Vegetation and Soil Relationships in the Inland Wadis Ecosystem of the Northern Sector of the Eastern Desert, Egypt

Ali A.Z. Al-Shammari[1], El-Sayed F. El-Halawany[1], Mahmoud E. Ali[2], and Yasser A. El-Amier[1]*

[1]Botany Department, Faculty of Science, Mansoura University, Mansoura - 35516, Egypt
[2]Plant Ecology and Range Management, Ecology and Cultivation of Arid Lands Division, Desert Research Center
* Corresponding author e-mail: dr@mans.edu.eg; Tel. +201017229120
ORCID ID: https://orcid.org/0000-0001-8920-8278

Abstract

The purpose of this research is to evaluate the vegetation and plant diversity in the northern sector of the Eastern Desert in relation to edaphic factors at three wadis (Wadi Hagoul, Wadi El-Rashrash, and Wadi Al-Atfihi). The total number of the recorded plant species surveyed in the present study is 87 species (31 annuals, two biennial and 54 perennials) belonging to 70 genera and related to 27 families. Asteraceae, Fabaceae, Poaceae and Chenopodiaceae are leading taxa and constitute the major bulk of the flora of the study area. The majority of the recorded species are therophytes (37.93%) followed by chamaephytes (32.18%). Chorological analysis of the surveyed flora (Table 2) revealed that, 67 species represented by 77.02% of the total number of recorded species are Saharo-Sindian taxa. In the present study, the application of TWINSPAN classification on the importance values (out of 200) of 87 plant species representing, led to the recognition of four vegetation groups. Among the most common plants you'll come across are *Ochradenus baccatus*, *Retama raetam*, *Zygophyllum coccineum* and *Zilla spinosa*. In the northern part of the Eastern Desert, the distribution of flora is mostly determined by soil physical qualities, soil salinity, and human activities.

Keywords: Vegetation, Eastern Desert, Floristic composition, Soil Analysis.

1. Introduction

In the dry and semi-arid regions, there is an abundance of wild plants and animals, and stunning scenery. Government administration cannot ignore this fascinating topic, even if it hasn't been given much thought to yet [1,2]. The world's semiarid and subhumid regions are frequently referred to as dryland farming areas. Agriculture in arid regions is mostly restricted to animal grazing, and even in semiarid areas, a major portion of the land is exclusively utilized for grazing. As a result, agricultural in dryland areas is far more extensive than dryland farming, especially in terms of area [3,4]. Egypt is a nation that may be found in northern Africa. Its quadrangular form extends 1229 km east to west and 1073 km north to south. Egypt covers little over one million square kilometers (1019 600 km^2) of Africa's total land area [5-7]. The whole country lies inside the huge desert belt that extends from the Atlantic across all North Africa and terminates in Arabia. Egypt's dry desert covers 95% of the country, and desert vegetation dominates natural plant life [8,9]. Bolous [10] found more plant life in the Eastern Desert than the Western Desert. He also said that the Sinai Peninsula and the northern wadis and mountains of the Eastern Desert west of the Suez Gulf share flora. The Eastern Desert has two primary phytogeographical regions: the Red Sea coastal area and the interior desert.

The region of the Eastern Desert known as the Sahara Desert is located east of the Nile River. It extends from the Nile Valley in the east to the Gulf of Suez and the Red Sea, covering around 223,000 km^2, or 21% of Egypt's total geographic area. The Eastern Desert is higher than the Western Desert as it consists essentially of a backbone of high, rugged mountains running parallel to and at a relatively short distance from the coast. It is also known as the Red Sea Hills [11,12]. Wadi Hagul is a hydrographic valley located in the Suez region of Egypt. It is one of the most notable and dry diverse wadis in the Eastern Desert. It includes most of the prospective project's areas in Egypt for relieving the over-population problem in the narrow strip of the Nile Delta [13]. Moreover, Wadi El-Rashrash (also known as Wadi ar Rashrash) is a depression in the northern section of Eastern Desert (Helwan Desert), Egypt. This wadi is subjected to moderate levels of grazing, wood cutting and collection of plants for economic purposes. Wadi Al Atfihi (Wadi Atfih) is a hydrographic wadi in Giza Province. It is located at an elevation of 59 meters above sea level. A Wadi is a valley or ravine, bounded by relatively steep banks, which in the rainy season becomes a watercourse; found primarily in North Africa and the Middle East.

The family Resedaceae is a small family with six genera and 85 species, mostly found in temperate regions of the Old World, with the Mediterranean Basin being its diversity center. Most species favour basic soils and thrive in steppes, deserts, and dry slopes [14]. Egypt's Resedaceae has 5 genera and 16 species [15]. In the Egyptian Flora, *Ochradenus baccatus* Delile is the only member of the genus *Ochradenus*. It is a huge, semi-evergreen shrub that thrives in the Middle Eastern sand and stone regions. It's a thick shrub between 0.5 and 2 meters tall, with a woody bases and many smooth, green, fleshy branches that turn a bluish green when fully developed. The *O. baccatus* shrub may be found in dry and semiarid regions from the heart of Africa to the southwest of Asia [16,17]. Drought- and salt-tolerant, it has been documented in nearly all of Egypt's deserts [15,18]. In several places, *O. baccatus* has been used for medicinal purposes for quite some time [19,20]. This work mainly aims to study the ecological status of wild plants associated with the *Ochradenus baccatus* Delile. in north sector of Eastern Desert.

