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Vegetation Composition and Ecological Gradients in Saint Katherine Mountain, South Sinai, Egypt

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Abstract: A case study was conducted to mountainous ecosystems in Saint Katherine Mountain, the highest peak in Egypt (2641m a.s.l.), lies in the center of the triangular mass of southern Sinai. The main aim of this study was to examine the spatial pattern of vegetation composition and the relationship between vegetation composition and environmental factors on Saint Catherine mountain. Vegetation sampling was carried out using 45 stands distributed on Saint Catherine Mountain. The environmental data included elevation, slope degree and exposure. Analysis of data involved two steps: classification (using TWINSPAN) and ordination (using CANOCO). Ten vegetation groups are obtained with the dominant species as follow: (1) *Cynodon dactylon*, (2) *Stachys aegyptiaca*, (3) *Achillea fragrantissima*, (4) *Echinops spinosus*, (5) *Launaea spinosa* (6) *Bufonia multiceps,* (7) *Tanacetum sinaicum*, (8) *Tanacetum sinaicum*, (9) *Seriphidium herba-album* and (10) *Paracaryum intermedium*. Two vectors of ordination scores produced by detrended correspondence analysis (DCA) and canonical correspondence analysis (CCA) are obtained. The second step involved relating the ordination scores of species to environmental parameters by correlation analysis.

Key words: Floristic composition · Ecological gradient · Saint Katherine Mountain · South Sinai

INTRODUCTION

Floristically, Sinai contains nearly 900 species and 250-300 associations [1]. As a floristic region it is part of the Saharo-Arabian territory with Saharo-Arabian, Irano-Turanian, Mediterranean and Sudanian elements [1, 2]. The southern part of Sinai (including Saint Catherine Mountain) represents a great pool of endemism [3, 4]. The estimated number of endemic species in Sinai is 28 which constitutes about 3.2% of its total flora [1]. The high mountains support mainly Irano-Turanian steppe vegetation dominated by *Artemisia judica*, *Tanacetum sinaicum* and *Gymnocarpos decandrus*. Saint Katherine Mountain, the highest peak in Egypt (2641m a.s.l.), lies in the center of the triangular mass of southern Sinai. It has three peaks of black volcanic rock that contrasts strongly with the surrounding rocks and contains two main deep gorges, Shaqq Musa and Wadi Garagneia. Katherine pluton forms a part of highly rugged mountains with acid plutonic and volcanic rocks belonging to the Precambrian basement complex of the southern part of Sinai Peninsula. This mountain has four main landform types; slopes, terraces, gorges and ridges. The mountain is dissected by faults and joints which play an important role in the movement of ground water [5]. Mount Katherine is considered as a centre of endemism [6]. The endemic species that are growing in this area represents 35% of the total number of endemic species present in Sinai. In particular, disturbances deriving from geomorphological processes, at various spatial and temporal scales, seem to control species distribution [7]. Moreover, environmental heterogeneity and disturbances

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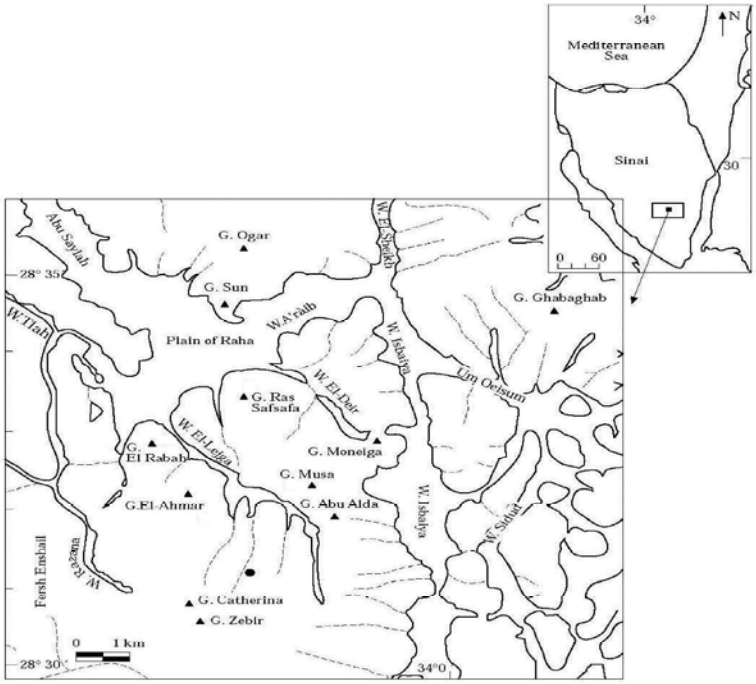

Map 1: Map showing the main locations of the present study in Saint Catherine area (●) and mountain tops (▲) (Gebel = G). Dashed lines indicate drainage into wadis (W).

influence plant species diversity patterns [8]. There is a general agreement that climate changes could play a major role in modifying species distribution in mountain areas controlling disturbance effects upon vegetation. In Sinai, several studies have provided qualitative assessments of the distribution of plant species and associations in relation to the physiographic factors in different areas of the peninsula [2, 9, 10, 11].

