Species

Floristic composition and soil characteristics of the vegetation associated with *Zilla spinosa* in the northern sector of the Eastern Desert, Egypt

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ABSTRACT

The objective of this work is to examine three wadis for edaphic factors and their impact on plant communities (Wadi Hagoul, Wadi El-Rashrash, and Wadi Araba) in the northern part of the Eastern Desert. There was a total of 92 plant species found in this research, including 35 annuals, 2 biennials, and 55 perennials, from 77 genera and 27 families. The dominant taxa and majority of the flora in the region under study include the Asteraceae, Boraginaceae, Fabaceae, Poaceae, Chenopodiaceae, and Zygophyllaceae families. The therophytes make up over 40% of all species, with chamaephytes coming in as a close second at 31%. According to a phytochorological analysis of the examined flora, 77.17% of the species reported are Saharo-Sindian taxa. Using the importance value (out of 200) of 92 plant species, this work was able to identify four distinct vegetation types. The most common plants in the region were found to include *Haloxylon salicornicum*, *Zilla spinosa*, *Ochardenus baccatus*, and *Zygophyllum coccinum*. Soil physical topography, soil salinity, and anthropogenic activities are main factors in determining plant distribution in the Northern Eastern Desert.

Keywords: *Zilla spinosa*, Vegetation, Eastern Desert, Floristic composition, Soil Analysis.

1. INTRODUCTION

Every continent on Earth has some kind of desert. In the dry and semi-arid regions, there is an abundance of wild plants and animals, and stunning scenery. Desert-dwelling creatures have adapted to survive severe conditions. Dryland areas house 40% of the world's population, including the poorest who survive on commerce and subsistence farming. In arid regions, most land is used for livestock grazing, especially in semiarid environments (Stewart and Thapa, 2016). Egypt occupies around 1% of Africa's territory, or about a million square kilometers (Abu Al-Izz,

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1971). The enormous desert belt that spans North Africa from the Atlantic to Arabia contains the whole country. Egypt's flora is mostly desert plants since 95% of the land is dry (Zahran and Willis, 2009; Abd El-Ghani et al., 2017). Eastern Desert vegetation is higher than Western Desert vegetation, according to. He noted the Sinai Peninsula, northern Wadis, and Eastern Desert highlands west of the Suez Gulf contain comparable vegetation. Eastern Desert phytogeography is dominated by the Red Sea coast and inland desert.

The region of the Eastern Desert known as the Sahara Desert is located east of the Nile River. From the eastern Nile Valley to the Gulf of Suez and Red Sea, it covers 223,000 km2, or 21% of Egypt's land. The Eastern Desert is higher than the Western Desert because it has a backbone of steep, craggy mountains parallel to and close to the shore (El-Khouly and Shawky, 2017). The most famous and arid Eastern Desert wadis are Hagul, El-Rashrash, and Araba. Moderate grazing, wood cutting, and plant harvesting are done in these wadis for profit. A wadi is a valley or ravine with steep sides that forms a watercourse in the wet season in North Africa and the Middle East (Seleem and Aboulela, 2011).

Cruciferae, or Brassicaceae, comprises 3709 species in 375 genera. Egypt has 53 genera and 105 species of this family (Bolous, 1999). Generally, herbs, annuals, biennials, or shrubs with herbaceous, upright, cylindrical, glabrous, or hairy, sturdy, branching stems. A commercially significant flowering plant family is Brassicaceae, or cabbages. Some vegetables were eaten and used as medicine. *Zilla*, a perennial xerophyte in dry Egypt, has one species that develops as an evergreen plant that flowers most of the year (Mahmoud, 2010). *Zilla spinosa* is one of the most frequent Brassicaceae plant species used as a drink to treat kidney and gall bladder stones in traditional medicine (Heneidy and Bidak, 2001). Egyptian desert, Saudi Arabia, has *Z. spinosa* at several locations (Bolous, 1999). Traditional medicine uses this plant to cure kidney and gall bladder stones, making it one of the most significant medicinal herbs (Heneidy and Bidak, 2001). This research focuses on the ecological state of *Zilla spinosa* associated wild plants in the northern Eastern Desert.

2. MATERIALS AND METHODS

Study area

The study area is eastern Nile Valley. The northern Eastern Desert research areas are Wadi Hagoul, El-Rashrash, and Araba. Wadi El-Rashrash is the biggest of the three (Figure 1). Wadi's xeric ecosystem is dominated by xerophytic flora. A gravel desert characterizes this Wadi. Physiographic and physiognomic heterogeneity is local (Seleem and Aboulela, 2011). Several climatic categorization systems show that the Eastern Desert is arid or extremely arid (Emberger, 1955). Meteorological data from Giza District suggests a hot, dry environment.

