

# Flora and Plant Communities of the Eastern Sector of Saint Katherine Protectorate, South Sinai, Egypt

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## Abstract

A total of 25 stands representing different habitats of Saint Katherine protectorate, south Sinai, Egypt have been chosen to represent the most common plant communities. Species were identified and their scientific names were updated. Nine distinct locations (Hamatet Abada, Shaq Elgragnia, Wadi Al Arbeen, Shaq Musa, El Talaa, Itlah, El Faraa, El Mesirdi and Ain Elshkia) at different elevation (1488-2076 m asl ). Five quadrats were set at each stand. For each stand density, frequency, abundance, relative density, relative frequency, relative abundance and the important value index were calculated for each species. A total of 61 species belonging to 26 families were recorded, Compositae and Libiatae were the most common families. Nine plant communities were identified, *Matthiola arabica* and *Artemisia herba-alba* were the most common dominant species at eight stands each, followed by *Alkanna orientalis* at two stands, *Fagonia mollis* at two stands, followed by *Phlomis aurea*, *Teucrium polium*, *Echinops glaberrimus*, *Hypericum sinaicum*, and *Cynodon dactylon*, each at only one stand.

## Introduction

Sinai is the meeting point of two continents; Africa and Asia. This union is reflected in the physiography, climate and plant cover of Sinai. Sinai is of special ecological interest because of its variable environment, beautiful landscape, distinctive flora and above all its uniqueness and contrasts (Zahran and Willis, 2009). Although Sinai is surrounded on three-fifths of its perimeter by water, the climate is dry and the peninsula contains large tracts of desert and high rugged mountains. No permanent rivers flow from Sinai, yet during winter storms torrents of water rush down the usually dry wadis and can wash away concrete bridges and roadbeds (Zahran and Willis, 2009). 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 a 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 Worldwide Fund for Nature (IUCN, 1994).

In 1993 the Egyptian government designated the Saint Katherine area as a future National Park. The Saint Katherine region is situated in the southern Sinai and is part of the upper Sinai massif (Danin, 1983). It is located between 33° 55' to 34° 30' East, and 28° 30' to 28° 35' North. Elevation ranges from 1300 to 2600 m asl. This region is characterized by outcrops of smooth granite uplifted to form several mountain peaks (e.g. Gebel Catherina 2641m asl, Gebel Abbas 2364 m, Gebel Musa 2285 m, and Gebel Ras Safsafa 2168 m) (Said, 1962).

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). Moustafa & Zaghloul (1996) reported that the highest percentage (57.1%) of these endemic species is found in gorge habitats of the rugged mountainous districts which contain the highest peaks in Egypt (Saint Katherine Mountain). (Khafagi et al., 2012) recorded 38 families dominant with Asteraceae (15 %), Lamiaceae (11.5 %), Scrophulariaceae (6.1 %) and Caryophyllaceae (5.3 %), *Hypericum sinaicum* was recorded as dominant species with 5 %. Recently, Hatim et al. (2016) recorded 496 species in Sinai belonging to 69 families and 281 genera formed the basis for further analysis. Asteraceae, Poaceae and Fabaceae were the most represented families. The lists contain 52 threatened, 16 endemic and 20 sub-endemic species. The percentage of

endemic species is highest in insular floras, peninsulas and mountain chains. **Abd El-Wahab et al. (2004)** studied the conservation of medicinal plants in St. Katherine Protectorate, South Sinai, Egypt. They assessed the present status of the medicinal plants in St. Katherine Protectorate, distribution, the causes of its loss and the specific threats facing conservation and sustainable use of these globally significant medicinal species.. Sinai has the highest mountain peak in Egypt, Saint Katherine mountain with altitude of 2641m asl .The area around mount Katherine is very unique, therefore, the area was declared to be one of the largest protected areas in Egypt. Vegetation of Saint Katherine has been studied by several authors (**Moustafa and Zaghoul, 1993; Ward et al., 2002; Tan, 2005 and Zahran and Willis, 2009**).

The present study aims at identifying some of the plant communities growing in the eastern sector of Saint Ktherine protectorate and species distribution along the study area.

### Materials and methods

Vegetation of twenty five stands, with five quadrats (5×5 m) using The Quadrate Transect Method (Fig.1). The GPS position of each stand was recooded including latitude, longitude, habitate 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) and Boulos (1999-2005)**. Plant names were updated after ([www.the.plantlist.org](http://www.the.plantlist.org)). Voucher herbarium specimens were prepared and kept in the herbarium of the Department of Botany and Microbiolgy, Faculty of Science, Al-Azhar University (Girl'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 stuiud) 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

