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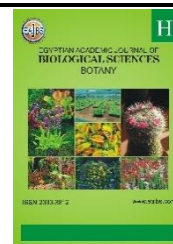
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## Vegetation Structure and Species Association in High-Altitude Mountain Island in Egypt

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### ABSTRACT

A total of 42 stands representing different habitats of the Saint Katherine protectorate (SKP) have been chosen to represent the most common plant communities of the Saint Katherine Protectorate. In total, 52 species were found in the vegetation survey. The species that had been recorded in the study area in vegetation were itemized on a list, and the total species recorded belonged to 24 families. At the family level, Compositae has the highest contribution to the total species ( 10 species = 19.23 %), followed by Labiateae ( 9 species = 17.31 %), followed by Cruciferae (4 species = 7.69 %), Zygophyllaceae, Scrophulariaceae and Caryophyllaceae (each comprises 3 species = 5.77%), At the species level and from vegetation survey, *Teucrium polium* has the highest presence percentage ( 34 stand = 81 %), followed by *Nepeta septemcrenata* and *Phlomis aurea* (32 stand = 76.2 %), *Chiliadenus montanus* and *Seriphidium herba-album* (29 stand = 69 %), *Echinops spinosus* and *Tanacetum sinaicum* (27 stand = 64.3 %), *Stachys aegyptiaca* (25 stand = 59.5 %), *Ballota undulata* (24 stand = 57.1 %), *Achillea fragrantissima* (22 stand = 52.4 %).

### INTRODUCTION

The Sinai Peninsula has geographical importance in that it is where the continents of Africa and Asia meet. The St. Katherine Protectorate covers the mountainous region of Southern Sinai. The Saint Katherine Protectorate (SKP) is one of Egypt's largest protected areas and includes the country's highest mountains. This arid, mountainous ecosystem supports surprising biodiversity and a high proportion of endemic and rare plants. The flora of the mountains differs from the other areas, due to its unique geology, morphology and climate. Sinai is currently recognized as one of the central regions for flora diversity in the Middle East by the IUCN the World Conservation Union and the Worldwide Fund for Nature (IUCN, 1994). In 1993 the Egyptian government designated the Saint Katherine area as a future National Park. Ayyad, *et al.*, (2000) suggested that Sinai contains approximately 1285 species, with South Sinai supporting 800, including 34 endemics; 62% were estimated as being rare or very rare.

The estimated number of endemic species in Sinai is 28 which constitutes about 3.2% of its total flora (Danin, 1986). The area around mount Katherine is very unique, therefore, the area was declared to be one of the largest protected areas in Egypt. The

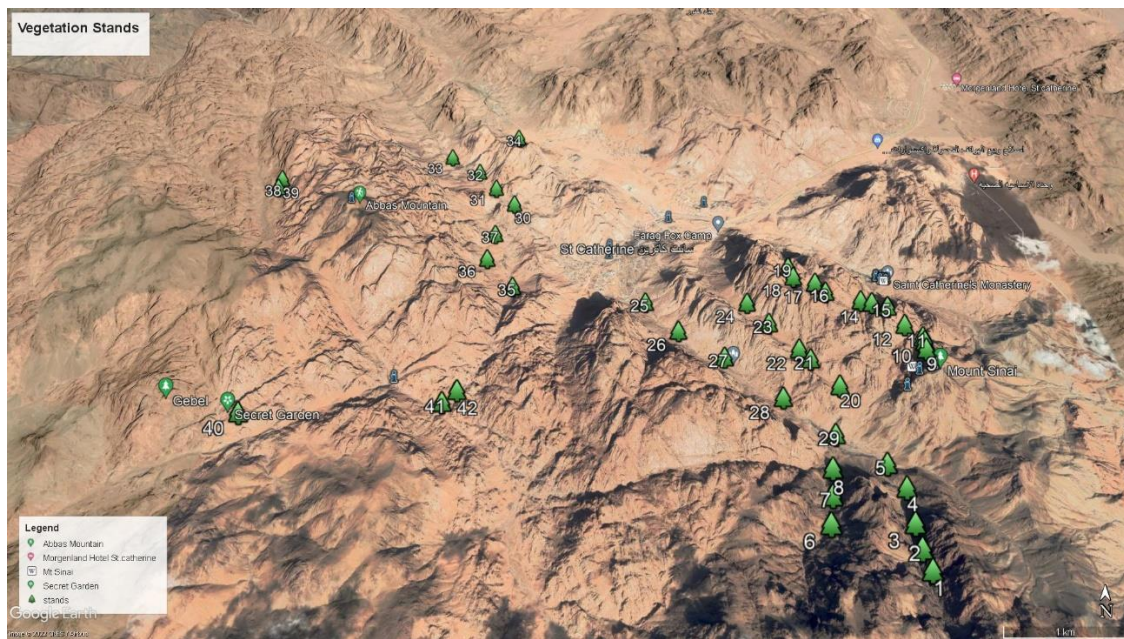
vegetation of Saint Katherine has been studied by several authors (Moustafa and Zaghoul, 1996; Ward, *et al.*, 2002; Tan, 2005; Zahran and Willis, 2009). The present study aims at identifying some of the plant communities growing in the eastern sector of the Saint Katherine protectorate and species distribution along the study area.

The landscape ranges from rugged mountains, which include Katherine (2642 m asl), Egypt's highest peak, whose slopes are incised by wadi rivers. Wadi rivers generally slope to the east, towards the Gulf of Aqaba, or to the west towards the Gulf of Suez (Alqamy, 2002). The aim of this part of the work is to study plant species distribution in the different wadi systems in St. Katherine's Protectorate, to assess how plant species are distributed

## MATERIALS AND METHODS

### Study Area:

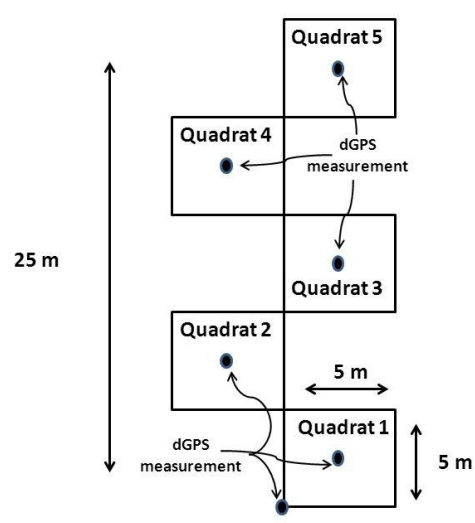
The research area is in Saint Katherine High altitude Mountain area (28.518911°N 33.959451°E) (Maps 1). The study period was from March 2011 to March 2012. Mount saint Katherine is one of the richest and highly diverse in its flora due to its sharp variation in altitude, soil characteristic and geomorphological 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).