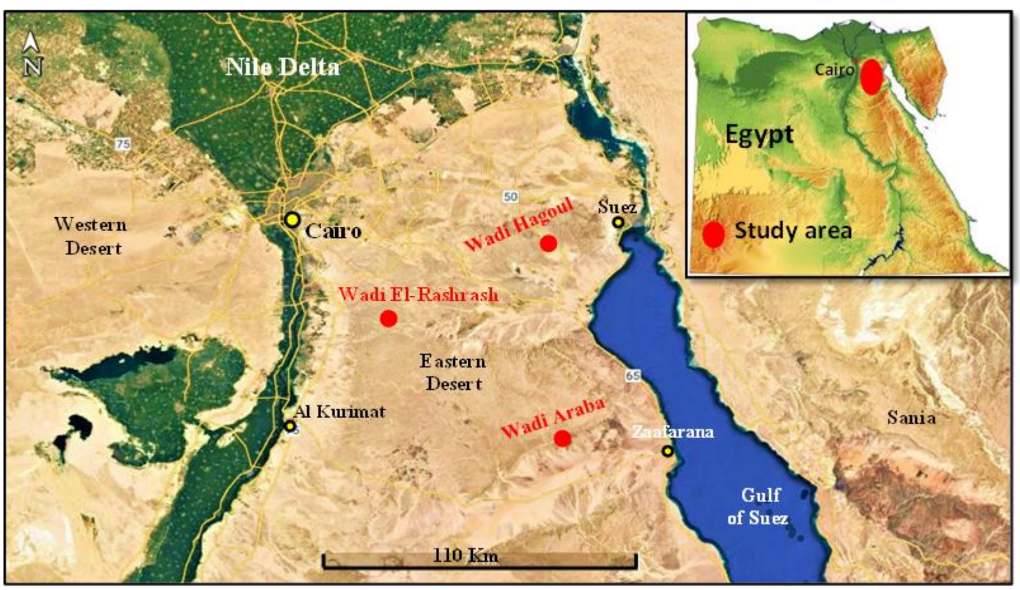

Figure 1 Map of Egypt showing the location of study area.

Vegetation analysis

From a 2022 reconnaissance survey, 58 random sample stands (20 m x 20 m) were chosen to illustrate diverse physiographic and environmental variations in the researched deserts. *Zilla spinosa* and related species were obtained from the northern Eastern Desert. In the examined stands, species density and cover were estimated (Canfield, 1941; Shukla and Chandel, 1989). With an IV of 200, we calculated the density, cover, and important value of every plant species in every stand. Tackholm, (1974) and Boulos, (1999) provided taxonomic nomenclature and phytogeographic range analysis.

Soil analysis

The 58 study sites each had three soil samples taken at 0-30 cm deep. Mixing the samples created a composite sample that was put on paper and air-dried. Physical and chemical analysis of soil samples were carried out according to standard methods (Piper, 1947; Jackson, 1962; Pierce et al., 1958; Allen et al., 1974).

Data analysis

TWINSPAN analysis of the Community Analysis Package (CAP) version 2.3 classified and ordinated vegetation associated with *Zilla spinosa* (Henderson and Seaby, 1999). DCA was used for indirect gradient analysis for ordination (Whittaker, 1967). Canonical Correspondence Analysis (CCA) examined vegetation-soil gradient relationships (Ter-Braak, 1987). A linear correlation coefficient (r) was generated to evaluate the predicted soil variables.

3. RESULTS AND DISCUSSION

Floristic composition

Three wadis illustrate the natural xeric ecosystem dominated by xerophytic flora. Table 1 displays the floristic composition of *Zilla spinosa*-associated plant species in three Wadis: Hagoul, El-Rashrash, and Araba (Figure 2). The current research assessed 92 plant species (35 annual, two biennials, and 55 perennial) from 77 genera and 27 families in 51 stands. In Table 1, the family Asteraceae has 20 species (21.27%) of the total reported plant species, followed by Boraginaceae (10.70%), Poaceae (9.63%), Fabaceae (7.44%), Chenopodiaceae (5.32%), and Zygophyllaceae (5.32%). The remaining 21 families had two or one species. The research area's flora is dominated by four families: Asteraceae, Boraginaceae, Fabaceae, Poaceae, Chenopodiaceae, and Zygophyllaceae. Other studies found similar findings (Abd El-Ghani, 2000; El-Amier et al., 2014). The habitat types in this research restrict reproductive capability, ecological, morphological, and genetic adaptability, which may explain perennials' dominance (58.51% of total species) (Harper, 1977).

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

Plant Species	Life form	Floristic analysis	Duration
Aizoaceae			
Mesembryanthemium forsskaoleii Hochst. Ex Boiss.	Th.	SA/SI	Annual
Amaranthaceae			
Aerva javaneica (Burm.F.) Juss. ex Schult.	Ch.	SA-SI+S/Z	Perennial
Apiaceeae			
Deverrea tortuoesa (Desf.) DC.	Ch.	SA/SI	Perennial
Asclepiadaceae			
Calotropeis proceera (Willd.) R.Br.	Ph.	SA/SI+S-Z	Perennial
Leptadeneia pyrotechneica (Forrsk.) Decne.	Nph.	SA/SI	Perennial
Pergulareia tomeentosa L.	Ch.	SA/SI	Perennial
Asteraceeae			
Achilleea fragrantissiema (Forssk.) Sch.Bip.	Ch.	SA/SI+IR/TR	Perennial
Anthemeis cotulea L.	Th.	ME	Annual
Artemiseia judieaca L.	Ch.	SA/SI	Perennial
Artemeisia monospeerma Delile.	Ch.	SA/SI+ME	Perennial
Atractylies cardeuus (Forssk.) C.Chr.	H.	SA/SI+ME	Perennial
Centaureea aegyptieaca L.	Th.	SA/SI	Biannual
Iflogia spiecata (Forssk.) Sch.Bip.	Th.	SA/SI	Annual

