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Assessing Soil-Vegetation Relationships in South Western Sinai, Egypt

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THE PRESENT work aims to study the vegetation analysis related to soil factors affecting species distribution and community types in South Western Sinai, Egypt. A total of 77 stands were studied, using 10 quadrats (10 m x10 m) per stand. Different physical and chemical soil factors (soil texture, electrical conductivity, total dissolved salts, pH, moisture content, chlorides, carbonates, sodium, potassium, organic carbon, calcium, and magnesium) were investigated to determine the significant factors that may affect the distribution of species throughout the study area. The majority of the soil classes in the study area were a mixture of coarse sand, fine sand, and gravel. The vegetation analysis was dominated by five plant communities; *Zygophyllum coccineum*, *Haloxylon salicornicum*, *Zilla spinosaa*, *Zygophyllum album*, and *Anabasis articulata*. TWINSPAN was used to classify the study area's stands and to reveal each group's indicator species. The classification resulted in five vegetation groups (1, 2, 3, 4, and 5) each group with its distinct indicator species. Using DECORANA to clarify the relation between soil factors and vegetation, showed that the stands and their groups were related to both axis 1 and 2. Groups 1, 2, and 3 were related to axis 2, while groups 4 and 5 were related to axis 1. ANOVA was used to detect the most significant factors affecting species distribution. Organic carbon with P value = 0.036 was the most significant factor in determining different ecological groups followed by sodium with P value = 0.033 followed by magnesium with P value = 0.02 followed by Simpson diversity with P value = 0.007 followed by chloride, EC, T.D.S, species richness and Shannon diversity with P value = 0.001.

Keywords: Sinai, Vegetation, Soil analysis, South Western, Plant communities.

1. Introduction

The Sinai Peninsula is a triangular plateau in northeastern Egypt, with its southern apex at Ras Mohammed, where the eastern coast of the Gulf meets the western coast of the Gulf of Aqaba (27°45'N). The Mediterranean Sea borders it to the north and can be divided into three regions based on its geomorphic features: northern, central, and southern (Zahran and Willis, 2009). The natural conditions and geographical location of the Sinai Peninsula make it an exceptional region. South Sinai is an arid to hyperarid region with unique ecological characteristics due to the diversity of geomorphology, geological structure, and climate. This results in a diversity of vegetation types, which are mainly characterized by the sparse and dominant presence of shrubs and subshrubs and a low number of trees (Moustafa and Klopatek, 1995; El-Demerdash et al., 1996; Helmy et al., 1996; Abd El–Wahab et al., 2006b; Marie, 2006). Migahed et al. (1959) reported that the habitats in the western and southern Sinai consist of sandy plains, river valleys, Rocky Mountains, oases, springs scattered in the main valleys, coastal salt marshes, and sand dunes in some places. Kassas and Zahran (1962 and 1965) noted that the coastal zone along the eastern coast of the Gulf of Suez is directly or indirectly affected by the seawater. The vegetation structure and composition of this salt marsh ecosystem are simple. Galaledin (1988) outlined the primary habitat types found in the midstream and upstream tributaries of Wadi Sudr in Southwest Sinai. Additionally, Zhang and Zhang (2000) noted that quantitative analysis, particularly through classification and ordination methods, is extensively utilized to reveal the ecological relationships between vegetation and their environments. They emphasized that understanding the correlation between soils and vegetation is crucial for most studies concerning plant habitats.

Soil quality serves as an effective model for evaluating and enhancing soil resources, offering a comprehensive approach to assess various soil characteristics and their interconnections (Soil Science Society of America, 1997). The growing concern regarding development in South Sinai highlights the necessity for

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thorough assessments of its natural resources to improve sustainable management practices. Investigating soil and its interactions with other ecosystem components equips us with essential knowledge to mitigate the degradation and loss of one of our most vital natural resources: soil (Abd El–Wahab et al., 2006b). While numerous ecological studies have quantitatively assessed the vegetation of South Sinai (EL-Ghareeb and Shabana, 1990; Mostafa, 1990; Mostafa and Zaghloul, 1993; Helmy et al., 1996; Zaghloul, 1997; Abd El-Wahab, 2003; Abd El–Ghani and Amer, 2003; Shaltout et al., 2004; Salama et al., 2013), the current study in Southwestern Sinai is the first to encompass the entire area from Oyoun Mousa in the north to Ras Mohamed in the south, with a particular focus on the region east of Abu Zenima.

The present study aims to investigate the vegetation of South Western Sinai as well as describe the relationship between the vegetation and the prevailing soil factors and their effect on plant distribution in the study area to explain these changes.

2. The Study area

The western coast of the Sinai Peninsula (eastern coast of Suez Gulf) extends from El-Shatt (Lat. 30 °N) in the north to Ras Muhammed (Lat. 27°40 N) in the south for about 340 km. It is characterized by oasis-like depressions, e.g. Oyoun Mousa (Mousa springs) and Hammam Feraon (Feraon bath). These two oases are at 20 and 240 km south of El-Shatt (Said, 1962). The study area is located in the southern part of the western Sinai coast, lying between latitudes 30° to 28°N and longitudes 33° to 34°E, adjacent to the eastern side of the Gulf of Suez. It is bordered by the Gulf of Suez on the west and the coastal plain and wadis of Sinai on the east. The plain is wider in the northern section but narrows south of Gebel Hammam Feraon (Zahran and Willis, 2009). This region encompasses five primary areas that exhibit diverse vegetation types, altitude variations, landform types, and climatic conditions. These include six main landforms: Oyoun Mousa, Ras Sudr, Abu Zenima, El-Tor, and Ras Mohammed Table 1 and Fig 1.

Table 1. The number of stands in the eight visited locations in the study area.

Stand No.	Location
1-8	Oyoun Mousa to Wadi Gharandl
9	Hammam Faraon
10-21	Wadi Abu Zenima and its runnels
22-30	Abu Zenima- El Tor coastal road
31-34	El Tor – Ras Mohammed coastal road
35-41	Ras Mohammed – Oyoun Mousa-new road
42-50	Oyoun Mousa- Ras Sudr to the begging of wadi Abu Zenima
51-70	East of Abu Zenima
71-77	Abu Zenima – Oyoun Mousa – new road

3. Materials and methods

Seventy-seven stands were chosen to represent South Western Sinai's vegetation in the spring period from 2021 to 2023. Stands were chosen at locations where either dense vegetation or change in species composition. According to Täckholm (1974) and Boulos (1999-2009), all plant species existing in each stand were listed after complete identification. The scientific names were updated after (https://www.world floraonline.org/). Voucher herbarium specimens were prepared and kept in the herbarium of the Department of Botany and Microbiology, Faculty of Science, Al-Azhar, University (Girl's Branch). Vegetation analysis of the study area includes density, percentage of frequency, abundance, cover, relative density, relative frequency, relative abundance, relative cover, importance value, and constancy classes were determined for each species in each site according to (Shukla and Chandel, 1989).

Three soil samples were taken at a depth of 0–30 cm from each stand. These samples were combined to create a single composite sample. According to Rowell (1994), a part of the soil sample was used to calculate the soil moisture content. The remaining soil sample was air-dried and stored at room temperature for further physical and chemical analysis. Soil texture was carried out using the sieve method according to Jackson (1967). Soil electrical conductivity (EC) and total dissolved salts (TDS) were measured using a digital portable TDS meter Adwa® AD201, in soil extract (1 g soil: 5 ml distilled water). Soil pH was determined in soil extract for each sample (1 g soil: 5 ml distilled water) using a digital portable pH meter Adwa® AD11. Organic carbon was determined using the titration method described by Piper (1950). Carbonates (CO_3^-) and chlorides (Cl^-) were determined by titration method according to Jackson (1967). Sulfates (SO_4^{--}) were determined after the turbid metric method described by Estefan et al. (2013). Sodium (Na^+) and potassium (K^+) were determined photometrically at wavelength 589 nm and 767 nm respectively according to Estefan et al. (2013). Calcium (Ca^{++}) and magnesium (Mg^{++}) were determined by titration method according to Page et al. (1982). PCORD ver. 5 (Data profile, TWINSPAN, and DCA; McCune and Mefford, 1999. SPSS ver. 18 (mean, standard error of mean, and ANOVA) (Anonymous, 2007). The GPS position of every stand was recorded and represented in a study area map using ESRI Arc GIS ver.10.5 software Fig. 1.