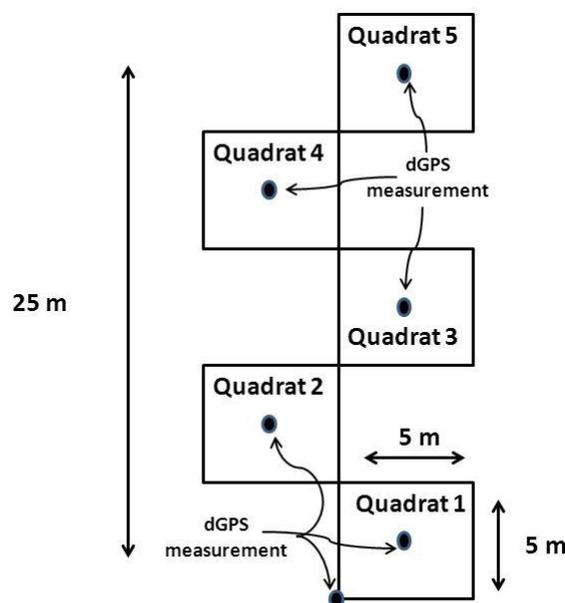


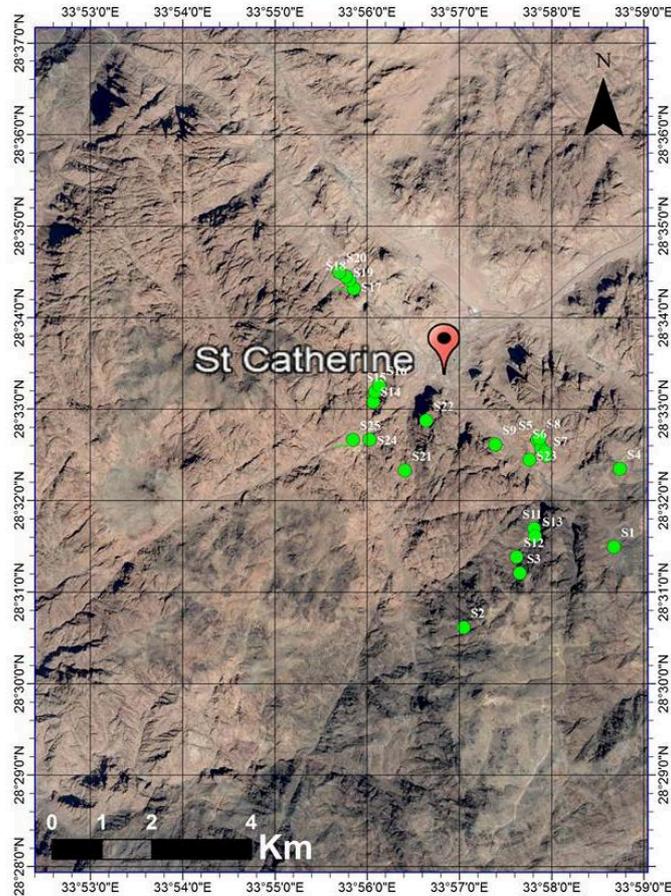
Fig 1. A schematic illustration for the vegetation survey method.

### Results

A total of 25 stands representing different habitats of Saint Khatherine protectorate (SKP) have been chosen to represent the most common plant communities of Saint Katherine protectorate. A total of 61 species belonging to 26 families were recorded. Asteraceae with 21.3% and Lamiaceae with 18% were the most common families (Fig 2.)

Table1. GPS position of the studied 25 stands including sites, habitate, longitude, latitude and altitude.

Site	Stands	Habitat	Latitude	Longitude	Altitude
<b>Hamatet Abada</b>	Stand 1	Wadi bed	28.52491	33.97797	1910
<b>Shaq Elgragnia</b>	Stand 2	Gorges	28.51023	33.95083	1810
	Stand 3	Gorges	28.52010	33.96090	1811
	Stand 4	Gorges	28.53911	33.97902	1820
<b>Wadi El-Arba'een</b>	Stand 5	Wadi bed	28.54440	33.96410	1724
	Stand 6	Wadi bed	28.54283	33.96477	1690
<b>Shaq Musa</b>	Stand 7	Gorges	28.54152	33.96576	1920
	Stand 8	Gorges	28.54469	33.96450	2076
	Stand 9	Gorges	28.54353	33.95651	1980
<b>El-Talaa</b>	Stand 10	Wadi bed	28.54217	33.96555	1643
	Stand 11	Wadi bed	28.52824	33.96354	1636
<b>Itlah</b>	Stand 12	Gorges	28.52303	33.96033	1542
	Stand 13	Gorges	28.52685	33.96371	1525
	Stand 14	Wadi bed	28.55129	33.93447	1503
	Stand 15	Wadi bed	28.55321	33.93482	1488
<b>Elfaraa</b>	Stand 16	Wadi bed	28.55435	33.93552	1809
	Stand 17	Wadi bed	28.57192	33.93098	1824
	Stand 18	Slope	28.57348	33.93016	1830
	Stand 19	Slope	28.57413	33.92950	1829
	Stand 20	Slope	28.57492	33.92829	1828
	Stand 21	Slope	28.53878	33.94013	1828
<b>El-Mesirdi</b>	Stand 22	Wadi bed	28.54790	33.94403	1912
	Stand 23	Terraces	28.54075	33.96265	1716
	Stand 24	Terraces	28.54443	33.93378	1694
<b>Ain El-shkia</b>	Stand 25	Terraces	28.54437	33.93078	1807



Map1. GPS position of the studied 25 stands (ArcGIS 10.2)

Table 2. List of the species and their families recorded in twenty five stands in the study area

No.	SPECIES	Family	Common Arabic name
1	<i>Adiantum capillus-veneris f. rimicola</i> (Sloss.)	Adiantaceae	كزبرة البير. شعر النبات
2	<i>Deverra triradiata</i> Hochst. ex Boiss	Apiaceae	زجوح - عليجان - قصوخ
3	<i>Phoenix dactylifera</i> L.	Areaceae	نخله
4	<i>Gomphocarpus sinaicus</i> Boiss	Apocynaceae	حرجل بري
5	<i>Achillea fragrantissima</i> (Forssk.) Sch. Bip.	Asteraceae	قيصوم
6	<i>Artemisia herba-alba</i> Asso	Asteraceae	شبح
7	<i>Centaurea aegyptiaca</i> L.	Asteraceae	يمرار
8	<i>Centaurea eryngioides</i> Lam.	Asteraceae	لحية البدن
9	<i>Centaurea scoparia</i> Sieber ex Spreng.	Asteraceae	برقان
10	<i>Chiliadenus montanus</i> (Vahl) Brullo.	Asteraceae	هنيدة، نهيدة
11	<i>Echinops glaberrimus</i> DC	Asteraceae	خشبر
12	<i>Echinops spinosissimus</i> Turra	Asteraceae	خشبر
13	<i>Erigeron trilobus</i> (Decne.) Boiss	Asteraceae	حاييه، سليسله
14	<i>Gymnarrhena micrantha</i> Desf.	Asteraceae	خرشيف
15	<i>Olivaea leptocarpa</i> DeJong & Beaman	Asteraceae	شجره زيتون
16	<i>Pulicaria undulata</i> (L.) C. A. Mey.	Asteraceae	دثاث . دثااث . سيد
17	<i>Tanacetum sinaicum</i> (Fresen.) Delile ex	Asteraceae	مر
18	<i>Alkanna orientalis</i> (L.) Boiss.	Boraginaceae	اللبيد
19	<i>Diplotaxis harra</i> (Forssk.) Boiss	Brassicaceae	حاره
20	<i>Farsetia aegyptia</i> Turra	Brassicaceae	جربه ، جريبي
21	<i>Matthiola arabica</i> Boiss.	Brassicaceae	خمخم
22	<i>Zilla spinosa</i> (L.) Prantl	Brassicaceae	زله - سلة - بسلة
23	<i>Capparis spinosa</i> L.	Cappariaceae	لصف - ورد الجبل
24	<i>Bufonia multiceps</i> Decne	Caryophyllaceae	عدمه
25	<i>Silene schimperiana</i> Boiss.	Caryophyllaceae	لصيق
26	<i>Pterocephalus sanctus</i> Decne.	Dipsacaceae	علجه . مجلينة . عسيل
27	<i>Euphorbia obovata</i> Decne	Euphorbaiceae	بينه
28	<i>Astracantha echinus</i> (DC.)podlech	Fabaceae	قدس
29	<i>Hypericum sinaicum</i> Hochst. ex Boiss	Hypericaceae	ركيح ، ليخ ، شاي الجبل
30	<i>Juncus rigidus</i> Desf.	Juncaceae	سمار ، سمار حصر ، سمار مر
31	<i>Ballota undulata</i> (Sieber ex Fresen.) Benth	Lamiaceae	الغاصة . زفرة
32	<i>Lavandula coronopifolia</i> Poir.	Lamiaceae	زيتة
33	<i>Mentha longifolia</i> (L.) L.	Lamiaceae	حبك ، حبق
34	<i>Nepeta septemcrenata</i> Ehrenb.ex Benth.	Lamiaceae	زيتيه ، مسبيسة
35	<i>Origanum syriacum</i> L	Lamiaceae	زعتن ، بردقوش
36	<i>Phlomis aurea</i> Decne.	Lamiaceae	عورور . زهيرة
37	<i>Salvia aegyptiaca</i> L.	Lamiaceae	زيتيه . رعة
38	<i>Salvia spinosa</i> L.	Lamiaceae	ذانون . ذان الحمار . شجرة الغزال
39	<i>Stachys aegyptiaca</i> Pers	Lamiaceae	جرطم - رغات - رغل
40	<i>Teucrium polium</i> L.	Lamiaceae	جعدة
41	<i>Thymus decussatus</i> Benth.	Lamiaceae	زعتران - زعيتن
42	<i>Ficus carica</i> L.	Moraceae	تين
43	<i>Peganum harmala</i> L.	Nitrariaceae	حرملان ، حرم
44	<i>Papaver aculeatum</i> Thunb.	Papaveraceae	اقبون
45	<i>Veronica anagalis -aquatica</i> L.	Plantaginaceae	عشب الميه
46	<i>Kickxia aegyptiaca</i> (L.) Nābelek.	Plantagonaceae	عشب الديب ، مجلينة
47	<i>Plantago sinaica</i> (Barneoud) Decne.	Plantagonaceae	لسان الحمل . رعية البدن . مديهنة
48	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	مديد - نجبلا
49	<i>Hyparrhenia hirta</i> (L.) Stapf.	Poaceae	سفسوف ، حميرة
50	<i>Polygala sinaica</i> Botsch.	Polygalaceae	هيكل . صر
51	<i>Cotoneaster orbicularis</i> Schldl.	Rosaceae	شوحط   شوحه
52	<i>Crataegus x sinaica</i> Boiss.	Rosaceae	زعرور

