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Vegetation Characteristics and Environmental Gradients of Musa Mountain in Saint Katherine Protectorate, South Sinai, Egypt

[1]Om Mohamed A. Khafagi, [2]Mohamed M. Moursy, [2]Hany A. Marghany and [1]Asmaa A. Zaghloul

[1]Botany and Microbiology Department, Faculty of Science (Girls), Al-Azhar University, Cairo, Egypt

[2]Botany and Microbiology Department, Faculty of Science (Boys), Al-Azhar University, Cairo, Egypt

*** Corresponding author: asmaazaghloul2828.2@gmail.com**

Abstract:

The present investigation was conducted to assess the effect of environmental gradients on vegetation characteristics, diversity and geographical distribution patterns in five different locations of mountain Musa, Saint Katherine protectorate area (SKP), southern Sinai, Egypt. Vegetation parameters and soil samples were collected from 25 stands distributed in five distinct locations at different elevations (Wadi Al-Far'aa at 1821-1847 meter above sea level, Farsh Al-Shoeibi at 1950-1984 m a.s.l., Farsh Al-Loza at 1985-2000 m a.s.l., Kaneset Al-Hammar at 2001-2023 m a.s.l. and Farsh Eilia at 2024-2031 m a.s.l.) present in Musa mountain area. Five quadrats (5x 5 m each) were set at each stand. Relative abundance, population density and frequency and the relative importance value and the relative importance index (IVI) were calculated for each species. Wadi Al-Far'aa had the lowest plant species density, frequency, abundance and (I.V.I.). It recorded the highest number of plant species (42) and diversity indices (Simpson's index, Shannon–Weiner's index and Brillouin's index). Farsh Al-Loza had the highest density, frequency, abundance and I.V.I., but had the lowest values of both diversity indices and number of families (8). The highest number of families (18) was recorded in farsh Eilia. 62 plant species from 22 families were recorded in this study. *Seriphidium herba-album* (Asso) Sojak is the most dominant plant species and Compositae is the most common family. The environmental gradients including soil chemical properties, topographic variables (slope, elevation and aspect) and climatic factors (temperature, rainfall, and air humidity are the major influencing factors causing variation in vegetation distribution and plant community structure.

Key words: Vegetation patterns; environmental gradients; Musa Mountain; Saint Katherine Protectorate area; South Sinai.

1. Introduction

Geographically, Sinai Peninsula is a part of the Saharo-Arabian territory with Saharo-Arabian Irano-Turanian, Mediterranean and Sudanian elements (**Danin, 1986**). The area of the Sinai Peninsula (61,000 km2) is about 6 % of that of Egypt. The Saint Katherine Protectorate (SKP) is situated in the southern part of Sinai and is a part of the upper Sinai massif. It was declared as a national protectorate in 1996, under the support of the Egyptian Environmental Affairs Agency (EEAA). It extends over 4350 km^2 of South Sinai, making it the fourth largest protectorate area in Egypt, between 33°55′ to 34° 30′ and 28° 30′ to 28° 35′ N with an elevation range of 1300-2600 m (a.s.l.) (**Moustafa and Klopatek, 1995**). Musa Mountain is located southeast of St Katherine Mountain, which is considered the third highest peak in SKP (2285m a.s.l.) (**Said, 1990**). The highest percentage (57.1 %) of these endemic species is found in gorge habitat of Saint Katherine Mountain (**Moustafa & Zaghloul, 1996**). **Boulos (1995)** recorded around 1261 species in Sinai. 472 plant species have been recorded as surviving and still occurring in SKP (**Fayed and Shaltout, 2004**), of these 19 species are endemic in SKP and more than 115 are with known medicinal properties used in traditional therapy and remedies. The estimated number of endemic species in Sinai is 28, which constitutes about 3.2 % of its total flora (**Danin, 1986**). These mountains had geologic structures lead to the differentiation of many habitats; such as gorge, farsh, terraces, slope, wadi bed, and runnel; each has its particular environmental conditions, unique landscape and flora that is rich in medicinal, rare and endemic plants (**Omar *et al*., 2012 and Khafagi *et al*., 2013**). A rocky substratum is the general feature of these habitats. Sediments are coarse with or without fine particles (**Migahid *et al*., 1959**). The water sources are: rainfall, surface water, ground water, Rain storms and snow (**Anonymous, 1985**).