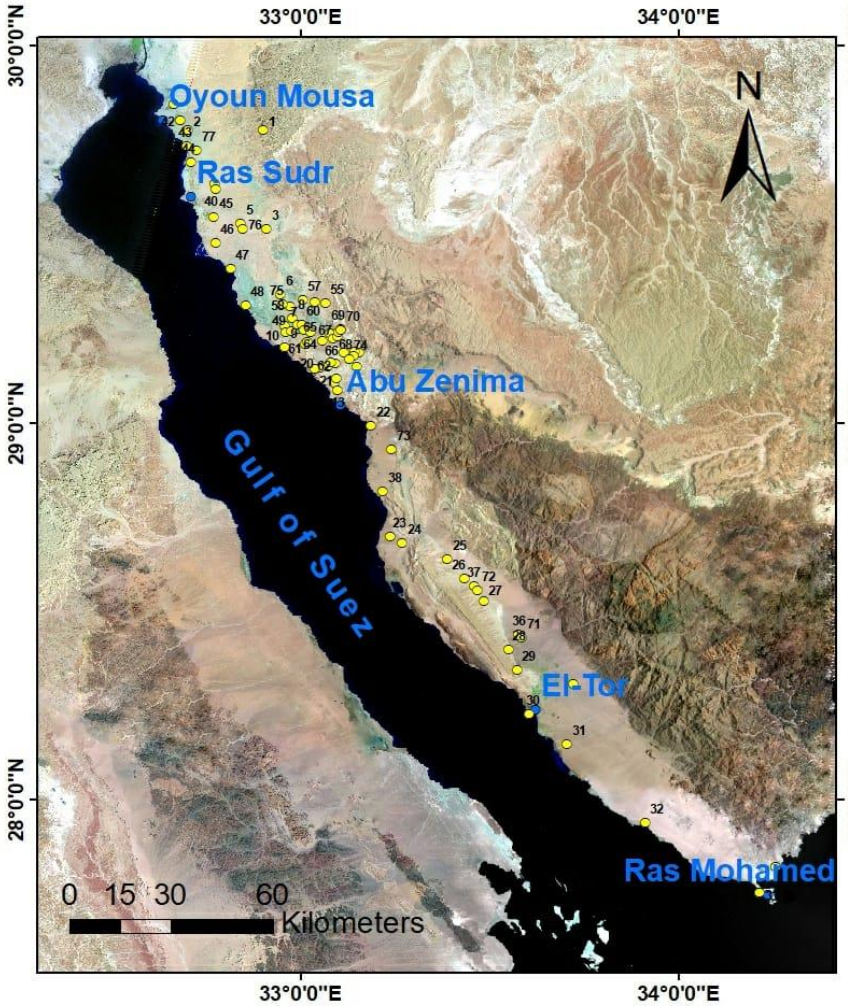

Fig. 1. Location map of the 77 stands selected in South Western Sinai.

4. Results

4.1 Soil analysis

The soil of the study area was represented by four classes; gravel, coarse sand, fine sand, and silt+clay. The first three classes were present in most of the studied stands with ranges from 0% to 92.89%; 0% to 78.95% and 0.37% to 99.48% respectively while silt+clay ranged from 0% to 74.6% in a few stands. Moisture content varied among different stands and ranged from 0.02 % to 26.6%, where the highest percentage was in stand 30 and the lowest percentage was in stand 48. The highest EC was recorded in stand 61 (9.66 ms/cm), while the lowest was in stand 35 (0.16 ms/cm). Soil pH ranged from 6.4 in stand 42 to 7.7 in stands 34 and 35. Chlorides varied from 1 meq/L in stand 77 to 100 meq/L in stand 42. Sodium concentration varied greatly from 0.26 meq/L in stands 36, 40, 52,57, and 77 to 90 meq/L in stands 43 and 61. Soil K^+ varied from 0.02 meq/L in stand 31 to 10.55 meq/L in stand 61. Soil Ca^{++} varied from 1.2 in stand 32 to 12 in stands 43 and 61. Magnesium varied from 0 in stand 39 to 47.2 in stand 10. Carbonates recorded a high percentage among all stands which ranged from 5.1 meq/L in stand 9 to 5.94 meq/L in stands 51, 59, 63, 66, and 70. Soil TDS varied from 102.4 mg/L in stand 35 to 6182 mg/L in stand 61. Organic carbon varied from 0.12 % in stands 1, 3, 12, 15, 42, 43, 51, 52, 53, 55 and 70 to 5.52% in stand 67. Sulfates varied from 0. 24 meq/L in stand 39 to 105.6 2meq/L in stand 10.

4.2 Vegetation characteristics

The vegetation analysis included 77 stands distributed in the study area as shown in Table 1. The dominant and co-dominant species of the selected stands are given in Table 2. Simpson diversity, species richness, evenness, and Shannon diversity were recorded as average values of 0.804, 11.73, 0.86, and 2.029 respectively. Photos from 1 to 5 show the most common dominant communities.

Table 2. Dominant and Co-dominant species of 77 selected stands and their locations in South Western Sinai area.

Stand No.	Location	Dominant species	Co-dominant species
1	**Oyoun Mousa to Wadi Gharandl**	*Tamarix senegalensis*	*Hyoscyamus muticus*
2		*Zygophyllum album*	*Anabasis articulata*
3		*Hyoscyamus muticus*	*Tamarix aphylla*
4		*Tamarix senegalensis*	*Haloxylon salicornicum*
5		*Zilla spinosa*	*Hyoscyamus muticus*
6		*Zygophyllum album*	*Haloxylon scoparium*
7		*Tamarix aphylla*	*Phragmites australis*
8		*Tamarix senegalensis*	*Phragmites australis*
9	**Hammam Faraon**	*Zygophyllum coccineum*	*Tamarix aphylla*
10	**Wadi Abo Zenima and its runnels**	*Zygophyllum coccineum*	*Tamarix aphylla*
11		*Zygophyllum coccineum*	*Phoenix dactylifera*
12		*Zygophyllum coccineum*	*Zilla spinosa*
13		*Zygophyllum coccineum*	*Tamarix senegalensis*
14		*Haloxylon salicornicum*	*Ochradenus baccatus*
15		*Haloxylon salicornicum*	*Zygophyllum coccineum*
16		*Haloxylon salicornicum*	*Zygophyllum coccineum*
17		*Haloxylon salicornicum*	*Zygophyllum coccineum*
18		*Zygophyllum album*	*Zygophyllum coccineum*
19		*Zygophyllum coccineum*	*Tamarix senegalensis*
20		*Zygophyllum coccineum*	*Haloxylon salicornicum*
21		*Zygophyllum coccineum*	*Capparis cartilaginea*
22	**Abo Zenima- El -Tor coastal road**	*Zygophyllum coccineum*	*Phoenix dactylifera*
23		*Anabasis articulata*	*Zygophyllum coccineum*
24		*Anabasis articulata*	*Zygophyllum coccineum*
25		*Anabasis articulata*	*Zygophyllum coccineum*
26		*Anabasis articulata*	*Zilla spinosa*
27		*Ephedra alata*	*Anabasis articulata*
28		*Zygophyllum coccineum*	*Zilla spinosa*
29		*Zilla spinosa*	*Zygophyllum coccineum*
30		*Halocnemum strobilaceum*	*Phragmites australis*
31	**El Tor – Ras Mohammed coastal road**	*Anabasis articulata*	*Zygophyllum coccineum*
32		*Anabasis articulata*	*Zygophyllum coccineum*
33		*Halocnemum strobilaceum*	*Zygophyllum album*
34		*Crotalaria aegyptiaca*	*Leptadenia pyrotechnica*
35	**Ras Mohammed – Oyoun Mousa- new road**	*Calligonum polygonoides*	*Zygophyllum coccineum*
36		*Anabasis articulata*	*Zygophyllum coccineum*
37		*Anabasis setifera*	*Zygophyllum coccineum*
38		*Zygophyllum coccineum*	*Zilla spinosa*
39		*Zygophyllum coccineum*	*Zilla spinosa*
41		*Zygophyllum coccineum*	*Zilla spinosa*
41		*Tamarix senegalensis*	*Atriplex halimus*
42	**Oyoun Mousa- Ras Sudr to the**	*Zygophyllum coccineum*	*Tamarix senegalensis*