The aim of this paper is to examine the spatial pattern of floristic composition at species and community levels and to clarify the relationship between floristic composition and environmental factors. The primary questions were: How do species richness and species composition change along the altitudinal gradient? And is there any relationship between the species richness and the vegetation types and their distribution?

Study Area: The research area is on Saint Katherine Mountain area (28.518911°N 33.959451°E) (Maps 1). The study period was throughout March 2011 to March 2012. Mount saint Katherine is one of the richest and highly diverse in its flora due to its sharp variation in the altitude, soil characteristic and geomorphological formations. This mountain consists of a group of huge, volcanic mountains overlapped with each other and forming the two main high peaks (Abu Rumail and Katherine). Mt. Katherine supports more than 130 species growing mainly in gorge and slope habitats with vegetation cover varying generally between 20-30 %.

MATERIALS AND METHODS

Vegetation Survey: Major vegetation communities were sampled using the quadrate transects method. Transects are distributed evenly across the entire site so all plants may be sampled. When transect are used, the size should reflect the vegetation type. There is a close relationship between diversity and area. Sampling sites were selected systematic-random in the different habitats to cover all micro-habitat, in each site A 25-m transect rope was established along a micro-habitat that contained some vegetation and five quadrates, each 5 x 5 m ($25m^2$), were placed along its length on alternating sides of the rope. Habitat types were designated as following: Wadi beds, slopes, terraces, gorge and runnels. The sum of all three relative values of density, frequency and abundance with value of 300 is scored against the name of every species to express its importance value index (I.V.I.).

Floristic Survey: The floristic survey aimed to record the distribution gradient of the vascular plant species along the altitudinal gradient as completely as possible. This can be done in a series of transects from the base of the mountain till its summit. The botanical nomenclature follows local floristic workers [12-17].

Data Analysis: Vegetation and related environmental factors were analyzed using ordination techniques. Classification [18] or ordination [19] is two possible means to obtain results from multivariate data analysis. A direct ordination method was used to enable us to testing the environmental variables collected for each releve (statement). The analyses were conducted using CAP and Canoco program (Version 4.5) [20, 21]. Detrended Correspondence Analysis (DCA) was used to detect the length of the environmental gradient. After DCA, Canonical Correspondence Analysis (CCA) was applied because the data set was relatively heterogeneous and therefore, the length of ordination axes in DCA was relatively long [22]. Clustering methods were used to determine the patterns underlying species distribution and how plant communities may delineate habitat types in the study area. Two Way Indicator Species Analysis [23] was used for this purpose.

RESULTS

Floristic Patterns: Forty five stands and ninety nine quadrates were sampled to represent the floristic patterns along Saint Catherine Mountain. The total no. of identified species in this work was 130 species belongs to 38 families (see appendix). At the family level, Compositae has the highest contribution to the total species (21species = 15.9 %), followed by Labiateae (13 species = 9.8%), Leguminoseae (10 species = 7.6%), Gramineae (9 species = 6.8%), Schrophulariaceae and Cruciferae (each comprises 8 species = 6.1%), Caryophyllaceae (6 species = 4.5%), Boraginaceae (4 species = 3%); Capparaceae, Papaveraceae, Polygalaceae, Resedaceae, Rosaceae, Solanaceae, Umbellifera and Zygophyllaceae (each comprises 3 species = 2.3 %) (Fig. 1). At the species level and from vegetation survey, The Important Value Index for everyone species in all stands aggregated then we found that, *Tanacetum sinaicum* has the highest IVI (1413.94 = 10.5 %), followed by *Seriphidium herba-album* (1076.1= 8%), *Paracaryum intermedium* (879.54 = 6.5%), *Echinops spinosus* (631.94 = 4.7%), *Teucrium polium* (558.23= 4.1%), *Paracaryum rugulosum* (459.7 = 3.4%), *Phlomis aurea* (448.14 = 3.3%), *Alkanna orientalis* (403.05 = 3%), *Astragalus cretaceous* (370 = 2.7%), *Bufonia multiceps* and *Zilla spinosa* (each comprises 2.5%), *Nepeta septemcrenata* (285.15 = 2.1%), *Ballota undulate* (274.73 = 2%); *Origanum syriacum* and *Launaea spinosa* (each comprises 1.7%), *Primula boveana* (200.6 = 1.5%).

Classification of Plant Community Types: The application of TWINSPAN classification technique on the floristic composition of the 45 naturalized stands led to classify them into 15 vegetation groups at level 6, 13 at level 5 and 10 at level 4 (Fig. 2). Segregation between 10 groups along DCA axes 1 and 2 indicated in Fig. 3.