2. Materials and Methods

2.1. Study area

The study area can be found on the eastern side of the Nile Valley. It is bounded to the south by the El-krumat - El-Zafrana Road, to the north by the Cairo-Suez Road, to the east by the Suez Gulf, and to the west by the Nile Valley. Wadi Hagoul, Wadi El-Rashrash, and Wadi Al-Atfihi are the three wadis that make up the study regions in the northern part of the Eastern Desert. Wadi El-Rashrash is the largest of the three wadis (Figure 1). Xerophytic vegetation dominates the Wadi basin's xeric habitat. The gravel desert defines this Wadi. It has local physiographic and physiognomic heterogeneity [13]. The application of several methods suggested for the classification of climate indicates that the Eastern Desert belong to arid or extreme arid climate [21-23]. Meteorological data of the Giza District shows that the climate of this region is obviously hot and dry.

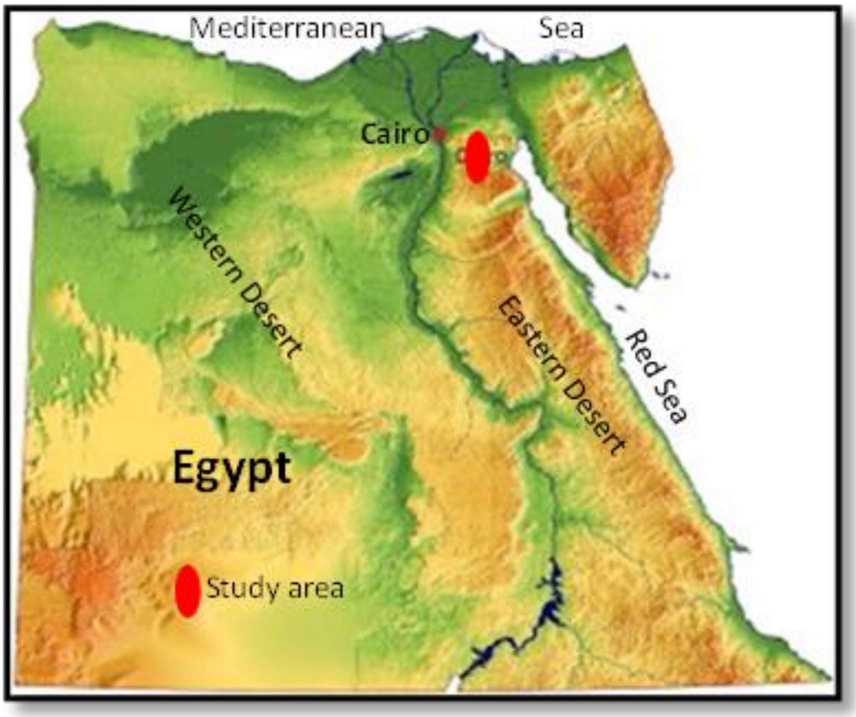

Figure 1. Map of Egypt showing the location of study area.

2.2. Vegetation analysis

After a reconnaissance survey that was conducted between 2022, 58 sample stands (20 m × 20 m) were randomly selected to represent a wide range of physiographic and environmental variation in the studied deserts. Specimens of the *Ochradenus baccatus* and the other associated species were collected from the north of the Eastern Desert. The relative density and cover of each species have been estimated in the studied stands [24,25]. Relative values of density and cover as well as importance value (IV = 200) for each plant species in each stand were calculated. A floristic count list was taken from the 58 sites to represent the plants in the study sites. Taxonomic nomenclature and analysis of phytogeographic ranges were used according to Zohary [26]; Tackholm [27] and Boulos [15].

2.3. Soil analysis

Each of the 58 study sites was represented by three soil samples were collected at depths of 0-30 cm. The samples were mixed together to form a single composite sample, which was then spread over sheets of paper and left to dry in the air. Soil texture, water holding capacity (WHC), organic carbon and sulphate were determined according to Piper [28]. Calcium carbonate content was determined by titration against 1N NaOH and expressed as a percentage [29]. Determination of electric conductivity and pH was determined in soil-water (1:5) extracts by the method adopted by Jackson [29]. Carbonates and bicarbonates were determined by titration using 0.1 N HCl [30]. Sodium and potassium were determined by flame photometry, while calcium and magnesium were estimated using atomic absorption spectrometer [31].

2.4. Data analysis

Classification and ordination of the associated vegetation of the studied geophytes were performed using TWINSPAN analysis by the Community Analysis Package (CAP) computer program, version 2.3 [32]. For ordination, the indirect gradient analysis was undertaken using detrended correspondence analysis (DCA) [33]. The relation between the vegetation and soil gradients was assessed using Canonical Correspondence Analysis (CCA) [34]. Linear correlations coefficient (r) was calculated for assessing the relationship between the estimated soil variables.

3. Results and Discussion

3.1. Floristic composition

These three wadis represent the natural xeric habitat which is mainly inhabited by xerophytic vegetation. Table (1) shows the floristic composition of plant species associated with *Ochradenus baccatus* Delile. in three Wadis (Northern sector of Eastern desert) namely: Wadi Hagoul, Wadi El-Rashrash and Wadi Al-Atfihi, 58 stands have been selected for sampling vegetation. The total number of the recorded plant species surveyed in the present study is 87 species (31 annuals, two biennial and 54 perennials) belonging to 70 genera and related to 27 families. Table (1) showed that, the family Asteraceae comprises 20 species (22.99%) of the total recorded plant species, followed by family Fabaceae and Poaceae 7 species each (8.05%), Chenopodiaceae 6 species (6.90 %), Brassicaceae and Zygophyllaceae comprise 5 species each (5.75 %), Caryophyllaceae and Plantiginaceae 4 species each (4.60), Asclepiadaceae, Boraginaceae and Polygonaceae each 3 species (3.45%). The remaining families (16) were represented by either two or one species. This indicated that four families (Asteraceae, Fabaceae, Poaceae and Chenopodiaceae) are leading taxa and constitute the major bulk of the flora of the study area. Similar results were also reported by other researchers [18,35, 36].