43	**begging of wadi Abo Zenima**	*Zygophyllum coccineum*	*Zygophyllum album*
44		*Zilla spinosa*	*Launaea nudicaulis*
45		*Zilla spinosa*	*Zygophyllum coccineum*
46		*Zilla spinosa*	*Haloxylon salicornicum*
47		*Nitraria retusa*	*Zygophyllum album*
48		*Calligonum polygonoides*	Zygophyllum coccineum
49		*Zygophyllum coccineum*	*Ochradenus baccatus*
50		*Zygophyllum coccineum*	*Zygophyllum album*
51	**East of Abu Zenima**	*Salsola imbricata*	*Ephedra alata*
52		*Zygophyllum coccineum*	*Haloxylon salicornicum*
53		*Zygophyllum dumosum*	*Zygophyllum simplex*
54		*Zygophyllum coccineum*	*Zilla spinosa*
55		*Zygophyllum coccineum*	*Haloxylon salicornicum*
56		*Tamarix aphylla*	*Zygophyllum coccineum*
57		*Haloxylon salicornicum*	*Zygophyllum album*
58		*Haloxylon salicornicum*	*Zygophyllum album*
59		*Haloxylon salicornicum*	*Zygophyllum coccineum*
60		*Haloxylon salicornicum*	*Ephedra alata*
61		*Zygophyllum coccineum*	*Nitraria retusa*
62		*Zygophyllum coccineum*	*Zilla spinosa*
63		*Zygophyllum coccineum*	*Tamarix senegalensis*
64		*Zygophyllum coccineum*	*Atriplex halimus*
65		*Zygophyllum coccineum*	*Haloxylon salicornicum*
66		*Haloxylon salicornicum*	*Zilla spinosa*
67		*Haloxylon salicornicum*	*Zilla spinosa*
68		*Haloxylon salicornicum*	*Zygophyllum coccineum*
69		*Haloxylon salicornicum*	*Zilla spinosa*
70		*Haloxylon salicornicum*	*Capparis spinosa*
71	**Abu Zenima – Oyoun Mousa – new road**	*Zygophyllum coccineum*	*Zilla spinosa*
72		*Diplotaxis acris*	*Zygophyllum coccineum*
73		*Zygophyllum coccineum*	*Zilla spinosa*
74		*Zygophyllum coccineum*	*Haloxylon salicornicum*
75		*Zygophyllum album*	*Anabasis articulata*
76		*Matthiola arabica*	*Tamarix aphylla*
77		*Zygophyllum album*	*Anabasis articulata*

Photo1. *Zygophyllum coccineum* community at Ras Mohammed – Oyoun Mousa-new road.

Photo 2. *Haloxylon salicornicum* community of narrow wadi and there are large barriers in this habitat of wadi Abu Zenima and its runnels and Mr. Hammad, one of the bedouin guides from South Western Sinai.

Photo 3. *Zilla spinosa* community in transported soil of Oyoun Mousa- Ras Sudr to the beginning of wadi Abu Zenima.

Photo 4. *Zygophyllum album* community in sand plain of Abu Zenima – Oyoun Mousa new road.

Photo 5. *Anabasis articulata* community in sand plain of El Tor – Ras Mohammed coastal road.

4.3 Multivariate analysis

Out of the Two-way indicator species analysis (TWINSPAN) classification, the 77 stands after three levels of classification were classified into five vegetation groups Fig.2. Group 1 included eight stands, *H. salicornicum* was the dominant species in stands 14,16 and 17 while, species *O. baccatus*, *Z. coccineum*, *C. polygonoides*, and *C. cartilaginea* were the co-dominant. The habitat of this group was wadi Abu odimat (narrow wadi) and gravel wadi. In stand 56 *T. aphylla*, *Z. coccineum,* and *Z. spinosa* were the dominant species. *H. salicornicum* was dominant in stands 66,67,68 and 70 with other co-dominant species shown in Table 2.

Group 2 with 13 stands, where the dominancy was for *Z. coccineum* in seven stands out of them (20, 21, 39, 54, 62, 64, and 74) in addition to *Z. spinosa*, *H. salicornicum*, *A. articulata* and *C. polygonoides* in the remaining stands. The habitat in this group ranges from gravel, and sand plain to transported soli but most of them were sand plain. Group 3 with 28 stands where its habitats were mixed of gravel, sand plain, and transported soil. The dominant plant species of this group was *A. articulata* in stands 23, 24, 26, 31, 32 and 36; *Z. coccineum* was dominant in stands 12, 28, 38, 49, 52, 55, 63, 65, 71, and 73; H. *salicornicum* was dominant in two stands 59and 60, and also the dominancy is for both *T. senegalensis*, *Z. spinosa*, *E. alata*, *C.* aegyptiaca, *A. setifera*, *C. polygonoides*, *S. imbricate*, *Z. dumosum* and *M. arabica* in the remaining stands. Group 4 with 12 stands in which different ranges of habitat types in this group: transported saline soil, transported soil, gravel plain, and sand plain. The dominancy of species in this group was for *Z. coccineum* in four stands (9,10,40 and 43), while *Z. album* was dominant in three stands (2, 6, and 77), *Z. spinosa* was dominant in stands 45 and 46, *T. senegalensis*, *H. muticus*, and *N. retusa* in the rest stands.

Group 5 included 16 stands. This group includes different habitats such as gravel plain, sand, and saline habitat. *Z. coccineum* was the dominant plant in seven stands (11,13,19, 22, 42, 50 and 61), *T. senegalensis* was dominant in two stands 8 and 41, *Z. album* was dominant in two stands 18 and 75, *H. salicornicum* was dominant in two stands 57 and 58, *H. strobilaceum* was dominant in two stands 30 and 33, and *T. aphylla* was dominant plant in one stand Fig. 2.

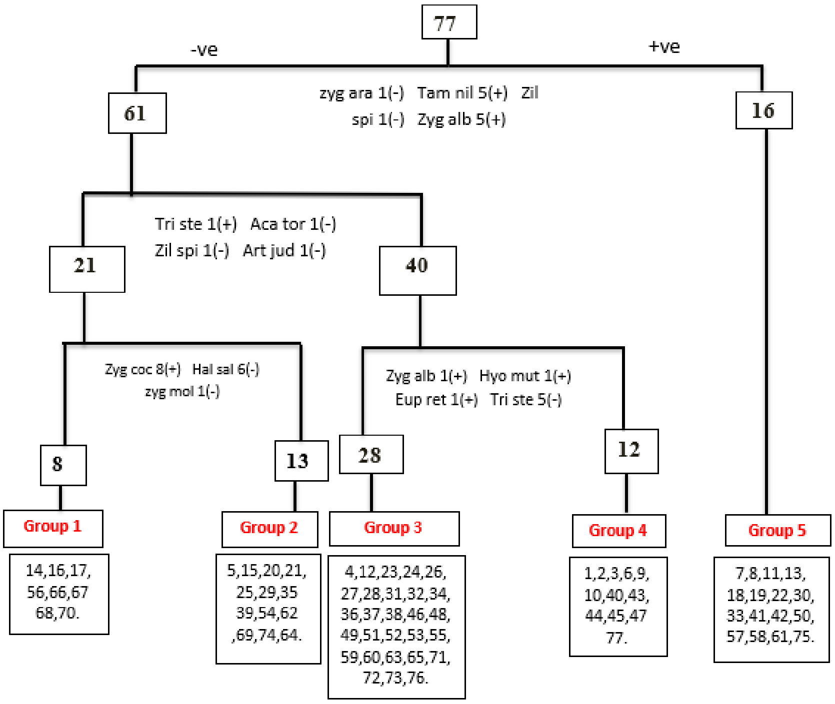

Fig. 2. TWINSPAN classification of the 77 stands in South Western Sinai.

4.4. Decorana

After TWINSPAN classification, data was analyzed by DECORANA (indirect gradient analysis). Five vegetation groups were used to identify plant compositions in South Western Sinai and their relationships to various environmental conditions shown in Fig. 3 and 4. Each group has a distinctive indicator species that defines it. The results showed that group 1 included 8 stands, the stands of this group moved to the extreme bottom of axis 2, but stand 5 at the east of Abu Zenima moved to the top of the group and approached group 2. This group (1) had *H. salicornicum* as an indicator species represented by seven stands and was positively correlated to gravel %, organic carbon, CO_3^- and K^+ content. Group2 included 13 stands, the stands of this group moved to axis 2, but stand 5 at the Oyoun Mousa to Wadi Gharandl moved to the extreme bottom of axis 2, and stand 25 at the Abu Zenima- El Tor coastal road moved to group 3 positions at the top of the axis 2. Group (2) had *Z. coccineum* as an indicator species represented by seven stands and the group was positively correlation with gravel%, coarse sand%, fine sand%, silt+clay%.

Group 3 included 28 stands and it is the largest group, this group moved to axis 2 but stands 4, 46 and 71 moved to the bottom of the region in axis 2. Group (3) had *A. articulata* as an indicator species represented by six and the group was positively correlation with gravel%, coarse sand%, fine sand%, and silt+clay%.
Group 4 this group considered an intermediated group containing 12 stands, stands (1, 2, 9, 6, 10, and 47) moved to axis 2, while stands (3,40, 43, 44, 45, and 77) moved to axis 1. Group (4) had *Z. coccineum* as an indicator species represented by four stands and the group was positively correlation with SO_4^{--} and pH.
Group 5 involved 16 stands; all stands moved to axis 1 except for stand 75. Group (5) had *Z. coccineum* as an indicator species, represented by 7 stands and the group was positively correlation with Cl^-, EC, TDS, moisture content, Ca^{++}, Mg^{++}, and Na^+ (Fig. 3). Soil parameters correlated to axis 1 and 2 were also examined.
Moisture content, T.D.S, EC, Na+, Mg ++, and chlorides were positively correlated to axis 1(0.351, 0.512, 0.513, 0.357, 0.328, and 0.497 respectively), while coarse and fine sand, pH and organic carbon were positively correlated to axis 2 (0.082, 0.058, 0.077 and 0.095 respectively). Indicator species in the study area showed that species *Z. coccineum, H. salicornicum, A. articulata,* and *Z. spinosa*a were related to axis 2, while *Z. album* was related to axis 1. Fig. 5 shows the DECORANA graph ordination of *Z. coccinum* distribution of the study area which represented the most dominant species.

