. The soil of the study area is related to river terraces of fluvial and deltaic origins and wind-blown deposits according to the Bioclimatic Map of FAO /UNESCO (1964), Younes *et al.*(1977) and Yaalon (1997). Ismailia Governorate belongs to the arid Province (Ayyad and Ghabbour, 1986). The mean monthly air temperature varies from 13.03°C in January to 27.31°C in July. The highest precipitation (26.04 mm) was recorded in November, while the lowest (0.76 mm) was recorded in July. The relative humidity varies between 64.75% in January and 51.15% in April. The mean evaporation rate varies between 3.8 mms/day and 9.8 mms/day (Ibrahim, 2017).

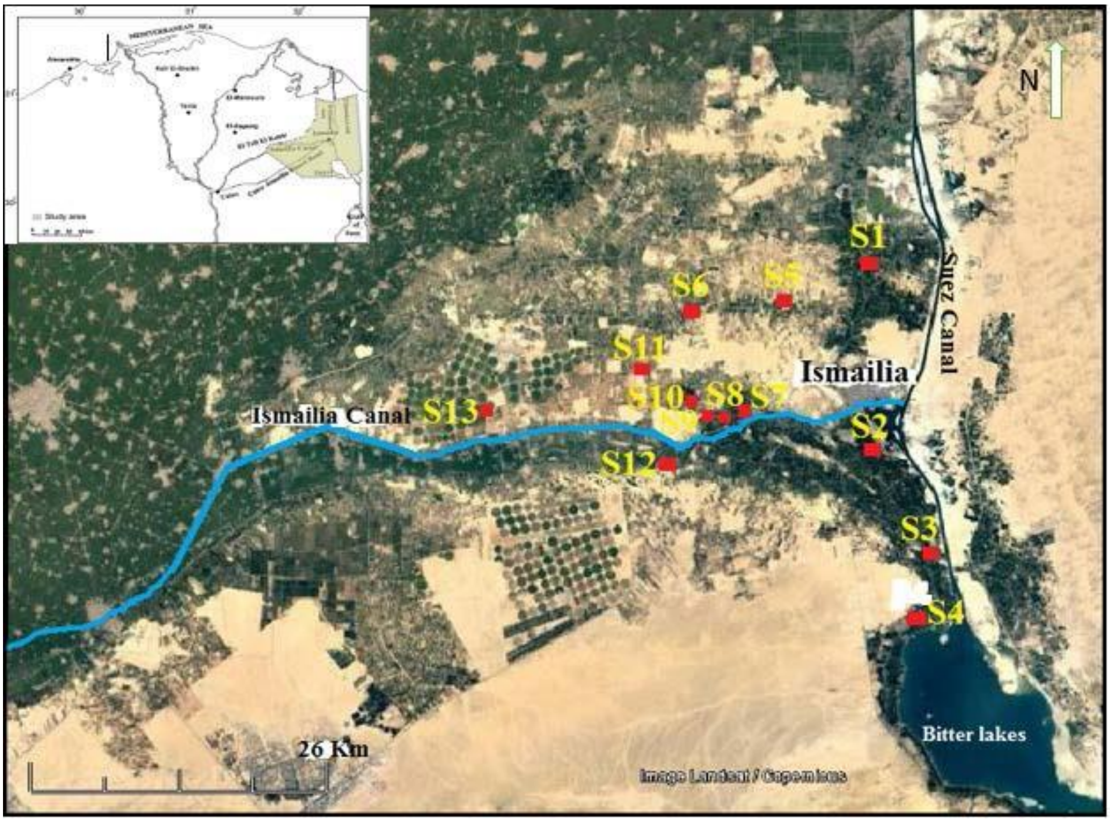

Figure 1. The location map of the 13 studied sites (■) in the study area. (1= Abu Khalifa, 2= Abu Atwaa, 3= Sarabium, 4= Abu Sultan, 5= Jameait alasher min ramadan, 6= Samy Saad, 7= El Wasifyia, 8= Fares, 9= El Elwany, 10= Abu Rageih, 11= Abu Kharoa, 12= Fifth Canal and 13= El Qassasin).

Material and methods

Vegetation sampling

Field data on the floristic composition were achieved throughout intensive fieldwork between the years 2016 and 2018. A total of 13 permanently visited sites (Fig. 1) included Abu Khalifa, Abu Atwaa, Sarabium, Abu Sultan, Jameait Alasher Min Ramadan, Samy Saad, El Wasifyia, Fares, El Elwany, Abu Rageih, Abu Kharoa, Fifth Canal and El Qassasin were surveyed, using a stratified sampling technique (Mueller-Dombois and Ellenberg, 1974).

Seventy-nine stands (5 m×10 m each, according to the minimal area) were selected to represent mango orchards in Ismailia Governorate. The stands were selected to cover three categories of mango orchards, classified according to the ages of mango trees to new (1-5 years), medium (6-15 years) and old orchards (>15 years). The chosen stands were distributed among the three categories of mango orchards as follows: 14 stands in the new orchards, 20 in the medium and 45 in the old one. In each stand, the plant species were recorded and species abundance was estimated according to Shukla and Chandel (1996). Presence percentages (P%) of each species was calculated as the number of stands where the species was recorded divided by the total number of stands for each mango category. The identification and nomenclature of the recorded species were according to Boulos (1999, 2000, 2002, 2005 and 2009). The plant life forms were classified according to Raunkiaer's life-form classification scheme (Raunkiaer, 1934). The phytogeographical range of species distribution was carried out according to Good (1974), Lind and Wickens (1976) and Abd El-Ghani (1985). Voucher specimens were deposited at the Herbarium of Suez Canal University (SCUI).

Measurement of species diversity

The species richness (α-diversity) of each category of mango orchard was calculated as the average number of species per stand. The Shannon–Wiener index (H') for the relative species evenness and the Simpson index (C) for the concentration of species dominance were calculated also for each category (Pielou, 1975; Magurran, 1988).