Many factors regulate the diversity and distribution of plants in Sinai, such as climatic factors, elevation, slope, aspect, degree of exposure, and the edaphic factors, particularly the available nutrients, and soil moisture content (**Abdou, 1997**). However, anthropogenic influences such as urban expansion, agriculture, overgrazing and overcutting have a strong effect on biodiversity, with at least 61 of the rare species of southern Sinai estimated to be already endangered as a result. Several studies have provided qualitative assessments of the distribution of plant species and associations in relation to the physiographic factors in different areas of Sinai Peninsula (**Abd El-Ghani and Amer, 2003**). It has long been established that patterns in the vegetation are correlated with gradients in environmental parameters (**Smith and Huston, 1989**). Vegetation in mountainous regions responds to small-scale variation in terrain like slope, which affects microclimatic conditions such as temperature and moisture (**Bolstade *et al*., 1998**). Temperature and moisture are the major microclimatic conditions affecting plant species distribution. Slope also has a strong effect on soil chemical properties, since the soils on steeper slope are influenced by bedrock and tend to be less moist and less acidic (**Tewolde, 1986**).

Hence, slope strongly affects the composition and structure of Saint Katherine mountain vegetation. Edaphic factors affect the vegetation distribution and species diversity (**Ayyad, 1976**). The present investigation was conducted to assess the relation between vegetation diversity and characteristics and the environmental gradients in Musa Mountain in Sinai, Egypt. Also, to clarify the most effective environmental factors or gradients on vegetation distribution and species diversity in the different locations in Musa Mountain.

II. Material and Methods

II.1. Study Area

Musa Mountain is the study area of the present study, situated in the southern east of Saint Katherine Mountain, and is located between 28.542558° to 28.542607° North, 33.965059° to 33.97404° east ; with altitude of 1821 to 2031 meter above sea level (m a.s.l) (Map 1). Musa Mountain is one of the richest and highly diverse areas in its flora due to the wide variation in altitude, soil and geomorphological characteristics of the area. Mountain Musa supports more than 62 species growing mainly in locations (**Zahran and Willis, 2009**).

Musa Mountain is the most active tourist area near the city of Saint Katherine. The presence of main vegetation in Musa Mountain occurs at an altitude between 1950 to 2031 m (a.s.l.), in four central areas, respectively from south to north as; Farsh Al-Shoeibi, Farsh Al-Losa, Farsh Kaneset Al-Hammar and Farsh Eilia. Also a few individuals of some species were recorded on relatively low altitude of 1821-1847 m a.s.l., in Wadi Al-Far'aa which is considered as the lower most valleys that receives the flooding water from the upper Kaneset Al-Hammar gully.

II.2. Topographic attributes analysis (Elevation, Slope and Aspect)

Topography is the principal controlling factor in vegetation status and that the type of soils and the amount of rainfall play secondary roles at the scale of hill slopes **(Dawes and Short, 1994)**. Elevation, aspect and slope are the three main topographic factors that control the distribution and patterns of vegetation in mountain areas **(Titshall *et al*., 2000 and Omar *et al*., 2012)**.

The elevation of a geographic location is its height above a fixed reference point, often the mean sea level. A topographical map is the main type of map used to depict elevation, often through use of contour lines. The slope is defined as the ratio of the altitude changes to the horizontal distance between any two points in the line. The aspect generally refers to the horizontal direction to which mountain slope face **(ESRI, 2001)**. In a Geographic Information System (GIS), digital elevation models (DEM) are commonly used to represent the surface (topography) of a place, through a raster (grid) dataset of elevations.

Digital terrain models are another way to represent terrain in GIS **(ESRI, 2001)**. Altitude was recorded at each site using GPS fix recorded in decimal degrees and datum WGS84 using Garmin 12 XL receiver. All data collected from the field will be classified according to elevation in order to detect the effect of elevation **(ESRI, 2001)**.