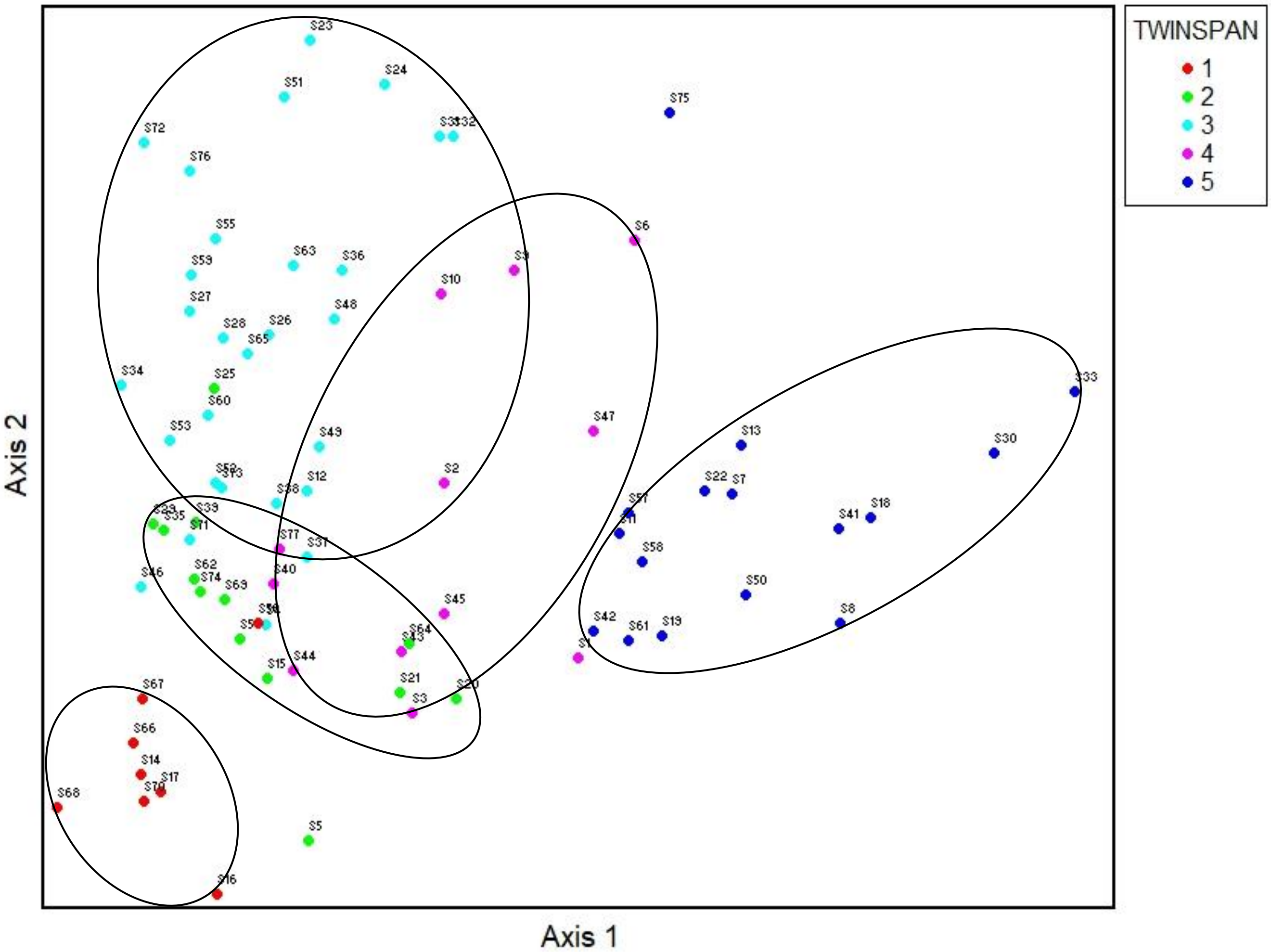

Fig. 3. Detrended Correspondence Analysis (DCA) ordination diagram for the vegetation of the 77 stands in South Western Sinai on axes 1 and 2, shows five superimposed TWINSPAN groups (1-5).

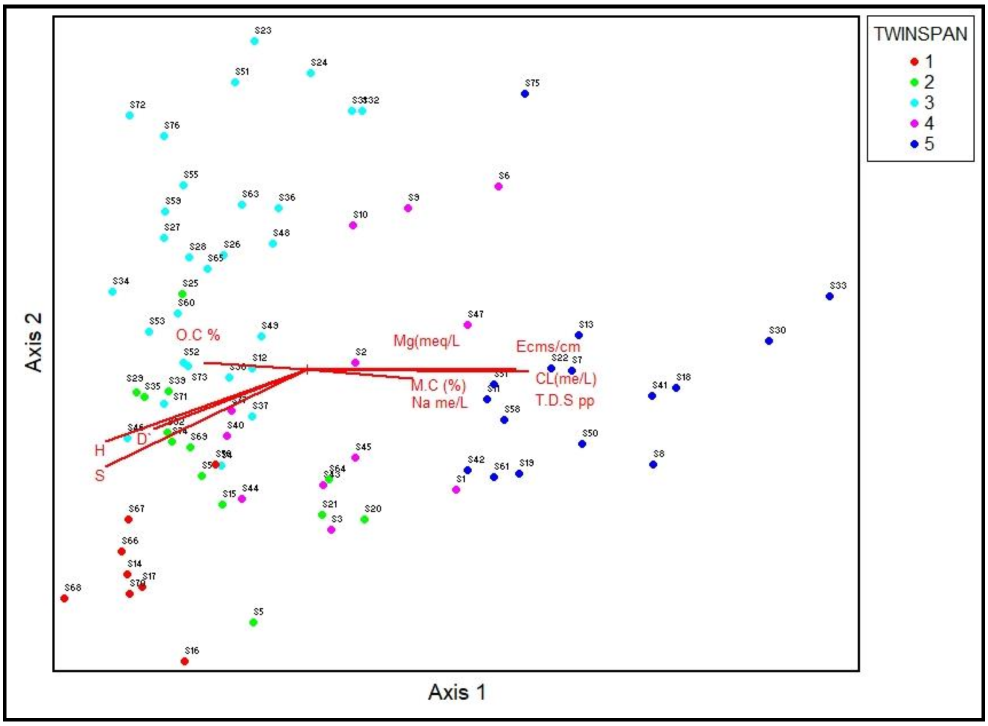

Fig. 4. DCA ordination diagram for the TWINSPAN groups of the 77 stands in South Western Sinai on axes 1 and 2 concerning different environmental factors, Moisture content(M.C, Magnesium (Mg (mq/L)), Electrical conductivity (EC(ms/cm)), Total dissolved salts (TDS (ppm)), Sodium (Na(mq/L)), Carbonate (Cl(mq/L)), Species richness(S), Simpson index(D)`, Shanon index(H) and Organic carbon (O.C (%).