Floristic similarity index

In order to compare species composition of mango orchards in the study area with that in other sites of Egypt, floristic similarities based on binary (presence-absence) data between pairs of sites were calculated by using Sorensen's similarity index (Sørensen, 1948) which considers the number of species shared among both samples as more important, so it counts it twice. Sorensen's similarity index is useful in a case that compared samples largely differ in species richness.

Coefficient of Similarity (%S) = 2a/b+c × 100
Where:
a = number of common presences for both floristic samples
b = number of presences in the first floristic sample
c = number of presences in the second floristic sample

Results

Species distribution patterns

The overall picture of the floristic composition of the weed communities in mango orchards was presented in Table (1). It is clear that the total number of the recorded species was 102 species, of which 42 species were recorded in the three categories of mango orchards, these included 5 perennials, 1 biennial, 8 all-the-year annuals of winter affinity, 8 all-the year annuals of summer affinity, 16 winter-spring annuals and 4 summer-autumn annuals. Whereas, 23 species were recorded in two categories; these included 6 perennials, 1 biennial, 1 all-the-year annuals of winter affinity, 1 all-the-year annuals of summer affinity, 11 winter- spring annuals and 3 summer- autumn annuals. On the other hand, 37 species have narrowest sociological range, i.e. confined to only one orchard category. These species distributed as follows: 12 species in the new, 6 species in the medium and 19 species in the old one.

The most common species of winter affinity (P>25%) in the three categories were *Chenopdium murale*, *Sonchus oleraceus* and *Malva parviflora*. Similarly, the most common species of summer affinity (P>25%) were *Bidens pilosa*, *Cenchrus biflorus, Commelina benghalensis, Portulaca oleracea* and *Amaranthus hybridus*. Common winter-spring weeds included *Euphorbia peplus, Anagallis arvensis, Senecio glaucus* and *Melilotus indicus,* while common summer-autumn species were *Digitaria sanguinalis* and *Setaria verticillata*. Commonly recorded perennial weeds included *Cynodon dactylon, Cyperus rotundus* and *Cynanchum acutum.*

The total number of species, biodiversity indices and presence percentages of weed species varied according to the age of mango orchards (Tables 1 & 2). The old mango orchards attained the highest values of species number (80 species), species richness (13.8 species/stand), Shannon-Wiener diversity index (2.44) and Simpson index (0.90), while the new orchards had the lowest values of the number of species (63 species), species richness (11.86 species/stand), Shannon-Wiener diversity index (2.30) and Simpson index (Table 2). The common species related to new mango orchards (P>50%) were *Cynanchum acutum*, *Chenopdium muraleand* *Cynodon dactylon* (P=57.1% for each). While *Bassia muricata, Chenopodium ambroesoides, Euphorbia hirta, Ifloga spicata, Ipomoea hederacea, Ricinus communis, Parapholis incurva, Shismus barabatus, Silene villosa, Stipagrostis plumosa, Traganum nudatum* and *Zygophyllum album* were confined to this type of orchards.The common species recorded in medium mango orchards were *Chenopdium murale* (P=60%), *Anagallis arvensis* (P=55%), *Euphorbia peplus* (P=55%) and *Sonchus oleraceus* (P=55%). The restricted species in these orchards were: *Alhagi graecorum, Amaranthus graecizans, Anchusa humilis, Tamarix nilotica, Phlaris minor* and *Vicia peregrina*.Whereas, the common species in old orchards were *Bidens pilosa* (P=66.7 %), *Galinsoga parviflora* (P=60.0%), *Euphorbia peplus* (P=57.8 %), *Chenopdium murale* (P=55.6%), *Sonchus oleraceus* (P= 55.6%) and *Solanum nigrum* (P=53.3%). Nineteen weed species were confined to the old orchards e.g. *Eluesine indica, Veronica polita, Lamium amplexicaule, Chenopodium ficifolium* and *Ipomea obscura* (Table 1).

Table (1): Floristic composition and presence percentages (P %) of weeds in mango orchards. **Abbreviations:** N=New orchards, M=Medium orchards, O=Old orchards. **Chorotype:** COSM= cosmopolitan, PAL=Palaeotropical, PAN= Pantropical, S-Z= Sudano-Zambezian, ME=Mediterranean, SA-SI=Saharo-Sindian, IR-TR=Irano-Turanian, ER-SR=Euro-Siberian, NEO=Neotropical. **Life forms:** Th=Therophytes, H= Hemicryptophytes, N.-Ph= Nanophanerophytes, Ch= chamaephytes, He=Helophytes, G=Geophytes. **Life span:** P=perennial, Bi=biennial, A.W= all-the-year annuals with winter affinity, A.S= all-the-year annuals with summer affinity, W=winter-spring annuals, S=summer-autumn annuals. **Highlighted cells:** refer to the presence of the confined species in each mango category.

