

Phytosociological Studies on the Western Sector of Saint Katherine Protectorate, South Sinai, Egypt

AlBaraa ElSaied¹, Om Mohammed Khafagi², Mohamed Metwally¹ and Asmaa Shehata²

¹ Botany Department, Faculty of Science, Al-Azhar University (Boys)

² Botany Department, Faculty of Science, Al-Azhar University (Girls)

baraa_elsaied@yahoo.com

Abstract

A total of 26 stands representing different habitats of Saint Katherine Protected area, South Sinai, Egypt have been chosen to represent the most common plant communities. Encountered species were collected during spring season. Species were identified and their scientific names were updated. Vegetation parameters in ten distinct sites at different elevations (1770 – 1971 m a.s.l.). Five quadrats were investigated at each stand. Relative abundance, population density and frequency and the relative importance value and the relative importance index (I.V.I) were calculated for each species in each stand. A total of 63 plant species from 29 families were recorded in this study. Asteraceae and Lamiaceae were the most common families. Eight plant communities were identified, *Pulicaria undulate*, *Mentha longifolia*, *Verbascum sinaiticum*, *Achillea fragrantissima*, *Diplotaxis harra*, *Erigeron bonariensis*, *Chiliadenus montanus* and *Euphorbia obovata*. *Pulicaria undulata* is the most dominant plant species dominating six stands, followed by *Achillea fragrantissima* and *Erigeron bonariensis* dominating five stands each.

Keywords: Saint Katherine Protectorate, plant communities, vegetation.

Introduction

Sinai Peninsula is the linkage between Asia and Africa with a total area of 61,000 km² (about 6 % of Egypt's area). For this reason its flora combines elements from these two continents: Saharo Arabian, Irano Turanian, Mediterranean and Sudanian elements (McGinnies *et al.*, 1968). It constitutes a transition between the Egyptian Deserts and those of the Middle East. It is an interesting phytogeographic area as it borders the Mediterranean, Irano-Turanian, Saharo-Arabian and Sudanian regions (Zohary, 1973). It is a triangular plateau in the northeast of

Egypt with its apex in the South at Ras Muhammed, where the eastern coast of the Suez Gulf meets the western coast of the Aqaba Gulf (Lat. 27°45'N). Its base, in the north extends along the Mediterranean Sea and more than half of its area is between the gulfs of Aqaba and Suez (Zahran and Willis, 2009).

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 mountain area differs from the other areas, due to its unique geology, morphology and climatic aspects. The high mountains of southern Sinai support mainly Irano-Turanian steppe vegetation. Smooth faced rock outcrops supply sufficient run-off water to permit the survival of the unique flora (Hatab, 2009). Vegetation of Saint Katherine has been studied by several authors (Ward *et al.*, 2002; Tan, 2005 and Zahran and Willis, 2009). Four hundred and ten plant species have been recorded as surviving and still occurring in SKP. Compositae, Gamineae, Leguminosae, Cruciferae and Labiatae were the most represented families. The threatened species according to the IUCN Red List Categories are 51 species: 13 endangered 14 vulnerable, 20 rare and 4 indeterminate species. Such species should take a priority in any conservation program (Shaltout *et al.*, 2004). Out of the 410 species, 19 species of the surviving flora are endemic and more than 115 are with known medicinal properties used in traditional therapy and remedies. Several species have properties that have attracted international medical interest, e.g. *Cleome droserifolia* is being investigated pharmaceutically for the treatment of diabetes (Khedr, 2007).

Many plant species of SKP have become endangered due to increasing aridity and human activities. The continuous overgrazing, overcutting and uprooting are

leading to the disappearance of the pastoral plant communities, a reduction of plant cover and soil erosion (Hatab, 2003). The SKP contains a wide range of micro-habitats and landscapes that are a consequence of varying microclimatic conditions, a wide range of altitudes, and variable topography. The landscape ranges from rugged mountains, which includes Mount Katherine (2642 m), Egypt’s highest peak, whose slopes are incised by Wadi Rivers. The Wadi Rivers generally slope towards the east, in the direction of the Gulf of Aqaba, or westwards towards the Gulf of Suez (El-Alqamy, 2002).

In general, types of communities are distinguished mainly on the basis of features of the plants, including their structure, the floristic composition of the vegetation. Characteristics of the habitat are, however, also taken into account (Zahran and Willis, 2009). Spatial distribution of plant species and communities over a small geographic area in desert ecosystems is related to heterogeneous topography and landform pattern (Kassas and Batanouny, 1984)

The present study aims at identifying some of the plant communities growing in Saint Katherine Protectorate and species distribution along the study area.

Materials and methods

A total of 26 stands distributed in ten sites were surveyed using The Circular Quadrate Method (Fig. 1). At each stand, five quadrats, each of size 5 m × 5 m, one quadrat at the center of the stand and 4 at each angle of the stand. The GPS position of each stand was recorded including altitude, latitude and longitude. In each site the floristic composition was recorded. All plant species existing in each site were listed after complete identification (according to Täckholm, 1974; Boulos, 1999 - 2009). Plant names were updated after (www.theplantlist.org). Voucher herbarium specimens were prepared and kept in the herbarium of the Department of Botany, Faculty of Science, Al-Azhar University (Girl's Branch). A check list 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 (IV) were calculated for each species in each site.