Iphieona mucreonata (Forssk.) Asch. & Schweinf.	Ch.	SA/SI	Perennial
Lactucea serrieola L	Th.	ME+IR-TR+ER-SR	Annuals
Launaeea capiteata (Spreng) Dandy	Th.	S-Z+SA-SI	Biannual
Launeaea mucreonata (Forssk.) Muschl.	H.	ME+SA-SI	Perennial
Launeaea nudicauleis (L.) Hook.f.	H.	SA/SI	Perennial
Launeaea spinosea (Forssk.) Sch.Bip. ex Kuntze.	Ch..	SA/SI	Perennial
Nauplieus graveeolens (Forssk.) Wilklund	Ch.	SA/SI	Perennial
Pulicareia inciesa (Lam.) DC.	Ch.	SA-SI	Perennial
Pulicariea undulaeta (L.) C.A.Mey.	Ch.	SA/SI +S-Z	Perennial
Reicharedia tingeitana (L.) Roth.	Th.	ME+IR/TR	Annuals
Seneceio glauicus L.	Th.	ME+IR/TR+SA/SI	Annuals
Volutareia lippeii (L.) Cass. ex Maire	Th.	SA/SI	Annuals
Boraginaceae			
Alkannea lehmaenii (Tin.) A.DC.	H.	ME	Perennial
Heliotropeium arbaineense Fresen.	Ch.	SA/SI	Perennial
Heliotropieum diegynum (Forssk.) C.Chr.	Ch.	SA/SI	Perennial
Triechodesma africeanum (L.) R.Br.	H.	S-Z+SA-SI	Perennial
Brassicaceeae			
Diplotaxeis acries (Forssk.) Boiss.	Th.	SA/SI	Annuals
Diplotaxeis harera (Forssk.) Boiss.	Ch.	ME+SA/SI	Perennial
Erysiemum repeandum L.	Th.	ME+IR-TR+ER-SR	Annuals
Farseteia aegypteia Turra.	Ch.	S-Z+SA/SI	Perennial
Matthieola longipetaela (Vent.) DC.	Th.	ME+IR-TR	Annuals
Zillea spinosea (L.) Prantl.	Ch.	SA/SI	Perennial
Caryophyllaceae			
Herniareia hemiestemon J.Gay	Th.	ME+ SA/SI	Annuals
Gypsopiela capiellaris (Forssk.) C.Chr	H.	IR-TR+SA/SI	Perennial
Polycarpaeea repeens (Forssk.) Asch.	Ch.	SA/SI	Perennial
Speregularia medeia (L.) C. Presl	H.	ME+IR-TR+ER-SR	Perennial
Chenopodiaceeae			
Anabaesis artieculata (Forssk.) Moq.	Ch.	SA/SI+IR/TR	Perennial
Atripleex lindleeyi Moq. subsp. *inflate* (F.Muell.) Wilson.	Th.	ME+IR-TR+ER/SR	Annuals
Bassiea muriceata (L.) Asch.	Th.	IR/TR+SA/SI	Annuals
Cheenopodium mureale L.	Th.	COSM	Annuals
Haloxyloen saliecornicum (Moq.) Bunge ex Boiss.	Ch.	SA/SI	Perennial
Cleomaceae			
Cleomee amblyocarpea Barratte & Murb.	Th.	SA/SI	Annuals
Cleornee droserifoelia (Forssk.) Delile	Ch.	SA-SI+IR-TR	Perennial
Euphorbiaceae			
Euphorbiea retusea Forssk.	Th.	SA/SI	Annuals
Fabaceae			
Acaecia tortileis (Forssk.) Hayne	Ph.	S-Z	Perennial
Astragaleus bombycienus Boiss.	Th.	SA/SI+IR/TR	Annuals
Astragaleus spinoesus (Forssk.) Muschl.	Ch.	SA/SI + IR/TR	Perennial
Crotalareia aegyptiaeca Benth.	Ch.	SA/SI	Perennial
Lotues glinoeides Delile.	Th.	S-Z	Annuals