II.3. Climatic variables

DIVA-GIS is a free computer program for mapping and geographic data analysis a geographic information system (GIS), BIOCLIM is a bioclimatic prediction system which uses surrogate terms (bioclimatic parameters) derived from mean monthly climate estimates, to approximate energy and water balances at a given location **(Abdullah, 2017)**.

II.4. Vegetation Survey

Major vegetation communities were sampled (from the total of 25 stands) using the quadrate - transects method. Transects were distributed evenly across the entire stand so all plants may be sampled. Sampling sites were selected systematic-randomly in the different habitats to cover all points which have vegetation, in each site 25 m transect rope was established along the area that contained some vegetation and five quadrates, 5 x 5 m (25 m^2) each, were placed along its length on alternating sides of the rope. The sum of all three relative values of density, frequency and abundance with value of 300 was scored against the name of every species to express its importance value index (I.V.I.).

II.5. Soil Collection

Three soil samples were collected from each stand from the depth of 0–30 cm. Most of the soil samples were collected from spots very close to an existing plant. Soil texture was determined by using sieves method (**Piper, 1950**), $CaCO_3$ was determined using titration against 1.0 N HCl (**Allen *et al.*, 1976**) and organic matter according to Walkley and Black method (**Black, 1965**). Soil water extracts of 1:5 were prepared for the determination of EC, soil reaction, chlorides, calcium, magnesium, bicarbonates and sulphates (**Allen *et al.*, 1986**).

II.6. Data Analysis

The differences in soil parameters among locations were statistically treated using one-way ANOVA, and the response curves were drawn to assess the relationships between the spatial variations in the estimated soil variables (**SPSS, 2006**). Species richness (α-diversity) Species richness is a simple and easily interpretable indicator of biological diversity (**Peet, 1974**). Species richness (α-diversity) was calculated as the average number of species per stand (**Myers and Bazely, 2003 & Shaltout *et al*. 2003**).

Diversity indices:

1) Shannon's index: $H = -\sum_i \frac{ni}{n} In \frac{ni}{n}$

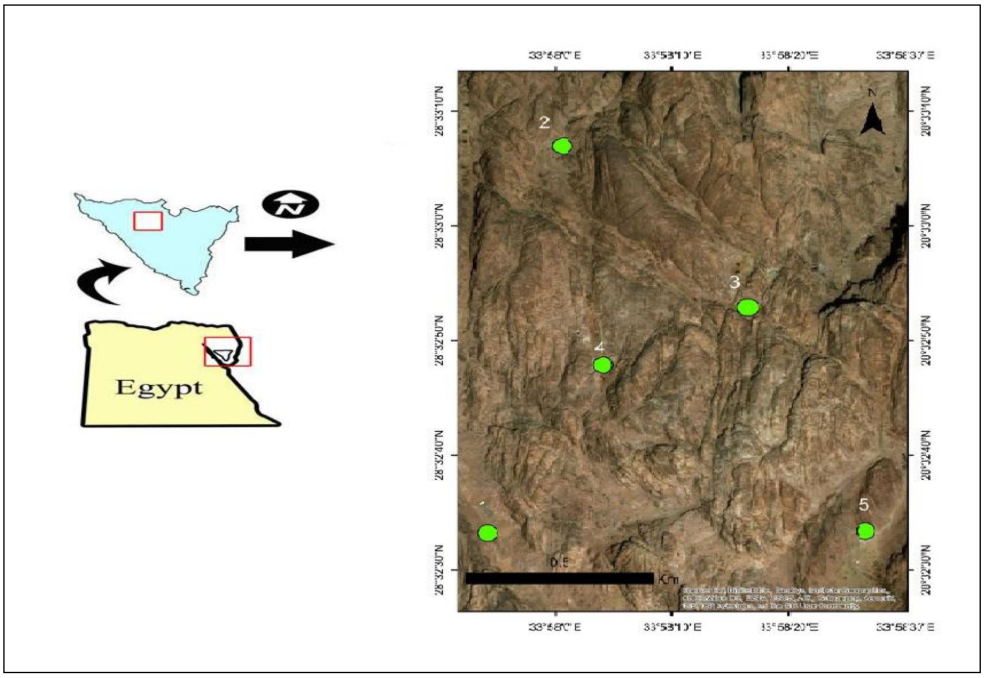
Shannon's index is a diversity index, taking into accounts the number of individuals as well as number of taxa (species). Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals **(Harper, 1999 & Myers and Bazely, 2003).**