53	<i>Rosa arabica</i> Crep.	Rosaceae	الورد البري
54	<i>Galium setaceum</i> Lam.	Rubiaceae	بسيصة
55	<i>Anarrhinum duriminium</i> (Brot.) Pers	Scrophulariaceae	أرفيجه رفيعة
56	<i>Scrophularia libanotica</i> Boiss.	Scrophulariaceae	شليك
57	<i>Verbascum sinaiticum</i> Benth.	Scrophulariaceae	خرماع
58	<i>Hyoscyamus muticus</i> L.	Solanaceae	سكران
59	<i>Solanum americanum</i> Mill.	Solanaceae	عنب الذئب . عنب الديب
60	<i>Fagonia arabica</i> L	Zygophyllaceae	حلو الجمل ، ورقة ، شيرق
61	<i>Fagonia mollis</i> Delile	Zygophyllaceae	الشكاعة ، ورقة

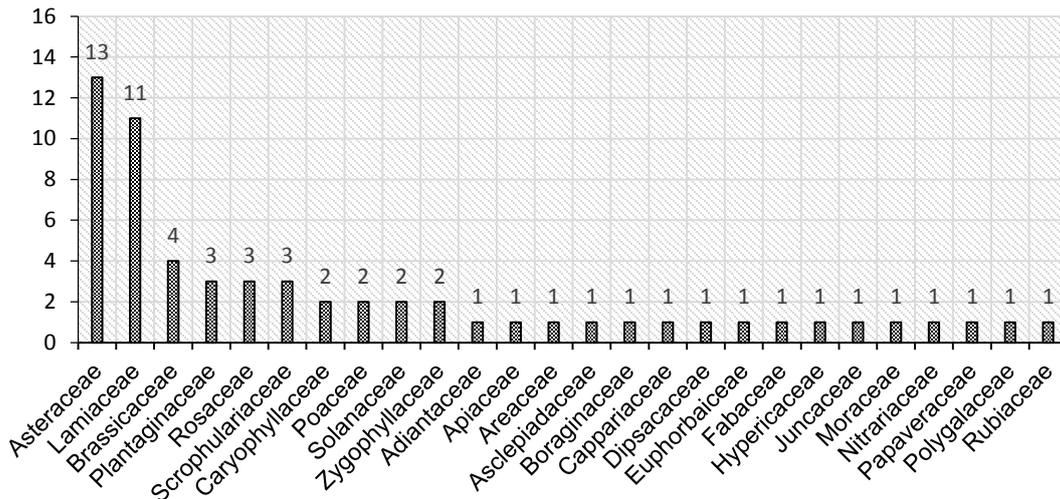


Fig 2. Shows 26 families represent the studied 25 stand in the present study

The selected 25 stands were located in nine sites, each site may contain one or more stands. In the following section, the description of the nine sites and the 25 stands is listed:

**Site 1: Hamatet A'bada**

Hamatet A'abada is located at 28.532065°N 33.970985° E, 28.513828°N 33.975373°E., with altitude range: 1850:2160 (m asl). Soil texture of the wadi Hammatet A'abada contains 15% Bolder, 30% Rocks, 30% Gravel and 25% Sand. It has medium grazing pressure. This wadi is in a steep gorge which rises from the end of Wadi Arbaein steeply upwards towards the summit of Mount St. Katherine. The gorge consists of bolder and rocks substrate with granite geology with sporadic sandstone features. The distance from Saint Kathreine city is about 4.2 km. The topography of the wadi is concave and the slope exposure varies from east to northeast to west. The distance from Saint Kathreine city is about 1.4 km. There is a high diversity and cover of species in this wadi. There is moderate to high disturbance impacts from grazing to human disturbance from Bedouin

gardens and wells. This site includes one stand (Stand 1)

**Stand 1 ‘Alkanna orientalis Community’**

In this stand, 7 species were recorded, the characteristic species of this community are *Alkanna orientalis* (I.V.I. = 126.55), *Artemisia herba-alb* (I.V.I. = 56.01), *Zilla spinosa* (I.V.I. = 37.44). Other associated species have lower importance values. The dominant species is *Alkanna orientalis*; *Artemisia herba-alb* is the co-dominant species. *Echinops spinosissimus*, *Gomphocarpus sinaicus*, *Achillea fragrantissima* are rare species.