**Map 1.** Map showing the main locations of the present study in the Saint Catherine area

Vegetation of Forty-two stands (Map.1), with five quadrats (5×5 m) using The Quadrata Transect Method (Fig.1). The GPS position of each stand was recorded including latitude, longitude, habitat and altitude were recorded (Table 1.), and are represented in Map 1. The floristic composition of each stand was recorded. All plant species existing in each site were listed after complete identification according to Täckholm, (1974); Boulos, (1999-2005). Plant names were updated after Voucher herbarium specimens were prepared and kept in the herbarium of the Department of Botany and Microbiology, Faculty of Science, Al-Azhar University (Boy's Branch). A checklist of all plant species is given in Table 2. Density (D), percentage of frequency (F), abundance (A), relative density (RD), relative frequency (RF), relative abundance (RA), and importance value (IVI) were calculated for each species in each site; According to the following equations (Braun – Blanquet, 1964).

1. **Density (D):** Total number of individuals of a species / Total number of quadrats studied ( $m^2$ )
2. **Relative density (R.D):** density of species /  $\Sigma$  of densities of all species) x 100
3. **Frequency (F):** Total number of quadrats in which a species occurs / total number of quadrats studied) x 100
4. **Relative frequency (RF):** Frequency of a species \  $\Sigma$  of % frequencies % of all species
5. **Abundance (A):** Total number of individuals of a species \ Total number of quadrats where the species is present
6. **Relative Abundance (RA):** Abundance of a species \  $\Sigma$  of abundances of all species
7. **Importance Value Index (I.V.I):** RD + RF + RA for each species Fig 1. A schematic illustration for the vegetation survey method.



**Fig 1.** A schematic illustration for the vegetation survey method

## RESULTS

A total of 42 stands representing different habitats of Saint Katherine protectorate (SKP) have been chosen to represent the most common plant communities of Saint Katherine protectorate. In total, 52 species were found in the vegetation survey. The species that had been recorded in the study area in vegetation were itemized on a list, and the total species recorded belonged to 24 families. At the family level, Compositae has the highest contribution to the total species (10 species = 19.23 %), followed by Labiateae (9 species = 17.31 %), followed by Cruciferae (4 species = 7.69 %), Zygophyllaceae, Scrophulariaceae and Caryophyllaceae (each comprises 3 species = 5.77%), (Fig. 2).

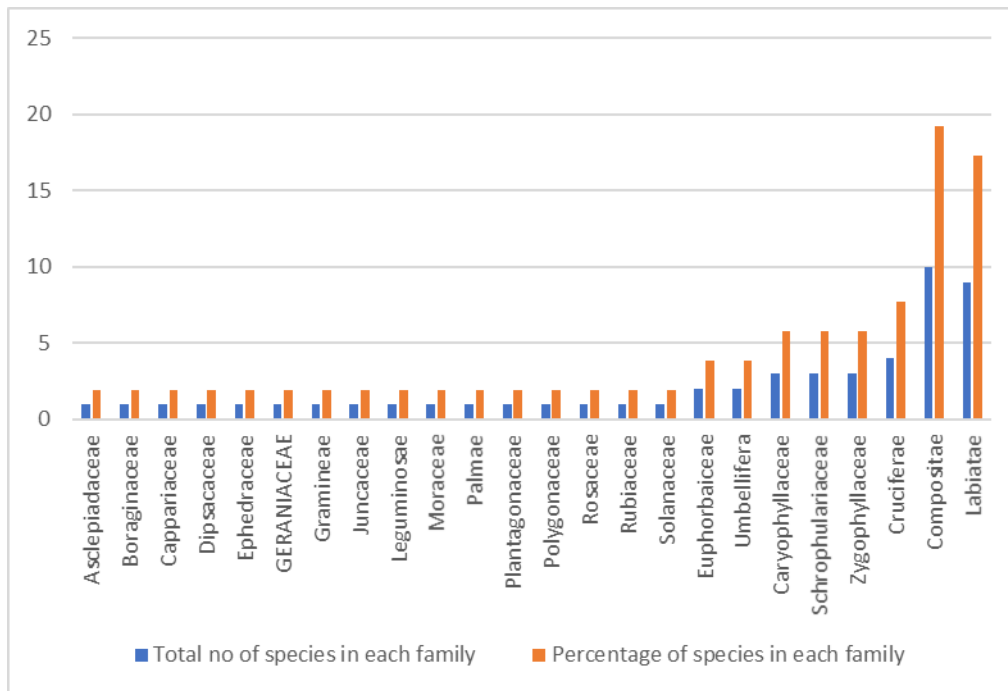
At the species level and from vegetation survey, *Teucrium polium* has the highest presence percentage (34 stand = 81 %), followed by *Nepeta septemcrenata* and *Phlomis aurea* (32 stand = 76.2 %), *Chiliadenus montanus* and *Seriphidium herba-album* (29 stand = 69 %), *Echinops spinosus* and *Tanacetum sinaicum* (27 stand = 64.3 %), *Stachys aegyptiaca* (25 stand = 59.5 %), *Ballota undulata* (24 stand = 57.1 %), *Achillea fragrantissima* (22 stand = 52.4 %) (Table 2).