2) Brillouin's index: $HB = \frac{\text{In}\,(n!) - \sum_i \text{In}(ni!)}{n}$

Where the number of individuals in species (I) and N is the total number of individuals in the sample **(Harper, 1999**).

3) Simpson's index =1- λ $\lambda = \sum_{i=1}^{S} \frac{ni(ni-1)}{N(N-1)}$

Where ni is the abundance of species i and is an estimate of sample coverage and I(ni) is inherited from Horvitz- Tompson**'s** equation where I(ni)=1 when the event is true i.e. species present in the sample, and I(ni)=0 i.e. one species dominates the community completely **(Myers and Bazely, 2003 & Abdullah, 2013)**.



Map 1. Location map of study area, 1- Wadi Al-Far'aa, 2- Farsh Al-Shoeibi, 3- Farsh Al-Losa, 4- Farsh Kaneset Al-Hammar, 5- Farsh Eilia.

III. Result and Discussion

III. 1. Vegetation description

The results showed that the variation in the vegetation characteristics in the five studied locations. The highest density, frequency, abundance and important value index (I.V.I.) were recorded at farsh Al-Loza (at elevation 1985-2000 m a.s.l.), while the lowest corresponding values were recorded in wadi Al-Far'aa (at elevation 1821-1847 m a.s.l.) (Table 1).

Also the result (in table 1) showed that highest number of families (18) was recorded in farsh Eilia at elevation rank of 2024-2031 m a.s.l., while the lowest number of families (8) was found in farsh Al-Loza at elevation of 1985-2000 m. (a.s.l.). Species number gives an indication of the diversity (or richness) of any community. Wadi Al-Far'aa recorded the highest species richness (42 spp), while farsh Kaneset Al-Hammar showed the lowest species richness (15 spp). Generally, this variation may come from the variation in individual species numbers and the way that species was distribute within the studied locations.

In this study result showed that *Seriphidium herba-album* (Asso) Sojak is the major plant community in the studied stands of farsh Al-Shoeibi, Kaneset Al-Hammar and farsh Eilia. *Tanacetum sinaicum* is the major plant communities in the studied stands of farsh Al-Loza. *Matthiola arabica* is the major plant communities in the studied stands of wadi Al-Far'aa (Table 1).

In order to assess the correlates between community structure and the environmental factors which might affect the community, From the above mentioned results, it could be concluded that the altitudinal gradient is correlated with significant differences in soil chemical characteristics and plant community structure among the five studied locations, and this totally agreed with **Khafagi *et al.* (2013) and Abdullah (2017).**

Table 1. Vegetation data recorded during the study from the different five locations.

Location	**Wadi Al-Far'aa**	**Farsh Al-Shoeibi**	**Farsh Al-Loza**	**Kaneset Al-Hammar**	**Farsh Eilia**
Elevation range	**1821-1847 m (a.s.l.)**	**1984-1950 m (a.s.l.)**	**1985-2000 m (a.s.l.)**	**2001-2023 m (a.s.l.)**	**2024-2031 m (a.s.l.)**
Density	7.18	12.89	36.4	10.55	15.29
Frequency	44.35	51.79	60	50.22	54.47
Abundance	3.26	4.64	9.9	4.38	5.01
I.VI.	51.69	83.26	270.9	71.71	109.24
No. of families	14	10	8	11	18
Sp. Richness	42	23	20	15	23
Main plant community	*Matthiola arabica*	*Seriphidium herba-album* (Asso) Sojak	*Tanacetum sinaicum*	*Seriphidium herba-album*(Asso) Sojak	*Seriphidium herba-album*(Asso) Sojak