According to Braun – Blanquet (1964), Mueller-Dombois and Ellenberg (1974) and Shukla, and Chandel, (1989) in each quadrat the following vegetation parameters were calculated:

1. **Density (D):**
$$\frac{\text{number of individuals in the sample plot}}{\text{total area of sample plot (m}^2\text{)}}$$
2. **Relative Density (RD):** **Error! Bookmark not defined.**
3. **Frequency (F):**
$$\frac{\text{number of quadrats in which aspecies occurs}}{\text{total number of quadrats in the samle}} \times 100$$
4. **Relative Frequency (RF):**
$$\frac{\text{frequency of a species in a sample}}{\text{total frequency of all species in the samle}} \times 100$$
5. **Abundance (A):**
$$\frac{\text{total number of individuals of species}}{\text{total number of plots in which species occurred}}$$
6. **Relative Abundance (RA):**
$$\frac{\text{The abundance of one species}}{\text{all species in the samle}}$$
7. **Importance Value (IVI):** relative density + relative abundance + relative frequency

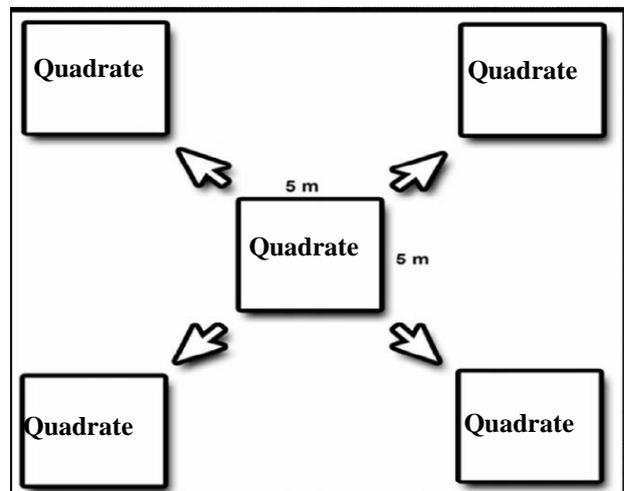


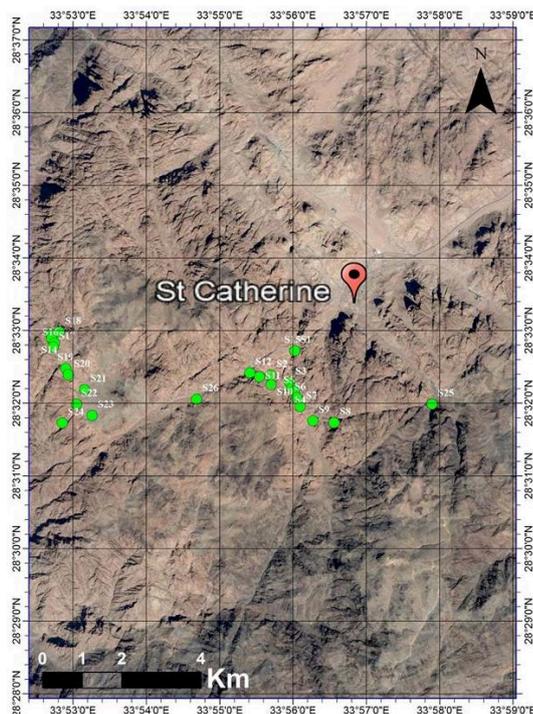
Fig 1. Schematic illustration for the sampled stand.

Results

A total of 26 stands representing different habitats of Saint Khatherine protectorate have been chosen to represent the most common plant communities. A total of 63 species belonging to 29 families were recorded. Asteraceae, Lamiaceae with 14.29 % and Poaceae with 7.94 % were the most common families (Table 2 and Fig. 2).

Table 1. GPS position of the studied 26 stands including sites, habitat types, latitude and altitude.

Location	Habitat	Stand No.	GPS		Altitude (m asl)
			N	E	
Wadi-Alshaq	Wadi bed	S1	28.54536°	33.93378°	1779
	Wadi bed	S2	28.53976°	33.92829°	1778
	Wadi bed	S3	28.53814°	33.93263°	1971
	gorge	S4	28.53673°	33.933°	1778
	gorge	S5	28.53608°	33.93362°	1814
	runnel	S6	28.53463°	33.93422°	1835
Kharazet- ElShaq	gorge	S7	28.53256°	33.93498°	1836
	terraces	S8	28.52884°	33.9427°	1828
Elgabal Elahmar	gorge	S9	28.5293°	33.93784°	1778
Elharezy	Wadi bed	S10	28.53755°	33.92836°	1875
Elzawitin	gorge	S11	28.53939°	33.9257°	1841
	Wadi bed	S12	28.54028°	33.92353°	1846
	gorge	S13	28.54918°	33.87835°	1867
Eltibk	Wadi bed	S14	28.54818°	33.87849°	1772
	Wadi bed	S15	28.54536°	33.93378°	1793
Selebat	gorge	S16	28.54709°	33.87911°	1776
	Wadi bed	S17	28.54625°	33.87882°	1770
Farsh Elromana	Farsh	S18	28.54966°	33.88023°	1784
	Farsh	S19	28.54135°	33.88171°	1791
	Farsh	S20	28.53983°	33.88227°	1794
	Farsh	S21	28.53643°	33.886°	1806
	Farsh	S22	28.53309°	33.88412°	1809
Ma'aroffiaa	Wadi bed	S23	28.53054°	33.88769°	1817
	Wadi bed	S24	28.52878°	33.8809°	1821
Abu Walei	Slope	S25	28.53312°	33.96494°	1879
	Runnel	S26	28.53429°	33.91142°	1869



Map 1. Shows GPS position of the studied 26 stands.