**Table1.** GPS position of the studied 42 stands including sites, longitude, latitude and altitude.

<b>Stand No</b>	<b>Location name</b>	<b>latitude</b>	<b>longitude</b>	<b>altitude.</b>
1	Shak Elgragnia	28.52115	33.97009	2063
2	Shak Elgragnia	28.52303	33.96990	2023
3	Shak Elgragnia	28.52524	33.97002	2027
4	Shak Elgragnia	28.52900	33.97060	1860
5	Shak Elgragnia	28.53147	33.96964	1820
6	Shak Mosa	28.52470	33.96277	2023
7	Shak Mosa	28.52777	33.96376	1929
8	Shak Mosa	28.53066	33.96452	1849
9	Gabal Mosa	28.54100	33.97505	2123
10	Gabal Mosa	28.54224	33.97539	2074
11	Gabal Mosa	28.54310	33.97557	2048
12	Farsh Ellia	28.54488	33.97438	1993
13	Ellosa	28.54806	33.97086	1988
14	Ellosa	28.54773	33.97188	1993
15	Ellosa	28.54684	33.97313	2034
16	Farsh Shoeibi	28.54896	33.96744	2017
17	Farsh Shoeibi	28.55018	33.96663	1997
18	Farsh Shoeibi	28.55141	33.96469	1988
19	Farsh Shoeibi	28.55291	33.96445	1982
20	Elfaraa	28.53922	33.96708	1848
21	Elfaraa	28.54236	33.96496	1831
22	Elfaraa	28.54370	33.96413	1850
23	Elfaraa	28.54690	33.96167	1807
24	Elfaraa	28.54980	33.95991	1802
25	Wadi Elarbein	28.55151	33.94953	1606
26	Wadi Elarbein	28.54740	33.95265	1623
27	Wadi Elarbein	28.54388	33.95693	1658
28	Wadi Elarbein	28.53888	33.96184	1718
29	Wadi Elarbein	28.53473	33.96588	1758
30	Wadi Itlah	28.56660	33.93485	1574
31	Wadi Itlah	28.56997	33.93246	1526
32	Wadi Itlah	28.57330	33.93018	1496
33	Wadi Itlah	28.57630	33.92645	1446
34	Wadi Eltalaa	28.57768	33.93496	1807
35	Wadi Eltalaa	28.55328	33.93526	1807
36	Wadi Eltalaa	28.55718	33.93227	1568
37	Wadi Eltalaa	28.56154	33.93288	1558
38	Abo Waleie	28.56688	33.90703	1897
39	Abo Waleie	28.56791	33.90733	1891
40	Abo Waleie	28.53577	33.91105	1900
41	Elzawitin	28.53755	33.92944	1843
42	Elzawitin	28.53886	33.93073	1844

**Table 2.** List of the species, their families, presence of species and percentage of presence recorded in Forty-two stands in the study area

	Species Name	Family	Common Name Arabic	Presence of species	% Of P
1	<i>Achillea fragrantissima</i> (Forssk.) Sch.	Composita	قيصوم	22	52.4
2	<i>Alkanna orientalis</i> (L.) Boiss.	Boraginace	الليبد	30	71.4
3	<i>Anarrhinum pubescens</i> Fresen.	Scrophulari	أرفيجه, رفيعة	10	23.8
4	<i>Andrachne aspera</i> Spreng.	Euphorbiac	عود العقرب, عين أم	2	4.8
5	<i>Asclepias sinaica</i> (Boiss.) Muschl.	Asclepiada	حرجل بري	8	19.0
6	<i>Astragalus sieberi</i> DC.	Leguminos	شوك النعاج, أصابع	3	7.1
7	<i>Atraphaxis spinosa</i> L.	Polygonace	سراس, سيرا	1	2.4
8	<i>Ballota undulata</i> (Fresen.) Benth.	Labiatae	الغاصة, زفرة	24	57.1
9	<i>Bufonia multiceps</i> Decne	Carvophyll	عدمه	8	19.0
10	<i>Capparis spinosa</i> L.var. <i>spinosa</i>	Cappariace	أصف, ليصوف,	1	2.4
11	<i>Centaurea eryngioides</i> Lam.	Composite	أحية الين	8	19.0
12	<i>Centaurea scoparia</i> Sieber ex Spreng.	Composite	برقان	1	2.4
13	<i>Chiliadenus montanus</i> (Vahl) Brullo.	Composite	هنيدة, نهيدة	29	69.0
14	<i>Crataegus x sinaica</i> Boiss.	Rosaceae	زعرور	3	7.1
15	<i>Cynodon dactylon</i> (L.) Pers.	Gramineae	مديد - نجبلا	3	7.1
16	<i>Deverra tortuosa</i> L.	Umbellifer	سكيح - شبت الجبل -	6	14.3
17	<i>Deverra triradiata</i> Poir.	Umbellifer	زجوح - عليجان -	7	16.7
18	<i>Diploxaxis harra</i> . (Forssk.) Boiss	Cruciferae	حاره	2	4.8
19	<i>Echinops spinosus</i> L.	Composite		27	64.3
20	<i>Ephedra pachyclada</i> Boiss.	Ephedracea	علاه	1	2.4
21	<i>Erodium laciniatum</i> (Boiss.) Batt. &	GERANIA	دهمية, دهمية	2	4.8
22	<i>Euphorbia sanctae-catharinae</i> Faved.	Euphorbaic	ليينه	9	21.4
23	<i>Fagonia arabica</i> var. <i>arabica</i> L.	Zygophylla	حلوة الجمل, ورقة,	7	16.7
24	<i>Fagonia mollis</i> Delile.	Zygophylla	الشكاعة, ورقة	17	40.5
25	<i>Farsetia aegyptia</i> Turra	Cruceferae	جربه, جريبي	1	2.4
26	<i>Ficus palmata</i> Forssk.	Moraceae	حماط, ثين البر	4	9.5
27	<i>Galium sinaicum</i> (Delile ex Decne.)	Rubiaceae	عثمه	10	23.8
28	<i>Gymnocarpus decandrus</i> Forssk	Carvophyll	جرد	3	7.1
29	<i>Hyoscyamus boveanus</i> (Dunal) Asch. &	Solanaceae	سكران	1	2.4
30	<i>Juncus rigidus</i> Desf.	Juncaceae	حصر سمار, سمار	5	11.9
31	<i>Launaea nudicaulis</i> (L.) Hook. F.	Composita	حوذان	1	2.4
32	<i>Launaea spinosa</i> (Forssk.) Sch. Bip. Ex	Composita	كيات	4	9.5
33	<i>Lavandula coronopifolia</i> Poir.	Labiatae	زيتة	1	2.4
34	<i>Matthiola arabica</i> Boiss.	Cruciferae	خمخ	13	31.0
35	<i>Mentha longifolia</i> (L.) Huds.	Labiatea	حبك, حبق	3	7.1
36	<i>Nepeta septemcrenata</i> Benth.	Labiatea	زيتيه, مسيسة	32	76.2
37	<i>Origanum syriacum</i> (Boiss.) Greater &	Labiatea	زعتن, بردقوش	17	40.5
38	<i>Peganum harmala</i> L.	Zygophylla	حرملا, حرملا	5	11.9
39	<i>Phlomis aurea</i> Decne.	Labiatea	عورور, زهيرة	32	76.2
40	<i>Phoenix dactylifera</i> L.	Palmae	البلح نخلة, نخل	1	2.4
41	<i>Plantago sinaica</i> (Barneoud) Decne.	Plantagona	لسان الحمل, رعية	12	28.6
42	<i>Pterocephalus sanctus</i> Decne.	Dipsacacea	علاه, مجلينة	4	9.5
43	<i>Pulicaria undulata</i> (L.) C. A. Mey.	Composite	دثا, دثا, دثا, سيد	8	19.0
44	<i>Scrophularia libanotica</i> Boiss.	Schrophula		9	21.4
45	<i>Seriphidium herba-album</i> (Asso) Sojak.	COMPOSI	شبح	29	69.0
46	<i>Silene schimperiana</i> Boiss.	Carvophyll	لصيق	9	21.4
47	<i>Stachys aegyptiaca</i> Pers.	Labiatea	- جرطم - رغات	25	59.5
48	<i>Tanacetum sinaicum</i> (fresen.) Delile ex	Composita	مر	27	64.3
49	<i>Teucrium polium</i> L.	Labiatea	جعدة	34	81.0
50	<i>Thymus decussatus</i> Benth.	Labiatae	زعتران - زعتن	7	16.7
51	<i>Verbascum sinaiticum</i> Benth.	Scrophulari	خرماع	15	35.7
52	<i>Zilla spinosa</i> (L.) Prantl in Engl. &	Cruciferae	زله - سلة - بسلة	17	40.5