III. 2. Soil analysis

Results of soil analysis reveal great variation in the values of average physical and chemical parameters of soil collected from the five locations. Statistical analysis of soil data indicated significant differences in soil chemical properties (such as PH, TDS, EC, $HCO3^-$, $SO4^{--}$, Cl^-, CaCO3, and organic matter, Ca^{++}, Mg^{++}, Na^+ and K^+), among the five locations (Table 2). Wadi Al-Far'aa had the highest content of sand, pH, $HCO3^-$, $SO4^{--}$ and CaCO3 and the lowest value of water content, TDS, EC, organic matter, Mg^{++} , Na^+ and K^+. Farsh Al-Shoeibi had the highest value of water content, silt, EC, organic matter and Na^+ and the lowest contents of clay, $HCO3^-$ and Ca^{++}. Farsh Al-Loza had the highest value of Ca^{++} and the lowest content of sand, EC, $SO4^{--}$, Cl^- and CaCO3. Kaneset Al-Hammar had the highest value of water content, silt, EC, organic matter, Na^+ and K^+ and the lowest content of clay and Ca^{++}. Farsh Eilia had the highest content of clay, TDS, EC, Cl^- and Mg^{++} and the lowest content of silt and PH.

Table 2. Soil Chemical and physical properties of the different locations; One way analysis of variance (ANOVA); significantly different according to LSD = significant at P < 0.05 and non-significant at P > 0.05

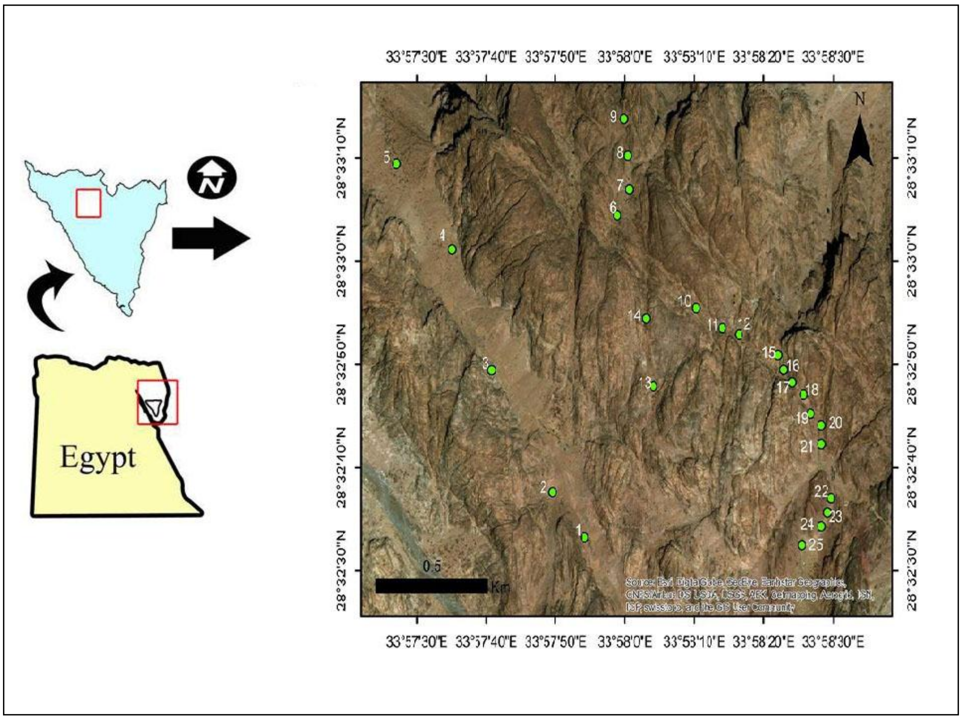
locations		Wadi Al-Far'aa	Farsh Al-Shoeibi	Farsh Al-Loza	Kaneset Al-Hammar	Farsh Eilia	F	Sig.
Altitude mean		±1834	±1967	±1992	±2012	±2027		
Soil physical properties	Water content %	1.1	2.8	1.6	2.8	1.6	0.85	NS
	Sand%	73.3	72.3	71.2	72.3	72.6	0.866	NS
	Silt%	14.6	18.3	16.0	18.3	13.9	0.42	NS
	clay%	12.1	9.4	12.8	9.4	13.4	0.42	NS
Soil chemical properties	pH	8.9	8.7	8.6	8.7	8.4	35.8	***
	TDS (ppm)	72.6	94.4	75.0	94.4	111.0	101.1	***
	EC (µS/cm)	0.1	0.2	0.1	0.2	0.2	101.1	***
	HCO_3^-(meq/L)	5.0	4.0	4.2	4.2	4.5	15.8	***
	SO_4^{--} (meq/L)	45.1	37.7	35.0	35.5	40.3	49.7	***
	Cl^-(meq/L)	31.8	33.1	30.6	33.1	38.6	16.26	***
	$CaCO_3$%	29.2	25.7	25.4	25.7	26.0	11.45	***
	Org. matter%	2.4	5.8	3.2	5.8	3.3	29.75	***
	Ca^{++} (meq/L)	2.6	0.7	3.8	0.7	2.7	8.56	***
	Mg^{++} (meq/L)	9.4	9.1	8.0	9.1	10.3	5.52	***
	Na^+(ppm)	15.8	35.5	16.3	35.5	24.1	101.1	***
	K^+(ppm)	22.0	28.6	22.7	37.7	33.7	101.1	***