Retamea raeteam (Forssk.) Webb&Berthel.	Np.h	SA/SI	Perennial
Trigoniella stiellata Forssk.	Th.	SA/SI+IR/TR	Annuals
Geraniaceae			
Erodieum lacinieatum (Cav.) Wild.	Th.	ME	Annuals
Labiatae			
Lavandulea coronopeifolia Poir.	Ch.	SA/SI	Perennial
Malvaceae			
Malvea parveifolra L.	Th.	ME+IR-TR	Annuals
Neuradaceae			
Neurada procumbiense L.	Th.	SA/SI +S/Z	Annuals
Nitrariaceae			
Nitrariea reetusa (Forssk.) Asch.	Ph.	SA/SI	Perennial
Orobanchaceae			
Cistanchee phelypaeea (L.) Cout.	P., G.	ME+SA-SI	Perennial
Plantaginaceeae			
Plantiago ciliiata Desf.	Th.	SA/SI+IR/TR	Annuals
Plantiago lagopuis L.	Th.	ME+IR/TR	Annuals
Plantiago notaita Lag.	Th.	IR-TR+SA/SI	Annuals
Plantiago ovaita Forssk.	Th.	IR-TR+SA/SI	Annuals
Poaceeae			
Cyondon dacteylon (L.) Pers.	G.	COSM	Perennial
Laseiurus scindiecus Henrard.	G.	SA-SI+S-Z	Perennial
Paniecum turgiedum Forssk.	H.	SA/SI	Perennial
Phragmietes australeis (Cav.) Trin.ex Steud.	G, He	COSM	Perennial
Hordeeum murienum L. subsp. *leporinum* (link) Arcang.	Th.	ME+IR-TR+ER-SR	Annuals
Hordieum spontianeum K. Koch	Th.	ME+IR-TR	Annuals
Loleium multieflorum Lam.	Th.	ME+IR-TR+ER-SR	Annuals
Parapholiis incurvia (L.) C.E.Hubb.	Th.	ME+IR-TR+ER/SR	Annuals
Poa annuia L.	Th.	COSM	Annuals
Polygonaceae			
Calligoneum polygonoiedes L. subsp. *comosum* (L'Hér.) Soskov	Nph.	IR/TR+SA/SI	Perennial
Emeex spinosea (L.) Campd.	Th.	ME+ SA/SI	Annuals
Rumeix vesicareius L.	Th.	ME+SA/SI+ S/Z	Annuals
Ochradenus baccatus Delile.	Nph.	SA/SI	Perennial
Reseida decursieva Forssk.	Th.	SA-SI	Annuals
Rutaceae			
Haplophylleum tubeerculatum (Forssk.) Juss.	H.	SA/SI	Perennial
Scrophulariaceae			
Kickxeia aegypteiaca (L.) Nάbelek.	Ch	ME+SA-SI	Perennial
Scophulareia desertei Delile	Ch.	SA/SI	Perennial
Solanaceae			
Hyoscyeamus muteicus L.	Ch.	SA/SI	Perennial
Lycieum shaweii Roem. & schult.	Np.h.	SA-SI+S-Z	Perennial
Tamaricaceeae			
Tamariex aphyllea (L.) H. Karst.	Nph.	SA/SI+S-Z	Perennial
Tamariex nilotieca (Ehrenb.) Bunge.	Nph.	SA/SI	Perennial

Urticaceae			
Forsskaeolea tenaceissima L.	H.	SA/SI + S/Z	Perennial
Zygophyllaceae			
Fagoniea arabeica L.	Ch.	SA/SI	Perennial
Fagoniea molleis Delile.	Ch.	SA/SI	Perennial
Zygophylleum coccieneum L.	Ch.	SA/SI	Perennial
Zygophylleum decumbeens Delile.	Ch.	SA/SI	Perennial
Zygophylluim simpliex L.	Th.	SA/SI	Annuals

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.

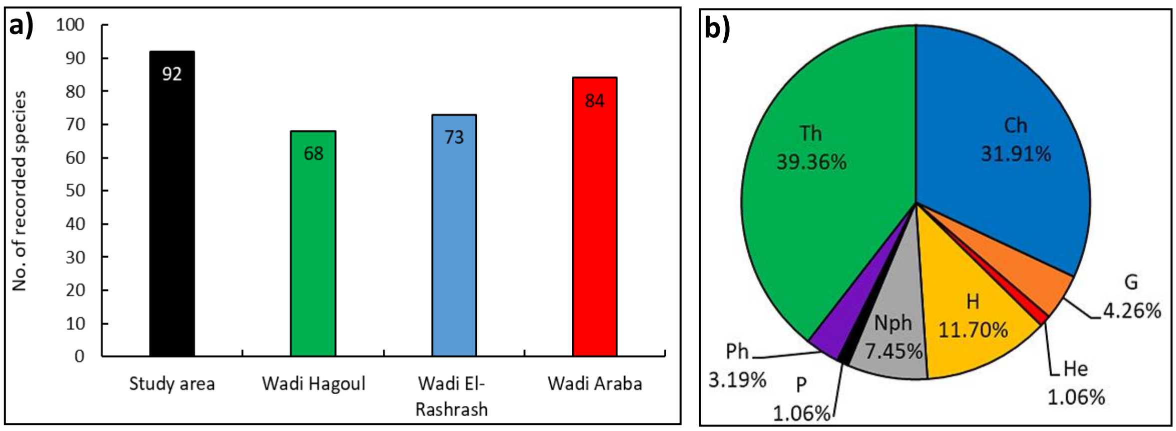

Figure 2 a) Number of recorded plant species in the study area and three Wadies, b) Plant life-forms in the study area

Season of study (March–May 2022) and short life cycle allow annuals to survive agro-ecosystem instability, explaining their substantial contribution (38.04% of all documented species) (Harper, 1977). According to Ayyad and El-Ghareeb, (1982), the information provided by the life form spectrum might be useful for evaluating how vegetation reacts to changes in environmental conditions. The majority of the species observed are therophytes (30.36%), followed by chamaephytes (31.91%), hemicryptophytes (11.70%), phanerophytes (10.64%), and geophytes (4.26%), as per the description and categorization of life-forms (Raunkiaer, 1934). Helophytes and parasites, with a value of 1.06% each, are the life-forms with the lowest documented value. The findings presented here are consistent with previous research (El-Amier et al., 2014; Abd-ElGawad et al., 2022).

Chorological affinities

Table 2 shows the results of a chorological study of the surveyed flora, which shows that 71 species (or 77.17 percent) are Saharo-Sindian taxa. These species may be classified as mono-, bi-, or pluri-regional (40.22%, 34.78%, 2.17%, respectively). Twenty-six species, or 28.26% of all species recorded, are taxa found in the Mediterranean. A total of 9 species (9.78%), 14 species (15.22%), and 3 species (3.26%) may be categorized as Pluriregional, Biregional, or Monoregional taxa. In addition, 4 species, or 4.35% of the total number of reported species, are Cosmopolitan, and 2 species, or 2.17% of the total, are Sudano-Zamdzeian. This agrees with on the phytogeographical study of Israel and Salama et al., (2013) on flora assessment and species diversity in South Sinai's coastal wadis. Because Saharo-Sindian plants are strong desert markers, the high prevalence of chorotype may be due to this. The species composition of the study region differed greatly from the Mediterranean shoreline.