**Site 2: Shaq El Gragnia**

Shaq Elgragnia is located at 28.532072°N 33.969543°E, 28.518591°N 33.970243°E. with altitude range: 1810:2150 (m asl). Soil texture of Shaq Elgragnia contains 40% bolder, 40% rocks, 15% gravel and 5% sand. It has low human activity, and low grazing pressure. The gorge consists of 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 Kathreine

city is about 4.5 km. This location included three stands (Stands 2, 3, 4).

#### Stand 2 “*Alkana orientalis* Community”

In this stand, 13 species were recorded, the characteristic species of this community are *Alkana orientalis* (I.V.I.=47.66), *Adiantum capillus-veneris* (I.V.I = 41.93), *Veronica anagalis* (I.V.I = 33.58). The other associated species have lower importance value. The dominant species is *Alkana orientalis*; *Adiantum capillus-veneris* is the co-dominant species. *Ficus caraca* and *Pterocephalus sanctus* are rare species. *Phlomis aurea* and *Ballota Undulata* are endemic plants. *Nepeta septemcrenata* is near endemic plant species.

#### Stand 3 “*Phlomis aurea* Community”

In this stand, 10 species were recorded, the characteristic species of this community are *Phlomis aurea* (I.V.I.=61.41), *Echinops spinosissimus* (I.V.I.=56.21), *Alkana orientalis* (I.V.I.= 51.95). The other associated species have lower importance values. The dominant species is *Phlomis aurea* species; *Echinops spinosissimus* is the co-dominant species. *Tanacetum sinaicum* and *Anarrhinum duriminium* are rare species. *Phlomis aurea*, *Ballota undulate*, *Tanacetum sinaicum* and *Anarrhinum duriminium* are endemic plants. *Nepeta septemcrenata* is near endemic plant species.

#### Stand 4 “*Artemisia herba-alb* community”

In this stand, 14 species were recorded, the characteristic species of this community are *Artemisia herba-alba* (I.V.I.=62.32), *Alkana orientalis* (I.V.I. = 35.74), *Origanum syriacum* (I.V.I. = 34.83). The other associated species have lower importance values. The dominant is *Artemisia herba-alba* species; *Alkana orientalis* is the co-dominant species. *Ficus caraca* is rare species. *Origanum syriacum*, *Ballota undulata* and *Phlomis aurea* are endemic plants. *Nepeta septemcrenata* is near endemic plant species.

#### Site 3: Wadi El-Arb'een

Wadi El –Arae'en is located 28.553238°N 33.948651°E, 28.534353°N 33.965879°E, with altitude range: 1620-1772 (m asl). Soil texture of Wadi El –Arae'en contains 30% bolder, 45 % rocks, 20 % gravel and 5 % sand. The wadi has high human activity and high grazing pressure. It is bounded by Gebel EL-Sarwo (2150 m asl) to the east, and extension of Gebel Safsafa (2168 m asl), and Gebel EL-Rabba at the Northern

boundary, (N: 28.54540, E: 33.95536). Wadi bed is moderately vegetated, with a rocky substrate. Large boulders are found near edges of Wadi. Trail heavily used by tourists and camels (route to Mt. Sinai and Mt. St. Katherine). Wadi bed is covered by small gravel (<5cm). Grazing is heavy on: *Stachys aegyptiaca*, *Ballota undulata*, and *Seriphidium herba-album*. In wadi El-Arbae'en, one can easily recognize the beautiful cave on the right hand side, which is one of most wonderful places in this wadi. This location included two stands (Stands 5, 6).

#### Stand 5 “*Fagonia mollis* community”

In this stand, 12 species were recorded, the characteristic species of this community are *Fagonia mollis* (I.V.I. = 84.33), *Alkana orientalis* (I.V.I. = 49.33), *Matthiola arabica* (I.V.I. = 34.19). The other associated species have lower importance values. The dominant is *Fagonia mollis* species; *Alkana orientalis* is the co-dominant species. *Peganum harmala*, *Tanacetum sinaicum*, *Galium setaceum*, *Chiliadenus montanus* and *Stachys aegyptiaca* are rare species. *Tanacetum sinaicum*, *Bufonia multiceps* and *phlomis aurea* are endemic plants. *Galium setaceum* is near endemic plant species.

#### Stand 6 “*Fagonia. Mollis* community”

In this stand, 20 species were recorded, the characteristic species of this community are *Fagonia mollis* (I.V.I. = 41.99), *Achillea fragrantissima* (I.V.I. =38.78), *Bufonia multiceps* (I.V.I. = 27.23). The other associated species have lower importance values. The dominant is *Fagonia mollis* specie; *Achillea fragrantissima* is the co-dominant species. *Tanacetum sinaicum*, *Gomphocarpus sinaica*, *Anarrhinum duriminium*, *Ballota undulata* and *Silene schimperiana* are rare species. *Origanum syriacum*, *Anarrhinum duriminium*, *Tanacetum sinaicum*, *Phlomis aurea*, *Ballota undulate* and *Bufonia multiceps* are endemic plants. *Galium setaceum* is near endemic plant.

#### Site 4: Shaq Musa

Shaq Musa is located at 28.533603°N 33.965518°E, 28.518911°N 33.959451°E. with altitude range: 1780-2080 (m asl). Soil texture composed of 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 which rises from the end of Wadi El-Arbae'en steeply upwards towards summit of Mount St. Katherine. The

gorge consists of bolder and rocks substrate with granite geology with sporadic sandstone features. The gorge has a rigid topography with Northwest slope exposure. The distance from Saint kathreine city is about 4.2 km. This location included three stands (Stands 7, 8, 9).

#### **Stand 7 “*Echinops glaberrimus* community”**

In this stand, 14 species were recorded, the characteristic species of this community are *Echinops glaberrimus* (I.V.I. = 58.63), *Phlomis aurea* (I.V.I. = 42.30), *Verbascum sinaiticum* (I.V.I. = 28.09). The other associated species have lower importance values. The dominant is *Echinops glaberrimus* species; *Phlomis aurea* is the co-dominant species. *Peganum harmala*, *Nepeta septemcrenata*, *Zilla spinosa*, *Gomphocarpus sinaicus* and *Stachys aegyptiaca* are rare species. *Tanacetum sinaicum*, *Origanum syriacum*, *phlomis aurea* and *Ballota undulata* are endemic plants. *Nepeta septemcrenata* is near endemic plant species.