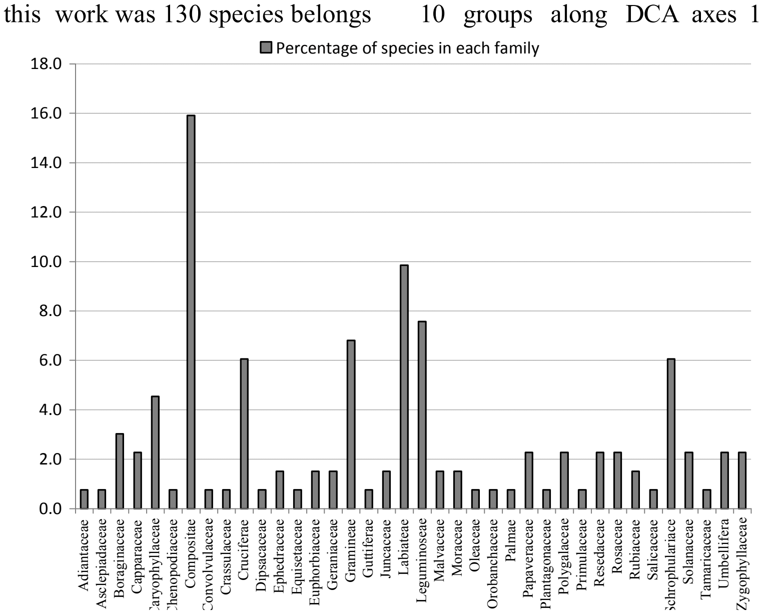

Fig. 1: Family representation of the species recording in vegetation and floristic survey in Saint Katherine Mountain.

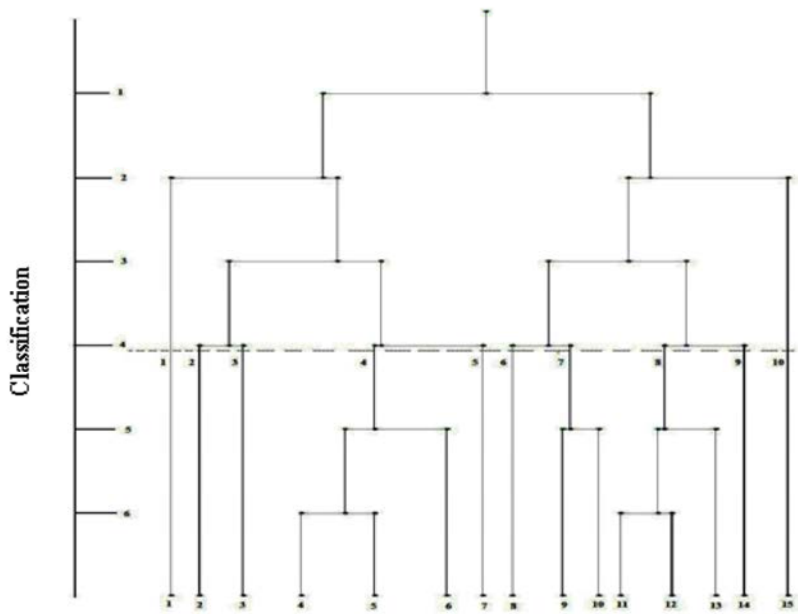

Fig. 2: Dendogram resulting from the Two-Way Indicator Species Analysis (TWINSPAN) of 45 Stands (Vegetation survey) in Saint Katherine Mountain, The 15 vegetation groups at level 6 and the 10 vegetation groups at level 4 are indicated.

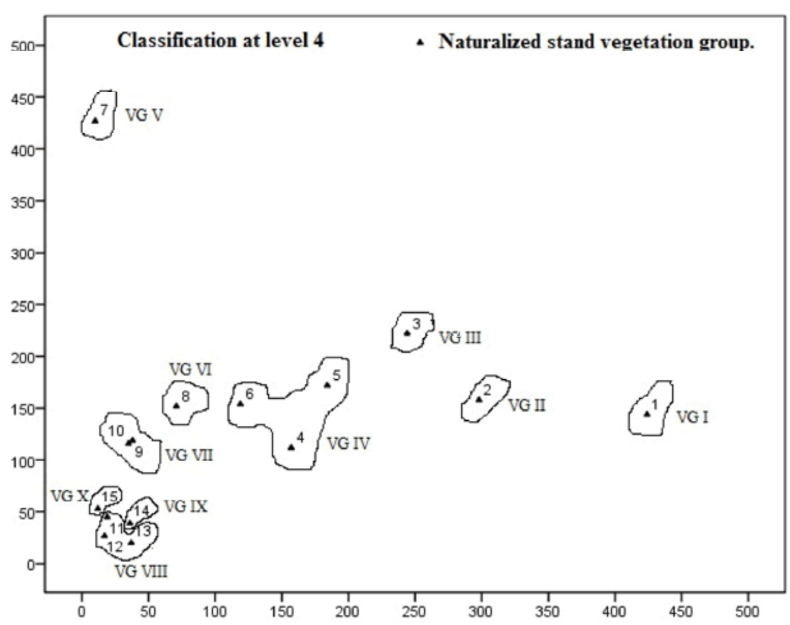

Fig. 3: Cluster centroids of the 14 vegetation groups (VG) of 45 Stands (Vegetation survey) in Saint Katherine Mountain, The 15 vegetation groups at level 6 and the 10 vegetation groups at level 4 are indicated.