This is mostly due to soil sediment variations. Mediterranean coastal floristic components have better climate than the rest of Egypt (Zahran and Willis, 1992). This lines up with the findings of Salama et al., (2013) about vegetation analysis and species diversity in the desert of coastal wadis of South Sinai, as well as with the conclusions drawn by with the phytogeographical study of the flora of Israel and Sinai. Plants of the Saharo-Sindian species are excellent indicators of arid climatic conditions, which may explain the high proportion of Saharo-Sindian chorotype. Relative to species compositions throughout the Mediterranean coast, the examined region differed significantly. Soil sediments vary greatly in composition, which may explain this. Compared to the rest of Egypt, the Mediterranean coastal strip has more favorable weather conditions for floristic components (Zahran and Willis, 1992).

Classification of vegetation

The research area was represented by 51 stands, and 92 plant species were recorded. Four vegetation groups were identified by using TWINSPAN classification to the significance ratings (out of 200) of these species (Figure 3 & 4). Table 3 displays the floristic components of various categories. Group A comprises 4 stands dominated by *H. salicornicum* (IV= 42.54). The abundant species include *A. articulata* (IV= 10.64), *A. lehmanii* (indicator species with IV= 3.14), *A. spinosus* (IV= 13.41), *M. longipetala* (IV=19.03), *Z. spinosa* (IV= 19.35), *Z. coccineum* (IV= 8.07) and *Z. simplex* (IV= 34.23). Group B comprises 12 stands dominated by *Z. spinosa* (IV =30.51). The abundant species include *B. muricata* (IV =11.48), *D. harra* (IV =14.70), *E. laciniatum* (IV =8.15), *H. salicornicum* (IV =19.66), *R. vesicarius* (IV =8.13), *S. glaucus* (IV=12.45), *Z. coccineum* (IV=12.95) and *Z. simplex* (IV =11.51). The indicator species in this group was *P. annua* (IV =2.11). Group C consists of 14 stands co-dominated by *O. baccatus* (IV=22.30) and *Z. spinosa* (IV=24.25). The abundant species include *Z. coccineum* (IV =17.47), *A. fragntissima* (IV =13.97), *P. tomentosa* (IV =9.39) and *R. raetam* (indicator species with IV =9.10).

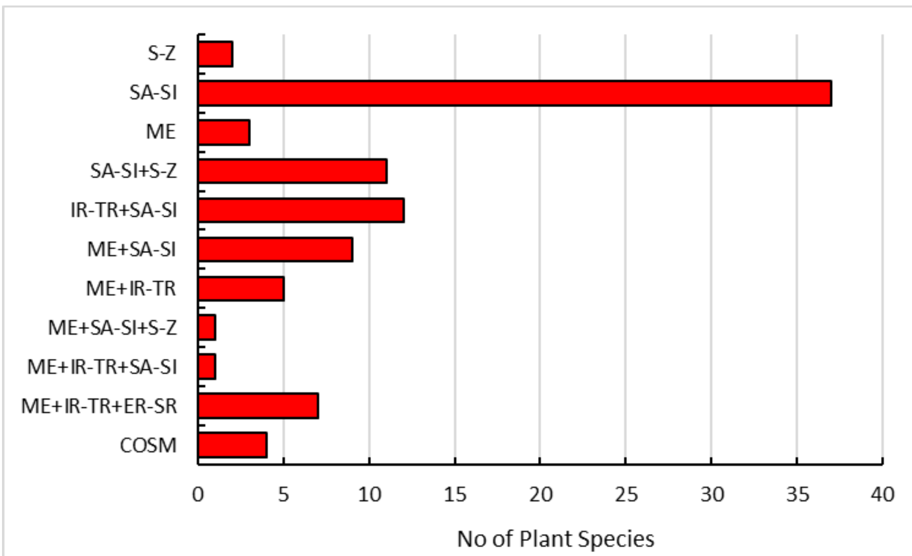

Figure 3 Number of species and percentage of various floristic categories of the study area.

Group D consists of 21 stands co-dominated by *Z. spinosa* (IV =26.12) and *Z. coccinum* (IV =27.62). The abundant species include *D. tortusa* (IV =7.76), *E. spinosus* (IV =7.28), *H. salicornicum* (IV =8.08), *L. spinosa* (IV =8.93) and *P. turgidum* (IV =8.55). The indicator species in this group were *V. lippii* (IV =9.42) and *O. baccatus* (IV =16.49). This finding is consistent with previous research conducted by Abd El-Wahab et al., (2018) in South Sinai's Gebel Serbal, in the northern Nile Valley's reclaimed lands, El-Amier et al., (2014) in coastal sand formation, El-Amier and Abdul-Kader, (2015) in Wadi Hagoul, located north of the Eastern Desert, and Abd-ElGawad et al., (2022) in Wadi Araba, also situated north of the Eastern Desert.