Table (2) List of species and their families recorded in the 26 stands of the study area

No.	Species name	Family	Arabic name
1	<i>Achillea fragrantissima</i> (Forssk.) Sch. Bip.	Asteraceae	قيصوم
2	<i>Alcea rosea</i> L.	Malvaceae	خطمية
3	<i>Alhagi graecorum</i> Boiss.	Fabaceae	عقول
4	<i>Alkanna orientalis</i> (L.) Boiss.	Boraginaceae	اللبيد
5	<i>Anarrhinum pubescens</i> Fresen.	Scrophulariaceae	أرفيجه, رفيعة
6	<i>Gomphocarpus sinaicus</i> Boiss	Apocynaceae	حرجل بري
7	<i>Asparagus stipularis</i> Forssk.	Liliaceae	عقول بري, هليون
8	<i>Ballota undulata</i> (Sieber ex Fresen.) Benth.	Lamiaceae	الغاصة, زفرة
9	<i>Bufonia multiceps</i> Decne.	Caryophyllaceae	عدمه
10	<i>Callipeltis cucullaris</i> (L.) DC.	Rubiaceae	بسياسة
11	<i>Centaurea aegyptiaca</i> L.	Asteraceae	يمرار
12	<i>Chiliadenus montanus</i> (Vahl) Brullo.	Asteraceae	هنيدة, نهيدة
13	<i>Colutea istria</i> Mill.	Fabaceae	يسر, شوحط
14	<i>Erigeron bonariensis</i> L.	Asteraceae	حشيش الجبل
15	<i>Crataegus x sinaica</i> Boiss.	Rosaceae	زعرور
16	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	مديد - نجبلا
17	<i>Deverra triradiata</i> Hochst. ex Boiss	Apiaceae	زجوج - عليجان - قصوخ
18	<i>Diptotaxis harra</i> . (Forssk.) Boiss	Brassicaceae	حاره
19	<i>Echinops glaberrimus</i> DC.	Asteraceae	خشبر
20	<i>Euphorbia obovata</i> Decne.	Euphorbaiceae	ودينه, زغلنتة
21	<i>Fagonia mollis</i> Delile.	Zygophyllaceae	الشكاعة, ورقة
22	<i>Ferula sinaica</i> Boiss.	Apiaceae	جلخ, شمر الجبل, الكلخ
23	<i>Ficus carica</i> L.	Moraceae	تين
24	<i>Foeniculum vulgare</i> Mill.	Apiaceae	شمر
25	<i>Galium sinaicum</i> (Delile ex Decne.) Boiss.	Rubiaceae	عشمه
26	<i>Globularia arabica</i> Jaub. & Spach.	Plantaginaceae	حندجوج, حندقوق, زريقة
27	<i>Helianthemum kahiricum</i> Delile.	Cistaceae	رعل, جنوم
28	<i>Hyparrhenia hirta</i> (L.) Stapf.	Poaceae	سفسوف, حميرة
29	<i>Hypericum sinaicum</i> Hochst. ex Boiss.	Hypericaceae	ركيح, ليخ, شاي الجبل
30	<i>Imperata cylindrica</i> (L.) Rausch.	Poaceae	حلفا, ذيل القط
31	<i>Juncus acutus</i> L.	Juncaceae	سمارمر
32	<i>Juncus rigidus</i> Desf.	Juncaceae	سمار, سمارمر
33	<i>Kickxia acerbiana</i> (Boiss.) Täckh. & Boulos.	Scrophulariaceae	ودين الفار
34	<i>Malva parviflora</i> L.	Malvaceae	رقمة, خبيزة
35	<i>Matthiola arabica</i> Boiss.	Brassicaceae	خمخ
36	<i>Mentha longifolia</i> (L.) L.	Lamiaceae	حبك, حبق
37	<i>Nepeta septemcrenata</i> Ehrenb. ex Benth.	Lamiaceae	زيتيه, مسيسة
38	<i>Onopordum ambiguum</i> Fresen.	Asteraceae	خرشف
39	<i>Origanum syriacum</i> L.	Lamiaceae	زعتن, بردقوش
40	<i>Peganum harmala</i> L.	Nitrariaceae	حرملان, حرم
41	<i>Pterocephalus sanctus</i> Decne.	Dipsacaceae	علجه, مجلينة, عسيل
42	<i>Phlomis aurea</i> Decne.	Lamiaceae	عورور, زهيرة
43	<i>Phoenix dactylifera</i> L.	Arecaceae	نخلة, نخل البلخ
44	<i>Phragmites australis</i> (Cav.) Trin. Ex Steud.	Poaceae	بوص, حجنة, غاب
45	<i>Plantago afra</i> L.	Plantaginaceae	قطونة
46	<i>Polygala sinaica</i> Botsch.	Polygalaceae	هيكل, صر
47	<i>Pulicaria undulata</i> (L.) C.A.Mey	Asteraceae	دثاث, دثدث, سيد
48	<i>Rhamnus dispermus</i> Boiss.	Rhamnaceae	عرين, زعرور, عرننل
49	<i>Rosa arabica</i> Crep.	Rosaceae	الورد البري
50	<i>Salvia aegyptiaca</i> L.	Lamiaceae	زيتيه, رعة