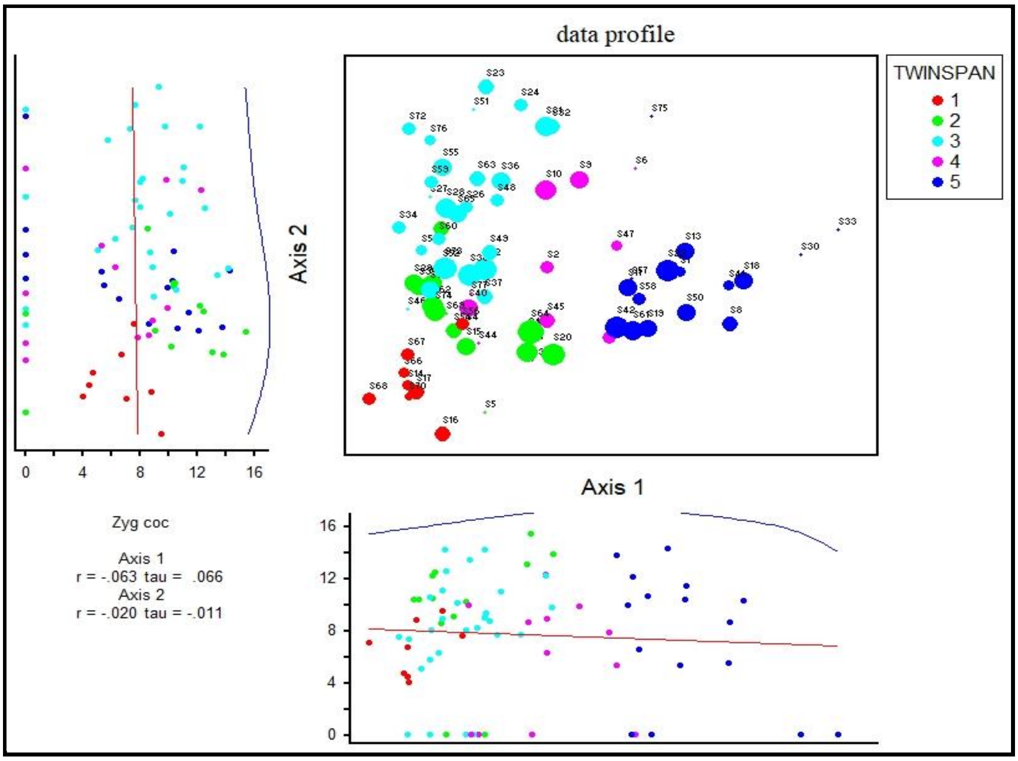

Fig. 5. Decorana graph ordinationof *Zygophyllum coccinum*.

4.5. Constancy classes

Constancy is the degree to which a species is represented in a series of stands of a community that is employed when equally measured sample plots (unit, area, quadrates) are used in each stand and is expressed by the percentage of stands in which it occurs or by the five-degree scale of constancy classes. Five vegetation groups were distinguished using TWINSPAN approach at the third level of arranged classification, data was analyzed by constancy classes Table 3. In each group, the number of plant species, the mean species richness, and also the number of annuals and their percentage were calculated. The species have been divided into five constancy classes (I-V), with class I (Rarely present) being allocated to species that appear in 0–20% of the stands, class II (Seldom present) to species that occur in 20.1–40% of the stands, class III (Often present) to species that occur in 40.1–60% of the stands, class IV (Mostly present) to species that occur in 60.1–80% of the stands and class V (Constantly present) to species that occur in 80.1–100% of the stands was calculated. Classes IV and V indicate the homogeneity of the community.

Group 1 included 54 species, *H. salicornicum* and *Z. coccineum* recorded the average significant value 94.V and 46.V respectively for both of them in all stands in the group. Group 2 included 64 species, *Z. coccineum* and *Z. spinosa* with 113.V and 29.IV respectively as average significant values for both species in all stands in the group. Group 3 included 81 species, *Z. coccineum* and *A. articulata* recorded 81.V and 49. II. Respectively as average significant values for both species in all stands in the group. Group 4 included 64 species, *Z. coccineum* recorded 52.V as the average significant value for the species in all stands in the group while, *Z. album* recorded 43.IV. Group 5 included 42 species, *Z. coccineum* recorded 79.V as the average significant value for the species in all stands in the group while, *Z. album* value was 67.IV. (Table 3).

Table 3. Species composition of the ٧٧ population stands in South Western Sainai, arranged in order of occurrence in the five TWINSPAN groups and Abbreviations used in TWINSPAN.

TWINSPAN Groups	Abbrev.	1	2	3	4	5
Group size		8	13	28	12	16
Total number of species		54	64	81	64	42
Mean species richness		17.5±2.6	12.2±1.1	11.4±1.02	13.9±1.5	7.3±0.8
Total number of annuals		9	10	30	14	8
% of annuals/ total species		16.60%	15.62%	37.03%	21.87%	19.04 %
***Haloxylon salicornicum* (Moq.) Bunge ex Boiss.**	Hal sal	**94.V**	28.III	23.III	12.III	38.II
***Zygophyllum coccineum* L.**	**Zyg** coc	**46.V**	**113.V**	**81.V**	**52.V**	**79.V**
***Zilla spinosa* Prantl**	Zil spi	26.IV	**29.IV**	30.III	33.III	2.I
***Tamarix aphylla* (L.) H.Karst.**	Tam aph	15.I	-	1.I	18.II	7.I
***Ochradenus baccatus* Delile.**	Och bac	11.IV	6.II	8.II	6.III	-
***Capparis spinosa* L.**	Cap spi	6.II	1.I	-	-	0.6.I
***Aerva javanica* (Burm.f.) Juss. ex Schult.**	Aer jav	4.I	-	-	-	-
***Asteriscus graveolens* (Forssk.) Less.**	Ast gra	6.II	-	-	-	-
***Calligonum polygonoides* L.**	Cal pol	7.II	10.I	2.I	-	-
***Retama raetam* (Forssk.) Webb.**	Ret rae	8.III	5 I	1.I	3.I	-
***Forsskaolea tenacissima* L.**	For ten	1.I	-	0.5.I	-	-
***Gymnocarpos decandrus* Forssk.**	Gym dec	1.I	2.I	-	4.I	-
***Zygophyllum arabicum* (L.) Christenn. Byng**	Zyg are	6.III	14.IV	14.V	8.II	2.I
***Vachellia tortilis*(Forssk.) Galasso & Banfi**	Vac tor	7.III	7.III	2.I	-	1.I
***Reaumuria hirtella* Jaub.& Spach.**	Rea hir	7.III	4.II	1.I	-	2.I
***Atriplex halimus* L.**	Atr hal	1.I	7.II	2.I	1.I	1.I
***Farsetia aegyptia* Turra.**	Far aeg	2.I	2.I	3.I	6.II	-
***Anabasis articulata* (Forssk.) Moq.**	Ana art	3.I	20.I	**49. II**	22.III	9.I
***Anabasis setifera* Moq.**	Ana set	-	2.I	7.I	4.I	-
***Arthrocnemum macrostachyum* (Moric.) K.Koch**	Art mac	-	-	-	-	1.I
***Atriplex dimorphostegia* Kar.& Kir.**	Atr dim	-	-	0.7.I	-	-

Atriplex leucoclada **Boiss**	Atr leu	-	-	1.I	0.9.I	-
Bassia indica **(Wight) A.J.Scott**	Bas ind	-	-	-	3.II	0.7.I
Bassia muricata **(L.) Asch.**	Bas mur	-	-	2.I	-	-
Dysohania ambrosioides **(L.) Mosyakin & Clemants**	Dys amb	-	-	1.I	-	-
Chenopodium murale **L.**	Che mur	-	-	-	0.3.I	-
Halocnemum strobilaceum **(Pall.) M.Bieb.**	Hal str	-	-	-	-	23.I
Halopeplis perfoliata **(Forssk.) Bunge ex Ung. Sternb.**	Hal per	-	1.I	-	-	-
Haloxylon salicornicum **(Moq.) Bunge ex Boiss.**	Hal sal	3.I	-	2.I	7.I	-
Haloxylon scoparium **Pomel**	Hal sco	-	-	2.I	0.8.I	0.7.I
Salsola imbricata **Forssk.**	Sal imb	-	-	1.I	6.II	-
Suaeda vermiculata **Forssk.ex J.F. Gmel.**	Sua ver	2.I	-	-	0.7.I	-
Deverra tortuosa **(Desf.) DC.**	Dev tor	-	-	-	1.I	18.III
Phoenix dactylifera **L.**	Pho dac	-	-	-	-	1.I
Gomphocarpus sinaicus Boiss.	Gom sin	-	0.8.I	2.I	4.II	-
Calotropis procera **(Aiton) Dryand**	Cal pro	-	-	0.4.I	7.II	-
Cynanchum acutum **L.**	Cyn acu	-	-	2.I	-	-
Leptadenia pyrotechnica **(Forssk.) Decne.**	Lep pyr	1.I	1.I	-	-	-
Pergularia tomentosa **L.**	Per tom	1.I	-	0.3.I	-	-
Achillea fragrantissima **(Forssk.) Sch.Bip.**	Ach fra	11.IV	3. I	1.I	-	-
Calendula arvensis **L.**	Cal arv	1.I	-	-	-	-
Carthamus eriocephalus (Boiss.) Greuter	Car eri	-	-	-	0.7.I	-
Centaurea aegyptiaca **L.**	Cen aeg	3.III	1.I	0.5.I	2.I	-
Pluchea dioscoridis (L.) DC.	Plu dio	-	0.8.I	-	1.I	0.8.I
Cornulaca monacantha **Delile**	Cor mon	-	-	0.5.I	-	-
Brocchia cinerea Vis.	Bro cin	-	-	4.II	-	-
Echinops spinosissimussub sp. Spinosissimus L.	Ech spi	1.I	-	-	-	-
Echinops macrochaetus Fresen.	Ech mac	-	-	-	-	0.5.I
Pulicaria undulata sub sp. Undulate	Pul und sub	0.5.I	0.8.I	0.4.I	1.I	-
Iphiona scabra **DC. ex Decne.**	Iph sca	-	2.I	0.7.I	-	-
Launaea nudicaulis **(L.) Hook.f.**	Lau nud	1.I	-	0.4.I	6.II	-
Launaea spinosa **(Forssk.) Sch. Bip. ex Kuntze.**	Lau spi	-	0.9. I	-	2.I	-
Picris cyanocarpa **Boiss.**	Pic cya	-	-	0.6.I	-	-
Pulicaria arabica Cass.	pul ara	2.I	-	-	-	-
Pulicaria undulata (**L.) C.A.Mey.**	Pul und	2.I	8.II	-	1.I	-
Reichardia tingitana Roth	Rei tin	-	-	1.I	-	-
Senecio glaucus **L.**	Sen gla	-	1.I	-	0.7.I	-
Sonchus oleraceus L.	Son ole	-	-	0.4.I	1.I	-
Alkanna orientalis **Boiss.**	Alk ori	-	-	1.I	-	-
Heliotropium arbainense **Fresen.**	Hel arb	3.II	-	1.I	3.I	1.I
Heliotropium bacciferum **Forssk.**	Hel bac	-	1.I	-	3.I	1.I
Heliotropium digynum **Asch. ex C.Chr.**	Hel dig	-	-	2.I	-	-
Trichodesma africanum (L.) Sm.	Tri afr	1.I	-	1.I	-	1.I
Diplotaxis acris Boiss.	Dip acr	-	-	9.II	-	-
Diplotaxis harra Boiss.	Dip har	4.I	4.II	11.III	12.III	4.I