The main characteristics of the 10 vegetation groups identified at level 4 of TWINSPAN are indicated in Table 1. The means of the soil characteristics of the 10 vegetation groups identified at level 4 of TWINSPAN is indicated in Table 2.

Spatial Variation of Vegetation Types in Relation to the Environmental Factors: DCA and CCA ordination were used to verify relationships between species and environment in the study area. The DCA ordination revealed that the first gradient is by far the longest one,

Table 1: Characteristics of the 10 vegetation groups identified at level 4 of TWINSPAN on the 45 naturalized stands in Saint Katherine Mountain.

VG	No. of stands	P% of stands	No. of species	P% of species	Dominant species
1	2	4.4	20	19.42	*Cynodon dactylon*
2	4	8.9	41	39.81	*Stachys aegyptiaca*
3	2	4.4	25	24.27	*Achillea fragrantissima*
4	14	22.2	56	54.37	*Echinops spinosus*
5	1	2.2	20	19.42	*Launaea spinosa*
6	3	6.7	26	25.24	*Bufonia multiceps*
7	5	11.1	30	29.13	*Tanacetum sinaicum*
8	8	17.8	30	29.13	*Tanacetum sinaicum*
9	3	6.7	14	13.59	*Seriphidium herba-album*
10	3	6.7	20	19.42	*Paracaryum intermedium*

Table 2: Mean of soil characteristics of the 10 vegetation groups (1-10) derived after the application of TWINSPAN on the 45 naturalized stands in Saint Katherine Mountain.

VG	1	2	3	4	5	6	7	8	9	10	F	Sig.
pH	7.9	8.0	8.2	8.2	7.7	8.2	8.2	8.1	8.2	8.3	4.296	.000
EC (µs/cm)	175.0	105.6	106.2	107.4	317.5	90.6	59.8	89.5	171.9	78.3	7.051	.000
T.D.S (ppm)	361.8	217.5	218.8	221.3	658.3	186.3	122.3	184.0	355.3	160.6	7.053	.000
water content	0.4	0.7	16.6	0.7	0.3	0.7	1.0	0.8	0.6	0.3	14.226	.000
OM %	5.3	5.1	6.7	6.1	6.0	4.6	5.0	6.4	5.6	5.0	1.652	.108
$CaCO_3$%	23.3	20.1	22.3	22.1	19.3	22.1	17.0	14.7	17.5	23.6	6.665	.000
Ca^{++} (meq/L)	20.3	21.3	16.3	19.7	15.0	18.3	14.5	15.8	26.7	12.5	2.416	.015
Mg^{++} (meq/L)	12.1	9.9	16.1	9.4	47.4	7.1	7.0	8.8	5.9	12.4	16.364	.000
Na^{+} (ppm)	24.1	23.5	18.5	40.7	43.2	19.3	52.7	48.8	28.8	28.4	1.689	.098
K^{+} (ppm)	26.6	33.0	27.4	47.3	24.3	27.2	35.6	52.6	31.0	63.5	2.901	.004
HCO_3^{-} (meq/L)	13.5	12.3	13.5	10.4	22.0	9.5	8.8	7.6	9.6	9.5	14.079	.000
Cl^{-} (meq/L)	13.0	16.8	14.0	14.2	19.6	13.3	13.0	13.8	15.4	12.8	4.420	.000
SO_4^{--} (meq/l)	75.0	84.8	62.5	60.5	112.5	59.5	50.7	57.8	70.1	54.5	6.216	.000

explaining about 9.8 % of the total species variability, whereas the second and higher axes is explained much less. Also, the second axis is very well correlated with the environmental data (r = 0.845) and the correlation for the other axis is considerably lower. All this suggests that the whole data set is governed by a single dominant gradient. The sum of all canonical eigenvalues in the printout corresponds to the sum of all canonical eigenvalues in the corresponding canonical analysis. The percentage variance of the species-environment relationship values represents percentages of this value. The number of axis scores calculated for a species–environmental variable bi-plot is restricted in a DCA, by default, to two. This is why the explained variability for the third and fourth axis is shown as 0. The projection of environmental variables reveals that the first axis is negatively correlated with soil pH gradient, with the increasing concentration of soil cations (Ca, K and Na) and also with increasing concentration of SO_4 and also with increasing concentration of total dissolved salts, with electrical conductivity and positively with the increasing concentration of cation (Mg) and soil organic matter, altitudinal gradient, with the increasing concentration of anions (HCO_3 and Cl_2) and also with $CaCO_3$ gradient. The positions of arrows for environmental variables suggest that there is a group of variables that are mutually highly positively correlated (Exposure, organic matter, SO_4, Cl_2 and $CaCO_3$) and negatively correlated with (Alt, pH, Na, K). A closer inspection of the correlation matrix in the CANOCO Log View shows that the variables are indeed correlated, but in some cases the correlation is not very great. The correlation matrix also confirms that the correlation of all the measured variables with the second axis is rather weak.