51	<i>Salix mucronata</i> Thunb	Salicaceae	صفصاف
52	<i>Lactuca orientalis</i> (Bioss) Bioss	Asteraceae	يحكيس- جخيص
53	<i>Artemisia herba-alba</i> Asso.	Asteraceae	شيح
54	<i>Silene schimperiana</i> Boiss.	Caryophyllaceae	لصيق
55	<i>Sisymbrium irio</i> L.	Brassicaceae	السليح , سليخ
56	<i>Solanum nigrum</i> L.	Solanaceae	عنب الذنب , عنب الديب
57	<i>Stachys aegyptiaca</i> Pers.	Lamiaceae	جرطم - رغات - رغل
58	<i>Stipa capensis</i> Thunb.	Poaceae	ابونا خور - سفوف
59	<i>Teucrium polium</i> L.	Lamiaceae	جعدة
60	<i>Thymus decussatus</i> Benth.	Lamiaceae	زعران - زعيتر
61	<i>Verbascum sinaiticum</i> Benth.	Scrophulariaceae	خرمrac - خرمة
62	<i>Vitis</i> Sp.	Vitaceae	عنب
63	<i>Zilla spinosa</i> (L.) Prrantl.	Brassicaceae	زله - سلة - بسلة

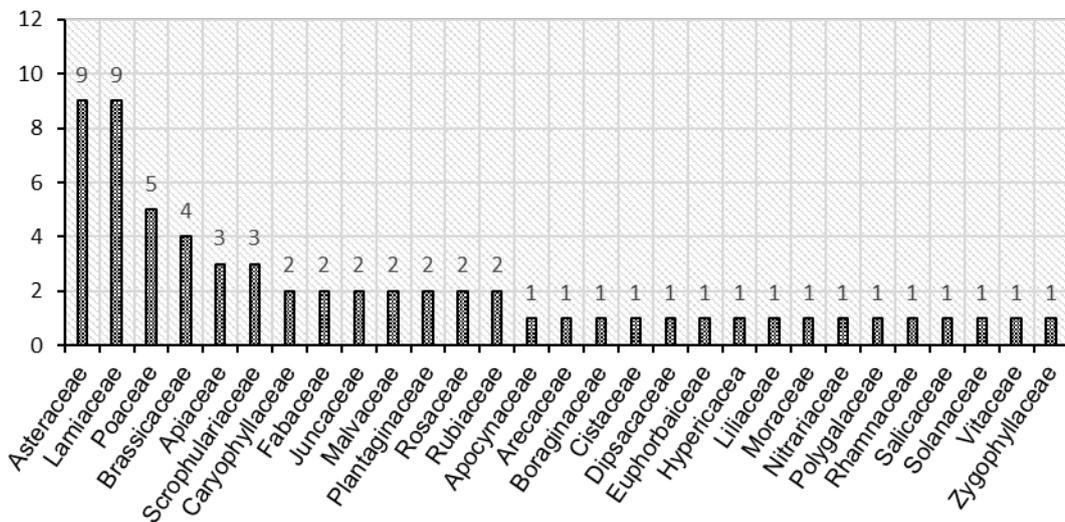


Fig 2. Shows the recorded families of the 26 studied stands.

The selected 26 stands were located in ten sites, each site may contain one or more stands. The description of the ten sites and the 26 stands is as follows.

Site 1: Wadi -Alshaq

Wadi -Alshaq is a valley about 1.5 - 2 Km. in length and is located between 28.54536 to 28.53976 N, and 33.93378 to 33.93240 E. It is a short narrow gorge lead to ascent to El-Gabal al-Ahmar. It consists of a fine sand to silt substrate with some large rocks with pink granite geology. Topography of the wadi is undulating with a variable slope exposure. The wadi consists of several water channels; it appears that there has been recent water action. There is a high plant cover. There is a moderate amount of human disturbance from litter and an established footpath along with moderate disturbance from grazing animals. Six stands were selected to represent Wadi-Alshaq (Stand 1, 2, 3, 4, 5 and 6)

Stand 1. “*Verbascum sinaiticum* Community”

In this stand, 19 species were recorded, the characteristic species of this community are *V. sinaiticum* (I.V.I = 60.35), *Pulicaria undulata* (I.V.I = 40.66), *Phlomis aurea* (I.V.I = 27.27). The other associated species have lower importance value. Here, *V.sinaiticum* is the dominant species *Pulicaria undulata* is the codominant species. *Zilla spinosa*, *Salix mucronata*, *Tanacetum sinaicum* are rare plants species. *Phlomis aurea* is endemic plant species.

Stand 2. “*Mentha longifolia* Community”

In this stand, 19 species were recorded, the characteristic species of this community are *M.longifolia* (I.V.I =56.62), *Stachys aegyptiaca* (I.V.I = 32.72), *Phlomis aurea* and *Verbascum sinaiticum* (I.V.I = 27.02). The other associated species have lower importance value. Here, *M.longifolia* is

the dominant species *Stachys aegyptiaca* is the codominant species. *Tanacetum sinaicum*, *Euphorbia obovata*, *Salix mucronata* are rare plants species. *Phlomis aurea*, *Ballota undulata* are endemic plants species.