***Lepidium draba* L.**	Lep dra	-	-	1.I	0.5.I	-
***Matthiola arabica* Boiss.**	Mat ara	-	0.7.I	4.II	1.I	2.I
***Moricandia sinaica* Boiss.**	Mor sin	8.III	-	-	-	-
Savignya parviflora (Delile) Webb.	Sav par	-	1.I	4.II	-	-
***Capparis cartilaginea* Decne.**	Cap car	11.III	15.II	-	-	0.6.I
***Gypsophila capillaris* C. Chr**	Gyp cap	0.7.I	1.I	-	1.I	-
***Paronychia argentea* Lam**	Par arg	1.I	-	0.5.I	--	-
***Pteranthus dichotomus* Forssk.**	Pte dic	1.I	-	0.6.I	-	-
***Spergularia diandra* (Guss.) Heldr.**	Spe dia	1.I	1.I	-	-	1.I
***Cleome amblyocarpa* Barratte & Murb.**	Cle amb	-	-	-	1.I	-
***Cleome droserifolia* (Forssk.) Delile.**	Cle dro	5.III	1.I	-	-	-
***Cressa cretica* L.**	Cre cre	-	1.I	-	-	4.I
***Convolvulus arvensis* L.**	Con arv	-	-	-	0.4.I	-
***Citrullus colocynthis* (L.) Schrad.**	Cit col	-	3.II	0.4.I	2.I	-
***Ephedra alata* Decne.**	Eph ala	2.I	3.I	15.II	6.II	-
***Chrozophora oblongifolia* (Delile) A. Juss. ex Spreng.**	Chr obl	-	2.I	0.8.I	-	-
***Euphorbia retusa* Forssk.**	Eup ret	-	2.I	-	7.II	-
***Erodium cicutarium* (L.) L'Hér.**	Ero cic	-	-	1.I	-	-
Erodium crassifolium L'Hér.	Ero cra	-	-	3.I	3.II	-
***Erodium glaucophyllum* (L.) L'Hér.**	Ero gla	-	-	5.II	-	2.I
***Erodium laciniatum* (CAV.) Willd.**	Ero lac	-	-	0.8.I	-	-
***Monsonia nivea* Webb**	Mon niv	-	-	0.8.I	-	-
***Lavandula coronopifolia* Poir.**	Lav cor	0.6.I	-	-	-	-
***Juncus rigidus* Desf.**	Jun rig	-	-	-	-	4.I
***Malva parviflora* L.**	Mal par	-	0.6.I	0.4.I	-	1.I
***Cocculus pendulus* (J.R. Forst. & G. Forst.) Diels.**	Coc pen	0.8.I	-	-	-	-
***Nitraria retusa* (Forssk.) Asch.**	Nit ret	3.II	2.I	-	7.I	18.III_
***Cistanche phelypaea* (L.) Cout.**	Cis phe	-	1.I	0.7.I	1.I	-
***Alhagi maurorum* Medic.**	Alh mau	-	1.I	-	-	7.I
***Astragalus dactylocarpus* Boiss.**	Ast dac	0.6.I	1.I	-	-	-
***Astragalus eremophilus* Boiss.**	Ast ere	-	-	2.I	-	-
***Astragalus sieberi* DC.**	Ast sie	1.I	-	0.4.I	-	-
***Astragalus tribuloides* Delile**	Ast tri	-	-	1.I	-	0.9.I
***Crotalaria aegyptiaca* Benth.**	Cro aeg	-	2.I	4.I	1.I	-
***Trigonella stellata* Forssk.**	Tri ste	-	1.I	13.IV	4.II	3.I
***Globularia arabica* Jaub.& Spach**	Glo ara	-	-	-	1.I	-
***Plantago ciliata* Desf.**	Pla cil	-	-	8.II	-	-
***Limonium pruinosum* (L.) Chaz.**	Lim pru	-	-	-	2.I	-
***Cynodon dactylon* (L.) Pers.**	Cyn dac	-	-	1.I	-	-
***Hordeum vulgare* L.**	Hor vul	-	-	-	1.I	-
***Hordeum murinum* L.**	Hor mur	-	-	-	1.I	-
***Imperata cylindrica* (L.) Raeusch.**	Imp cyl	-	-	1.I	2.I	1.I
Lolium perenne L.	Lol per	-	-	-	1.I	-
***Melica persica* Kunth**	Mel per	-	-	-	-	0.9.I
***Panicum turgidum* Forssk.**	Pan tur	-	1.I	-	-	-

Cenchrus divisus (J. F. Gmell.) Verloove, Govaerts & Buttler	Cen div	-	-	-	1.I	-
***Phragmites australis* (Cav.) Trin. ex Steud.**	Phr aus	-	-	-	-	24.II
***Polypogon monspeliensis* (L.) Desf.**	Pol mon	-	-	0.7.I	-	-
***Sorghum bicolor* (L.) Moench**	Sor bic	-	-	-	-	0.9.I
***Stipagrostis obtusa*(Nees&Meyen)Hitchc.**	Sti obt	-	2.I	-	-	-
***Calligonum polygonoides* L.**	Cal pol	-	-	0.6.I	0.7.I	-
***Rumex dentatus* L.**	Rum den	-	-	0.2.I	-	-
Emex spinosa (L.) Campd	Eme spi	-	1.I	-	-	-
***Caylusea hexagyna* (Forssk.) M.L.Green.**	Cay hex	1.I	1.I	0.6.I	-	-
***Solanum nigrum* L.**	Sol nig	-	-	1. I	-	-
***Reseda urnigera* Webb**	Res urn	-	7.II	3.I	3.I	-
***Reseda muricata* C. Presl.**	Res mur	-	0.9. I	-	-	-
***Reseda pruinosa* Delile.**	Res pru	-	-	0.6.I	2.I	-
***Reseda stenostachya* Boiss.**	Res ste	7.II	1.I	-	-	-
***Haplophyllum tuberculatum* (Forssk.) A.Juss.**	Hap tub	7.III_	-	-	-	-
***Kickxia aegyptiaca* (L.) Nábělek.**	Kic aeg	1.I	2.I	-	18.II	-
***Scrophularia deserti* Delile**	Scr des	8.III	-	-	-	-
***Hyoscyamus muticus* L.**	Hyo mut	8.II	2.I	-	-	-
***Hyoscyamus aureus* L.**	Hyo aur	-	-	1.I	-	-
***Tamarix senegalensis* DC.**	Tam sen	-	7.II	9.I	14.I	45.III
***Typha domingensis* Pers.**	Typ dom	-	-	-	-	1.I
***Zygophyllum bruguieri* (DC.) Christenn.Byng**	Zyg bru	-	3.I	-	1.I	-
***Zygophyllum glutinosa* (Delile) Christenn.Byng**	Zyg glu	-	-	0.4.I	-	-
***Zygophyllum mollis* (Delile) Christenn.Byng**	Zyg mol	12.III	1.I	0.9.I	-	-
***Zygophyllum scabrum* (Forssk.) Christenn.Byng**	Zyg sca	1.I	2.I	-	-	-
***Peganum harmala* L.**	Peg har	-	1.I	0.4.I	3.I	4.I
***Tribulus terrestris* L.**	Tri ter	-	-	0.8.I	-	-
***Zygophyllum album* L. F.**	Zyg alb	-	2.I	0.5.I	**43.IV**	**67.IV**
***Zygophyllum dumosum* Boiss.**	Zyg dum	-	5.I	4.I	1.I	-
***Zygophyllum simplex* L.**	Zyg sim	-	2.I	0.6.II	3.I	3.I