The dominance of perennials (62.07% of total recorded species) may be related to the nature of the habitat types in the present study in which the reproductive capacity, ecological, morphological and genetic plasticity are the limiting factors [37,38]. The high contribution of annuals (35.63% of total recorded species) can be attributed to time of study (March – May 2022) and short life cycle that enables them to resist the instability of the agro- ecosystem [37].

The life form spectra provide information which may help in assessing the response of vegetation to variations in environmental factors [39]. According to the description and classification of life-forms [40], the majority of the recorded species are therophytes (37.93%) followed by chamaephytes (32.18%), then hemicryptophytes

(13.79%), nanophanerophytes (8.05%), geophytes (4.60%) and phanerophytes (3.45%). The lowest value of life-forms is recorded as helophytes and parasite which attained value of (1.15 %). The above results agree with those of other reports [18,36,41].

Table 1. Floristic composition of the plant life in the study area.

Plant Species	Family	Life form	Floristic analysis
Perennial			
Acacia tortilis **(Forssk.) Hayne**	Fabaceae	Ph	S-Z
Achillea fragrantissima **(Forssk.)Sch.Bip.**	Asteraceae	Ch	SA-SI+IR-TR
Aerva javanica **(Burm.F.) Juss. ex Schult.**	Amaranthaceae	Ch	SA-SI + S-Z
Alkanna lehmanii **(Tin.) A.DC.**	Boraginaceae	H	ME
Anabasis articulata **(Forssk.) Moq.**	Chenopodiaceae	Ch	SA-SI+IR-TR
Artemisia judiaca **L.**	Asteraceae	Ch	SA-SI
Artemisia monosperma **Delile.**	Asteraceae	Ch	SA-SI+ME
Astragalus bombycinus **Boiss.**	Fabaceae	H	SA-SI + IR-TR
Astragalus spinosus **(Forssk.) Muschl.**	Fabaceae	Ch	SA-SI + IR-TR
Atractylis carduus **(Forssk.) C.Chr.**	Asteraceae	H	ME+SA-SI
Calligonum polygonoides **L.** subsp. *comosum* **(L'Hér.)Soskov**	Polygonaceae	Nph	IR-TR+SA-SI
Calotropis procera **(Willd.) R.Br.**	Asclepiadaceae	Ph	SA-SI + S-Z
Cistanche phelypaea **(L.) Cout.**	Orobanchaceae	P, G	SA-SI+ME
Cleorne droserifolia **(Forssk.) Delile**	Cleomaceae	Ch	SA-SI + IR-TR
Crotalaria aegyptiaca **Benth**	Fabaceae	Ch	SA-SI
Cyondon dactylon **(L.)Pers**	Poaceae	G	COSM
Deverra tortuosa **(Desf.)DC**	Apiaceae	Ch	SA-SI
Diplotaxis harra **(Forssk.) Boiss.**	Brassicaceae	Ch	ME+ SA-SI
Echinops spinosus **L.**	Asteraceae	H	ME+SA-SI
Fagonia arabica **L.**	Zygophyllaceae	Ch	SA-SI
Fagonia mollis **Delile.**	Zygophyllaceae	Ch	SA-SI
Farsetia aegyptia **Turra.**	Brassicaceae	Ch	S-Z+SA-SI
Francoeuria crispa **(Forssk.) Cass.**	Asteraceae	Ch	SA-SI
Gypsopila capillaris **(Forssk.) C.Chr.**	Caryophyllaceae	H	IR-TR+SA-SI
Haloxylon salicornicum **(Moq.) Bunge ex Boiss.**	Chenopodiaceae	Ch	SA-SI
Haplophyllum tuberculatum **(Forssk.) Juss**	Rutaceae	H	SA-SI
Heliotropium arbainense **Fresen.**	Boraginaceae	Ch	SA-SI
Herniaria hemistemon **J.Gay**	Caryophyllaceae	H	SA-SI
Hyoscyamus muticus **L.**	Solanaceae	Ch	SA-SI
Iphiona mucronata **(Forssk.) Asch. &Schweinf.** Asteraceae		Ch	SA-SI
Kickxia aegyptiaca **(L.) Nάbelek**	Scrophulariaceae	Ch	ME+SA-SI
Lasiurus scindicus **Henrard.**	Poaceae	G	SA-SI+S-Z
Launaea mucronata **(Forssk.) Muschl.**	Asteraceae	H	ME+SA-SI
Launaea nudicaulis **(L.) Hook.f.**	Asteraceae	H	SA-SI