Stand 3. “*Erigeron bonariensis* Community”

In this stand, 19 species were recorded, the characteristic species of this community are *E. bonariensis* (I.V.I =66.32), *Verbascum sinaiticum* (I.V.I. = 53.61), *Achillea fragrantissima* (I.V.I. = 22.12). The other associated species have lower importance value. Here, *E. bonariensis* is the dominant species *Verbascum sinaiticum* is the codominant species. *Gomphocarpus sinaicus*, *Euphorbia obovata*, *Salix mucronata* are rare plants species. *Phlomis aurea*, *Anarrhinum pubescens* are endemic plants species.

Stand 4. “*Pulicaria undulata* Community”

In this stand, 16 species were recorded, the characteristic species of this community are *P.undulata* (I.V.I =59.06), *Anarrhinum pubescens* and *Centaurea eryngioides* (I.V.I. = 31.61), *Achilla fragrantissima* (I.V.I. = 27.61). The other associated species have lower importance value. Here, *P.undulata* is the dominant species *Anarrhinum pubescens* and *Centaurea eryngioides* is the codominant species. *Teucrium polium*, *Artemisia herba-alba* are rare plants species. *Anarrhinum pubescens* is endemic plant species.

Stand 5. “*Erigeron bonariensis* Community”

In this stand, 24 species were recorded, the characteristic species of this community are *E.bonariensis* (I.V.I =42.70), *Achillea fragrantissima* (I.V.I. = 32.98), *Chiliadenus montanus* (I.V.I. = 30.48). The other associated species have lower importance value. Here, *E.bonariensis* is the dominant species; *Achillea fragrantissima* is the codominant species. *Kickxia acerbiana*, *Echinops glaberrimus*, *Salix mucronata* are rare plants species. *Phlomis aurea*, *Anarrhinum pubescens* and *Euphorbia obovata* are endemic plants species.

Stand 6. “*Erigeron bonariensis* Community”

In this stand, 17 species were recorded, the characteristic species of this community are *E.bonariensis* (I.V.I =102.14), *Pulicaria undulata* (I.V.I. = 40.17), *Mentha longifolia* (I.V.I. = 31.43). The other associated species have lower importance value. Here, *E.bonariensis* is the dominant

species; *Pulicaria undulata* is the codominant species. *Stachys aegyptiaca*, *Achillea fragrantissima* are rare plants species. *Anarrhinum pubescens* is endemic species.

Site 2: Kharazet- Elshaq

Kharazet- Elshaq is a valley about 1.5 - 2 Km in length and is located between 28.53463 to 28.53256 N, and 33.93422 to 33.93498 E. It is a short narrow gorge lead to ascent to El-Gabal al-Ahmar. It consists of a fine sand to silt substrate with some large rocks with pink granite geology. Topography of the wadi is undulating with a variable slope exposure. The wadi consists of several water channels; it appears that there has been recent water action. There is a high plant cover. There is a moderate amount of human disturbance from litter and an established footpath along with moderate disturbance from grazing animals. Two stands were selected to represent Kharazet- Elshaq (Stands 7 and 8)

Stand 7. “*Diplotaxis harra* Community”

In this stand, 23 species were recorded, the characteristic species of this community are *D.harra* (I.V.I = 54.81), *Erigeron bonariensis* (I.V.I. = 47.63), *Verbascum sinaiticum* (I.V.I. = 33.26). The other associated species have lower importance value. Here, *D. harra* is the dominant species *Erigeron bonariensis* is the codominant species. *Centaurea aegyptiaca*, *Ficus carica*, *Kickxia acerbiana*, *Zilla spinosa* are rare plants species. *Origanum syriacum*, *Ballota undulata* *Anarrhinum pubescens* are endemic plants species.

Stand 8. “*Mentha longifolia* Community”

In this stand, 20 species were recorded, the characteristic species of this community are *M.longifolia* (I.V.I =59.97), *Achillea fragrantissima* (I.V.I. = 36.06), *Phlomis aurea* and *Chiliadenus montanus* (I.V.I. = 27.04). The other associated species have lower importance value. Here, *M.longifolia* is the dominant species; *Achillea fragrantissima* is the codominant species. *Pulicaria undulata*, *Onopordum ambiguum*, *Hypericum sinaicum* are rare plants species. *Phlomis aurea*, *Anarrhinum pubescens* are endemic plants species.

Site 3: Elgabal Elahmar

Elgabal Elahmar is located at 28.52884°N 33.94270°E with altitude of 1778 m asl. Soil texture of Elgabal Elahmar consists of 50 % bolder, 30 % rocks, 15 % gravel and 5

% sand. It has a high human activity and high grazing pressure. The site is a gorge consists of boulder and rocks with granitic geology. The topography of gorge is concave and the slope exposure varies from northeast to northwest. There is a high diversity and cover of species in this gorge. One stand was selected to represent Elgabal Elahmar (Stand 9).

Stand 9. “*Erigeron bonariensis* Community”

In this stand, 23 species were recorded, the characteristic species of this community are *C.bonariensis* (I.V.I =52.73), *Anarrhinum pubescens* (I.V.I. = 32.47), *Tanacetum sinaicum* (I.V.I. = 29.73). The other associated species have lower importance value. Here, *C.bonariensis* is the dominant species *Anarrhinum pubescens* is the codominant species. *Diploaxis harra*, *Hypericum sinaicum*, *Alkanna orientalis*, *Rosa arabica* are rare plants species. *Bufoia multiceps*, *Phomis aurea*, *Anarrhinum pubescens* are endemic plants species. And *Nepeta septemcrenata*, *Thymus decussatus* are near endemic plants species.