Plant species	Family	Life form	Chorotype	Life span	P (%)		
					N	M	O
Amaranthus hybridus L.	Amaranthaceae	Th	COSM	A.S	14.3	15	46.7
Amaranthus lividus L.	Amaranthaceae	Th	ME+IR-TR	A.S	7.1	20	35.5
Anagallis arvensis L.	Primulaceae	Th	COSM	W	21.4	55	13.3
Bidens pilosa L	Asteraceae	Th	PAN	A.S	28.6	45	66.7
Erucastrum arabicum Fisch. & C.A.Mey.	Brassicaceae	Th	PAN	W	7.1	5	28.9
Brassica tournefortii Gouan	Brassicaceae	Th	ME+IR-TR+SA-SI	W	28.6	15	4.4
Bromus catharticus Vahl	Poaceae	Th	COSM	W	14.3	30	17.8
Cenchrus biflorus Roxb	Poaceae	Th	SA-SI+S-Z	A.S	35.7	25	22.2
Chenopodium album L.	Chenopodiaceae	Th	COSM	A. W	21.4	15	20.0
Chenopodium murale L.	Chenopodiaceae	Th	COSM	A. W	57.1	60	55.6
Commelina benghalensis L.	Commelinaceae	H	PAL	A.S	35.7	10	33.3
Convolvulus arvensis L.	Convolvulaceae	H	COSM	P	7.1	30	13.3
Conyza bonariensis (L.) Cronquist	Asteraceae	Th	ME	A. W	28.6	25	13.3
Coronopus didymum (L.) Sm	Brassicaceae	Th	COSM	W	7.1	20	31.1
Cynanchum acutum L.	Apocynaceae	H	ME+IR-TR+ER-SR	P	57.1	40	11.1
Cynodon dactylon (L.) Pers.	Poaceae	G	PAN	P	57.1	50	11.1
Cyperus rotundus L.	Cyperaceae	G	PAN	P	35.7	30	44.4
Dactyloctenium aegyptium (L.) Willd.	Poaceae	Th	PAL	S	14.3	10	17.8
Digitaria sanguinalis (L.) Scop.	Poaceae	Th	PAL	S	35.7	10	33.3
Echinochloa colona (L.) Link	Poaceae	Th	PAN	S	7.1	5	22.2
Emex spinosa (L.) Campd.	Polygonaceae	Th	ME+SA-SI	A. W	35.7	25	11.1
Euphorbia peplus L.	Euphorbiaceae	Th	ME+IR-TR+ER-SR	W	14.3	55	57.8
Euphorbia heterophylla L.	Euphorbiaceae	Th	PAN	A.S	14.3	10	28.9
Launea nudicaulis Hook. f.	Asteraceae	H	SA-SI	P	42.9	20	2.2
Lolium rigidum Gaudin	Poaceae	Th	ME+IR-TR	W	7.1	45	11.1
Malva parviflora L.	Malvaceae	Th	ME+IR-TR	A. W	50.0	50	42.2
Melilotus indicus (L.) All.	Fabaceae	Th	ME+IR-TR+SA-SI	W	28.6	45	24.4
Misopates orontium (L.) Rafin.	Scrophulariaceae	Th	ME+IR-TR+ER-SR	W	7.1	5	6.7
Poa annua L.	Poaceae	Th	COSM	W	7.1	5	8.9
Polypogon monspeliensis (L.) Desf.	Poaceae	Th	COSM	W	21.4	25	8.9
Portulaca oleracea L.	Portulacaceae	Th	COSM	A.S	21.4	30	28.9
Reichardia tingitana (L.) Roth	Asteraceae	Th	ME+IR-TR+SA-SI	W	7.1	25	6.7
Rorippa palustris (L.) Besser	Brassicaceae	Th	M+ER-SR	Bi	14.3	5	6.7
Rumex dentatus L.	Polygonaceae	Th	ME+IR-TR+ER-SR	A. W	7.1	25	33.3
Senecio glaucus L.	Asteraceae	Th	ME+IR-TR+SA-SI	W	42.9	25	13.3
Setaria verticillata (L.) P.Beauv.	Poaceae	Th	COSM	S	7.1	20	48.9
Sisymbrium irio L.	Brassicaceae	Th	ME+IR-TR+ER-SR+SA-SI	W	14.3	25	13.3

Solanum nigrum L.	Solanaceae	Th	COSM	A. W	21.4	30	53.3
Sonchus oleraceus L.	Asteraceae	Th	COSM	A. W	35.7	55	55.6
Trifolium resupinatum L.	Fabaceae	Th	ME+IR-TR	W	21.4	35	8.9
Urospermum picroides (L.) Scop. ex F.W.Schmidt	Asteraceae	Th	ME+IR-TR	W	7.1	20	6.7
Xanthium strumarium L.	Asteraceae	Th	COSM	A.S	7.1	5	13.3
Bassia indica (Wight) A.J.Scott	Chenopodiaceae	Th	S-Z+IR-TR	A.S	7.1	5	
Corchorus olitorius L.	Tiliaceae	Th	PAN	S	14.3	5	
Eruca sativa Mill.	Brassicaceae	Th	ME+IR-TR	W	7.1	5	
Melilotus messanensis (L.) All.	Fabaceae	Th	ME+IR-TR	W	7.1	5	
Euphorbia helioscopia L.	Euphorbiaceae	Th	ME+IR-TR+SA-SI	W	28.6		20.0
Gynandropsis gynandra (L. Briq.)	Cleomaceae	Th	PAN	S	7.1		26.6
Imperata cylindrica (L.) Raeusch.	Poaceae	G	PAL+ME	P	7.1		4.4
Sida alba L.	Malvaceae	Th	ME+IR-TR+PAN	Bi	14.3		2.2
Trianthema portulacastrum L.	Aizoaceae	Th	PAN	S	7.1		11.1
Ammi majus L.	Apiaceae	Th	ME+IR-TR+ER-SR	W		10	6.7
Avena fatua L.	Poaceae	Th	PAL	W		20	8.9
Capsella bursa-pastoris (L.) Medik.	Brassicaceae	Th	COSM	W		20	11.1
Cichorium endivia L. subsp. Pumilum	Asteraceae	Th	ME+IT-TR	W		20	2.2
Galinsoga parviflora Cav.	Asteraceae	Th	COSM	W		10	60.0
Oxalis corniculata L.	Oxalidaceae	G	COSM	P		30	26.7
Plantago major L.	Plantaginaceae	H	ME+IR-TR+ER-SR	P		10	2.2
Pluchea dioscoridis (L.) DC.	Asteraceae	N.ph	S-Z+SA-SI	P		5	2.2
Phragmites australis (Cav.) Trin. ex Steud.	Poaceae	G,He	COSM	P		20	2.2
Phyla nodiflora (L.) Greene	Verbenaceae	H	PAN	P		10	2.2
Pseudognaphalium luteoalbum (L.) Hilliard&Burt.	Asteraceae	Th	COSM	W		10	4.4
Raphanus raphanistrum L.	Brassicaceae	Th	ME+ER-SR	W		20	15.6
Stellaria pallida (Dumort.) Crép.	Caryophyllaceae	Th	ME+ER-SR	W		15	28.9
Urtica urens L.	Urticaceae	Th	ME+IR-TR+ER-SR	A. W		15	33.3
Bassia muricata (L.) Asch.	Chenopodiaceae	Th	SA-SI+IR-TR	A. W	7.1		
Chenopodium ambrosioides L.	Chenopodiaceae	Th	COSM	A. W	7.1		
Euphorbia hirta L.	Euphorbiaceae	Th	PAN	S	7.1		
Ifloga spicata (Forssk.) Sch.Bip.	Asteraceae	Th	ME+IR-TR+SA-SI	W	7.1		
Ipomoea hederacea (L.)Jacq.	Convolvulaceae	H	PAL+NEO	S	21.4		
Parapholis incurva (L.) C.E.Hubb.	Poaceae	Th	ME+IR-TR	W	7.1		
Ricinus communis L.	Euphorbiaceae	N.Ph	PAN	Per	7.1		
Schismus barbatus (L.) Thell.	Poaceae	Th	ME	W	7.1		
Silene villosa Forssk.	Caryophyllaceae	Th	SA-SI	W	7.1		
Stipagrostis plumosa (L.) Munro ex T.Anderson	Poaceae	H	ME+IR-TR+SA-SI	Per	7.1		
Traganum nudatum Del.	Chenopodiaceae	Ch	SA-SI+S-Z	Per	7.1		
Zygophyllum album L.f.	Zygophyllacae	Ch	ME+IR-TR+SA-SI	Per	28.6		
Anchusa humilis (Desf.) I.M.Johnst.	Boraginaceae	Th	ME+SA-SI	W		5	
Phalaris minor Retz.	Poaceae	Th	ME+IR-TR	W		5	
Alhagi graecorum Boiss.	Fabaceae	Ch	PAL	Per		5	
Amaranthus graecizans L.	Amaranthaceae	Th	ME+IR-TR	S		5	
Tamarix nilotica (Ehrenb.) Bunge	Tamaricaceae	N.Ph	SA-SI+S-Z	P		5	
Vicia peregrina L.	Fabaceae	Th	ME+IR-TR	W		5	