Edaphic factors such as soil moisture availability, which is a function of altitude variation, nature of soil surface and soil texture is the most limiting factor in the distribution of plant communities in south Sinai that agree with (**Mostufa and Zaghloul, 1996 & Moustafa and Zayed, 1996**) . In this study sand recorded the highest value followed by silt in studied locations and this agrees with (**Omar, 2013 & Amer, 2013**). In studied location Kaneset Al-Hammar recoded the highest value of sand and the lowest value of silt and this agree with (**Shaltout *et al*., 2015**).

The studied locations in Musa Mountain contain alkaline soil reaction (PH) and this agrees with (**Omar *et al*., 2012; Omar, 2013; Amer, 2013; Abdulla, 2013; Shabana, 2013 and Shaltout *et al*., 2015**).

III. 3. Topographic attributes analysis (Elevation, Slope and Aspect)

The mean of the lowest elevation point in the study area was recorded at wadi Al-Far'aa (1834 m a.s.l.) and mean of the highest was recorded at farsh Eilia (2027m a.s.l.) (Table3). This makes high altitudinal range of 210 m (Map 2).



Map 2. Elevation map for study area altitude showed different elevation ranks.

Results showed that the slope degree of the populated sites was high as the species was found in slope between 5- 15 degree. Farsh Al-Shoeibi and Kaneset Al-Hammar are located in high slope at 5- 15 degree, while wadi Al-Far'aa, farsh Al-Loza and farsh Eilia recorded lower slope degree at 0-5 degree (Table 3). As for aspect, wadi Al-Far'aa, farsh Al-Loza and farsh Eilia are located at North East (NE), Kaneset Al-Hammar is located at North West (NW) and farsh Al-Shoeibi is located at North (N) (Table 3).

Table 3. Topography data recorded during study from the different five locations.

Location	Wadi Al-Far'aa	Farsh Al-Shoeibi	Farsh Al-Loza	Kaneset Al-Hammar	Farsh Eilia
Elevation range	**1821-1847 m (a.s.l.)**	**1984-1950 m (a.s.l.)**	**1985-2000 m (a.s.l.)**	**2001-2023 m (a.s.l.)**	**2024-2031 m (a.s.l.)**
Mean Elevation effect value m. a.s.l.	1834	1967	1992	2012	2027
slope effect	0-5	5-15	0-5	5-15	0-5
Aspect	NE	N	NE	NW	NE

Topography is the principle controlling factor in vegetation growth and type of the soil. Elevation, aspect and slope are three main topographic factors that determine microclimate and thus control the spatial distribution, patterns of vegetation and abundance of species (**Omar, 2012; Dawes and Short, 1994 & Titshall *et al*., 2000**).