#### **Stand 8 “*Artemisia herba-alba* community”**

In this stand, 14 species were recorded, the characteristic species of this community are *Artemisia herba-alba* (I.V.I. = 84.87), *Echinops glaberrimus* (I.V.I. = 39.96), *Tanacetum sinaicum* (I.V.I. = 30.28). The other associated species have lower importance values. The dominant is *Artemisia herba-alba* species; *Echinops glaberrimus* is the co-dominant species, *Tanacetum sinaicum*, *Teucrium polium*, *Gymnarrhena micrantha* and *Verbascum sinaiticum* are rare species. *Tanacetum sinaicum*, *Ballota undulata* and *phlomis aurea* are endemic plants.

#### **Stand 9 “*Artemisia herba-alba* community”**

In this stand, 20 species were recorded, the characteristic species of this community are *Artemisia herba-alba* (I.V.I.= 69.83), *phlomis aurea* (I.V.I. = 37.28), *Echinops glaberrimus* (I.V.I. = 28.03). The other associated species have lower importance values. The dominant is *Artemisia herba-alba* species; *phlomis aurea* is the co-dominant species, *Rosa arabica*, *Polygala sinaica*, *Gymnarrhena micrantha*, *Verbascum sinaiticum* and *Achillea fragrantissima* are rare species. *Tanacetum sinaicum*, *Origanum syriacum*, *Ballota undulata*, *phlomis aurea* and *Polygala sinaica* are endemic plants.

#### **Site 5: Eltalaa**

Wadi Eltalaa is located 28.568102N 33.933169 E, 28.530832 N 33.934723 E, with altitude range: 1530-1810 (m asl). Soil texture of wadi Eltalaa contains 35% bolder, 35 % rocks, 25 % gravel, and 5 % sand. The wadi has high human activity and high grazing pressure. Wadi bed consists of coarse 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 distance from Saint Kathreine city is about 1.4 km. There is a high diversity and cover of species in this wadi. There is moderate to high disturbance impacts from grazing and human disturbance from Bedouin gardens and wells. The vegetation is suffering from high intensity of disturbance and grazing by camels that are used for riding. This location included five stands (Stands 10, 11).

#### **Stand 10 “*Matthiola arabica* community”**

In this stand, 19 species were recorded, the characteristic species of this community are *Matthiola arabica* (I.V.I. = 48.62), *Origanum syriacum* (I.V.I. = 31.54), *Teucrium polium* (I.V.I. = 28). The other associated species have lower importance value. Here, the dominant is *Matthiola arabica* species; *Origanum syriacum* is co-dominant species, *Peganum harmala*, *Zilla spinosa*, *Diptotaxis harra*, *Echinops glaberrimus*, *Anarrhinum duriminium* and *Tanacetum sinaicum* are rare species, *Origanum syriacum*, *Tanacetum sinaicum*, *phlomis aurea* and *Anarrhinum duriminium* are endemic plants.

#### **Stand 11 “*Matthiola Arabica* community”**

In this stand, 19 species were recorded, the characteristic species of this community are *Matthiola arabica* (I.V.I.= 77.17), *Euphorbia obovata* (I.V.I. = 33.66), *Pulicaria undulata* (I.V.I. = 22.23). The other associated species have lower importance values. The dominant is *Matthiola arabica* species; *Euphorbia obovatae* is the co-dominant species, *Stachys aegyptiaca* and *Anarrhinum duriminium* are rare species. *Euphorbia obovata*, *Origanum syriacum*, *Tanacetum sinaicum*, *phlomis aurea*, *Anarrhinum duriminium* and *Ballota undulata* are endemic plants.

#### **Site 6: Shaq Itlah**

Shaq Itlah is located is 28.543386 N 33.933071 E, with altitude range: 1360-1980 (m asl). Soil texture of Shaq Itlah contains 35 % bolder, 35 % rocks, 25 % gravel and 5%

sand. Shaq Itlah has high human activity, and medium grazing pressure. The gorge consists of boulder and rocks with granite geology. The topography of the gorge is concave and the slope exposure is northwest. The distance from Saint Kathreine city is about 5 km. There is a high plant diversity and cover of species in this gorge. This location included four stands ( Stands 12, 13, 14 and 15).

#### **Stand 12 “*Matthiola arabica* community”**

In this stand, 23 species were recorded, the characteristic species of this community are *Matthiola arabica* (I.V.I. =60.49), *Euphorbia obovata* (I.V.I. =30.58), *Achillea fragrantissima* (I.V.I. = 26.51). The other associated species have lower importance values. The dominant is *Matthiola arabica* species; *Euphorbia obovata* is the co-dominant species. *Diploaxis harra*, *pulicaria undulate*, *Fagonia arabica*, *Farsetia aegyptia*, *Ficus Carica*, *Mentha longifolia*, *Solanum americanum*, *Alkana orientalis*, *Bufonia multiceps*, *Phlomis aurea*, *Origanum syriacum*, *Salvia spinosa* and *Zilla spinosa* are rare species. *Euphorbia obovata*, *phlomis aurea*, *Anarrhinum duriminium* and *Bufonia multiceps* are endemic plants. *Galium setaceum* is near endemic plant.

#### **Stand 13 “*Matthiola arabica* community”**

In this stand, 12 species were recorded, the characteristic species of this community are *Matthiola arabica* (I.V.I. =89.07), *Fagonia mollis* (I.V.I. =38.46), *Verbascum sinaiticum* (I.V.I. =28.53). The other associated species have lower importance values. The dominant is *Matthiola arabica* species; *Fagonia mollis* is the co-dominant species. *Ficus Carica*, *Deverra triradiata*, *Juncus rigidus* and *Ballota undulata* are rare species. *Origanum syriacum* and *Ballota undulata* are endemic plants.

#### **Stand 14 “*Matthiola arabica* community”**

In this stand, 21 species were recorded, the characteristic species of this community are *Matthiola arabica* (I.V.I. =42.01), *Achillea fragrantissima* (I.V.I. =34.27), *Diploaxis harra* (I.V.I. = 31.40). The other associated species have lower importance values. The dominant is *Matthiola arabica* species; *Achillea fragrantissima* is the co-dominant species. *Verbascum sinaiticum* is rare species, *Origanum syriacum*, *Bufonia multiceps*, *Phlomis aurea*, *Anarrhinum duriminium* and *Tanacetum sinaicum* are endemic plants. *Galium setaceum* is near endemic plant.