Launaea spinosa **(Forssk.) Sch.Bip. ex Kuntze.**	Asteraceae	Ch	SA-SI
Lavandula coronopifolia **Poir.**	Lamiaceae	Ch	SA-SI
Leptadenia pyrotechnica **(Forrsk.) Decne.**	Asclepiadaceae	Nph	SA-SI
Lycium shawii **Roem. & schult.**	Solanaceae	Nph	SA-SI+S-Z
Nauplius graveolens **(Forssk.) Wilklund**	Asteraceae	Ch	SA-SI
Nitraria retusa **(Forssk.) Asch.**	Nitrariaceae	Ph	SA-SI
Ochradenus baccatus **Delile.**	Resedaceae	Nph	SA-SI
Panicum turgidum **Forssk.**	Poaceae	H	SA-SI
Pergularia tomentosa **L.**	Asclepiadaceae	Ch	SA-SI
Phragmites australis **(Cav.) Trin.exSteud**	Poaceae	G, He	COSM
Polycarpaea repens **(Forssk.) Asch.**	Caryophyllaceae	Ch	SA-SI
Pulicaria undulata **(L.) C.A.Mey.**	Asteraceae	Ch	SA-SI
Retama raetam **(Forssk.)Webb&Berthel.**	Fabaceae	Nph	SA-SI
Spergularia media **(L.) C. Presl**	Caryophyllaceae	H	ME+ IR-TR+ER-SR
Tamarix aphylla **(L.) H. Karst.**	Tamaricaceae	Nph	SA-SI+S-Z
Tamarix nilotica **(Ehrenb.) Bunge.**	Tamaricaceae	Nph	SA-SI
Trichodesma africanum **(L.) R.Br.**	Boraginaceae	H	S-Z+SA-SI
Zilla spinosa **(L.) Prantl.** .	Brassicaceae	Ch	SA-SI
Zygophyllum coccinum **L.**	Zygophyllaceae	Ch	SA-SI
Zygophyllum decumbens **Delile.**	Zygophyllaceae	Ch	SA-SI
Biennials			
Centaurea aegyptiaca **L.**	Asteraceae	Th	SA-SI
Launaea capitata **(Spreng)Dandy**	Asteraceae	Th	S-Z+SA-SI
Annuals			
Anthemis cotula **L.**	Asteraceae	Th	ME+IR-TR+ER-SR
Bassia indica **(Wight) Scott.**	Chenopodiaceae	Th	S-Z+IR-TR
Bassia muricata **(L.)Asch.**	Chenopodiaceae	Th	IR-TR+SA-SI
Atriplex lindleyi Moq. subsp. inflate (F.Muell.)Wilson.	Chenopodiaceae	Th	ME+IR-TR+ER-SR
Chenopodium murale **L.**	Chenopodiaceae	Th	COSM
Cleome amblyocarpa **Barratte & Murb.**	Cleomaceae	Th	SA-SI
Emex spinosa **(L.) Campd.**	Polygonaceae	Th	ME+SA-SI
Erodium laciniatum **(Cav.) Wild.**	Geraniaceae	Th	ME
Erysimum repandum **L.**	Brassicaceae	Th	ME+IR-TR+ER-SR
Euphorbia retusa **Forssk.**	Euphorbiaceae	Th	SA-SI
Hordeum spontaneum **K. Koch**	Poaceae	Th	ME+IR-TR
Ifloga spicata **(Forssk.) Sch.Bip.**	Asteraceae	Th	SA-SI
Lactuca serriola **L.**	Asteraceae	Th	ME+IR-TR+ER-SR
Lolium multiflorum **Lam.**	Poaceae	Th	ME+IR-TR+ER-SR
Lotus glinoides **Delile**	Fabaceae	Th	S-Z
Malva parvifolra **L.**	Malvaceae	Th	ME+IR-TR
Matthiola longipetala **(Vent.) DC.**	Brassicaceae	Th	ME+IR-TR
Mesembryanthemum forsskaolii **Hochst.ex Boiss.**	Aizoaceae	Th	SA-SI
Neurada procumbens **L.**	Neuradaceae	Th	SA-SI+S-Z
Plantago ciliata **Desf.**	Plantaginaceae	Th	SA-SI + IR-TR
Plantago lagopus **L.**	Plantaginaceae	Th	ME+IR-TR
Plantago notata **Lag.**	Plantaginaceae	Th	IR-TR+SA-SI

Plantago ovata Forssk.	Plantaginaceae	Th	IR-TR+SA-SI
Poa annua **L.**	Poaceae	Th	COSM
Reichardia tingitana **(L.) Roth**	Asteraceae	Th	ME+IR-TR
Reseda decursiva **Forssk.**	Resedaceae	Th	SA-SI
Rumex vesicarius **L.**	Polygonaceae	Th	SA-SI+ME+S-Z
Senecio glaucus **L.**	Asteraceae	Th	ME+IR-TR+SA-SI
Trigonella stellata **Forssk.**	Fabaceae	Th	SA-SI+IR-TR
Volutaria lippii **(L.) Cass. ex Maire**	Asteraceae	Th	SA-SI
Zygophyllum simplex **L.**	Zygophyllaceae	Th	SA-SI

Abbreviations: Life Form: H.= Hemicryptophytes Th. = Therophytes, Ph. = Phanerophytes, Ch. = Chamaephytes, Nph = Nanophanerophytes, G = Geophytes, He = Helophytes, P = Parasite; **Floristic Category:** COSM = Cosmopolitan, NEO = Neotropical, ME = Mediterranean, SA-SI = Saharo-Sindian, ER-SR = Euro-Siberian, IR-TR = Irano-Turanian, S-Z=Sudano-Zambezian

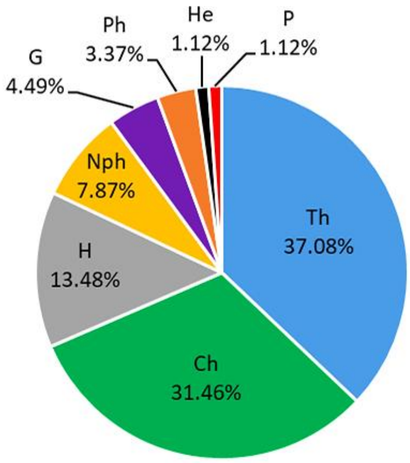

Figure 2. Plant life-forms in the study area

3.2. Chorological affinities

Chorological analysis of the surveyed flora (Table 2) revealed that, 67 species represented by 77.02% of the total number of recorded species are Saharo-Sindian taxa. These taxa are either Monoregional (36 species = 41.38%), Biregional (29 species = 33.33%) and Pluriregional (2 species = 2.30%). It has been found 23 species or represented 26.44% of the total number of recorded species are Mediterranean taxa. These taxa are either Pluriregional (8 species = 9.20%), Biregional (13 species = 14.94%) or Monoregional (2 species= 2.30 %). Additionally, 4 species or represented by 4.60% Cosmopolitan and two species or represented 2.30% of the total number of recorded species are Sudano-Zamdzeian.