**Fig. 2.** Family representation of the species recorded in vegetation Survey.

The present study is carried out in twelve main localities of South Sinai, Map 1. represents the study locations from 1 to 12 (from stand 1 to 42) as follows: Shak Elgragnia, Shak Mosa, Gabal Mosa, Farsh Ellia, Farsh Ellosa, Farsh Shoeibi, Wadi Elfaraa, Wadi Alarbein, Wadi Itlah, Wadi Eltalaa, Abo Waleie, Elzawitin. The selected 42 stands were located in twelve sites, each site may contain one or more stands. In the following section, the description of the twelve sites and the 42 stands are listed:

#### **Site 1: Shaq El Gragnia.**

Shaq Elgragnia is located at 28.532071°N 33.969542°E, 28.518592°N 33.970243°E. with an altitude range: of 1800:2130 (m asl). The soil texture of Shaq Elgragnia contains 45% bolder, 35% rocks, 15% gravel and 5% sand. It has low human activity and low grazing pressure. The gorge consists of a bolder and rocks substrate with granite and basalt geology. The gorge has a rigid topography with a North to Northwest slope exposure. The distance from Saint Katherine city is about 4.5 km. This location included five stands (Stands 1, 2, 3, 4, 5).

##### **Stand (1) "Phlomis aurea Decne. community"**

Eleven species have been recorded in this stand, *Phlomis aurea* Decne representing the dominant species with (I.V.I = 92.05), and the co-dominant species is *Nepeta septemcrenata* Benth. (I.V.I. = 37.29) and *Origanum syriacum* L. (I.V. I= 32.33), the other associated species have a low important value index.

##### **Stand (2): "Origanum syriacum L.community"**

In this stand Twelve species have been recorded in this stand, indicator species of the stand as dominant species is *Origanum syriacum* L.with Important Value Index (I.V.I. = 76.00), *Nepeta septemcrenata* Benth representing the co-dominant species with Important Value Index (I.V.I. = 56.30), *Mentha longifolia* (L.) Huds.with (I.V.I= 30.41), and the other associated species with a low important value index.

##### **Stand (3): "Nepeta septemcrenata Benth. community"**

Eight plant species have been recorded during the survey of this stand, where representing the dominant species *Nepeta septemcrenata* Benth with (I.V.I. = 66.71),

*Phlomis aurea* Decne representing the co-dominant species with (I.V.I. = 62.21) while the other associated species have a lower Important Value Index.

**Stand (4):** “*Phlomis aurea* Decne. Community”

Eleven species have been recorded in this stand, *Phlomis aurea* Decne. is representing the dominant species with (I.V.I. = 50.75), *Echinops spinosus* L. representing the co-dominant species (I.V.I. = 44.45), *Origanum syriacum* L. with (I.V.I.= 41.31), the other associated species have lower important value.

**Stand (5):** “*Phlomis aurea* Decne. Community”

Twelve plant species have been recorded inside this stand; the characteristic species of this community is *Phlomis aurea* Decne. (I.V.I.= 41.71), co-dominant is *Origanum syriacum* L. (I.V.I.= 37.06), *Fagonia mollis* Delile. (I.V.I.= 36.61). The other associated species have low important value.

**Site 2: Shak Mosa.**

Shaq Musa is located at 28.533603°N 33.965518°E, 28.518911°N 33.959451°E. with an Altitude range of 1780-2020 (m asl). The soil texture of Shaq Musa contains 45% bolder, 40% rocks, 10% gravel and 5% sand. It has Medium human activity and Medium grazing pressure. This wadi is in a steep gorge that rises from the end of Wadi Arbacin steeply upwards towards to summit of Mount St. Katherine. Gorge consists of bolder and rocks substrate with granite geology with sporadic sandstone features. The Gorge has a rigid topography with a Northwest slope exposure. The steepness of the gorge ranges from 30°-50° while the steepness of the slope ranges from 70°-90°. The gorge has approximately a width range from 15-50 meters; gorge length is approximately 2.8 km. The distance from Saint katherine city is about 4.2km. This location included One stand (Stand 6).

**Stand (6):** *Achillea fragrantissima* (Forssk.) Sch. Bip. Community.

Fourteen have been recorded in this stand; the characteristic species of this stand are *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I. = 68.87), *Echinops spinosus* L. (I.V.I. = 46.88), *Phlomis aurea* Decne. (I.V.I.= 38.01). The other associated species with a lower important value index.