#### **Stand 15 “*Matthiola arabica* community”**

In this stand, 23 species were recorded, the characteristic species of this community are *Matthiola arabica* (I.V.I. =84.52), *Cynodon dactylon* (I.V.I. =21.82), *Lavandula coronopifolia* (I.V.I.=20.50). The other associated species have lower importance values. The dominant is *Matthiola arabica* species; *Cynodon dactylon* is the co-dominant species. *Verbascum sinaiticum*, *Pulicaria undulate*, *Capparis spinosa*, *Origanum Syriacum*, *Echinops glaberrimus*, *Anarrhinum duriminium*, *Galium setaceum*, *Diploaxis harra*, *Hyoscyamus muticus* and *Chiliadenus montanus* are rare species. *Origanum syriacum* and *Anarrhinum duriminium* are endemic plants. *Galium setaceum* is near endemic plant.

#### **Site 7: Al- Far'aa**

Wadi Elfaraa is located at °N: 28.54440°, E: 33.96410, with altitude range: 1809-1830 (m asl). Soil texture of Wadi Elfaraa contains 10 % bolder, 10 % rocks, 40 % gravel and 40 % sand. Elfaraa has high human activity and high grazing pressure. This location consists of two slops between them wadi bed. Two stands were established in right slop, two stands were established on left slop and two stands in wadi bed. This location included six stand stands (Stands 16, 17, 18, 19, 20, and 21).

#### **Stand 16 “*Artemisia herba-alba* community”**

In this stand, 12 species were recorded, the characteristic species of this community are *Artemisia herba-alba* (I.V.I.= 118.30), *Bufonia multiceps* (I.V.I. = 45.46), *Thymus decussatus* (I.V.I.= 31.60). The other associated species have lower importance values. The dominant is *Artemisia herba-alba* species; *Bufonia multiceps* is the co-dominant species. *Pulicaria undulata*, *Stachys aegyptiaca* and *Fagonia mollis* are rare species *Tanacetum sinaicum*, *Bufonia multiceps* are endemic plants and *Thymus decussates* is near endemic plant.

#### **Stand 17 “*Artemisia herba-alba* community”**

In this stand, 13 species were recorded, the characteristic species of this community are *Artemisia herba-alba* (I.V.I. = 74.19), *Tanacetum sinaicum* (I.V.I. = 59.67), *Zilla Spinoza* (I.V.I.= 35.80). The other associated species have lower importance values. The dominant is *Artemisia herba-alba* species; *Tanacetum sinaicum* is the co-

dominant species. *Matthiola arabica*, *Pterocephalus sanctus*, *Ballota undulata*, and *Fagonia mollis*, are rare species. *Tanacetum sinaicum*, *Ballota undulata*, *phlomis aurea* are endemic plants. *Galium setaceum* is near endemic plant.

**Stand 18 “*Teucrium polium* community ”**

In this stand, 15 species were recorded, the characteristic species of this community are *Teucrium polium* (I.V.I. = 35.54), *Chiliadenus montanus* (I.V.I.= 35.24), *Pterocephalus sanctus* (I.V.I. = 29.91). The other associated species have lower importance values. The dominant is *Teucrium polium* species; *Chiliadenus montanus* is the co-dominant species. *Crataegus x sinaica* and *Ballota undulata* are rare species. *Tanacetum sinaicum*, *Ballota undulata*, *phlomis aurea* and *Plantago sinaica* are endemic plants. *Galium setaceum* is near endemic plant.

**Stand 19“*Artemisia herba-alba* community ”**

In this stand, 10 species were recorded, the characteristic species of this community are *Artemisia herba-alba* (I.V.I.= 87.89), *Tanacetum sinaicum* (I.V.I. = 43.24), *Stachys aegyptiaca* (I.V.I. = 39.12). The other associated species have lower importance values. The dominant is *Artemisia herba-alba* species; *Tanacetum sinaicum* is the co-dominant species. *Galium setaceum* and *Alkanna orientalis* are rare species. *Tanacetum sinaicum* and *phlomis aurea* are endemic plants. *Galium setaceum* is near endemic

**Stand 20“*Artemisia herba-alba* community”**

In this stand, 11 species were recorded, the characteristic species of this community are *Artemisia herba-alba* (I.V.I. = 69.17), *Stachys aegyptiaca* (I.V.I.= 67.75) , *Teucrium polium* (I.V.I. = 45.79). The other associated species have lower importance values. The dominant is *Artemisia herba-alba* species; *Stachys aegyptiaca* is the co-dominant species. *Echinops glaberrimus*, *Centaurea scoparia* are rare species. *Tanacetum sinaicum*, *phlomis aurea* and *Plantago sinaica* are endemic plant.

**Stand 21“*Artemisia herba-alba* community”**

In this stand, 14 species were recorded, the characteristic species of this community are *Artemisia herba-alba* (I.V.I.= 161.13), *Stachys aegyptiaca* (I.V.I. = 26.68), *Bufonia multiceps* (I.V.I.= 21.14). The other associated species have lower importance values. The dominant is *Artemisia herba-alba*

species; *Stachys aegyptiaca* is the co-dominant species. *Gomphocarpus sinaicus*, *Fagonia mollis*, *Nepeta septemcrenata*, *Deverra triradiata*, *Silene schimperiana*, *Diploaxis harra* and *Pterocephalus sanctus* are rare species. *Tanacetum sinaicum* and *Bufonia multiceps* are endemic plants. *Nepeta septemcrenata* is near endemic plant species.

**Site 8: El- Elmsirdi**

El msirdi is located at 28.532751 N 33.940485 E, 28.547157 N 33.940460 E, with altitude range: 1650-1915 (m asl). Soil texture of El msirdi contains 40 % bolder, 30 % rocks, 20 % gravel and 10 % sand. It has high human activity, and high grazing pressure. The gorge consists of boulder and rocks with granitic geology. The topography of the gorge is concave and the slope exposure varies from north to north east. The distance from Saint Kathreine city is about 1.8 km. There is a high plant diversity and cover of species in this gorge. This location included three stands (Stands 22, 23 and 24).

**Stand 22“*Matthiola arabica* community”**

In this stand, 19 species were recorded, the characteristic species of this community are *Matthiola arabica* (I.V.I. = 65.90), *Anarrhinum duriminium* (I.V.I. = 40.28), *Origanum syriacum* (I.V.I. = 31.27). The other associated species have lower importance values. The dominant is *Juncus rigidus* species; *Verbascum sinaiticum* is the co-dominant species. *Nepeta septemcrenata*, *Astragalus echinus* are rare species. *Origanum syriacum*, *Anarrhinum duriminium*, *Tanacetum sinaicum*, *Ballota undulate*, *Phlomis aurea* are endemic plants. *Nepeta septemcrenata* is near endemic.