This is in accordance with the results obtained by Danin & Plitman [42] on the phytogeographical analysis of the flora of Israel and Sinai, and Salama et al. [43] on vegetation analysis and species diversity in the desert of coastal wadis of South Sinai. The high percentage of Saharo-Sindian chorotype may be attributed to the fact that plants of the Saharo-Sindian species are good indicators for desert environmental conditions. It is worth noting that the species composition of the studied area varied considerably from those of the Mediterranean coast. This may be attributed mainly to the differences in the nature of soil sediments. The floristic elements of the Mediterranean coastal belt enjoy better climatic conditions than those of the other parts of Egypt [44].

Table 2. Number of species and percentage of various floristic categories of the study area.

Floristic category	Study area		Geographical distribution
	No.	%	
COSM	4	4.60	Worldwide
ME+IR-TR+ER-SR	6	6.90	Pluriregional elements
ME+IR-TR+SA-SI	1	1.15	
ME+SA-SI+S-Z	1	1.15	
ME+IR-TR	5	5.75	Biregional elements
ME+SA-SI	8	9.20	
IR-TR+SA-SI	12	13.79	
IR-TR+S-Z	1	1.15	
SA-SI+S-Z	9	10.34	
ME	2	2.30	Mono-regional elements
SA-SI	36	41.38	
S-Z	2	2.30	
Total	87	100.00	

3.3. Classification of vegetation

The application of TWINSPAN classification on the importance values (out of 200) of 87 plant species recorded in 58 stands representing the study area, led to the recognition of four vegetation groups (Figure 3). Group A comprises 14 stands co-dominated by *Ochradenus baccatus* (IV= 34.45) and *Retama raetam* (IV= 35.51). The abundant species include *Launaea spinosa* (IV= 15.81), *Leptadenia pyrotechnica* (IV= 14.02), *Zilla spinosa* (IV= 18.57), *Zygophyllum coccineum* (IV= 13.84), *Centaurea aegyptiaca* (IV = 7.53) and *Volutaria lippii* (IV= 6.69). Group B comprises 15 stands dominated by *Ochradenus baccatus* (IV = 43.59). The abundant species include *Zilla spinosa* (IV=24.25), *Deverra tortuosa* (IV = 11.73), *Haloxylon salicornicum* (IV =10.43), *Tamarix nilotica* (IV = 10.30), *Echinops spinosus* (IV = 9.81), and *Iphiona mucronata* (IV = 8.92). Group C consists of 22 stands dominated by *Zygophyllum coccineum* (IV=33.52). The abundant species include *Haloxylon salicornicum* (IV = 17.94), *Ochradenus baccatus* (IV= 21.56), *Zilla spinosa* (IV = 15.40), *Zygpphyllum simplex* (IV = 19.64), *Matthiola longipetala* (IV = 9.01), and *Retama raetam* (IV = 8.54). Group D consists of 21 stands co-dominated by *Ochradenus baccatus* (IV= 44.18) and *Zilla spinosa* (IV= 41.01). The abundant species include *Farsetia aegyptia* (IV = 10.90), *Haloxylon salicornicum* (IV = 12.44), *Zygophyllum coccineum* (IV= 11.44), *Echinops spinosus* (IV = 9.88) and *Diplotaxis harra* (IV= 9.40). These results are in line with those of Abd El-Wahab et al. [45] in Gebel Serbal of South Sinai, Abd El-Ghani et al. [46] in the reclaimed lands along the northern sector of the Nile Valley; El- Amier et al. [36] in costal sand formation and El-Amier and Abdul-Kader [18] in Wadi Hagoul, north of the Eastern Desert, and Abd-ElGawad et al. [41] in Wadi Araba, north of the Eastern Desert.

The ordination of the surveyed stands in the study area given by Detrended Correspondence Analysis (DCA) is shown in Figure (4). The DCA ordination of stands is indicated on the plane of the first and second DCA axes. It is obvious that, the vegetation groups yielded by TWINSPAN classification are distinguishable and having a clear pattern of segregation on the ordination plane. Group A dominated by co-dominated by *O. baccatus* and *R. raetam* as well as group B dominated by *O. baccatus* are segregated at the upper part of the left side of the DCA diagram. The vegetation groups A and B are clearly superimposed. While Group C dominated by *Z. coccineum* is separated at the upper part of the right side of the DCA diagram. On the other hand, group D co-dominated by *Z. coccinum* and *O. baccatus* is segregated at the middle part of the DCA diagram. The distinction between vegetation groups C and D is obvious. It is of interest to note that interspecific relationships between the above-mentioned vegetation groups may be due to the close similarities of their floristic composition and natural habitats.