4.6. ANOVA (Analysis of Variance)

To detect the most significant factors affecting the grouping of TWINSPAN, mean and standard error of mean as well as ANOVA, analysis of variance, were calculated for each environmental factor to each TWINSPAN cluster all were shown in Table 5. Results showed that many environmental factors were highly significant in certain groups while others were less significant as group 1 recorded low values of pH, EC, TDS, moisture content, Mg^{++}, Cl^-, $Na^{+,}$ and high values of organic carbon, $k^{+,}$ and CO_3^-. Group 2 showed low values of Ca^{++}, SO_4^{--}, and CO_3. Group 4 values were high in pH and SO_4^{--} and low in k^+. Group 5 recorded the highest values in most factors comparing other groups as high EC, TDS, moisture content, Ca^{++}, Mg^{++}, organic carbon, Cl^-, and Na^+. Gravel (%), coarse sand (%), fine sand (%), and silt + clay (%) were recorded as the highest value in groups 2, 5, 1, and 3 respectively, and the lowest value in groups 1, 2, and 4. Species richness, Species evenness, Shanon diversity, and Simpson's diversity were recorded as the highest value in group 1, and the lowest value was in group 5.

Table 5. Mean, standard error, and ANOVA results of the different environmental factors in the stands representing the five TWINSPAN clusters in South Western Sinai.

	TWINSPAN Groups						
Parameter	**1**	**2**	**3**	**4**	**5**	**F value**	**P value**
gravel%	27.32 ± 9.865	41.74 ± 7.400	21.85 ± 4.126	32.58 ± 8.699	32.24 ± 7.025	1.4252	0.234
coarse sand%	27.37 ± 3.835	25.23 ± 5.914	28.92 ± 4.416	29.55 ± 7.839	29.50 ± 5.810	0.0877	0.986
fine sand%	34.96 ± 9.082	16.52 ± 4.201	28.64 ± 4.138	28.34 ± 8.736	25.30 ± 5.123	1.0105	0.408
Silt+ clay%	10.18 ± 2.422	14.16 ± 4.478	20.21 ± 4.184	9.477 ± 3.100	12.44 ± 3.948	1.1807	0.327
pH	6.937 ± 0.032	7.084 ± 0.079	7.017 ± 0.054	7.1 ± 0.084	6.893 ± 0.064	1.4726	0.219
Ec ms/cm	1.16 ± 0.167	1.51 ± 0.330	1.64 ± 0.309	1.873 ± 0.595	4.426 ± 0.692	7.4174	0***
T.D.S ppm	742.4 ± 106.9	966.4 ± 211.6	1049. ± 198.1	1161. ± 382.6	2832. ± 442.9	7.4388	0***
M.C (%)	0.653 ± 0.234	0.792 ± 0.295	1.401 ± 0.742	2.898 ± 1.648	4.852 ± 1.900	1.9644	0.109
Ca^{++} (meq. /L)	4.175 ± 0.744	3.4 ± 0.363	4.528 ± 0.459	4.433 ± 0.766	5.025 ± 0.822	0.8029	0.527
Mg^{++} (meq/L)	6.725 ± 1.138	7.138 ± 1.897	7.042 ± 1.468	13.31 ± 4.249	15.57 ± 2.493	3.115	0.02*
O.C %	2.64 ± 0.626	2.390 ± 0.444	2.117 ± 0.303	1.39 ± 0.358	1.095 ± 0.183	2.7215	0.036*
Cl (me/L)	4.475 ± 1.413	5.276 ± 1.175	5.921 ± 2.741	11.06 ± 5.368	33.91 ± 8.128	6.8445	0***
SO_4^{--} me/L	7.81 ± 2.214	6.74 ± 1.698	11.30 ± 3.372	16.44 ± 8.847	15.27 ± 4.069	0.7001	0.594
Na^{+} me/L	3.216 ± 1.295	4.013 ± 1.127	3.789 ± 1.709	12.98 ± 7.678	18.73 ± 6.196	2.7901	0.033*
K^{+} me/L	1.091 ± 0.425	0.487 ± 0.110	0.487 ± 0.098	0.351 ± 0.180	0.94 ± 0.642	0.7339	0.572
CO_3^{-} me/L	5.782 ± 0.048	5.561 ± 0.073	5.571 ± 0.059	5.465 ± 0.069	5.572 ± 0.059	1.7282	0.153
S (Species richness)	17.5 ± 2.652	12.23 ± 1.166	11.42 ± 1.021	13.91 ± 1.529	7.312 ± 0.804	6.2121	0***
E (Species evenness)	0.886 ± 0.020	0.834 ± 0.020	0.857 ± 0.014	0.889 ± 0.012	0.848 ± 0.015	1.428	0.233
H (Shanon diversity)	2.484 ± 0.164	2.061 ± 0.129	2.020 ± 0.108	2.286 ± 0.112	1.599 ± 0.118	5.4271	0.001***
D`` (Simpson's diversity)	0.870 ± 0.020	0.802 ± 0.025	0.800 ± 0.021	0.858 ± 0.016	0.734 ± 0.027	3.8559	0.007**

*= Pvalue < 0.05, **Pvalue<0.01, ***Pvalue<0.001

5. Discussion

5.1. Soil characteristics

Numerous studies conducted in Sinai have provided qualitative assessments of plant species distribution and their relationships with physiographic features across different regions of the peninsula (Migahid et al., 1959; Danin, 1983; Batanouny, 1985; El-Bana et al., 2002; Marie, 2001 and 2006; Abd El–Ghani and Amer, 2003; Salama et al., 2013; Khafagi et al., 2013 and 2018; Shaltout et al., 2020; Moustafa et al., 2020). These studies have explored variations in plant diversity and other vegetation factors concerning habitat heterogeneity. The current study showed that the mechanical analysis in the majority of the stands consisted of a mixture of coarse sand, fine sand, and gravel, with high proportions of these soil particles. These results follow the findings of Youssef (1994) in Wadi Sudr. Additionally, Danin (1983), Moustafa et al. (2001), Abd El–Wahab et al (2006a), and Marei et al. (2016) highlighted the significant role of edaphic factors in plant distribution and this was shown in soil analysis results within the study area.

Hazelton and Murphy (2007) stated that soil EC is a crucial environmental factor as it shows the presence of an accumulation of salts that are soluble in water, mainly Na^{+} and also K^{+}, Ca^{++}, Mg^{++}, Cl^{-}, SO_4^{--}, and CO_3^{-}. These salts can impact negatively on plant growth, land use, and soil erosion. Across all stands in the study area, carbonates recorded a high proportion. Yassin et al. (2023) found that elevated CaCO3 considerably affects soil fertility status, hence reducing crop yields. Additionally, it causes the total number of pores in the soil to rise and the area of pores to decrease, which lowers the soil's ability to hold water and causes the soil to harden and develop surface crusts when it dries (Abou Hussien et al., 2023; Nada and Elbaalawy, 2023). In addition, Abd El-Ghani (1998) stated that Organic carbon and organic matter are essential for soil fertility, while Na^+ is a key factor in the management of saline and sodium-containing soils. The effects of these factors may lead to loss of ecosystem, biodiversity, and agricultural yield/output (Abdullahi et al., 2023; El-Ramady et al., 2024). During the present study and by applying TWINSPAN, ordination, and ANOVA, to identify vegetation and its relation to different environmental factors the results showed that the moisture content and salinity indicators (EC, TDS, chlorides, sodium, and magnesium) were the major environmental factors affecting the separation of different ecological groups and consequently affecting species diversity as well. These results match with the findings of Greenway and Osmond (1972) also Abdel Khaliq et al. (2013) and Alata et al. (2013) who stated that significant differences in soil EC, pH, and mineral content impact the distribution of plants.

Other physical environmental factors such as altitude, salinity, and soil surface conditions were stated by Helmi et al. (1996) as the main factors influencing the distribution of woody plant communities of seven common shrubs and trees in southern Sinai (*Acacia tortilis*, *Retama raetam*, *Nitraria retusa*, *Moringa peregrina*, *Crategus sinaica*, *Lycium shawii*, and *Salvadora persica*). Similar findings were reported by Mashaly (2006), who observed that the most important soil variables influencing the distribution of halophytic species in South Sinai were sodium cations, moisture content, sand fraction, electric conductivity, and chloride contents. On the other hand, the most effective soil variables influencing the distribution of xerophytic species were magnesium, calcium carbonate, total nitrogen, calcium cations, silt and clay fractions, and pH. These results also align with the outcomes of the current study. Diversity indices showed high values in some TWINSPAN groups and according to the habitat type of the studied areas and the presence of some elevations and depressions (Wadis), species richness for certain taxa simply decreases, whereas for other taxa, species richness takes on the form of a bell curve these results following Lèvèque and Mounolou (2003).