Now we can continue with the direct (constrained) ordinations. While in DCA we first extract the axes of maximum variation in species composition and only then fit the environmental variables, now we directly extract the variation that is explainable by the measured environmental variables. A Monte Carlo permutation test suggested that both the test on the first axis is not significant ($P = 0.312$) and the test on all axes (on the trace) are significant ($P = 0.02$ with 499 permutations, which is the maximum under the given number of permutations). However, the F value is much higher for the test on the first axis ($F = 1.831$) than for the test on the trace ($F = 1.279$) (Table 3).

Table 3: Summary of Monte Carlo test.

Test of significance of first canonical axis: eigenvalue = 0.450	
	F-ratio = 1.831 P-value = 0.3120
Test of significance of all canonical axes : Trace = 3.164	
	F-ratio = 1.279 P-value = 0.0200
(499 permutations under reduced model)	

This pattern also appears in the Summary table, where the first axis explains more than the second, third and fourth axes do together.

Table 4: Environmental parameters used in the CCA and their eigenvalues

Axes	1	2	3	4	Total inertia
Eigenvalues	0.450	0.431	0.305	0.273	7.092
Species-environment correlations	0.913	0.901	0.909	0.907	--
Cumulative percentage variance					
of species data	6.3	12.4	16.7	20.6	--
of species-environment relation	14.2	27.9	37.5	46.1	--
Sum of all eigenvalues	--	--	--	--	7.092
Sum of all canonical eigenvalues	--	--	--	--	3.164

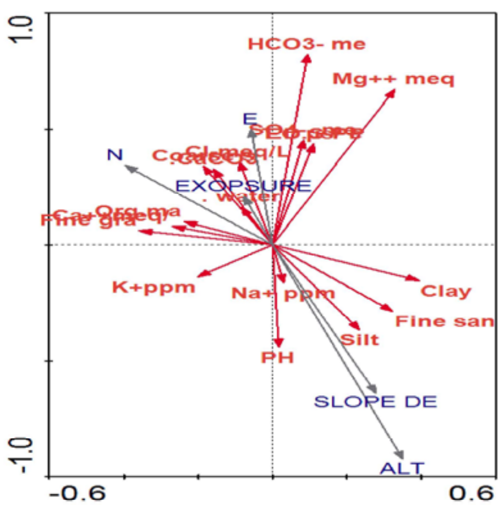

Fig. 4: The Topology - environmental variables bi-plot of CCA with environmental variables selected by the forward selection procedure

Comparing this summary with that from the DCA used before, one will notice that the percentage variance explained by the first axis is very close to that explained by the first axis in the unconstrained DCA (6.3 in comparison with 9.8) and also that the species-environment correlation is only slightly higher. This suggests that the measured environmental variables are those responsible for species composition variation. And indeed, in the ordination diagrams of DCA and CCA (not shown here), the first axis of CCA is very similar (both for the species and for the sample scores) to the first axis of DCA. However, the second axes differ: the CCA shows a remarkable arch effect-the quadratic dependence of the second axis on the first one.