Brachiaria deflexa (Schumach.) C.E.Hubb. ex Robyns	Poaceae	Th	PAL	S			2.2
Chenopodium ficilifolium Sm.	Chenopodiacee	Th	COSM	A. W			6.7
Dichanthium annulatum (Forssk.)Stapf	Poaceae	H	PAN	Per			2.2
Eclipta prostrata (L.) L.	Asteraceae	Th	PAN	A. W			2.2
Gnaphalium polycaulon Pers.	Asteraceae	Th	COSM	W			2.2
Eleusine indica (L.) Gaertn	Poaceae	Th	PAL	S			13.3
Hibiscus trionum L.	Malvaceae	Th	PAL	S			2.2
Ipomoea obscura (L.) Ker Gawl.	Convolvulaceae	H	PAL+ SA-SI	S			8.9
Lamium amplexicaule L.	Lamiaceae	Th	ME+IR-TR+ER-SR	W			8.9
Lotus glaber Mill.	Fabaceae	H	ME+IR-TR+ER-SR	Per			2.2
Oxalis anthelmintica A.Rich.	Oxalidaceae	G	ME+PAL	Per			2.2
Setaria viridis (L.) P.Beauv.	Poaceae	Th	ME+IR-TR+ER-SR	S			2.2
Silene rubella L.	Caryophyllaceae	Th	ME+IR-TR	W			2.2
Solanum villosum Mill.	Solanaceae	Th	ME+IR-TR+ER-SR	W			4.4
Stellaria media (L.) Vill.	Caryophyllaceae	Th	COSM	W			2.2
Symphyotrichum squamatum (Spreng.) Nesom	Asteraceae	Ch	NEO	A. W			2.2
Tribulus terrestris L.	Zygophyllacae	H	COSM	S			2.2
Veronica anagallis-aquatica L.	Scrophulariaceae	G,He	COSM	Per			4.4
Veronica polita Fr.	Scrophulariaceae	H	ME+IR-TR+ER-SR	W			11.1

Floristic diversity

The weed flora of mango orchards comprises 102 species related to 85 genera and belonging to 30 families (3 monocots and 27 dicots). The recorded species included 23 species (22.55%) of the monocots and 79 species (77.45%) of the dicots (Table 3). Among all the families, Poaceae was found to be the largest one comprising 20 genera (23.53%) and 21 species (20.59%), followed by Asteraceae comprising 16 genera (18.82%) and 16 species (15.69%), Brassicaceae comprising 8 genera (9. 41%) and 8 species (7.8%). Fabaceae was represented by 5 genera (5.88%) and 6 species (5.88%), while Chenopodiaceae was represented by 3 genera (3.53%) and 7 species (6.86%). Euphorbiaceae and Caryophyllaceae were represented by 2 genera each (2.35%), while Euphorbiaceae comprising 5 species (4.9%) and Caryophyllaceae 4 species (3.92%). Twenty-three families were either represented by 3, 2 or one species. The largest genera include *Chenopodium* and *Euphorbia* (4 species for each), *Amaranthus* (3 species), *Silene,Stellaria,Setaria,Veronica, Solanum, Ipomoea* and *Melilotus* (2 species for each).

Table (2): Total number of species and biodiversity indices of the three categories of mango orchards.