5.2. Wide Ecological Amplitude

The study proved that Five species namely *Z. coccineum, Z. spinosa, H. salicornicum, Z. album, and A. articulata* exhibit a wide ecological amplitude, including. Zahran and Willis (2009) noted that *Z. coccineum* was prevalent in the Eastern Desert and abundant along the Sinai coast of the Suez Gulf, often appearing as an associated species in nearly all communities. Marie (2001) highlighted its abundance in the Cairo-Suez desert and Wadi Hagul, particularly in the main channels and terraces of the drainage system in the Eastern Desert of Egypt. This species is one of the most widely distributed in the drainage channels of the limestone desert (Kassas, 1953; Kassas and Imam, 1954; Kassas and El-Abyad, 1962). *H. salicornicum*, as reported by Zahran and Willis (2009) was found in both the Western and Eastern deserts, as well as in Sinai's dry regions. Marie (2001) indicated the plant thrives in the sand and gravel ecosystems of Egypt's Isthmic desert, rather than in the limestone desert. *Z. spinosa* is also recorded as a plant of high amplitude in the Western and Eastern deserts and Sinai (Marie, 2001; Zahran and Willis, 2009). *Z. album*, according to Zahran and Willis (2009), is abundant along the Sinai coast of the Suez Gulf and is an associate species in nearly all communities, dominating in both the Western and Eastern deserts. It thrives in dry, salt-affected areas and phytogenic sand mounds along the Suez Gulf coast, and is widespread in the dry saline plains and littoral salt marsh vegetation of the Red Sea and Sinai (Ahmed, 1983). Marie (2001) reported *A. articulata* as a high-amplitude plant in the main channels of the Kattamia-Ain-Sukhna area, particularly in calcareous plains with increased CO_3^- deposits. Numerous studies have documented the widespread distribution of *A. articulata* in the Egyptian desert, including those by Kassas (1952), Migahid et al. (1959), Ramadan (1988), and Moustafa (1993) in the Egyptian desert.

5.3. Medium Ecological Amplitude

Four species exhibit medium ecological amplitude including *T. senegalensis*, *H. strobilaceum*, *C. polygonoides*, and *T. aphylla*. *T. senegalensis* is a widely distributed shrub or tree found in the western coastal region of Sinai (Zahran and Willis, 2009). According to Zahran and Willis (2009), this species is recorded as both a community and an associated plant in the Western and Eastern deserts. Marie (2001) noted that *T. senegalensis* forms a pure community in the Sinai area and Wadi El-Gudairat, where it serves as both a halophyte and xerophyte in the Isthmic desert. *H. strobilaceum* is reported by Zahran and Willis (2009) as a community and an associated plant in the coastal habitats of Sinai and the Eastern desert, where it is linked to halophytic plants. *C. polygonoides* is recognized as a pioneer community. Additionally, Zahran and Willis (2009) documented *T. aphylla* as a community present in the wadies of Allaqi, Hagul, and El-Assiuti in the Eastern desert, as well as in Gebel Halal and El-Maghara in North Sinai, where it is also found as an associated species with other communities.

5.4. Low Ecological Amplitude

Nine plant species exhibit low ecological amplitude, including *Z. dumosum*, *D. acris*, *N. retusa*, *E. alata*, *A. setifera*, *C. aegyptiaca*, *H. muticus*, *S. imbricata*, and *M. arabica*. Zahran and Willis (2009) documented *Z. dumosum* forming a community with *A. articulata* in the Plateau and the Jabal al Halal area. Marie (2001) noted that *D. acris* grows in the Isthmic desert but does not form communities there, while El-Sayed et al. (2003) reported it as a community type in Wadi Zaghra within the Saint Catherine Protectorate. However, Zahran and Willis (2009) indicated that *D. acris* is a rare associated species that does not form distinct communities. *N. retusa* was found in dry salt marsh communities in the Western and Eastern deserts and Sinai, often near depressions and coastlines, where it forms associations with *Z. album*, *T. senegalensis*, and *A. articulata* (Zahran and Willis, 2009). Marie (2001) recorded it as a community along the Gifgafa-Abu Awegella Road in North Sinai. Nour et al. (2020) identified *E. alata* as a community in Wadi Degla, where it co-dominates in one stand. Zahran and Willis (2009) reported that *E. alata* is well-represented in Wadi Etheily and Wadi Gendali, as well as in the limestone areas of the Cairo-Suez desert, and is found as an associated species in the Western Desert and communities in the Eastern deserts and Sinai. *A. setifera*, according to Zahran and Willis (2009), replaces *Z. coccineum* in several areas of the Helwan Desert, growing in wadi channels covered with coarse rock detritus. The steep escarpment of Gebel El-Tih supports a pioneer community dominated by *A. setifera*. Nour et al. (2020) recorded this species as a community in the valley depression between Gebel Ataqa and the Kahaliya ridge. Zahran and Willis (2009) noted *C. aegyptiaca* as a commonly associated species in the Eastern desert, particularly in the eastern part of El-Laqeita plain and Wadi Zaidun, where it is associated with *L. pyrotechnica*. This species is also found on the Western coast of the Aqaba Gulf. *H. muticus* is recorded by Zahran and Willis (2009) as a community in the sand plains of Kharga Oasis, thriving in non-saline habitats in both the Western and Eastern deserts as an associated plant. *S. imbricata* is found as a community in Wadi Allaqi of the Eastern desert, while *Matthiola arabica* is recognized as a pioneer community.

The five plant species, *H. salicornicum*, *Z. coccineum*, *Z. spinosa*, *Z, album*, and *Anabasis articulata* which represent the indicators of the vegetation groups obtained in TWINISPAN classification are summarised as the following:

Zygophyllum coccineum community

the plant was recorded in the study area as a community in most of the studied stands. The habitat for this plant in these stands is transported soil, gravel plain, sand plain, and saline habitat.

Haloxylon salicornicum community

The plant was recorded in the study area as a community in 13 stands and as an associated plant in six stands Table 2. The habitat for this plant in these stands is gravel plain and sand plain but the mostly was gravel plain.

Zilla spinosa community

The plant was recorded in the study area as a community in five stands and as an associated plant in 12 stands Table 2. The habitat for this plant in these stands is gravel plain, sand plain, and transported soil.

Zygophyllum album community

The plant was recorded in the present study as a community in five stands and recorded as an associated plant in 6 stands Table 2. The habitat for this plant in these stands is gravel saline habitat and coastal saline habitat, also sand plain.

Anabasis articulata community

The species was recorded in the study area as a community in seven stands and recorded as an associated plant in four stands Table 2. The habitat for this plant in these stands is gravel plain and sand plain.

5.4. Constancy classes

According to the constancy level in the five groups, it was found that *Z. coccineum* is the most constant species, as it is situated in the highest level of constancy (V), in four of the five groups (2, 3, 4 and 5). *Z. album* is one of the most distinctive species since it is found in the fourth level of stability (IV) in two consecutive groups (4 and 5). Nasseib, (2023) recorded that the constancy level in Wadi Feiran of South Sinai was the six groups, it was found that *A. articulata* was the most constant species, as it was situated in the highest level of constancy (V), in three of the six groups (4, 5 and 6). *A. judaica* was the second most stable species, as it is situated in the fifth level of constancy (V) in two of the six groups (2 and 3). *Z. spinosa* was one of the most distinctive species since it was found in the fourth level of stability (IV) in three consecutive groups (2, 3 and 4), although not belonging to the fifth level of constancy.

ANOVA analysis showed that the soil factors that affect the distribution of the different groups in the sites and indicators plants of the different vegetation groups of the sites into five groups 1, 2, 3, 4, and 5, which also have significant differences as follows: EC, TSD < Cl, Mg, OC and Na. These results followed what was proved in previous studies by (Marie, 2006; El-Gazzar et al., 2007; Marie et al., 2016; El Khulyand Ramadan, 2017).

Conclusion

Finally: The research deals with inventorying the plants of Southwest Sinai through the following: The old coastal road and the new road established by the Egyptian state to be a wonderful road for travel, in which plants were not confined before. Also, the hot spot here is the site east of the city of Abu Zenima, on a very far road from the main road, so the recommendation here is to continue beyond the east of Abu Zenima in the future. By inventorying plants, new species may be recorded that have not been recorded before.

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