DISCUSSION

Floristic Patterns and Ecological Gradients: It has long been established that patterns in vegetation are correlated with gradients in environmental parameters [24, 25]. Multivariate analysis including classification and ordination can provide more detailed and comprehensive information on the patterns in vegetation and the response of plant species to the underlying gradients [26, 27]. In Saint Katherine Mountain, the plant species distribution and hence the patterns in vegetation are mainly influenced by the gradients in terrain variables such as altitude, slope and distance from the riverbanks. Vegetation in mountainous regions responds to small-scale variation in terrain like slope which affect microclimatic conditions such as temperature and soil moisture [28]. Temperature and moisture are the major microclimatic conditions affecting plant species distribution. Altitude is an important terrain variable, since it affects atmospheric pressure, moisture and temperature, which in turn influence the growth and development of plants and the patterns in vegetation distribution [29]. Both DCA and CCA assess the soil-vegetation relationships. The results of DCA analysis reveals that the first axis is negatively correlated with soil pH gradient, with the increasing concentration of cations (Ca, K and Na), SO_4, total dissolved salts, as well as with electrical conductivity and positively with the increasing concentration of cation (Mg) and soil organic matter, altitudinal gradient, with the increasing concentration of anions (HCO_3 and Cl_2) and also with $CaCO_3$ gradient. The positions of arrows for environmental variables suggest that there is a group of variables that are mutually highly positively correlated (exposure, soil organic matter, SO_4, Cl_2 and $CaCO_3$) and negatively correlated with Alt, pH, Na, K. A closer inspection of the correlation matrix in the CANOCO Log View shows that the variables are indeed correlated, but in some cases the correlation is not very great. Both ordination techniques clearly indicated that altitude, slope degree and exposure are the most important factors for the distribution of the vegetation pattern in Saint Katherine Mountain. Slope also has a strong effect on soil chemical properties, since the soils on steeper slopes are influenced by bedrock and tend to be less moist and less acidic [30]. Hence, slope strongly affects the composition and structure of Saint Katherine Mountain vegetation. The organic matter content plays an important role as a key element in soil fertility, as shown for other desert ecosystems in Egypt by Sharaf El Din and Shaltout [31] and Abd El-Ghani [32, 33] and in Saudi Arabia by El-Demerdash *et al*. [34].

The southern part of Sinai is relatively floristically rich compared to the rest of Sinai. In agreement with Danin [2, 35] the nature of the soil surface is one of the most important factors influencing the floristic richness of the landforms along with the climatic variations due to orographic influences. Narrow *wadis* (including springs) and gorges support the richest assemblage of plants followed by the high-elevation slopes and terraces, respectively. The Saint Catherine area is characterized by large outcrops of smooth-faced rocks which function as a refuge for more mesophilic plants [2]. In agreement with Moustafa and Klopatek [36] the flora of the Saint Catherine area is composed of a 'skeleton' of very common species (*Seriphidium herba-alba, Gymnocarpos decandrum, Artemisia judaica, Tanacetum sinaicum, Achillea fragrantissima* and *Fagonia mollis*) that cover most of the area and dominate many of the sub-shrub communities. Also, many rare species have a limited distribution in the Saint Catherine area. There are true rare species that are local endemics (*Primula boveana* and *Rosa arabica*) and the species where scarcity is brought on by overgrazing and overcutting. The Saint Catherine Mountains are a centre of endemism [3, 4, 6]. Danin [1] estimated 28 endemic species, 3•2% of its total flora. More than 50% of these species are found in the present study area growing in the floristically rich landform types (gorges, springs and high terraces) that have a wetter microclimate than other habitats of the Sinai. Previous work by Danin [1, 35, 37], Moustafa [6, 38] and Boulos and Gibali [39] indicated that the Saint Catherine flora area is represented mainly by Irano–Turanian elements. Most of the endemic species in Sinai are confined to the mountain region [40]. Eleven threatened and endemic species and four near endemic Based on the list of Boulos [16] of rare species in southern Sinai and the data of the present study, more than 61 rare species are threatened due to overcutting and livestock grazing. The results of these disturbances are: (1) disappearance of palatable plant species, rare species and endemic species; (2) wadis and ridge habitats being dominated by pure communities of plants such as *Artemisia judaica, Anabasis articulata* and *Fagonia mollis*; (3) changes in the soil surface and moisture retain ability and (4) reduction of the total plant cover that protects the soil surface, slows down erosion and stabilizes the relief. It is noticed, in certain plant communities, that the most common species is the least grazed.

Spatial distribution of plant species and communities over a small geographic area in desert ecosystems is related to heterogeneous topography and landform pattern [41]. The heterogeneity of local topography, edaphic factors, microclimatic conditions lead to variation of the distributional behavior of the plant associations of the study area. In terms of classification, the vegetation that characterizes the study area can be divided into five vegetation groups. The importance of the study area from a phyto-geographical point of view may be due to its position on the Sinai Peninsula, which is located in the center of the triangular mass of southern Sinai. This may reflect that Mount Saint Katherine is one of the richest and highly diverse in its flora. The application of TWINSPAN classification technique on the floristic composition of the 45 naturalized stands led to classify them into 15 vegetation groups at level 6, 13 at level 5 and 10 at level 4 (Fig. 2). Segregation between 10 groups along DCA axes 1 and 2 indicated in Fig.3. The main characteristics of the 10 vegetation groups identified at level 4 of TWINSPAN are indicated in Table 1. As to the species-environment relationship, there are mainly two different opinions. Several authors have found really poor correlations among environmental characteristics and vegetation in the western United States because many species have such wide ecological amplitude [42, 43]. However, our results show that silt and clay content, organic matter and electrical conductivity are mainly related to vegetation distribution. In addition, Ayyad [44] determined that edaphic factors provided the primary explanation for describing the distribution of plant communities in the Western Desert of Egypt. Soil texture controls dynamics of soil organic matter in many simulation models or organic matter decomposition and formation [45-47] and influences infiltration and moisture retention and the availability of water and nutrients to plants [48]. Under the conditions of low and irregular rainfall which prevail in the study area, local topography is one of the overriding factors controlling sedimentation and water redistribution within the local landscape [49]. Therefore, topographic variations usually translate into high habitat heterogeneity and corresponding species diversity [50].