Measure	**Mango orchards**		
Bioiversity indices	New	Medium	Old
Total number of species	63	66	80
Species richness	11.86	13.4	13.82
Shannon_indices	2.3	2.41	2.44
Simpson_indices	0.88	0.89	0.9

Table (3): Different taxa, their corresponding numbers and percentages in the study area

	Family	No. of genera	(%)	No. of species	(%)
Monocotyledons					
1	Commelinaceae	1	1.18	1	0.98
2	Cyperaceae	1	1.18	1	0.98
3	Poaceae	20	23.53	21	20.59
Dicotyledons					
1	Aizoaceae	1	1.18	1	0.98
2	Amaranthaceae	1	1.18	3	2.94
3	Apiaceae	1	1.18	1	0.98
4	Apocynaceae	1	1.18	1	0.98
5	Asteraceae	16	18.82	16	15.69
6	Boraginaceae	1	1.18	1	0.98
7	Brassicaceae	8	9.41	8	7.84
8	Caryophyllaceae	2	2.35	4	3.92
9	Chenopodiaceae	3	3.53	7	6.86
10	Cleomaceae	1	1.18	1	0.98
11	Convolvulaceae	2	2.35	3	2.94
12	Euphorbiaceae	2	2.35	5	4.9
13	Fabaceae	5	5.88	6	5.88
14	Lamiaceae	1	1.18	1	0.98
15	Malvaceae	3	3.53	3	2.94
16	Oxalidaceae	1	1.18	2	1.96
17	Plantaginaceae	1	1.18	1	0.98
18	Polygonaceae	2	2.35	2	1.96
19	Portulacaceae	1	1.18	1	0.98
20	Primulaceae	1	1.18	1	0.98
21	Scrophulariaceae	2	2.35	3	2.94
22	Solanaceae	1	1.18	2	1.96
23	Tamaricaceae	1	1.18	1	0.98
24	Tiliaceae	1	1.18	1	0.98
25	Urticaceae	1	1.18	1	0.98
26	Verbenaceae	1	1.18	1	0.98
27	Zygophyllacae	2	2.35	2	1.96
Total	**30**	**85**	**100**	**102**	**100**

Life span

The plant life span spectrum showed that annuals constituted the main bulk of the weed flora (77.45%). They comprised 13.72% all-the-year annuals with winter affinity, 8.82% all-the-year annuals with summer affinity, 39.22% winter-spring species and 15.69% summer-autumn species (Table 4). The new orchards contained the highest percentages of winter and summer affinity annuals (15.87 and 14.29%, respectively), while the medium orchards embraced the highest percentage of winter-spring annuals (43.94%) and the old orchards included the highest percentage of the summer-autumn annuals (15%). The highest number of perennials (18.75%) had been recorded in old orchards but the lowest value was 15.87% in new one. The biennials represented by few numbers of species in the three categories (2 species) in each of the new and old habitats and one species in medium orchards.

Table (4): Life span spectrum of the weed flora in the three categories of mango orchards.

Life span	**Mango orchards**							
	New		Medium		old		Total	
	No.	%	No.	%	No.	%	No.	%
Perennials	10	15.87	12	18.18	15	18.75	21	20.59
Biennials	2	3.17	1	1.52	2	2.5	2	1.96
Annuals								
All-the-year annuals with winter affinity	10	15.87	9	13.64	12	15	14	13.72
All-the-year annuals with summer affinity	9	14.29	9	13.64	8	10	9	8.82
Winter -spring annuals	23	36.51	29	43.94	31	38.75	40	39.22
Summer-autumn annuals	9	14.29	6	9.1	12	15	16	15.69
Total	63	100	66	100	80	100	102	%1oo

Life-forms

The plant life-form spectrum of the study area showed that therophytes (73.53%) were the most common life-form, followed by hemicryptophytes (12.75%), geophytes (4.9%), chamaephytes (3.92%), nanophanerophytes (2.94%) and helophytes (1.96%). The life-form spectra varied between the three categories of mango orchards where therophytes showed the highest representation (80.95%) in new orchards and the lowest value (75%) in the old one. The old mango orchards had the highest values of hemicryptophytes and geophytes (13.75 and 6.25%, respectively). Chamaephytes showed the highest contribution in new orchards (3.17%) and attained the lowest value (1.28%) in old one. The highest representation of nanophanerophytes was achieved in medium orchards (3.08%) and the lowest value in old (1.25%). Helophytes were missed in new orchards, but they attained the highest value (1.56%) in medium and the lowest value (1.25%) in old one (Fig. 2).

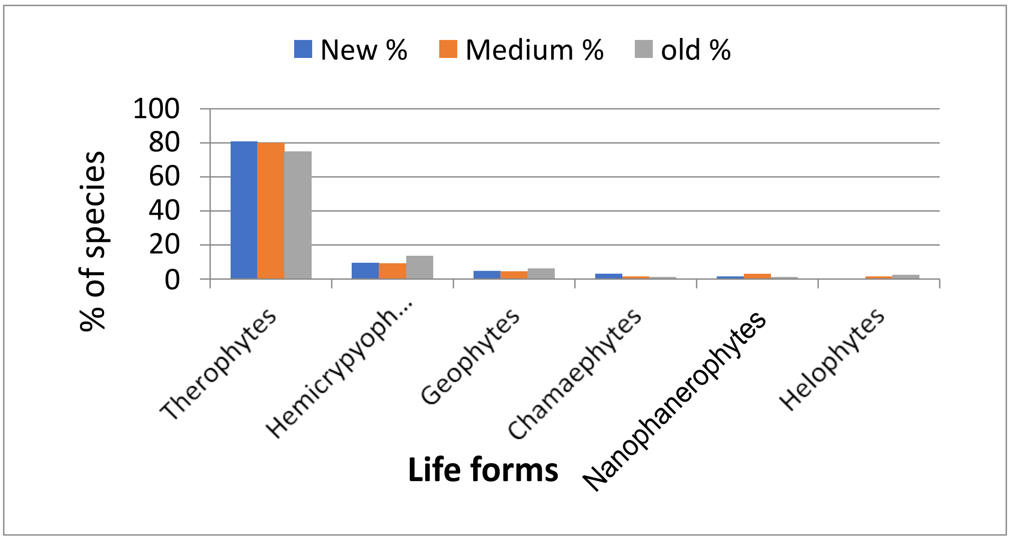

Figure (2): Plant life forms of the recorded species in the three categories (new, medium and old) of mango orchard.