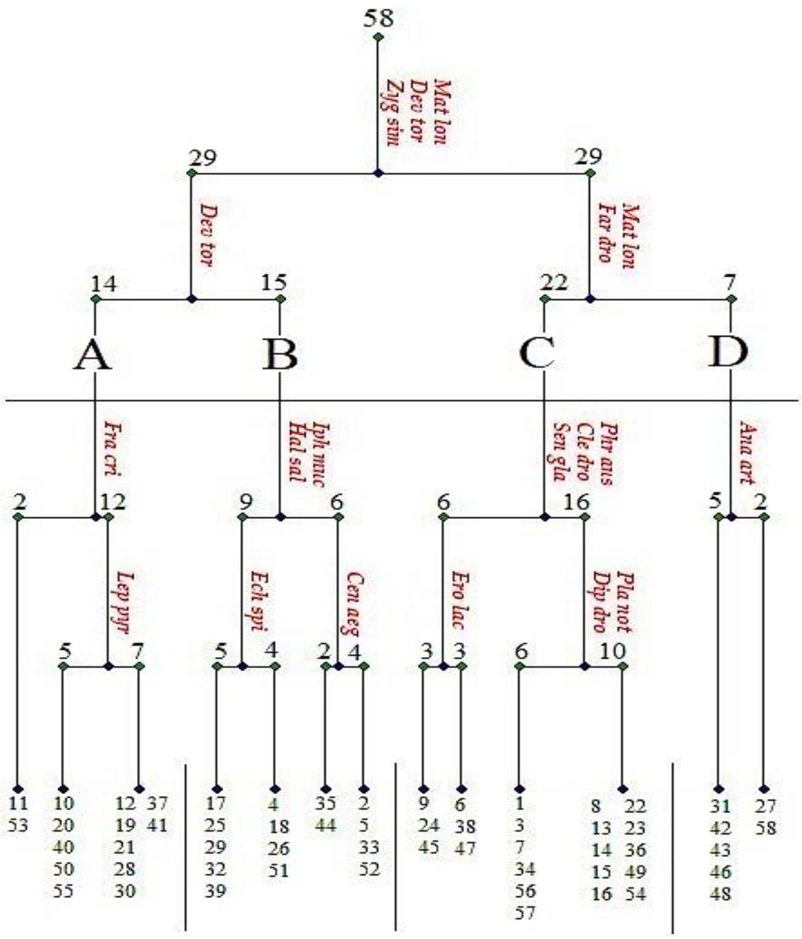

Figure 3. Two Way Indicator Species Analysis (TWINSPAN) dendrogram of the 58 sampled stands based on the importance values of the 87 species. The indicator species are abbreviated by the first three letters of genus and species respectively.

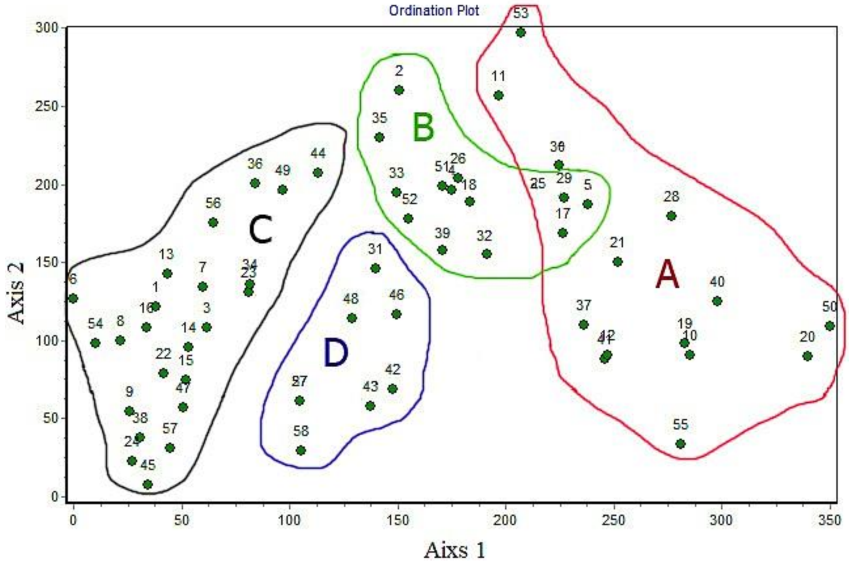

Figure 4. Detrended Correspondence Analysis (DCA) ordination diagram of the 58 stands with vegetation groups.

3.4. Vegetation-Soil Relationships

The gravel desert is one of the most characteristic features of three Wadis occupies the valley depression between Gebel Ataqa to the north and the Kahaliya ridge to the south, its main channel of each wadi, collects drainage on both sides and debouch into the Gulf of Suez. It is characterized by local physiographic variations and physiognomic heterogeneity.

3.4.1. Relationship between soil variables of the vegetation groups

The variation of soil variables (mean value ± standard error) of the four vegetation groups of stands derived from TWINSPAN classification are shown in Table (3). The soil texture in all groups is formed mainly of coarse fraction, (sand) and partly of fine fractions (silt and clay). It is obvious that, the physical soil variables are comparable in all groups. The group D sample had the highest percentage of coarse fractions (sand = 89.69%), whereas group A had the highest percentages of clay (3.66%) and silt fraction (7.89%). While groups A, D, and B got the lowest amounts of sand (88.44%), clay (2.51%), and silt (7.78%), respectively. The highest values of soil porosity (41.13%) and water-holding capacity (33.39%) were found in group A, respectively. While group A had the lowest percentage of soil porosity (39.51%) and water holding capacity (29.74%) Table (3).