Detrended Correspondence Analysis (DCA) provided the ordination of the surveyed stands in the research region, which is shown in (Figure 5). On the plane of the first and second DCA axis, you can see the DCA ordination of stands. Classification of vegetation using TWINSPAN clearly produces distinct groups that have a distinct pattern of separation on the ordination plane. Group A dominated by *H. salicornicum*, and group B dominated by *Z. spinosa* are segregated at the upper part of the left side of the DCA diagram. While Group C co-dominated by *O. baccatus* and *Z. spinosa* is separated at the upper part of the right side of the DCA diagram. On the other hand, group D co-dominated by *Z. spinosa* and *Z. coccinum* is segregated at the middle part of the DCA diagram.

Vegetation-Soil Relationships

Table 2 shows the soil variable variance (mean value ± standard error) of the four vegetation categories of TWINSPAN-classified stands. All groups' soils are mostly sand and partly silt and clay. All groups have similar physical soil factors. Group A had the largest sand fraction, whereas groups B and C had the highest clay and silt fractions, respectively. Groups C and B had the highest soil porosity (40.15%) and water-holding capacity (31.08%). The groups exhibited variations in terms of the chemical soil variables (Table 2). The highest mean values of calcium carbonate, Na^+, HCO_3^-, K^+, Ca^{++}, Mg^{++} and SAR are estimated in group C (19.15%, 267.41 mg/100g dry soil, 1.23%, 47.05 mg/100g dry soil, 103.39%, 50.65 mg/100g dry soil and 29.05, respectively). Organic carbon and PAR showed the highest value in group C (0.24% and 5.44 mg/100g dry soil, respectively). The soil samples of group D attained the highest values of electrical conductivity (783.90 mS cm^{-1}). The pH and SO_4^{--} mean values in group A are the highest, at 8.22% and 0.49%, respectively. Group C is projected to have the highest chloride mean levels, at 0.34%.

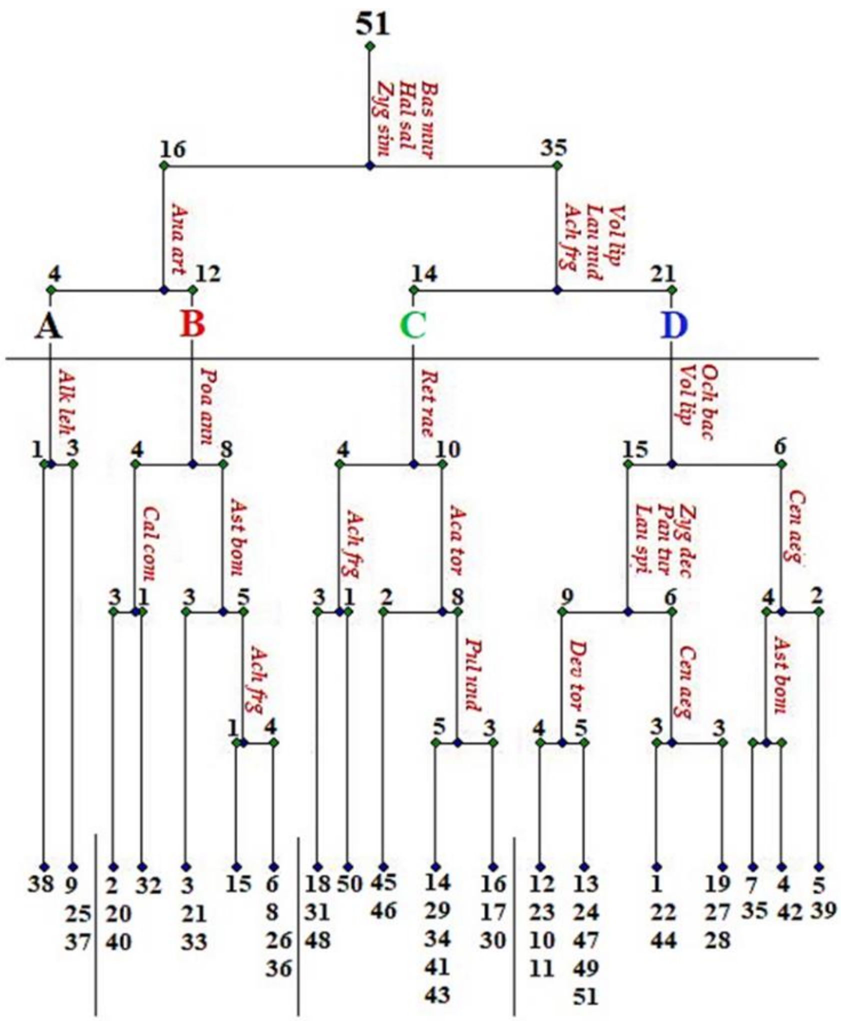

Figure 4 Two Way Indicator Species Analysis (TWINSPAN) dendrogram of the 51 sampled stands based on the importance values of the 92 species. The indicator species are abbreviated by the first three letters of genus and species respectively.