Species distribution patterns of the weed flora in mango orchards

Chorological affinities

The chorological analysis of the surveyed flora revealed that 42 species (41.18%) of the total recorded species were Mediterranean taxa. These taxa were either pluriregional (23.53%), biregional (16.67%) or monoregional (1.96%). The other major chorotypes were cosmopolitan (24.51%), pantropical (13.73%) and palaeotropical (7.84%). Saharo-Sindian chorotype comprised of 20 species (19.6%) including 2 monoregional, 6 biregional and 10 plurriregional taxa. The other chorotypes were poorly represented (Table 5). The floristic features of the weed flora showed a distinct variation between the three categories of mango orchards. The old orchards attained the highest number of Mediterranean chorotype (32 species), while new and medium mangoes attained 27 & 29 species, respectively. The Cosmopolitan chorotype showed the highest number (23 species) in old orchards, but the lowest (15 species) in the new one, whereas the pantropical chorotype was represented by 11 species in each of the new and old orchards, and 8 species in medium one. The highest number of palaeotropical category (7 species) was recorded in old orchard but the lowest (3 species) in the new one. The Saharo-Sindian chorotype was highly represented in new orchards (15 taxa) followed by medium (11 taxa), then old one (10 taxa). The other chorotypes were either represented by a few number of species in some orchards or missed in the other (Table 5).

Table (5): Chorological analysis of the recorded flora in mango orchards examined as numbers and percentages of the total species recorded. **Abbreviations:** COSM= cosmopolitan, PAL= Palaeotropical, PAN= Pantropical, S-Z= Sudano-Zambezian, ME=Mediterranean, SA-SI=Saharo-Sindian, IR-TR=Irano-Turanian, ER-SR= Euro-Siberian, NEO=Neotropical.

Chorotypes	Mango orchard categories						Total	
	New		Medium		Old			
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Mono - regional								
ME	2	3.17	1	1.54	1	1.25	2	1.96
SA – SI	2	3.17	1	1.54	1	1.25	2	1.96
Sum	**4**	**6.34**	**2**	**3.08**	**2**	**2.5**	**4**	**3.92**
Bi- regional								
ME + ER-SR	1	1.59	3	4.62	3	3.75	3	2.94
ME+ IR-TR	8	12.7	11	16.67	8	10	12	11.76
ME+ SA -SI	1	1.59	2	3.08			2	1.96
ME+PAL	1	1.59			2	2.5	2	1.96
SA - SI + S - Z	2	3.17	3	4.62	2	2.5	4	3.92
SA - SI + IR-TR	1	1.59					1	0.98
S-Z+IR-TR	1	1.59	1	1.54			1	0.98
Sum	**15**	**23.8**	**20**	**29.2**	**15**	**18.7**	**25**	**24.5**
Pluri - regional								
ME + IR-TR + ER-SR	4	6.35	7	10.77	12	15	12	11.76
ME + IR-TR + SA-SI	8	12.7	4	6.15	5	6.25	9	8.82
ME+PAN+IR-TR	1	1.59			1	1.25	1	0.98
ME+IR-TR+ER-SR+SA-SI	1	1.59	1	1.54	1	1.25	1	0.98
Sum	**14**	**22.23**	**12**	**18.46**	**19**	**23.75**	**23**	**22.54**
World-wide								
Cosmopolitan	15	23.81	19	29.23	24	30	25	24.51
Pantropical	11	17.46	8	12.31	11	13.75	14	13.73
Palaeotropical	3	4.76	5	7.69	7	8.75	8	7.84

Neotropical					1	1.25	1	0.98
Palaeotropical+Neotropical	1	1.59					1	0.98
Palaeotropical+ Saharo-Sindian					1	1.25	1	0.98
Sum	**30**	**47.6**	**32**	**49.2**	**44**	**55**	**50**	**49.0**
Total	**63**	**100**	**66**	**100**	**80**	**100**	**100**	**100**

Discussion

The present study showed that the weed flora of the mango orchards comprised of 102 species belonging to 85 genera and 30 families, where Poaceae, Asteraceae, Brassicaceae, Chenopodiaceae and Fabaceae were the major families (about 56.86% of the total recorded species). These families represent the most common in the Mediterranean North African flora (Quézel, 1978), additionally reported as the foremost frequent in similar relevant floristic studies of the orchards and other agro-ecosystems in various parts of Egypt: El-Bakry (1982) in Cairo-Ismailia region, El-Halawany (2000) in the Nile Delta, Mashaly and Awad (2003) on the weed flora of orchards in the Nile Delta, Abd El-Hamid (2005) on the weed vegetation in Ismailia Governorate, Abd El-Ghani *et al.* (2013) in the reclaimed lands along the northern sector of the Nile Valley, and Mashaly *et al.* (2016) in the newly reclaimed areas of the Nile Delta.

The species surveyed in this study showed the highest number of weed species (80 species), species richness (13.8 species/stand), Shannon-Wiener diversity index (2.44) and Simpson index (0.90) was recorded in the old cultivated mango orchards. This may be attributed to their soil characteristics. They have heavy textured soil with relatively high values of water holding capacity and organic matter. Soil texture may affect soil or productivity via influence on the soil water holding capacity, infiltration rate, moisture availability for plants and consequently plant nutrition (Sperry *et al.*, 2002). Organic matter content is an essential soil fertility factor can affect phytodiversity (Zhang *et al.*, 2010; Wei *et al.*, 2018). On the other hand, the lowest values of the number of species (63 species), species richness (11.86 species/stand), Shannon-Wiener diversity index (2.30) and Simpson index were recorded in newly cultivated mango orchards, which mostly located in the recently reclaimed lands with sandy soil characteristics. This may be ascribed to the fact that the sandy soil has low levels of water-olding capacity and organic matter. Such soil type enable few number of weed species to grow (Mashaly and Awad, 2003).