Variables of the chemical composition of the soil varied from one group to another Table (3). Calcium carbonate and organic carbon are predicted to have the lowest mean values in group B (10.42 and 0.23%, respectively), while the greatest percentages are found in groups D and C (12.54 and 0.33%, respectively). The pH levels in group D (8.20) are predicted to be the highest, while those in group B are the lowest (7.01). The soil samples from group A had the highest electrical conductivity (719.14 mS cm^{-1}), Cl- (0.57), and SO_4^{--} (0.55%) values, whereas the soil samples from groups C, B, and C had the lowest values (686.01 mS cm^{-1}, 0.28%, and 0.46%, respectively) Table (3). The lowest percentages of HCO_3^- , Na^+, K^+, Ca^{++}, Mg^{++} and PAR are estimated in group A (0.85%, 136.67, 36.57, 57.40, 34.16 mg/100g dry soil and 5.99, respectively), while the highest percentages of HCO_3^- and Ca^{++} are attained in group C (1.08% and 91.14 mg/100g dry soil, respectively), and Na^+, K^+, Mg^{++} and PAR are attained in group B (255.53, 47.01, 47.96 mg/100g dry soil and 6.62). The highest mean values of SAR (27.38) in group B, while group C attained the lowest value (23.77) Table (3).

Soil texture, salinity and organic carbon can affect phytodiversity of wild communities [47-49]. The correlation coefficient (r) between the different soil variables in the sampled stands are shown in Table (4). It has been found that, some soil variables are positively or negative correlated with other soil variables, while some soil variables showed no correlations with any variables. These results suggest the effective role of these soil parameters in the study area community structure and diversity. The present findings agree with those of Al-Sodany [50], El-Halawany [51], Zahran et al. [52] and Abd-ElGawad et al. [41]. 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 [53,54].

Table 3. Mean and standard error of the different soil variables in the stands representing the different vegetation groups obtained by TWINSPAN classification in the study area.

Soil variables		Vegetation groups			
		A	B	C	D
Sand	%	88.44±5.69	89.27±4.55	88.50±4.63	89.69±4.66
Silt	%	7.89±4.22	7.78±4.29	7.85±3.97	7.80±4.98
Clay	%	3.66±2.30	2.96±1.63	3.65±2.08	2.51±1.15
Porosity	%	41.13±6.86	39.51±5.75	39.74±6.18	40.57±6.44
WHC	%	33.39±4.34	29.74±5.55	30.45±5.05	32.08±4.92
$CaCO_3$	%	10.54±8.00	10.42±6.57	11.16±5.98	12.54±7.77
OC	%	0.28±0.10	0.23±0.10	0.31±0.11	0.30±0.14
pH		8.12±0.21	7.01±2.79	8.06±0.17	8.20±0.17
EC mS cm^{-1}		719.14±58.92	694.74±35.56	686.01±45.38	701.07±28.77
Cl^-	%	0.57±0.51	0.28±0.27	0.40±0.29	0.50±0.36
SO_4^{--}	%	0.55±0.26	0.50±0.43	0.46±0.32	0.51±0.23
HCO_3^{--}	%	0.85±0.57	0.87±0.72	1.08±0.92	0.89±0.41
Na^+	mg/100g dry soil	136.67±83.41	255.53±89.71	208.39±69.90	209.14±71.52
K^+	mg/100g dry soil	36.57±17.78	47.01±23.93	44.54±21.45	41.79±19.76
Ca^{++}	mg/100g dry soil	57.40±21.40	84.47±14.57	91.14±32.31	71.20±30.26
Mg^{++}	mg/100g dry soil	34.16±12.76	47.96±20.32	45.55±14.66	41.18±17.13
SAR		19.75±8.85	27.38±11.82	23.77±10.15	24.52±11.68
PAR		5.99±1.34	6.62±1.41	6.08±1.79	6.43±1.21

Table 4. Pearson-moment correlation (r) between the soil variables in the stands surveyed in the study area.

Soil variables	Sand	Silt	Clay	Por.	WHC	$CaCO_3$	OC	pH	EC	Cl^-	SO_4^{--}	HCO_3^-	Na	K	Ca	Mg	SAR	PAR
Sand	1																	
Silt	-.915**	1																
Clay	-.518**	0.128	1															
Por.	.672**	-.568**	-.448**	1														
WHC	0.035	-0.047	0.012	0.028	1													
$CaCO_3$	-.340**	.458**	-0.135	-0.127	-0.004	1												
OC	.371**	-.441**	0.022	.352**	0.138	-.455**	1											
pH	0.066	-0.13	0.112	0.011	0.011	0.159	.314*	1										
EC	-0.113	-0.108	.504**	-.311*	-0.051	-0.203	-0.045	0.158	1									
Cl^-	.528**	-.518**	-0.2	.576**	0.109	-.436**	.634**	0.139	-0.171	1								
SO_4^{--}	.394**	-.304*	-.323*	.509**	0.096	0.105	.452**	0.137	-.319*	.594**	1							
HCO_3^-	-0.016	0.166	-.313*	0.222	-0.126	.556**	-0.12	0.161	-0.235	-0.086	0.189	1						
Na	-0.117	0.166	-0.065	-0.049	-.414**	.304*	-.268*	0.137	.318*	-.317*	-0.22	0.242	1					
K	-0.197	.277*	-0.102	-0.081	-0.228	.369**	-.325*	0.126	.327*	-.380**	-.259*	.338**	.931**	1				
Ca	-0.235	.277*	-0.01	-0.073	-0.255	.382**	-.350**	0.135	.288*	-.369**	-.289*	.275*	.861**	.918**	1			
Mg	-0.182	.265*	-0.115	-0.073	-0.248	.361**	-.314*	0.128	.309*	-.367**	-.262*	.341**	.939**	.994**	.931**	1		
SAR	-0.138	0.167	-0.014	-0.128	-.476**	.270*	-.269*	0.175	.338**	-.338**	-0.219	0.249	.968**	.863**	.766**	.871**	1	
PAR	-0.156	.269*	-0.185	0.03	-0.115	.441**	-0.188	-0.057	0.068	-0.232	0.075	.479**	.583**	.658**	.436**	.617**	.550**	1