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Appendix: recorded species during the study:

Family	Plant Name	Common Name Arabic
Adiantaceae	*Adiantum capillus-veneris* L.	كزبرة البير, شعر البنات
Asclepiadaceae	*Asclepias sinaica* (Boiss.) Muschl.	حرجل بري
Boraginaceae	*Alkanna orientalis* (L.) Boiss.	اللبيد
	Anchusa milleri Spring	كحله
	Paracaryum intermedium (Fresen.) Lipsky.	سليسله ، أملبيد ، غبيشة
	Paracaryum rugulosum (DC.) Bosis	أم لبيد
Capparaceae	*Dianthus sinaicus* Boiss.	صمه
	Capparis sinaica Veill.	لصف - ورد الجبل
	Capparis spinosa L.	
Caryophyllaceae	*Arenaria deflexa* Decne.	لبخ
	Bufonia multiceps Decne	عدمه
	Gymnocarpos decandrus Forssk	جرد
	Silene leucophylla Boiss.	
	Silene linearis Decne.	وسبي , عبيش , وصبية
	Silene schimperiana Boiss.	لصيق
Chenopodiaceae	*Chenopodium murale* L.	لسان الطير، أبو عفين
Compositae	*Achillea fragrantissima* (Forssk.) Sch. Bip.	قيصوم
	Artemisia judaica L.	بعثران
	Iphiona mucronata (Forssk.) Asch. and Schweinf.	ظفره ، دفيرة
	Iphiona scabra (Forssk.) Asch. and Schweinf.	دفرة الحمار
	Launaea nudicaulis (L.) Hook. F.	حوذان
	Launaea spinosa (Forssk.) Sch. Bip. Ex Kuntze.	كباث
	Phagnalon nitidum Fresen.	بدن ، خنانة نعجة
	Scariola orientalis (Boiss.) Sojak.	يحكيس , جخيص
	Scorzonera schweinforthii Boiss.	ذبهليل
	Seriphidium herba-album (Asso) Sojak.	شيح
	Tanacetum sinaicum (fresen.) Delile ex Bremer and humphries.	مر
	Centaurea eryngioides Lam.	--
	Centaurea scoparia Sieber ex Spreng.	برقان
	Chiliadenus montanus (Vahl) Brullo.	هنيده، نهيدة
	Conyza bonariensis (L.) Cronquist.	حشيش الجبل
	Conyza bovie	--
	Echinops spinosus L.	--
	Onopordum ambiguum Fresen.	--
	Pulicaria incisa (Lam.) DC.	ربل , شاي الجبل , شاي جبل
	Pulicaria undulata (L.) C. A. Mey.	دثاث , دثداث , سبد
	Reichardia picroides (L.) Roth.	مرار , حوا

Appendix: Continue

Family	Plant Name	Common Name Arabic
Convolvulaceae	*Convolvulus arvensis* L.	عليق
Crassulaceae	*Umbilicus horizontalis* (Guss.) DC.	--
Cruceferae	*Farsetia aegyptia* Turra	جربه ، جريبي
	Carrichtera annua (L.) DC.	قليقلة
	Diplotaxis harra. (Forssk.) Boiss	حاره
	Matthiola arabica Boiss.	خمخم
	Matthiola longipetala	شقارة
	Sisymbrium erysimoides	السليح , سليخ
	Sisymbrium irio L.	السليح , فجل الجمل
	Zilla spinosa (L.) Prrantl in Engl. and Prantl.	زله - سلة - بسلة
Dipsacaceae	*Pterocephalus sanctus* Decne.	علجه , مجلينة , عسيل
Ephedraceae	*Ephedra ciliata* Fischer and C. A. Mey	--
	Ephedra pachyclada Boiss.	علده
Equisetaceae	*Equisetum ramosissimum* Desf	حجينه
Euphorbaiceae	*Euphorbia obovata*	لبينه
	Andrachne aspera Spreng.	عود العقرب, عين أم سليمان
Geraniaceae	*Eremobium aegyptiacum*	--
	Erodium ciutarium (L.) L'Her. in Aiton.	--
Gramineae	*Aristida adscensionis* L.	سبل أبو الحصين
	Bromus pectinatus Thunb.	سقسوف، ياداب
	Cynodon dactylon (L.) Pers.	مديد - نجيلا
	Phragmites australis (Cav.) Trin. ex Steud.	بوص ، حجنة ، غاب
	Stipa parviflora Desf.	ابو الحصين سفسوف - سبل
	Stipagrostis ciliata (Desf.) de Winter.	حميرة - نصى
	Stipia sp	--
Guttiferae	*Hypericum sinaicum* Boiss.	ركيح ، لبخ ، شاي الجبل
Juncaceae	*Juncus acutus* L.	سمارمر
	Juncus rigidus Desf.	حصر ،سمار مر سمار ، سمار
Labiatae	*Ajuga chamaepitys* (L.) Schreb.	--
	Ballota saxatilis C. Presl.	--
	Ballota undulata (Fresen.) Benth.	الغاصة , زفرة
	Lavandula pubescens Decne.	عطان ، عطن
	Thymus decussatus Benth.	زعتران - زعيتر
	Mentha longifolia (L.) Huds.	حبك ، حبق
	Nepeta septemcrenata Benth.	زيتيه ، مسيسة
	Origanum syriacum (Boiss.) Greater and Burdet.	زعتر ، بردقوش
	Phlomis aurea Decne.	عورور , زهيرة
	Salvia spinosa L.	ذانون , ذان الحمار , شجرة الغزال
	Teucrium leucocladum Boiss.	--
	Teucrium polium L.	جعدة
	Stachys aegyptiaca Pers.	رغل - جرطم - رغات