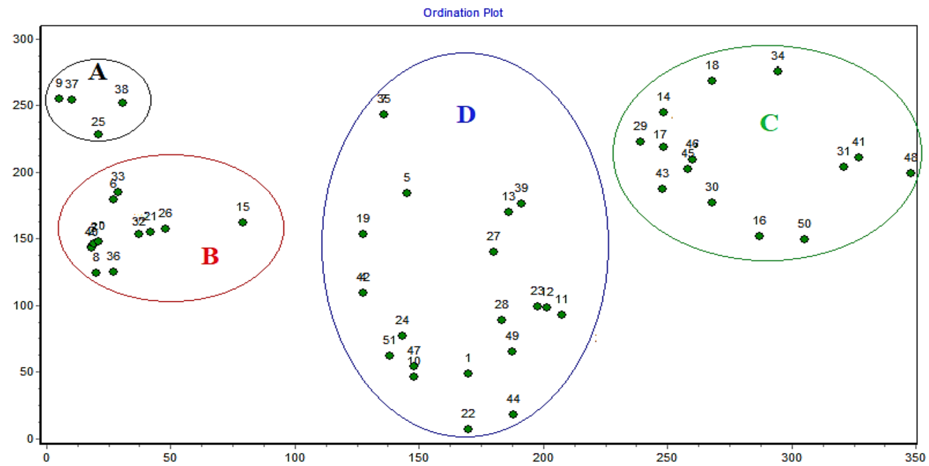

Figure 5 Detrended Correspondence Analysis (DCA) ordination diagram of the 51 stands with vegetation groups.

Table 2 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	%	89.67±5.30	87.21±6.45	87.26±7.97	86.71±6.32
Silt	%	7.22±3.73	8.68±5.50	10.47±7.43	9.33±5.08
Clay	%	3.12±2.43	4.11±2.77	2.26±0.74	3.96±2.95
Porosity	%	39.44±8.60	37.74±6.61	40.15±4.84	37.42±6.57
WHC	%	29.20±1.36	31.08±4.56	29.82±6.80	29.82±5.39
CaCO3	%	13.29±11.70	14.56±15.42	19.15±11.53	14.70±12.65
OC	%	0.18±0.06	0.18±0.11	0.24±0.09	0.24±0.11
pH		8.22±0.36	6.79±3.11	8.09±0.20	8.09±0.11
EC mS cm-1		667.75±45.53	491.58±33.32	603.57±32.24	783.90±54.74
Cl-	%	0.31±0.25	0.23±0.30	0.34±0.50	0.23±0.30
SO4--	%	0.49±0.33	0.25±0.23	0.38±0.26	0.33±0.32
HCO3--	%	0.48±0.38	0.63±0.83	1.23±0.79	0.80±0.72
Na+	mg/100g dry soil	76.65±30.24	136.43±52.48	267.41±96.27	202.19±21.73
K+	mg/100g dry soil	23.57±2.43	28.32±11.58	47.05±14.09	36.82±15.22
Ca++	mg/100g dry soil	29.84±7.55	63.39±18.23	103.39±32.84	71.33±19.47
Mg++	mg/100g dry soil	17.88±4.23	25.76±7.37	50.65±17.50	37.01±11.84
SAR		15.25±2.49	19.76±4.81	27.05±9.40	25.13±6.43
PAR		4.87±0.16	4.62±0.95	5.44±1.14	5.04±1.01

Table 3 displays the correlation coefficient (r) among the various soil factors in the stands that were sampled. Researchers have discovered that different soil variables have different degrees of positive or negative connection with one another, and that certain soil variables don't correlate with anything at all. The ordination diagram that is generated from the species-environment biplot using Canonical Correspondence Analysis (CCA) illustrates the relationship between soil properties and vegetation. Environmental variables are represented by arrows, the length and direction of which indicate the significance and direction of the gradient of changes within the measured location. The degree of connection between an axis and an arrow is represented by the angle between the two. Among the soil variables that demonstrated a strong link with the first and second axes of the CCA ordination diagram, the most effective ones are the percentages of organic carbon, calcium carbonate, electrical conductivity, cations, bicarbonate, PAR, and SAR (Figure 6).

Table 3 Pearson-moment correlation (r) between the soil variables in the stands surveyed in the study area.

Soil variables	Sand	Silt	Clay	Por.	WHC	CaCO3	OC	pH	EC	Cl-	SO4--	HCO3-	Na	K	Ca	Mg	SAR	PAR
Sand	1																	
Silt	-0.928**	1																
Clay	-0.518**	0.161	1															
Por.	0.676**	-0.547**	-0.533**	1														
WHC	0.145	-0.118	-0.112	0.043	1													
CaCO3	-0.092	0.215	-0.248	0.058	0.164	1												
OC	.391**	-0.416**	-0.08	0.266	0.169	-0.303*	1											
pH	0.088	-0.099	-0.003	0.002	0.013	0.244	0.341*	1										
EC	-0.028	-0.226	0.592**	-0.27	-0.071	-0.255	0.093	0.184	1									
Cl-	0.525**	-0.478**	-0.293*	0.541**	0.139	-0.362**	0.579**	0.138	-0.112	1								
SO4--	0.381**	-0.225	-0.492**	0.492**	0.107	0.08	0.433**	0.146	-0.369**	0.568**	1							
HCO3-	-0.048	0.192	-0.312*	0.273	-0.125	0.699**	-0.071	0.169	-0.318*	-0.075	0.205	1						
Na	-0.008	0.063	-0.125	0.029	-0.431**	0.212	-0.177	0.147	0.274	-0.271	-0.174	0.208	1					
K	-0.032	0.119	-0.187	0.026	-0.258	0.370**	-0.191	0.154	0.238	-0.307*	-0.182	0.307*	0.942**	1				
Ca	-0.097	0.136	-0.055	0.010	-0.271	0.373**	-0.261	0.151	0.225	-0.318*	-0.244	0.242	0.851**	0.915**	1			
Mg	-0.041	0.125	-0.178	0.022	-0.271	0.365**	-0.199	0.149	0.236	-0.304*	-0.199	0.311*	0.941**	0.996**	0.924**	1		
SAR	-0.076	0.099	-0.026	-0.066	-0.506**	0.177	-0.171	0.192	0.306*	-0.302*	-0.182	0.210	0.961**	0.862**	0.738**	0.859**	1	
PAR	0.036	0.106	-0.337*	0.065	-0.151	0.335*	-0.091	0.122	0.13	-0.243	-0.034	.325*	0.818**	0.881**	0.642**	0.849**	0.776**	1