**Site 3: Gabal Musa.**

Gabal Musa is located at 28.553754°N 33.977687°E, 28.538883°N 33.974826°E. with an Altitude range of 1620-2285 (m asl). The soil texture of Gabal Musa contains 10% bolder, 50% rocks, 30% gravel and 10% sand. It has High human activity and High grazing pressure. This wadi is in a steep gorge that rises from the end of Sifsafa Mountain. Gorge consists of rocks and gravel substrate with granite geology with sporadic sandstone features. Gorge has a concave topography with a North to Northwest slope exposure. The steepness of the gorge ranges from 30°-50° while the steepness of the slope ranges from 70°-90°. The gorge has approximately a width range from 10-30 meters; gorge length is approximately 3.5 km. The distance from Saint katherine city is about 3.5 km. The mountain is climbed every night by hundreds of tourists in order to witness the raising of the sun over the mountains of southern Sinai (Stands 7,8,9,10, 11).

**Stand (7):** “*Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. & *Deverra triradiata* Hochst.ex Boiss. community”

Twelve species have been recorded in this stand. The characteristic species of this community are two species: *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. And *Deverra triradiata* Hochst.ex Boiss. with (I.V.I.= 55.62), Co-dominant is *Nepeta septemcrenata* Benth and *Silene schimperiana* Boiss. (I.V.I.= 26.69). The other species with lower important value index.

**Stand (8):** *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. Community

Ten species have been recorded in this stand; the characteristic species of this community are *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. (I.V.I.=



43.61), co-dominant is *Seriphidium herba-album* (Asso) Sojak. (I.V.I.= 38.57) , *Verbascum sinaicum* (I.V.I.= 33.52). The other species with low Important Value Index.

**Stand (9):** *Seriphidium herba-album* (Asso) Sojak. Community

Nine species have been recorded in this stand; the most characteristic species are *Seriphidium herba-album* (Asso) Sojak. (I.V. I= 108.58), co-dominant is *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. (I.V. I= 60.30). The other species with lower important value index.

**Stand (10):** *Nepeta septemcrenata* Benth. Community

Nine species have been recorded within this stand and the most Characteristic species recorded in this community are *Nepeta septemcrenata* Benth. (I.V.I. = 94.22) as dominant species, *Seriphidium herba-album* (Asso) Sojak., *Ballota undulata* (Fresen.) Benth & *Echinops spinosus* L. (I.V.I. = 29.56) as co-dominant. The other associated species have a lower Important Value Index.

**Stand (11):** *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. community

Eleven species have been recorded in this stand, and the characteristic species of this community are: *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. (I.V.I.= 55.04) as the dominant species, the co-dominant species is *Nepeta septemcrenata* Benth. (I.V.I.= 42.93) and *Seriphidium herba-album* (Asso) Sojak. (I.V.I.= 39.57). The other associated species have a lower important value index.

**Site 4. Farsh Ellia.**

Farsh Ellia is located at 28.545105°N 33.974471°E, 28.544498°N 33.974803°E. with an Altitude range of 2000-2035 (m asl). The soil texture of Farsh Ellia contains 10% bolder, 20% rocks, 40% gravel and 30% sand. It has High human activity and High grazing pressure. This farsh is an Open area located between Farsh Ellosa and Gabal Musa. This farsh consists of gravel substrate with granite geology with sporadic sandstone features. Farsh has a concave topography with East slope exposure. The steepness of the farsh ranges from 5°-10° while the steepness of the slope ranges from 40°- 60°. The farsh has an approximate width range from 20-100 meters; Farsh length is approximately 190 m. The distance from Saint kathreine city is about 3 km (Stand 12).

**Stand (12):** *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. community

Eleven species have been recorded in this stand; the Characteristic species of this community are: *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. (I.V.I.= 75.54) dominant species, co-dominant is *Teucrium polium* L. (I.V.I.= 46.28) and *Seriphidium herba-album* (Asso) Sojak. (I.V.I. = 46.02). The other species with lower Important Value Index.

**Site 5. Farsh Elloza.**

Farsh Elloza is located at 28.549602°N 33.968520°E, 28.547010°N 33.973186°E. with an Altitude range of 1985-2050 (m asl). The soil texture of Farsh Elloza contains 40% bolder, 35% rocks, 15% gravel and 10% sand. It has High human activity and High grazing pressure. Microhabitats in this location vary from farsh to wadi bed. located between Farsh Sheibi and Farsh Ellia. This wadi consists of rocks and gravel substrate with granite geology with sporadic sandstone features. wadi has a concave topography with East and Northwest slope exposure. The steepness of the wadi ranges from 20°-40° while the steepness of the slope ranges from 40°- 60°. The wadi has an approximate width range from 10-85 meters; Wadi length is approximately 790 m. The distance from Saint kathreine city is about 2.7 km (Stands 13, 14, 15).

**Stand (13):** *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. community.

Twelve species have been recorded in this stand during the survey and the most characteristic species representing this community is: the dominant species *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. with (I.V.I.= 120.21), the co-dominant species is *Nepeta septemcrenata* Benth. with (I.V.I.= 29.34), *Peganum harmala* L. &

*Alkanna orientalis* (L.) Boiss. (I.V.I.= 23.96). The other species recorded a lower Important value Index

**Stand (14):** “*Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. Community”

Ten species have been recorded in this stand; the characteristic species of this community is *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. with important value index = (86.94), *Nepeta septemcrenata* Benth. (I.V.I. = 73.24) is the co-dominant species. The other associated species have low important value.

**Stand (15):** “, *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. Community”

In this stand Ten species have been recorded, *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. representing the indicator species (I.V.I. = 80.63) and *Nepeta septemcrenata* Benth. are the co-dominant species (I.V.I. = 79.37), *Chiliadenus montanus* (Vahl) Brullo (I.V.I. =31.48) and the other associated species have a low importance value index.

#### **Site 6. Farsh Shoeibi.**

Farsh Shoeibi is located at 28.552658°N 33.967283°E, 28.549445°N 33.967230°E. with an Altitude range of 1985-2050 (m asl). The soil texture of Farsh Shoeibi contains 20% bolder, 35% rocks, 35% gravel and 10% sand. It has High human activity and High grazing pressure. Microhabitats in this location vary from farsh to wadi bed. This wadi consists of rocks and gravel substrate with pink granitic geology with sporadic sandstone features. wadi has a concave topography with Northeast and Northwest slope exposure. The steepness of the wadi ranges from 5°-15° while the steepness of the slope ranges from 25°- 45°. The wadi has approximately a width range from 10-100 meters; Wadi length is approximately 440 m. The distance from Saint kathreine city is about 2.0 km (Stands 16, 17, 18, 19).

**Stand (16)** “*Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. community”

Twelve species have been recorded in this stand, *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. representing the dominant species with (I.V.I = 69.79), and the co-dominant species is *Teucrium polium* L. (I.V.I. = 61.07). The other associated species have a low important value index.