3.4.2. Correlation between soil variables and Vegetational gradients

The correlation between vegetation and soil characteristics is shown on the ordination diagram produced by Canonical Correspondence Analysis (CCA) of the biplot of species-environment. The direction and length of an arrow is representing a given environmental variable provide an indication of the importance and direction of the gradient of environmental changes, for that variable, within the site of sampled measured. The angle between an arrow and each axis is a reflection of its degree of correlation with the axis.

As shown in Figure (5), it is clear that, the percentages of sand, WHC, organic carbon, calcium carbonate, electrical conductivity, cations (Na, Ca, K and Mg), anions (Cl^-, SO_4^{--} and HCO_3^-) and SAR are the most effective soil variables, which showed a high significant correlation with the first and second axes of CCA ordination diagram. *Retama raetam* as the codominant and abundant species in groups A and C, respectively, as well as abundant species of group A (*Leptadenia pyrotechnica*, *Volutaria lippii* and *Launaea spinosa*) are separated at the upper right side of CCA-biplot diagram. These species showed a close relationship with WHC, EC and Cl^- (Figure 5). Whereas *Ochradenus baccatus* is the dominant species in group B and the codominant species in groups A and D, *Matthiola longipetala* and *Zygpphyllum simplex* are the abundant species in group C, and *Haloxylon salicornicum* is the abundant species in groups B, C, and D are separated at the upper left side of CCA biplot diagram and exhibited a distinct relationship with cations (Na, K, Ca and Mg), HCO_3^- and pH (Figure 5).

The abundant species of group B (*Echinops spinosus Deverra tortuosa*, *Tamarix nilotica* and *Iphiona mucronata*), and abundant species (*Diplotaxis harra*) in group D are separated at the lower left side of CCA-biplot diagram and exhibited a distinct relationship with sand and SO_4^{--} (Figure 5). On the other hand, *Zygophyllum coccinum* is the dominant species in group C and the codominant species in group D, abundant species in groups A, B and C (*Zilla spinosa*) and *Farsetia aegyptia* as the abundant species in group D are separated at the lower left side of CCA-biplot diagram and exhibited a distinct relationship with organic carbon, $CaCO_3$, SAR and PAR (Figure 5).

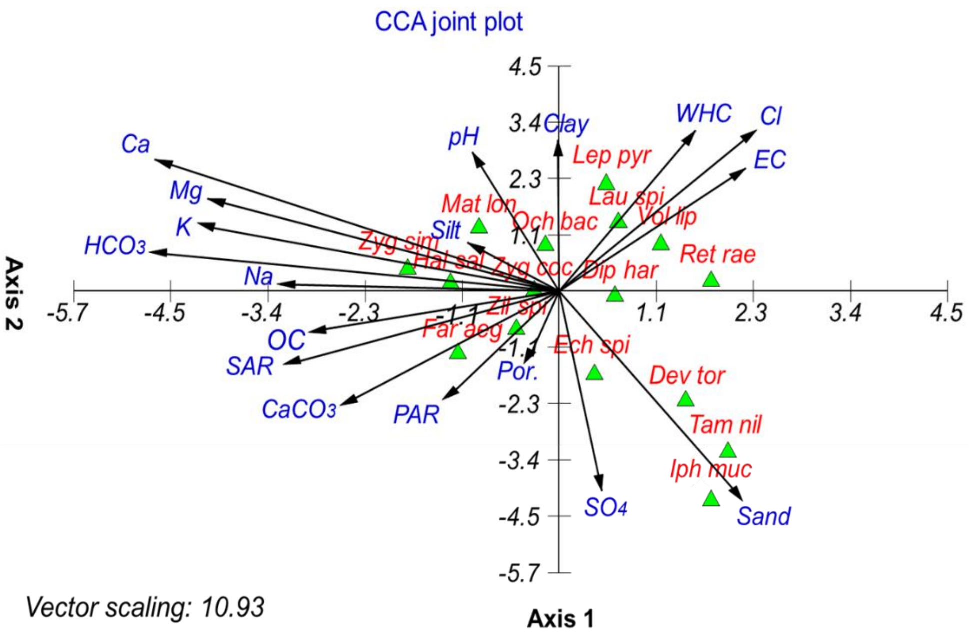

Figure 5. Canonical Correspondence Analysis (CCA) ordination diagram of plant species with soil variables represented by arrows in the study area. The indicator and preferential species are abbreviated to the first three letters of the genus and species respectively.

4. Conclusion

To assist in the management and conservation of these natural resources, the current study provided an assessment of the vegetation and plant variety in the northern part of the Eastern Desert. The biodiversity of the Eastern Desert is in danger as a result of a variety of human activities and influences, such as urbanization, agriculture, mining and quarrying, excessive gathering, and excessive cutting of woody species. As a result, it is of the utmost need to preserve the natural habitats that are found in this desert. The economic and therapeutic potential of each of these 87 plant species has been extensively researched and documented. Hence, prudent use of the Egyptian desert, particularly the inland desert, is required, as is the implementation of environmentally responsible development practices.

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