On the right side of the CCA-biplot diagram are the four most numerous species in group D: *E. spinosus, D. tortusa, L. spinosa,* and *P. turgidum*. There was a strong correlation between these species and EC, OC, HCO3, and SAR. Figure 6 shows that there is a clear association between clay and the codominant *Z. spinosa* in groups B and D, as well as numerous species (*B. muricata, D. harra, E. laciniatum, R. vesicarius,* and *S. glaucus*) in group B, which are separated at the top left side of the CCA biplot diagram. *A. fragntissima* and *R. raetam* as the abundant species in group C, as well as *V. lippii* and *O. baccatus* as the indicator species in group D are separated at the lower right side of the diagram. These species exhibited a clear relationship with silt, CaCO3, Cations and PAR. The dominant species of group A (*H. salicornicum*), codominant species of group D (*Z. coccinum*), and abundant species (*A. articulata, A. spinosus, Z. simplex, M. longipetala*) in group A are separated at the lower left side of CCA-biplot diagram and exhibited a distinct relationship with sand, WHC and porosity (Figure 6).

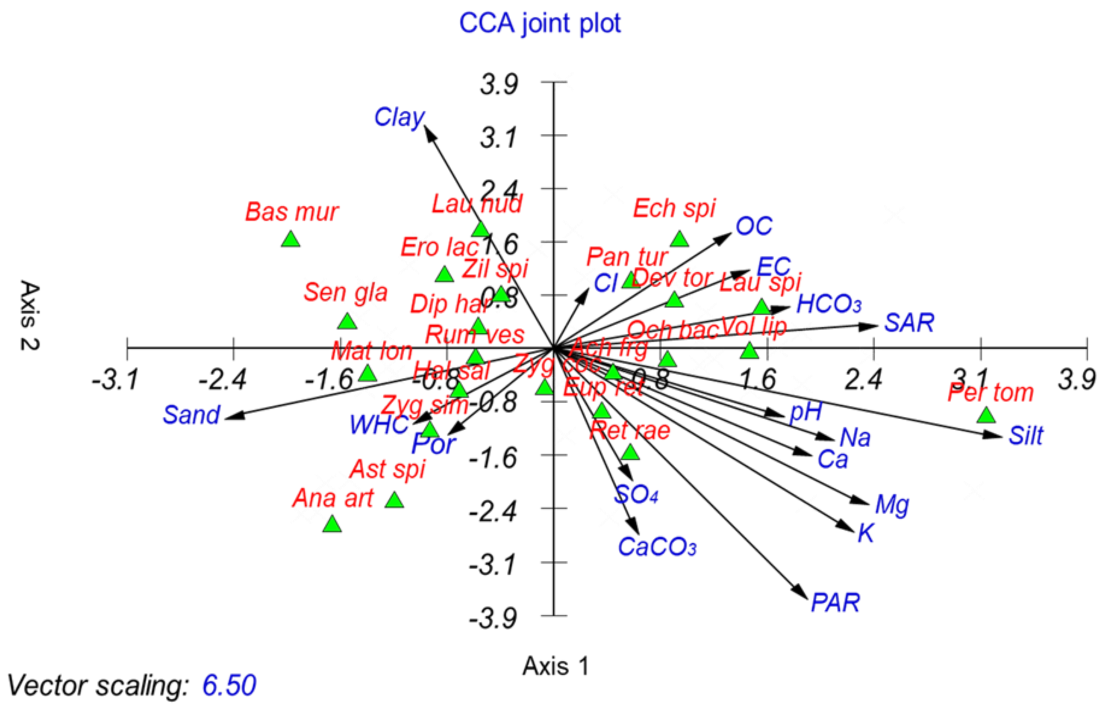

Figure 6 Canonical Correspondence Analysis (CCA) ordination diagram of plant species with soil variables represented by arrows in the study area. The indicator and preferential species are abbreviated to the first three letters of the genus and species respectively.

4. CONCLUSION

The present research evaluated the vegetation and plant diversity in the northern section of the Eastern Desert to aid in the management and protection of these natural resources. Urbanization, agriculture, mining and quarrying, excessive collection, and excessive cutting of woody species are only some of the human activities and effects that threaten the Eastern Desert's biodiversity. Therefore, it is of the highest importance to protect the desert's natural ecosystems. Each of these 92 plant species has had substantial study done on its economic and medicinal possibilities. Therefore, it is necessary to make responsible use of the Egyptian desert, especially the inland desert, and to adopt environmentally sound development policies.

Conflicts of interests:

The authors declare that there are no conflicts of interests.

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Ethical approval

The ethical guidelines for plants & plant materials are followed in the study for species collection & identification.

Data and materials availability

All data associated with this study are present in the paper.

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