Aspect had significant effects on plant community structure (**Whittaker, 1975**) and on the formation of soils (**Carter and Ciolkosz, 1991**). In agreement with **Khafagi and Omar (2012)** NE, E and N directions have the highest species richness, these aspects are cooler and have low soil evaporation resulting from low amount of solar radiation coming from few hours of sun facing these aspect.

III. 4. Climatic variables analysis (Temperature, rainfall, wind speed and humidity)

South Sinai is characterized by a wide range of variation in air temperature. The annual maximum temperature ranged between 13.9 ^{o}C in January and 32.1 ^{o}C in July, with an average of 23.2 ^{o}C. The annual minimum temperature ranged between 1.2 ^{o}C in February and 18.5 ^{o}C in July, with an average of 9.6 ^{o}C. The annual rainfall ranged between 0 mm in June and July and 9.1 mm in January, with mean annual rainfall of 2.7 mm. The mean annual wind speed ranged between 5.9 Km/h in December and 18.9 Km/h in June, with an average of 10.8 Km/ha. The relative humidity in St. Katherine area ranged between 25.1 % in June and 50.1 % in January, with an average of 34.9 % (Table 4).

Climatic conditions such as temperature, wind speed, humidity and rainfalls plays secondary roles at the scale of mountainous slope. Temperature, atmospheric pressure and moisture are the major microclimatic affects by altitude. Microclimatic influenced on the growth and development of plants and patterns in vegetation distribution (**Hedberge, 1964**).

Table 4. Monthly variation in mean temperature (˚C), mean rainfall (mm), mean wind speed (km/ ha) and mean Humidity (%) in Saint Katharine during 2014, (Maximum and minimum values are underlined), (Saint Katherine Methodological station).

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Max Temp. (^{o}C)	13.9	14.8	15.9	23.9	29.1	30.2	32.1	29.3	28.1	26.5	19.2	15.3	**23.2**
Min Temp. (^{o}C)	1.5	1.2	3.9	8.1	13.6	17.4	18.5	15.9	14.8	10.8	6.2	3.8	**9.6**
Rainfall (mm)	9.1	8.1	7.3	0.6	0.3	0	0	0.1	0.2	0.8	1.2	5.2	**2.7**
Mean Wind speed (Km /ha)	8.9	7.2	8.5	10	12	18.9	17.2	14.1	10.9	7.5	8.8	5.9	**10.8**
Mean Humidity (%)	50.1	48.5	40.2	30.3	26.9	25.1	28.9	29.8	30.9	29.7	35.8	43.1	**34.9**

III. 5. Floristic Composition

In this study, 22 families and 62 species were recorded within the five sites during vegetation survey on Musa Mountain. Asteraceae had the highest contribution to total species (10 species = 16.2 %) and this agreed with **Amer (2013)**, followed , descending by Lamiaceae (9 species = 14.52%), Fabaceae (7 species = 11.29 %), Scrophulariaceae (5 species = 8.06 %), followed by Caryophyllaceae, Brassicaceae, Euphorbaiceae and Poaceae, (each comprised 3 species = 4.83 %), followed by Juncaceae, Polygalaceae, Rubiaceae and Zygophyllaceae (each comprised 2 species = 3.23 %), followed by Asclepiadaceae, Boraginaceae, Chenopodiaceae, Dipsacaceae, Geraniaceae, Moraceae, Plantagonaceae, Resedaceae, Rosaceae and Umbellifera had the lowest contribution to total species (1 species = 1.61 %) (Table 5).

Table 5. Family representation of the species is recorded during vegetation survey in Musa Mountain in South Sinai.

Family	Species No.	Species %
Asclepiadaceae	1	1.61
Boraginaceae	1	1.61
Caryophyllaceae	3	4.83
Asteraceae	10	16.12
Brassicaceae	3	4.83
Chenopodiaceae	1	1.61
Dipsacaceae	1	1.61
Euphorbaiceae	3	4.83
Geraniaceae	1	1.61
Poaceae	3	4.83
Juncaceae	2	3.23
Lamiaceae	9	14.52
Fabaceae	7	11.29
Moraceae	1	1.61
Plantagonaceae	1	1.61
Polygalaceae	2	3.23
Resedaceae	1	1.61
Rosaceae	1	1.61
Rubiaceae	2	3.23
Scrophulariaceae	5	8.06
Umbellifera	1	1.61
Zygophyllaceae	3	4.83

On species level, *Seriphidium herba-album* (11 stands from 25 with 44 %), *Tanacetum sinaicum* (7 stands from 25 with 28 %), (Table 6). The recorded presence of *Seriphidium herba-album* in Musa Mountain area matched with its habitat preference, *Seriphidium herba-album* preferred and distributed largely in Musa Mountain.