**Stand 23 “*Hypericum sinaicum* community”**

In this stand, 13 species were recorded, the characteristic species of this community are *Hypericum sinaicum* (I.V.I. = 69.46), *Verbascum sinaiticum* (I.V.I. = 48.31), *Mentha longifolia* (I.V.I. = 39.99). The other associated species have lower importance values. The dominant is *Hypericum sinaicum* species; *Verbascum sinaiticum* is the co-dominant species. *Phoenix dactylifera*, *Olivaea leptocarpa*, *Papaver aculeatum* is rare species. *Origanum syriacum* is endemic plants.

**Stand 24 “*Matthiola arabica* community”**

In this stand, 21 species were recorded, the characteristic species of this community are *Matthiola arabica* (I.V.I. =

57.24), *Verbascum sinaiticum* (I.V.I. = 51.91), *Alkana orientalis* (I.V.I. = 38.98). The other associated species have lower importance values. The dominant is *Matthiola arabica* species; *Verbascum sinaiticum* is the co-dominant species. *Centaurea eryngioides*, *Zilla spinosa*, *Silene schimperiana*, *Artemisia herba-alba*, *Echinops glaberrimus*, *Tanacetum sinaicum*, *Solanum americanum*, *Phlomis aurea*, *Deverra triradiata* and *Anarrhinum duriminium* are rare species. *Origanum syriacum*, *Tanacetum sinaicum*, *Anarrhinum duriminium* and *Phlomis aurea* are endemic plants. *Galium setaceum* is near endemic plant.

#### Site 9: Ain El- Shekaia

Ain El-Shekia is located at 28.32.601°N, 33.55.964°E., with altitude 1807 (m asl). Soil texture of Ain El-Shekia contains 90 % bolder, % 2 rocks, 3 % gravel and 5 % sand. It has high human activity, and high grazing pressure. Cliff consists of boulders with granite geology. The topography of the cliff is sharpen and the slope exposure to west. A spring of water through the rocks is present characterized by a good rate of water flow all over the year. Bedouins and tourists consider it as a first rest in their trip to El-Galt El-Azraq. The water is always cool, and is a favorite watering site for camels. There is a high diversity of species in this gorge. There is moderate to high disturbance impacts from grazing to human disturbance (Tourism). This location included one stands (25).

#### Stand 25“*Cynodon dactylon* community”

In this stand, 17 species were recorded, the characteristic species of this community are *Cynodon dactylon* (I.V.I. = 41.57), *Mentha longifolia*, *Alkana orientalis* and *Matthiola arabica* (I.V.I. = 27.29), *Verbascum sinaiticum* and *Achillea fragrantissima* (I.V.I. = 25.10). The other associated species have lower importance values. The dominant species is *Cynodon dactylon* species; *Mentha longifolia*, *Alkana orientalis* and *Matthiola Arabica* are the co-dominant species. *Adiantum capillus-veneris*, *Teucrium polium*, *Ficus carica*, *Nepeta septemcrenata*, *Plantago sinaica* and *Echinops glaberrimus* are rare species. *Phlomis aurea* and *Plantago sinaica* are endemic plants. *Nepeta septemcrenata* is near endemic plant.

#### Discussion

The present study aimed at identifying major plant communities dominating the 25 studied stands from Saint Katherine protectorate. Results showed the presence of

nine plant communities along the nine sites of the study area. The major plant communities were *Matthiola arabica*, *Artemisia herba-alba* species, *Alkana orientalis*, *Fagonia mollis*, *Phlomis aurea*, *Teucrium polium*, *Echinops glaberrimus*, *Hypericum sinaicum*, and *Cynodon dactylon*

#### *Matthiola arabiaca* community:

*Matthiola arabiaca* is the most common dominant species, dominating eight stands belonging to three sites out of the 25 studied stands and the nine sites (10, 11 in tala , 12, 13, 14, 15 in Itlah and 22, 24 in El Mesirdi), with elevation range between 1488 m asl and 1912 m asl. *Matthiola arabica* is dicotyledoneae plant from family Cruciferae. *Matthiola arabica* is perennial species which found in different landforms (Gorges, Slopes, Terraces) in St. Katherine area (Ayyad *et al.*, 2000). Grazing activity is moderate with *Matthiola arabica* being heavily impacted in Safsafa Mountain (Guenther *et al.*, 2005). High elevation sites were dominant by *Matthiola arabiaca* with considerably higher plant coverage and species richness (Guenther *et al.*, 2005). *Matthiola arabica* is present as an associated species in (Arbain, Itlah, Ferah, Naqb Hawa, El Roumana, Tynia, Ahmar, Shraig, Tellacah) are high-elevation (1385-1859 m asl) wadis with a varied geology (granite, sandstone, and basalt), Vegetation richness and percentage cover are high, perhaps because of a moderately high moisture availability throughout this group of wadi's (Guenther *et al.*, 2005).

#### *Artemisia herba-alba* community:

*Artemisia herba-alba* is dominant species at eight stands belonging to three sites out of the 25 studied stands and the nine sites (4 in El Gagnia 8, 9 in Shaq Musa and 16, 17 and 19, 20, 21 in El Faraa), with elevation range between 1809 m asl and 2076 m asl. *Artemisia herba-alba* is a perennial species found in different landforms (Gorges, Slopes, Terraces and Ridges) in St. Katherine area (Ayyad *et al.*, 2000). *Artemisia herba-alba* is the dominant species characterizing the mountainous habitats (Moustafa *et al.*, 2006). *Artemisia herba-alba* is most abundant species on the very steep gorges, in the crevices between boulders and large stones. *Artemisia herba-alba* is growing in very low species richness, and grows in the fine and looser soil texture (Ayyad *et al.*, 2000). *Artemisia herba-alba* species is considered as an indicator of high soil quality and is an associated with *Peganum harmala* and *Zilla spinosa*

(Moustafa *et al.*, 2006). *Artemisia herba-alba* was an associated species in Farsh El Luz, Shaq Musa in the region to signify abundant water resources (Guenther *et al.*, 2005). In the high-elevation sites surrounding the ring dyke, the dominant plant species include *Artemisia herba-alba* (Guenther *et al.*, 2005). *Artemisia herba-alba* occurs at high elevations (2200–2400 m asl), and occupies a wide range of landform types such as open slopes, slopes with depressions, shaded gorges and, in some cases, terraces (Ayyad *et al.*, 2000).