Site 4: Elharezy

Elharezy is located at 28.52930°N 33.93784°E with altitude of 1875 m asl. Soil texture of the wadi Elharezy consists of 15 % bolder, 25 % rocks, 45 % gravel and 15 % sand. It has a high human activity and high grazing pressure. The site is a wadi bed consists of a coarse sand substrate with granite geology. The Wadi has a concave topography with a southwestern slope exposure. 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. One stand was selected to represent Elharezy (Stand 10).

Stand 10. “*Achillea fragrantissima* Community”

In this stand, 25 species were recorded, the characteristic species of this community are *A.fragrantissima* (I.V.I =65.14), *Stachys aegyptiaca* (I.V.I. = 38.95), *Phlomis aurea* (I.V.I. = 25.86). The other associated species have lower importance value. Here, *A.fragrantissima* is the dominant species; *Stachys aegyptiaca* is the codominant species. *Echinops glaberrimus*, *Artemisia herba-alba*, *Alkanna orientalis* are rare plants species. *Bufoia multiceps*, *Origanum syriacum*, *Phlomis aurea* are endemic plants species. And *Nepeta septemcrenata* is near endemic plant species.

Site 5: Elzawitin

Elzawitin is located at 28.53755°N 33.92836°E, 28.54028°N 33.92353°E with altitude range of 1841 – 1867 m asl. Soil texture of the wadi Elzawitin consists of 15 % bolder, 25 % rocks, 45 % gravel and 15 % sand. It has a high human activity and high grazing pressure. The site is a wadi bed consists of a coarse sand substrate with granite geology. The Wadi has a concave topography with a southwestern slope exposure. The distance from Saint Kathreine city is about 3.3 km. There is a 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. Three stands were selected to represent Elzawitin (Stand 11, 12 and 13).

Stand 11. “*Chiliadenus montanus* Community”

In this stand, 20 species were recorded, the characteristic species of this community are *C.montanus* (I.V.I =60.26), *Plantago afra* (I.V.I. = 44.67), *Hypericum sinaicum* (I.V.I. = 26.44). The other associated species have lower importance value. Here, *C.montanus* is the dominant species; *Plantago afra* is the codominant species. *Erigeron bonariensis*, *Juncus rigidus*, *Artemisia herba-alba* are rare plants species.

Stand 12. “*Achillea fragrantissima* Community”

In this stand, 26 species were recorded, the characteristic species of this community are *A.fragrantissima* (I.V.I =41.67), *Diploaxis harra* (I.V.I. = 30.06), *Euphorbia obovata* (I.V.I. = 21.13). The other associated species have lower importance value. Here, *A.fragrantissima* is the dominant species; *Diploaxis harra* is the codominant species. *Silene schimperiana*, *Hypericum sinaicum*, *Pulicaria undulata* are rare plants species. *Origanum syriacum*, *Phlomis aurea* and *Euphorbia obovata* are endemic plants species.

Stand 13. “*Achillea fragrantissima* Community”

In this stand, 22 species were recorded, the characteristic species of this community are *A.fragrantissima* (I.V.I =84.89), *Alkanna orientalis* (I.V.I. = 37.04), *Stachys aegyptiaca* (I.V.I. = 30.81). The other

associated species have lower importance value. Here, *A.fragrantissima* is the dominant species *Alkanna orientalis* is the codominant species. *Centaurea aegyptiaca*, *Zilla spinosa*, *Gomphocarpus sinaicus*, *Verbascum sinaiticum* are rare plants species. *Origanum syriacum*, *Euphorbia obovata* are endemic plant species.

Site 6: Eltibk

Eltibk is located at 28.54918°N 33.87835°E, 28.54818°N 33.87849°E with altitude range of 1770 m asl – 1793 m asl. Soil texture of Eltibk consists of 20 % bolder, 25 % rocks, 35 % gravel and 20 % sand. It has medium human activity and high grazing pressure. The site is awadi consists of rocks and gravel with granitic geology with some sandstone features. The topography of the wadi is concave and the slope exposure is west. The distance from Saint Kathreine city is about 7 km. There is a high diversity and cover of species in this wadi. Feral donkeys are the biggest threat in this area. Two stands were selected to represent Eltibk (Stand 14 and 15).

Stand 14. “*Chiliadenus montanus* Community”

In this stand, 20 species were recorded, the characteristic species of this community are *C.montanus* (I.V.I =45.44), *Hypericum siaicum* (I.V.I. = 32.67), *Mentha longifolia*, *juncus rigidus* and *juncus acutus* (I.V.I. = 19.91). The other associated species have lower importance value. Here, *C.montanus* is the dominant species; *Hypericum siaicum* is the codominant species. *Phoenix dactylifera*, *Ficus carica*, *Pulicaria undulata*, *Stachys aegyptiaca* are rare plants species. *Phlomis aurea* is endemic plant species.

Stand 15. “*Mentha longifolia* Community”

In this stand, 14 species were recorded, the characteristic species of this community are *M. longifolia* (I.V.I =89.94), *Juncus rigidus* (I.V.I. = 39.29), *Achillea fragrantissima* (I.V.I. = 27.17). The other associated species have lower importance value. Here, *M. longifolia* is the dominant species; *Juncus rigidus* is the codominant species. *Juncus acutus*, *Teucrium polium* are rare plants species.