Appendix: Continue

Family	Plant Name	Common Name Arabic
Leguminosae	*Alhagi graecorum* Boiss.	عقول
	Astragalus asterias (Butt.) Greuter.	--
	Astragalus cretaceus Boiss. and Kotschy	
	Astragalus dactylocarpus Boiss.	
	Astragalus sieberi DC.	شوك النعاج, أصابع العروس
	Astragalus spinosus (Forssk.) Muschl.	
	Astragalus tribuloides Delile.	عدرس, بيض الجمل
	Astragalus sp.	--
	Bituminaria bituminosa (L.) C. H. Stirt.	ذوينات الفار
	Lotononis platycarpa (Viv.) Pic. Serm.	عدرس ، عشب ، عشوب
	Trigonella stellata Forssk.	جرجس - درهمية
Malvaceae	*Alcea rosea* L.	خطمية
	Malva parviflora L.	رقمة ، خبيزة
	Ficus carica L.	تين
	Ficus palmata Forssk.	حماط ، تين البر
Oleaceae	*Olea europea*	زيتون
Orobanchaceae	*Cistanche tubulosa* (Schenk) Hook.f.	--
Palmae	*Phoenix dactylifera* L.	البلح نخلة , نخل
Papaveraceae	*Glaucium arabicum* Fresen.	النعمان
	Papaver decaisnei Elkan.	قريعية
	Papaver rhoeas L.	زغليل ديدهان ،
Plantagonaceae	*Plantago sinaica* (Barneoud) Decne.	لسان الحمل , رعية البدن , مديهنة
Polygalaceae	*Polygala sinaica* Botsch.	هيكل , صر
	Atraphaxis spinosa L.	سراس , سرا
	Rumex vesicarius L.	--
Primulaceae	*Primula boveana* Decn. and Duby.	خس الجبل - لباخ , سحسيح
Resedaceae	*Caylusea hexagyna* (Forssk.) M. L. Green.	دنابه، دنبان
	Ochradenus baccatus Delile.	قرضي
	Reseda muricata C. Presl.	خزامة
Rosaceae	*Cotoneaster orbicularis* Schltdl.	شوحط
	Crataegus x *sinaica* Boiss.	زعرور
	Rosa arabica Crep.	الورد البري
Rubiaceae	*Crucianella ciliata* Lam.	عشد، عشب
	Galium sinaicum (Delile ex Decne.) Boiss.	عثمه
Salicaceae	*Populus* sp.	--
Schrophulariaceae	*Scrophularia deserti* Delile.	--
	Scrophularia libanotica Boiss.	--
	Anarrhinum pubescens Fresen.	أرفيجه, رفيعة
	Kickxia aegyptiaca (L.) N?belek.	مجينينة عشب الديب ،
	Verbascum decaisneanum Kuntze	--
	Verbascum sinaiticum Benth.	خرماع

Appendix: Continue

Family	Plant Name	Common Name Arabic
	Veronica anagalis –aquatica L.,	عشب الميه
Solanaceae	*Hyoscyamus pusillus* L.	صوفيره
	Lycium shawii	عوسج
	Solanum nigrum L.	عنب الذئب , عنب الديب
Tamaricaceae	*Reaumuria hirtella* Jaub. and Spach.	عدبه , مليح
Umbellifera	*Deverra tortuosa* L.	زجوح - عليجان - قصوخ
	Deverra triradiata Poir.	--
	Pycnocycla tomentosa Decne.	سي سبان
Zygophyllaceae	*Fagonia arabica*	حلوة الجمل ، ورقة ، شبرق
	Fagonia mollis Delile.	الشكاعة ، ورقة
	Peganum harmala L.	حرملان ، حرمل