***Alkanna orientalis* community:**

*Alkanna orientalis* is dominant species at two stands belonging to two sites out of the 25 studied stands and the nine sites (1 in Hamatet Abada and 2 in El Gragnia), with elevation at 1810 m asl and 1910 m asl. *Alkanna orientalis* is perennial species which found in different landforms (Gorges, Slopes, Terraces, Ridges) in St. Katherine area (Ayyad *et al.*, 2000). *Alkanna orientalis* is common in the mountains surrounding the St Katherine (Zahran and Willis, 2009). *Alkanna orientalis* is dominant species in the rocky slopes of the mouth of Wadi El-Raha. *Alkanna orientalis* grows in fissures of the boulders of gully bed in the mouth of Wadi El-Arbaeen, *Alkanna orientalis* is associated with *Peganum harmala* (Zahran and Willis, 2009).

***Fagonia mollis* community:**

*Fagonia mollis* is dominant species at two stands belonging to one sites out of the 25 studied stands and the nine sites (5 and 6 in Wadi Al Arbeen) with elevation at 1724 m asl, 1690 m asl. *Fagonia mollis* is perennial species found in different landforms (Gorges, Slopes, Terraces, Ridges) in St. Katherine area (Ayyad *et al.*, 2000). The flora of the Sinai mountains is dominated by Irano-Turanian species, it is accompanied by *Fagonia mollis* in stony alluvium (Zahran and Willis, 2009). *Fagonia mollis* is calcicolous species in the large tributaries of Wadi Sidri. *Fagonia mollis* is associated species in the flood channel (wadi bed) of the upstream part of Wadi El-Tor. In the wadi bed *Fagonia mollis* is an associated species. On the flat soil of the gully bed, between the boulders, *Fagonia mollis* is common. *Fagonia mollis* is common plant on sandy habitat (Zahran and Willis, 2009).

***Phlomis aurea* community:**

*Phlomis aurea* is dominant species at one stand belonging to one sites out of the 25 studied stands and the nine sites (3 in El Gragnia), with elevation of 1811 m asl. *Phlomis aurea*

(Lamiaceae) is a wild Golden-woolly perennial species growing in Sinai especially in Gebel Mousa and Saint Katharine mountains, its common Arabic name is Awarwar (Täckholm 1974, Boulos 2002). *Phlomis aurea* is endemic, restricted to the high altitudes in Southern Sinai (Boulos 2009). *Phlomis aurea* is not used as medicinal plant in South Sinai. *Phlomis aurea* individuals grow well in the moist-shade habitats as individuals that grow in moist soil and under the boulders or rocks have good vitality (Shabana, 2013). *Phlomis aurea* is dominant at 2000:2200 (m asl) (Khafagi and Omar, 2012). The bed of Wadi El-Arbaeen has a rich flora includes *Phlomis aurea*. *Phlomis aurea* is common species on the northern slope of Gebel Musa, also *Phlomis aurea* is abundant in the flora of midway to the summit of Gebel Musa. In the flat part of Farsh El-Gebel the vegetation is thinner than in the runnels *Phlomis aurea* is common there. *Phlomis aurea* is an associated species with *Peganum harmala* in the mouth of Wadi El-Arbaeen (Zahran and Willis, 2009).

***Teucrium polium* community:**

*Teucrium polium* is dominant at one stand belonging to one sites out of the 25 studied stands and the nine sites (18 in El Faraa), with elevation of 1830 m asl. *Teucrium polium* is the dominant on the lower dunes of the Mediterranean coastal area of Sinai (Kassas, 1952). *Teucrium polium* is associated at the final stage there are huge sand dunes with rocky centres. *Teucrium polium* is also found on the flat soil of the gully bed, between the boulders, and is growing in fissures of the boulders. *Teucrium polium* is rare species to *Peganum harmala* in the mouth of Wadi El-Arbaeen. *Teucrium polium* is rare in midway to the summit of Gebel Musa (Zahran and Willis, 2009).

***Echinops glaberrimus* community:**

*Echinops glaberrimus* is dominant at one stand belonging to one sites out of the 25 studied stands and the nine sites (7 in Shaq Musa), with elevation of 1920 m asl. *Echinops glaberrimus* is dicotyledoneae plant from family Compositae (Guenther *et al.*, 2005). *Echinops glaberrimus* is perennial species found in different landforms (Gorges, Slopes, Terraces, Ridges) in St. Catherine area (Ayyad *et al.*, 2000). *Echinops glaberrimus* is occur at high elevations (2200–2400 m asl), also occupies a wide range of landform types such as open slopes, slopes with depressions, shaded gorges and, in some cases, terraces

(Ayyad et al., 2000). *Echinops glaberrimus* is found in the mountains surrounding the St Katherine monastery. *Echinops glaberrimus* is

common on the northern slope of Gebel Musa (Zahran and Willis, 2009).



Fig. 3. Showing different nine sites of the study area

***Hypericum sinaicum* community:**

*Hypericum Sinaicum* is dominant at one stand belonging to one sites out of the 25 studied stands and the nine sites (23 in El Mesirdi) , with elevation of 1716 m asl. *Hypericum Sinaicum* is dominant at 2000:2200 (m asl) (Khafagi and Omar, 2012). Most of the *Hypericum sinaicum* populations were small and the plants occurred sporadically in space, as little groups or as individuals. The survey showed that there was no specific habitat preference for *Hypericum*, Cliffs and Gorges are equal in recordings the highest presence (27.2 % for each). It was found that *H. sinaicum* has a narrow range of distribution between 1515 m asl and 2036 m asl. A bout 50

% of *H. sinaicum* individuals' concentrated between elevations 1800 m asl : 2000 m asl (Omar, 2013). *Hypericum Sinaicum* is common in the bed of Wadi El-Arbaeen. *Hypericum Sinaicum* is recorded in the southern mountain (Zahran and Willis, 2009).

***Cynodon dactylon* community:**

*Cynodon dactylon* is dominant at one stand belonging to one sites out of the 25 studied stands and the nine sites (25 in Ain Elskkia), with elevation of 1807 m asl. *Cynodon dactylon* is growing in the high-elevation (1763-2004 m asl) wadis (Guenther et al., 2005). *Cynodon dactylon* is a common species

every where in coastal habitats in northern Mediterranean coast of Sinai. *Cynodon dactylon* is an associate species in the coast of Sheikh Zuwayid (about 20 km west of Rafah) and extended for about 22 km from sea landward (Zahran and Willis, 2009). *Cynodon dactylon* is an associated species in depressions between the dunes contain a characteristic salt marsh. The interdune depression is an adverse habitat being divided into saline and non-saline facies due to the level of ground water. In non-saline areas, *Cynodon dactylon* is an associate species in the

downstream part of Wadi El-Tor communities in the saline areas *Cynodon dactylon* is also an associate species (Zahran and Willis, 2009).

### Conclusion

The present work is a contribution to the vegetation of Saint Katherine protectorate. Nine sites including 25 stands were studied and nine 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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