**Stand (17):** ‘*Seriphidium herba-album* (Asso) Sojak. community”

In this stand Thirteen species have been recorded this stand, indicator species of the stand as dominant species is *Seriphidium herba-album* (Asso) Sojak. with Important Value Index (I.V.I. = 81.16), *Teucrium polium* L. representing the co-dominant species with Important Value Index (I.V.I. = 57.01), *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. with (I.V.I= 36.08), and the other associated species with a low important value index.

**Stand (18):** “*Seriphidium herba-album* (Asso) Sojak. community”

Thirteen plant species have been recorded during the survey of this stand, where representing the dominant species *Seriphidium herba-album* (Asso) Sojak. with (I.V.I. = 80.65), *Teucrium polium* L. represents the co-dominant species with (I.V.I. = 45.14) while the other associated species have a lower Important Value Index.

**Stand (19):** “*Seriphidium herba-album* (Asso) Sojak. Community”

Thirteen species have been recorded in this stand, *Seriphidium herba-album* (Asso) Sojak. is representing the dominant species with (I.V.I. = 60.81), *Thymus decussatus* Benth. representing the co-dominant species (I.V.I. = 52.30), *Juncus rigidus* Desf. with (I.V.I.= 34.02), the other associated species have a lower important value.

#### **Site 7. Wadi Elfaraa.**

Wadi Elfaraa is located at 28.536204°N 33.968113°E, 28.553065°N 33.957832°E. with an Altitude range of 1815-1880 (m asl). The soil texture of Wadi Elfaraa contains 10% bolder, 45% rocks, 35% gravel and 10% sand. It has High human activity and High grazing pressure. This wadi consists of rocks and gravel substrate with pink granitic geology. The footpath in the area comes down from Safsafa Mountain and leads down to Wadi Arbaein.

Wadi starts from the end of Wadi Alarbein and terminates by Wadi Shoreage. Wadi has a concave topography with West to Northeast slope exposure. The steepness of the wadi ranges from 5°-15° while the steepness of slope ranges from 45°- 60°. The wadi has an approximate width range from 50-150 meters; Wadi length is approximately 2.4 km. The distance from Saint kathreine city is about 2.4 km (Stands 20,21, 22, 23, 24).

**Stand (20):** “*Seriphidium herba-album* (Asso) Sojak. Community”

Fourteen plant species have been recorded inside this stand; the characteristic species of this community are *Seriphidium herba-album* (Asso) Sojak. (I.V.I.= 54.36), co-dominant is *Teucrium polium* L. (I.V.I.= 45.32), *Galium sinaicum* (Delile ex Decne.) Boiss. (I.V.I.= 35.80). The other associated species have low important value.

**Stand (21):** “*Seriphidium herba-album* (Asso) Sojak. Community”

Fourteen species have been recorded in this stand; the characteristic species of this community are *Seriphidium herba-album* (Asso) Sojak. (I.V.I. = 88.31), *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. (I.V. I= 46.26), and *Galium sinaicum* (Delile ex Decne.) Boiss (I.V. I= 29.02). The other associated species are lower in their important value.

**Stand (22):** *Seriphidium herba-album* (Asso) Sojak. Community.

Eighteen species have been recorded in this stand. The characteristic species of this community are *Seriphidium herba-album* (Asso) Sojak. (I.V. I=84.67), *Teucrium polium* L. (I.V.I.= 38.58), *Bufonia multiceps* Decne (I.V. I=31.85). The other associated species have a lower important value index.

**Stand (23):** *Seriphidium herba-album* (Asso) Sojak. Community.

Twenty species have been recorded in this stand; the characteristic species of this stand are *Seriphidium herba-album* (Asso) Sojak. (I.V.I. = 97.17), *Bufonia multiceps* Decne. (I.V.I. = 28.52), *Stachys aegyptiaca* Pers. (I.V.I.= 21.21). The other associated species with a lower important value index.

**Stand (24):** *Seriphidium herba-album* (Asso) Sojak. Community.

Twenty species have been recorded in this stand. The characteristic species of this community are *Seriphidium herba-album* (Asso) Sojak. (I.V.I.= 55.60), Co-dominant is *Echinops spinosus* L (I.V.I.= 26.75) and *Bufonia multiceps* Decne & *Stachys aegyptiaca* Pers. (I.V.I.= 26.34). The other species with lower important value index.

#### **Site 8. Wadi Alarbein.**

Wadi Alarbein is located at 28.553238°N 33.948651°E, 28.534353°N 33.965879°E. with an Altitude range of 1620-1772 (m asl). The soil texture of Wadi Alarbein contains 30% bolder, 45% rocks, 20% gravel and 5% sand. It has High human activity and High grazing pressure. Wadi bed is moderately vegetated with a rocky substrate. Plant richness is relatively high with high vegetation coverage. Rock sizes range from 5 cm to 60 cm. large boulders were found near the edges of wadi. Granitic geology. Trail heavily used by tourists and camels (route to Mt. Sinai and Mt. St. Katherine). Wadi has a concave topography with North to Northeast slope exposure. The steepness of the wadi ranges from 5°-15° while the steepness of slope ranges from 45°- 60°. The wadi has approximately a width range from 90-160 meters; Wadi length is approximately 2.7 km. The distance from Saint kathreine city is about 1.3 km (Stands 25, 26, 27, 28, 29).

**Stand (25):** *Achillea fragrantissima* (Forssk.) Sch. Bip. Community

Twenty species have been recorded in this stand. The characteristic species of this community are *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 45.44), co-dominant is *Stachys aegyptiaca* Pers. (I.V.I.= 31.28), *Seriphidium herba-album* (Asso) Sojak. (I.V.I.= 24.67). The other species with low Important Value Index.

**Stand (26):** *Achillea fragrantissima* (Forssk.) Sch. Bip. Community

Fourteen species have been recorded in this stand; the most characteristic species are *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V. I= 57.30), co-dominant is *Seriphidium*

*herba-album* (Asso) Sojak. (I.V.I.= 35.16), *Stachys aegyptiaca* Pers. & *Alkanna orientalis* (L.) Boiss (I.V.I.= 27.18). The other species with lower important value index.