Site 7 - Selebat

Selebat is a small area located at the bottom tala'at abu-Geifa about 0.3 - 0.35 Km in length and located between 28.54709 and

28.54625 N and 33.87911 and 33.93298 E. To the right you will see Wadi al-Tal'a, which starts at Sed Dawoud, meaning Dawoud's Dam. Wadi bed consists of coarse sand to silt substrate with some small rocks with pink granite geology. The wadi seems to have high moisture content. There is a high diversity of species and excellent plant health. There is a moderate amount of disturbance occurring in this wadi. Two stands were selected to represent Selebat (Stands 16 and 17).

Stand 16. “*Achillea fragrantissima* Community”

In this stand, 16 species were recorded, the characteristic species of this community are *A.fragrantissima* (I.V.I =105.21) *Alcea rosea* (I.V.I. = 31.51), *Verbascum sinaiticum* (I.V.I. = 31.07). The other associated species have lower importance value. Here, *A.fragrantissima* is the dominant species; *Alcea rosea* is the codominant species. *Juncus rigidus*, *Stachys aegyptiaca*, *Tanacetum sinaicum*, *Teucrium polium*, *Peganum harmala* are rare plants species. *Phlomis aurea* is endemic plant species.

Stand 17. “*Euphorbia obovata* Community”

In this stand, 28 species were recorded, the characteristic species of this community are *E.obovata* (I.V.I =40.26), *Erigeron bonariensis* (I.V.I. = 39.33), *Pulicaria undulata* (I.V.I. = 29.66). The other associated species have lower importance value. Here, *E.obovata* is the dominant species; *Erigeron bonariensis* is the codominant species. *Kickxia acerbiana*, *Alkanna orientalis*, *Salix mucronata*, *Salvia aegyptiaca* are rare plants species. *Phlomis aurea*, *Anarrhinum pubescens*, *Origanum syriacum* and *Euphorbia obovata* are endemic plants species.

Site 8: Farsh Elromana

Farsh Elromana is located at 28.54966°N 33.8803°E, 28.53309°N 33.88412°E with altitude range of 1784 m asl – 1809 m asl. Soil texture of Farsh Elromana consists of 15 % bolder, 45 % rocks, 25 % gravel and 15 % sand. It has a high human activity and high grazing pressure. The site is a wide farsh about 3 to 3.5 Km. in length consists of boulder and rocks with granite geology. The topography of this farsh is concave and the slope exposure is to east. Moderate grazing pressure by donkeys, camels, and goats. Heavy human use evident with a highly used foot trail. Bedouin gardens are

found nearby. Five stands were selected to represent Farsh Elromana (Stands 18, 19, 20, 21 and 22).

Stand 18. “*Pulicaria undulata* Community”

In this stand, 19 species were recorded, the characteristic species of this community are *P.undulata* (I.V.I =72.68), *Verbascum sinaiticum* (I.V.I. = 37.28), *Mentha longifolia* (I.V.I. = 25.93). The other associated species have lower importance value. Here, *Pulicaria undulata* is the dominant species; *Verbascum sinaiticum* is the codominant species. *Diploaxis harra*, *Echinops glaberrimus*, *Globularia arabica*, *Zilla spinosa* are rare plants species. *Anarrhinum pubescens*, *Phlomis aurea* are endemic plants species.

Stand 19. “*Euphorbia obovata* Community”

In this stand, 18 species were recorded, the characteristic species of this community are *E.obovata* (I.V.I =66.31), *Callipeltis cucullaris* (I.V.I. = 32.73), *Zilla spinosa* (I.V.I. = 28.35).The other associated species have lower importance value. Here, *E.obovata* is the dominant species; *Callipeltis cucullaris* is the codominant species. *Globularia arabica*, *Teucrium polium*, *Hypericum sinaicum*, *Centaurea aegyptiaca*, *Juncus acutus* are rare plants species. *Euphorbia obovata* is endemic plant species.

Stand 20. “*Pulicaria undulata* Community”

In this stand, 15 species were recorded, the characteristic species of this community are *P.undulata* (I.V.I =58.57) *Verbascum sinaiticum* (I.V.I. = 52.87), *Mentha longifolia* (I.V.I. = 47.79). The other associated species have lower importance value. Here, *P.undulata* is the dominant species; *Verbascum sinaiticum* is the codominant species. *Stachys aegyptiaca*, *Silene schimperiana*, are rare plants species. *Phlomis aurea* and *Euphorbia obovata* are endemic plants species.

Stand 21. “*Erigeron bonariensis* Community”

In this stand, 15 species were recorded, the characteristic species of this community are *E.bonariensis* (I.V.I =56.55), *Pulicaria undulata* (I.V.I. = 38.39), *Mentha longifolia* (I.V.I. = 35.12). The other associated species have lower importance value. Here, *C.bonariensis* is the dominant species; *Pulicaria undulata* is the codominant

species. *Zilla spinosa*, *Salix mucronata*, *Callipeltis cucullaris* are rare plants species. *Phlomis aurea*, *Anarrhinum pubescens* and *Euphorbia obovata* are endemic plants species.