Concerning the distributional pattern of weed flora in mango orchards, 42 species were distributed in the three categories of mango orchards. The most common of them were *Chenopodium murale, Sonchus oleracrus, Malva parviflora* and *Bidens pilosa*. These species were rather similar to those recorded as common weed species in orchards by El-Kady *et al.* (1999), Mashaly and Awad (2003) and Abd El-Hamid (2005). The wide distribution ranges of some weeds may be attributed to their being ubiquitous species with a wide amplitude often caused by phenotypic plasticity and heterogeneity (Holzner, 1978; Shaltout and El-Din, 1988). On the other hand, some species were confined to one category of the mango orchards such as *Bassia muricata* in new habitat, *Anchusa humilis* in medium habitat and *Oxalis anthelmintica* in old one. The restricted distribution of some weeds may be related to the need for special environmental attributes such as soil type as sandy soil for new reclaimed lands or heavy textured soil of high organic matter and moisture as in old lands. In addition, the shading and microclimate result from the age and cover of mango trees concerning the weed distribution (Abd El-Hamid, 2005).

The present study indicated the predominance of therophytes (annuals) (73.53%). This could be attributed to their short life cycle, which enables them to cope with the instability of the agro-ecosystems in which they occur (El-Kady *et al.*, 1999). Annual weeds produce very high amount of seeds to ensure propagation and survival.

Besides, sufficient amount of small seeds ensures high probability of dispersal and re-infestation (Shivakumar *et al.*, 2014). It is also presumed that the dominance of therophytes and hemicryptophytes may have partly resulted from disturbance in vegetation and grazing (Subramani *et al.*, 2007). Similar phytoclimatic association has also been reported by Mashaly *et al.* (2016) who concluded that the majority of life form in orchards was therophytes followed by hemicryptophytes and cryptophytes. It was also found that the percentage of therophytes in newly cultivated mango orchards was higher than that in medium and old ones. This may be related to adverse climatic conditions, moisture deficiency and substrate instability characterizing the newly reclaimed desert stands. The same conclusion was reported by Shaltout *et al.* (2010) and Eid and Shaltout (2014). The dominance of therophytes seems to be a response to the hot-dry climate, topographic variation and biotic influence (Heneidy and Bidak, 2001). On the contrary, the low number of perennials (20.59%) might be related to the anthropogenic activities including various cropping practices, ploughing, weeding, harrowing, collecting food and fodder species, which could affect vegetative growth structures, as well as the life cycles of the perennial weeds; this fact also reported by Abd El-Ghani and Abdel-Khalik (2006), Abd El-Ghani *et al.* (2013) and Bhattacharjya and Sarma (2016).

The chorological spectrum of the surveyed flora showed that Mediterranean taxa were relatively highly represented (41.18%), followed by cosmopolitan (24.51%), pantropical (13.73%) and palaeotropical (7.84%) chorotypes. This confirms the findings of El-Halawany (2000), Mashaly and Awad (2003), Abd El-Hamid (2005) and Mashaly *et al.* (2012 & 2016). Besides, the high representation of the Mediterranean taxa in the study area was supported by Kosinová (1974) who concluded that an important part of weed flora of Egypt has a Mediterranean origin or distribution. The high contribution of the widely distributed species belonging to cosmopolitan, pantropical and palaeotropical indicating that the floristic structure of the study area is relatively simple as compared with other areas of Egypt, being more affected by human disturbances (Salama *et al.*, 2016) . The other chorotypes such as Irano-Turanian, Saharo-Sindian, Euro-Siberian, Sudano-Zambezian and Neotropical were represented by variable number of species. This can be ascribed to human activities, history of agriculture of this region and capability to penetrate the study area from several adjoining phytogeographical regions (Mashaly *et al.,* 2012*)*. The presence of species related to distinctive chorotype categories was related prior to the position of Egypt at the border line between the African and Asiatic continents, and its floristic composition showed affinities in all directions (Said, 1956). Furthermore, El-Hadidi (1993) reported that as a result of Egypt being a meeting point, its natural vegetation belongs principally to Afro-Asiatic: Saharo- Sindian elements, African: Sudano Zambazian elements, also Euro–Asiatic: Mediterranean elements and some taxa with western Asiatic affinities eventually Irano-Turanian elements. Distribution of the major chorotypes in the three categories of mango orchards showed the increase of the Saharo-Sindian taxa in the new and medium orchards and the decrease in the numbers of the Mediterranean taxa on the contrary to old orchards. This may be attributed to the fact that plants of the Saharo-Sindian region are good indicators for desert environmental conditions, while Mediterranean species stand for more mesic environment (Danin and Plitman 1987; Salama *et al.*, 2013; El-Amier and Abdul-Kader, 2015).

Comparison between the present floristic study and previous studies of mango orchards in Ismailia Governorate

Floristic study and species composition of the present study was compared with previous floristic studies in mango orchards either in the same area or in the adjoining areas (Mahgoub, 1993; Abd El-Hamid, 1996 & 2005; EL-Kady *et al.*, 1999; Mashaly and Awad, 2003).

Abd El-Hamid (1996 & 2005) reviewed the weed communities of mango orchards in Abu-suwier village and Ismailia Governorate. The results of the present study were compared with those of the previous studies carried out almost 22 years ago in the same area (Table 6). A total of 178 different plant species were recorded in all studies. The recorded species are grouped into 3 groups where group: **A** refers to the number of established species; **B** refers to the number of disappeared species in the present study; **C** refers to number of newly recorded species in 2018.

Table (6): Summarized the number of species with their percentages in the species composition of the present study compared to the earlier studies in Ismailia Governorate. **Abbreviation: A:** the number of established species; **B:** the number of disappeared species; **C**: number of newly recorded Species in 2018.

	Abd El-Hamid (1996)	Abd El-Hamid (2005)	Current study (2016-18)	A	B	C
Number of species	40	128	102	82	76	20
(%)	22.47	71.91	57.30	46.06	42.69	11.23

The comparison of the present floristic study with previous studies in the same area indicated a considerable change in the total number of species. Undoubtedly, it has been noticed that the weed flora has been substantially altered since then as new herbicides and crop management techniques have been introduced. The number of weed species, however, different: 102 in 2018, 128 in 2005 and 40 in 1996. Records showed that 82 out of the 178 species (46.06%) have the ability to colonize and establish in mango orchard during 1996-2018. In contrast, results concluded that 20 species (11.23 %) were recoded as new additions in the present study. This may be due to the introduction of alien invasive weeds that may cause substantial shifts in weed communities (Wei *et al*., 2018). It is also worth noting that 76 species (42.69%) disappeared in the present study. The loss of these species may be due to agriculture practices and logging the trees (Volis, 2016). The previous changes in species composition may be attributed to the impact of human disturbance, and several plant species might have disappeared following such disturbance (Zhao *et al*., 2015).