**Stand (27):** *Seriphidium herba-album* (Asso) Sojak. Community.

Ten species have been recorded within this stand and the most Characteristic species recorded in this community are *Seriphidium herba-album* (Asso) Sojak. (I.V.I. = 69.05) as dominant species, *Teucrium polium* L. (I.V.I. = 49.86) as co-dominant, *Fagonia mollis* Delile. (I.V.I. = 44.07). The other associated species have a lower Important Value Index.

**Stand (28):** *Achillea fragrantissima* (Forssk.) Sch. Bip. Community.

Sixteen species have been recorded in this stand, and the characteristic species of this community are: *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 66.65) as dominant species, the co-dominant species is *Fagonia mollis* Delile. (I.V.I.= 43.68) and *Teucrium polium* L. (I.V.I.= 33.45). The other associated species have a lower important value index.

**Stand (29):** *Achillea fragrantissima* (Forssk.) Sch. Bip. Community.

Twelve species have been recorded in this stand; the Characteristic species of this community are: *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 93.37) dominant species, co-dominant is *Stachys aegyptiaca* Pers. (I.V.I.= 44.77) and *Alkanna orientalis* (L.) Boiss. (I.V.I. = 26.53). The other species with lower Important Value Index.

#### **Site 9. Wadi Itlah.**

Wadi Itlah is located at 28.565158°N 33.936247°E, 28.587947°N 33.920303°E with an Altitude range of 1410-1680 (m asl). The soil texture of Wadi Itlah contains 25% bolder, 45% rocks, 25% gravel and 5% sand. It has High human activity and High grazing pressure. Wadi bed consists of a coarse sand substrate with granite geology and basalt dykes. The topography of the wadi is concave and the slope exposure varies from flat to northwest to northeast. The wadi orientation varies from the southeast to the north. The width of the wadi ranges from 25 meters to 75 meters while wadi length is approximately 3.5 km. The distance from Saint kathreine city is about 1.7km. The steepness of the wadi bed ranges from 1-25% while the steepness of slope ranges from 45°-50°. There is high diversity and cover of species in this wadi. There are moderate to high disturbance impacts from grazing to human disturbance from Bedouin gardens and wells (Stands 30, 31, 32, 33).

**Stand (30):** *Launaea nudicaulis* (L.) Hook. F. community.

Fourteen species have been recorded within the stand and the most characteristic species representing the community are: *Launaea nudicaulis* (L.) Hook. F. (I.V.I.= 67.32) which represents the dominant species, the co-dominant species is *Bufonia multiceps* Decne. (I.V.I.= 51.86), *Alkanna orientalis* (L.) Boiss. (I.V.I.= 37.43). The other associated species with lower Important Value Index.

**Stand (31):** *Euphorbia sanctae-catharinae* Fayed. Community.

In this stand, eighteen species have been recorded during the survey and the most characteristic species representing this community is the dominant species *Euphorbia sanctae-catharinae* Fayed. with (I.V.I.= 45.61), the co-dominant species is *Fagonia mollis* Delile. with (I.V.I.= 40.13), *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 36.84). The other species recorded a lower Important value Index.

**Stand (32):** *Achillea fragrantissima* (Forssk.) Sch. Bip. community.

Eighteen species have been recorded within this stand, the most Characteristic species in this community are: *Achillea fragrantissima* (Forssk.) Sch. Bip. with (I.V.I.= 38.63) as dominant species, *Andrachne aspera* Spreng. with (I.V.I.= 35.57) as co-dominant species, *Centaurea eryngioides* Lam. & *Fagonia mollis* Delile. with (I.V.I.= 28.38). The other with lower Important Value Index.

**Stand (33):** *Euphorbia sanctae-catharinae* Fayed. Community.

Nineteen species have been recorded within the stand and the most characteristic species representing the community are *Euphorbia sanctae-catharinae* Fayed. (I.V.I.=

38.23) which represent the dominant species, the co-dominant species is *Juncus rigidus* Desf. & *Stachys aegyptiaca* Pers. (I.V.I.= 24.55), *Pulicaria undulata* (L.) C. A. Mey. (I.V.I.= 23.28). The other associated species with lower Important Value Index.

**Site 10. Wadi Eltalaa.**

Wadi Eltalaa is located at 28.568015°N 33.933169°E, 28.548125°N 33.934407°E with an Altitude range of 1530-1810 (m asl). The soil texture of Wadi Eltalaa contains 35% bolder, 35% rocks, 25% gravel and 5% sand. It has High human activity and High grazing pressure. This Wadi bed consists of a course sand substrate with granite geology and basalt dykes. The topography of the wadi is concave and the slope exposure varies from east to northeast to west. The width of the wadi ranges from 50 meters to 100 meters while wadi length is approximately 1.4 km. The distance from Saint kathreine city is about 1.4km. The steepness of the wadi bed ranges from 1-25% while the steepness of slope ranges from 45°-50°. There is high diversity and cover of species in this wadi. There are moderate to high disturbance impacts from grazing to human disturbance from Bedouin gardens and wells (Stands 34, 35, 36, 37).

**Stand (34):** *Euphorbia sanctae-catharinae* Fayed..community.

In this stand, seventeen species have been recorded during the survey and the most characteristic species representing this community is: the dominant species is *Euphorbia sanctae-catharinae* Fayed. with (I.V.I.= 58.19), the co-dominant species is *Echinops spinosus* L. with (I.V.I.= 37.68), *Origanum syriacum* L. (I.V.I.= 25.75). The other species recorded a lower Important value Index.

**Stand (35):** *Seriphidium herba-album* (Asso) Sojak.Community

Eight species have been recorded in this stand. The characteristic species of this community are *Seriphidium herba-album* (Asso) Sojak. (I.V.I.= 137.65), co-dominant is *Chiliadenus montanus* (Vahl) Brullo. (I.V.I.= 49.95) , *Stachys aegyptiaca* Pers. (I.V.I.= 28.32). The other species with low Important Value Index.

**Stand (36):** *Achillea fragrantissima* (Forssk.) Sch. Bip. Community.

Sixteen species have been recorded within this stand and the most Characteristic species recorded in this community are: *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I. = 36.42) as dominant species, *Origanum syriacum* L. (I.V.I. = 31.75) as co-dominant, *Nepeta septemcrenata* Benth. (I.V.I. = 30.50). The other species with low Important Value Index.