Table 6. Dominant species recorded within the study.

No.	**Dominant Sp.**	No. of sites	%
1	*Seriphidium herba-album (Asso) Sojak*	11	44
2	*Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphriescne	7	28
4	*Matthiola arabica*	2	8
5	*Juncus rigidus* Desf	2	8
6	*Imperata cylindrica*	1	4
7	*Peganum harmala* L.	1	4
8	*Nepeta septemcrenata* Benth	1	4

III. 6. Floral diversity

Examination of more detailed indices of diversity of patterns supported a good view for plant diversity in Musa Mountain. During the vegetation survey, a total of 62 species in five locations was recorded, the number of species within each location and diversity indices was estimated.

The diversity indices of the five locations in Musa Mountain are given in Table 7. The species inhabiting wadi Al-Far'aa at elevation 1821-1847 m (a.s.l.) had the highest contribution to the total recorded species and individuals (42 species = 117 individuals). In other words, wadi Al-Far'aa had the highest diversity value of Simpson's index, Shannon-Wiener index and Brillouin's index (0.95, 3.17 and 2.49, respectively). Farsh Al- Loza had the lowest diversity value of Simpson's index, Shannon-Wiener index and Brillouin's index (0.69, 1.79 and 1.24, respectively). In these regards, many studies (**Puerto *et al*., 1990 and Shaltout, 1995**) reported high species diversity due to terrain heterogeneity in some Mediterranean communities. These studies indicated that higher levels of species diversity were brought about by a local differentiation in soil properties around the individual plant, as heterogeneity of environment allows satisfaction of the requirements of the diverse species within a community.

Table 7. Diversity indices in five locations in Musa Mountain.

Elevation range	**1821-1847 m (a.s.l.)**	**1984-1950 m (a.s.l.)**	**1985-2000 m (a.s.l.)**	**2001-2023 m (a.s.l.)**	**2024-2031 m (a.s.l.)**
Sites	**Wadi Al-Far'aa**	**Farsh Al-Shoeibi**	**Farsh El-Loza**	**Kenest Al-Hammar**	**Farsh Eilia**
Taxa_S	42	19	20	15	34
Individuals	117	120	93	115	675
Simpson's index	0.95	0.87	0.69	0.81	0.9
Shannon-Wiener index	3.17	2.34	1.79	1.95	2.64
Brillouin's index	2.49	1.93	1.24	1.55	2.19

Environmental variables like edaphic factors, topography and climate conditions changes led to variation of the distribution of the plant associations within the different locations of the study area. Musa Mountain is characterized by terrain variables like slope, aspect and elevations which affect microclimate conditions such as temperature and moisture, and all in turn, affect plant species distributions.

V. Conclusion

The environmental factors are owner of the major role that affects the response of vegetation distribution and plant community structure to gradient in most environmental factors such as the elevation above sea level, temperature, rainfall and some soil chemical properties noticed among the five different locations of the present study. It is clear from the current survey that species richness varies with spatial scales and through latitudinal, longitudinal and/or altitudinal gradients. Also, flora diversity in communities is significantly related to different locations and elevation.

The use of GIS played a crucial role in analysis, management and extract of spatial variation for different habitats by using simple information collected from field will give the great analysis just by using such programs; 3D analyst tools show advanced spatial analysis. Elevation, slope and contour maps easily arise by these applications, which it has been used in a deeper understanding of the vegetation structure and distribution of plant communities.

Based on the findings, which were based on the field surveys suggest the possible recommendations for decision-makers to take advantage of that study during the development of the strategic plan for the sustainable use of natural resources.

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