Comparing the floristic studies of mango orchards in Ismailia Governorate and those of adjoining areas in Egypt

Comparison between floristic studies in Mango orchards of the present study in Ismailia Governorate (site1) and the flora of mango orchards of the adjoining areas prepared by other authors: Mashaly and Awad (2003) in four Northern Governorates of the Nile Delta region (site 2); El-Kady *et al.* (1999) in Nile Delta (site 3) and Mahgoub (1993) in Northwest of the Delta (site 4) were carried out**.**

Analyzing and comparing the data of the current study with those obtained from adjacent area resulting in dividing the species into 4 groups: group (I) is the established and colonized species in all mango orchard sites that comprised of 11 species (7.10%) namely *Cynodon dactylon, Cyperus rotundus, Euphorbia peplus, Rumex dentatus, Sisymbrium irio, Solanum nigrum, Sonchus oleraceus, Chenopodium murale, Stellaria pallid*a, *Conyza bonariensis* and *Malva parviflora*; group (II) comprised of the confined species to Ismailia mango orchard that constituted 31 species (20%); group (III) comprised of 60 species (38.71%) that represent the shared species recorded in Ismailia Governorate and at least one other region; and group (IV) comprised of the disappeared species in Ismailia but recorded in other regions and this group contained 53 species (34.19%; Fig. 3).

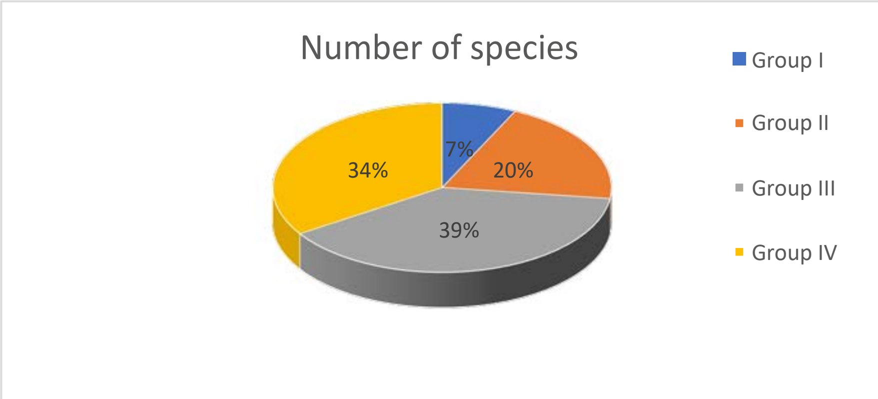

Figure (3): A quantitative Comparisons in floristic composition between the current study area with other adjoining areas. Abbreviation: group **(I)** colonized species in all mango orchard; group **(II)** unicate species to Ismailia only; group **(III)** the shared species recorded in Ismailia region and other region; group **(IV)** species disappear from Ismailia orchards.

Moreover, Sørenson's Similarity Index (Table 7) showed that different sites vary according to the presence/absence of species, with sites 1, 2 and 3 having < 41% similarity, and site 3 showing the least similarity to sites 1 and 4. However, the percentage similarity between site 1 (present study area) and site 4 was higher than that between site 1 and sites 2–3. Great similarity was observed between the flora of North west delta and the flora of mango orchards of Ismailia with highest similarity (**61.24 %**) where 64 species present in common with both.

Table (7): Coefficient of Similarity (%) between the four sites of mango orchards on the basis of the number of species, and the shared species between each two sites (between parentheses). **Site1**: current study; **Site 2:** four Northern governorates of the Nile Delta region; **Site 3:** Nile Delta; **Site 4:** North west of the Delta.

	Site 1	Site 2	Site 3	Site 4
Site 1		(28)	(18)	(64)
Site 2	39.72		(13)	(28)
Site 3	28.35	40.63		(19)
Site 4	61.24	38.36	28.79	
Total number of species per each site	102	39	25	107

Comparing the number of recorded species of mango orchards of Ismailia Governorate with other adjoining areas (sites) revealed that the total numbers of species change significantly among the different sites where it ranged between 25 species in site3, 39 in site 2, 102 in site 1 to 107 species in site 4 with a total of 155 different species. The variation in the recorded species from one site to another may be attributed to the variation in the size of the study areas and the ages of mango orchards. Sørenson similarity index revealed high similarity between the flora of the study area and Northwest of the Delta (61.24) which can be inferred as these two sites represent transitional habitats between the old cultivated land and reclaimed desert that represent species-rich environments (Witting, 2002); whereas large areas in the Western and Eastern Egyptian deserts and Sinai were subjected to land reclamation. About 61% of the reclaimable land through the Nile waters is located on the fringes of the Delta region where soil, in parts of these areas, is loamy in nature; cultivation can be relatively successful (Biswas, 1993). Moreover, orchards comprised different microclimate. The vegetation components consisted of desert weeds such as *Reichardia tingitana, Parapholis incurva, Bassia muricata, Ifloga spicata* and *Schismus barbatus;* canal bank plants *e.g. Phyla nodiflora, Symphyotrichum squamatum* and *Rorippa palustris;* roadsides *e.g .Bassia indica* and *Alhagi graecorum;* water-loving species e.g. *Veronica anagallis-aquatica* and *Pseudognaphalium luteoalbum,* and salt marshes *e.g. Tamarix nilotica.* The variation also may be attributed to the fact that the orchard environment exhibited two different microhabitats according to light conditions: the shaded microhabitat below trees and the sunny microhabitat between trees (Abd El-Ghani *et al.*, 2013). The results of this study concerned the distributional pattern of weed flora in mango orchards. This knowledge could be very useful for setting weed management and research priorities.

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