**Stand (37):** *Euphorbia sanctae-catharinae* Fayed. Community.

Nineteen species have been recorded in this stand, and the characteristic species of this community are *Euphorbia sanctae-catharinae* Fayed. (I.V.I.= 39.60) as the dominant species, the co-dominant species is *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 33.67) and *Chiliadenus montanus* (Vahl) Brullo. & *Juncus rigidus* Desf. (I.V.I.=22.02). The other associated species have a lower important value index.

**Site 11. Abo Waleie.**

Abo Waleie is located at 28.536110°N 33.907304°E, 28.533957°N 33.911195°E with an Altitude range of 1880-1900 (m asl). The soil texture of Abo Waleie contains 5% bolder, 25% rocks, 45% gravel and 25% sand. It has High human activity and High grazing pressure. Abo Waleie is a Narrow steep wadi where flash floods are especially violent. The wadi consists of rocks and gravel with granitic geology with some sandstone features. The topography of the wadi is concave and the slope exposure is southwest. The width of the wadi ranges from 10 meters to 30 meters while wadi length is approximately 1 km. The distance from Saint kathreine city is about 5.3 km. The steepness of the wadi ranges from 5°- 15° while the steepness of slope ranges from 45°-75°. There is high diversity and cover of species in this wadi. Feral donkeys are the biggest threat in this area. Bedouin gardens widespread in this area (Stands 38, 39, 40).

**Stand (38):** *Achillea fragrantissima* (Forssk.) Sch. Bip.Community.

In this stand, seventeen species have been recorded during the survey and the most characteristic species representing this community is: the dominant species *Achillea fragrantissima* (Forssk.) Sch. Bip. with (I.V.I.= 94.98), the co-dominant species is *Euphorbia sanctae-catharinae* Fayed with (I.V.I.= 22.34), *Alkanna orientalis* (L.) Boiss. ; *Origanum syriacum* L. & *Verbascum sinaiticum* Benth. (I.V.I.= 21.15). The other species recorded a lower Important value Index.

**Stand (39):** *Euphorbia sanctae-catharinae* Fayed. Community.

Eight species have been recorded within this stand and the most Characteristic species recorded in this community are *Euphorbia sanctae-catharinae* Fayed. (I.V.I. = 104.63) as dominant species, *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I. = 60.32) as co-dominant, *Centaurea eryngioides* Lam. (I.V.I. = 41.86). The other associated species have a lower Important Value Index.

**Stand (40):** *Euphorbia sanctae-catharinae* Fayed. community

Thirteen species have been recorded in this stand, and the characteristic species of this community are *Euphorbia sanctae-catharinae* Fayed. (I.V.I.= 99.17) as the dominant species, the co-dominant species is *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 53.98) and *Plantago sinaica* (Barneoud) Decne. (I.V.I.=31.02). The other associated species have a lower important value index.

#### **Site 12. Elzawitin.**

Elzawitin is located at 28.539435°N 33.922390°E, 28.536107°N 33.915695°E. with an Altitude range of 1920-1945 (m asl). The soil texture of Elzawitin contains 15% bolder, 25% rocks, 45% gravel and 15% sand. It has High human activity and High grazing pressure. This Wadi bed consists of a coarse sand substrate with granite geology. Wadi has a concave topography with a southwestern slope exposure. The steepness of the wadi ranges from 5°-25°. The wadi bed is approximately 25 meters wide while wadi length is approximately 930 m. The distance from Saint Katherine city is about 3.3 km. There is high diversity and cover of species in this wadi. Feral donkeys are the biggest threat in this area. Wadi bed is adjacent to Bedouin garden with a footpath along the top of wadi channel (Stans 41, 42).

**Stand (41):** *Euphorbia sanctae-catharinae* Fayed. Community.

Fourteen species have been recorded in this stand, and the characteristic species of this community are *Euphorbia sanctae-catharinae* Fayed. (I.V.I.= 81.26) as the dominant species, the co-dominant species is *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 63.20) and *Stachys aegyptiaca* Pers. (I.V.I.=33.67). The other associated species have a lower important value index.

**Stand (42):** *Achillea fragrantissima* (Forssk.) Sch. Bip. Community.

Ten species have been recorded in this stand; the Characteristic species of this community are: *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 90.61) dominant species, co-dominant is *Teucrium polium* L. (I.V.I.= 41.50) and *Pteroccephalus sanctus* Decne. (I.V.I. = 31.53). The other species with lower Important Value Index.

## **DISCUSSION**

The southern part of Sinai is relatively floristically rich compared to the rest of Sinai. In agreement with Danin (1978 & 1983), Moustafa and Klopatek, (1995) 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. The present study aimed to identify major plant communities dominating the 42 studied stands from Saint Katherine protectorate. Results showed the presence of Twelve plant communities along the Twelve sites of the study area. The major plant communities were *Teucrium polium* has the highest presence percentage (34 stand = 81 %), followed by *Nepeta septemcrenata* and

*Phlomis aurea* (32 stand = 76.2 %), *Chiliadenus montanus* and *Seriphidium herba-album* (29 stand = 69 %), *Echinops spinosus* and *Tanacetum sinaicum* (27 stand = 64.3 %), *Stachys aegyptiaca* (25 stand = 59.5 %), *Ballota undulata* (24 stand = 57.1 %), *Achillea fragrantissima* (22 stand = 52.4 %).

In agreement with (Moustafa and Klopatek, 1995) 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 (Zohary, 1973; Shmida, 1984; Moustafa, 1990). Danin (1986) estimated 28 endemic species, 3.2% of its total flora. More than 50% of these species are found in the 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 (1972 & 1978, 1986); Moustafa (1986 & 1990); Boulos and Gibali (1995) indicate 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 (El-Hadidi, 1967). Eleven threatened and endemic species and four near endemics Based on the list of Boulos (2009) of rare species in southern Sinai and our data, 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 retention ability; and, (4) a reduction of the total plant cover that protects the soil surface, slow down erosion and stabilizes the relief. It is noticed, in certain plant communities, that the most common species is the least grazed.

Saint Katherine mountains are a centre of endemism. twenty endemics and 29 near-endemics were recorded (Boulos 2009), about 50% of them are growing in the floristically rich landforms types that have a wetter microclimate than other habitats of Sinai (Mosallam, 2007)

#### Conclusion

The present work is a contribution to the vegetation of THE Saint Katherine protectorate. Twelve sites including 42 stands were studied and Twelve plant communities have been identified. Further studies investigating vegetation and monitoring different environmental changes and anthropogenic activities in Saint Katherine protectorate are strongly recommended.

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