Stand 22. “*Pulicaria undulata* Community”

In this stand, 16 species were recorded, the characteristic species of this community are *P.undulata* (I.V.I =61.14) *Erigeron bonariensis* (I.V.I. = 55.59), *Achillea fragrantissima* (I.V.I. = 30.93). The other associated species have lower importance value. Here, *P.undulata* is the dominant species. *Erigeron bonariensis* is the codominant species; *Globularia arabica*, *Colutea Istria*, *Deverra triradiata*, *Plantago afra* are rare plants species. *Origanum syriacum*, *Phlomis aurea* are endemic plants species.

Site 9 - Ma‘aroffiaa

It is about 0.8-1 Km. and located between 28.52878 to 28.553054 N, and 33.88090 to 33.88769 E. Wadi bed consists of a coarse sand to fine gravel substrate with small rocks with pink granite geology. There is a high plant cover. Wadi used for gardening by Bedouin. Moderate grazing activity by donkey, and camel. Two stands were selected to represent Ma‘aroffiaa (Stand 23 and 24).

Stand 23. “*Pulicaria undulata* Community”

In this stand, 12 species were recorded, the characteristic species of this community are *P.undulata* (I.V.I =79.51) *Verbascum sinaiticum* (I.V.I. = 45.22), *Achillea fragrantissima* (I.V.I. = 33.20). The other associated species have lower importance value. Here, *P.undulata* is the dominant species; *Verbascum sinaiticum* is the codominant species. *Anarrhinum pubescens*, *Centaurea erynjioides* are rare plants species. *Phlomis aurea*, *Anarrhinum pubescens*, *Euphorbia obovata* are endemic plants species. And *Nepeta septemcrenata* is near endemic plant species.

Stand 24. “*Verbascum sinaiticum* Community”

In this stand, 17 species were recorded, the characteristic species of this community are *V.sinaiticum* (I.V.I =52.78), *Pulicaria undulata* (I.V.I. = 50.68), *Mentha longifolia* (I.V.I. = 33.90). The other associated species have lower importance value. Here, *V.sinaiticum* is the dominant species; *Pulicaria undulata* is the codominant

species. *Diploaxis harra*, *Juncus rigidus*, *Teucrium polium*, *Echinops glaberrimus* are rare plants species. And *Ballota undulata* is endemic plant species.

Site 10: Abu Walei

Abu Walei is located at 28.53312°N 33.96494°E, 28.93429°N 33.91142°E with altitude range of 1869 m asl – 1879 m asl. Soil texture of Abu Walei consists of 5 % bolder, 25 % rocks, 45 % gravel and 25 % sand. It has a high human activity and high grazing pressure. The site is a narrow steep wadi where flash flood 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 distance from Saint Kathreine city is about 5.3 km. There is a high diversity and cover of species in spread in this area. Two stands were selected to represent Ma'aroffiaa (Stands 25 and 26)

Stand 25. “*Euphorbia obovata* Community”

In this stand, 11 species were recorded, the characteristic species of this community are *E. obovata* (I.V.I =126.74), *Zilla spinosa* (I.V.I. = 32.75), *Mentha longifolia* (I.V.I. = 24.91). The other associated species have lower importance value. Here, *E.obovata* is the dominant species; *Zilla spinosa* is the codominant species. *Diploaxis harra*, *Juncus rigidus*, are rare plants species. And *Euphorbia obovata* is endemic plant species.

Stand 26. “*Pulicaria undulata* Community”

In this stand, 22 species were recorded, the characteristic species of this community are *P.undulata* (I.V.I =67.81), *Verbascum sinaiticum* (I.V.I. = 40.48), *Stachys aegyptiaca* (I.V.I. = 37.05). The other associated species have lower importance value. Here, *P.undulata* is the dominant species; *Verbascum sinaiticum* is the codominant species. *Zilla spinosa*, *Juncus rigidus*, *Peganum harmaa*, *Echinops glaberrimus* are rare plants species. And *Phomis aurea* is endemic plant species.

Discussion

The present study aimed at identifying major plant communities dominating the 26 studied stand from SKP. Results showed the presence of eight plant communities along the ten sites of the study area (Figs 3 and 4). The major plant communities were *Pulicaria*

undulate, *Achillea fragrantissima*, *Erigeron bonariensis*, *Mentha longifolia*, *Euphorbia obovata*, *Chiliadenus montanus*, *Verbascum sinaiticum* and *Diploaxis harra*.

Pulicaria undulata community:

Pulicaria undulate is the most common dominant species, dominating six stands belonging to four sites out of the 26 studied stands and the ten sites (3 in Wadi-Alshaq, 18, 22, 24 in Farsh Elromana, 22 in Ma'aroffiaa and 26 in Abu Walei) with elevation range between 1784 m asl and 1971 m asl. *Verbascum sinaiticum* is often the co-dominant species of *pulicaria undulata*. Associate species of this community in this study are *Anarrhinum pubescens*, *Mentha longifolia* and *Centaurea aegyptiaca*. *P. undulata* is densely white – woolly branched erect herb (Andrews, 1956). *P. undulata* is a medicinal plant used to treat inflammation and also an insect repellent and herbal tea (Ravandeh et al., 2011). Landforms supporting this community are high-elevation sites surrounding the ring dyke. These high-elevation sites have high plant diversity, with a high number of species recorded and a relatively high plant cover. Associate species of this community are *Peganum harmala*, *Artemisia herba-alba*, *Zilla spinosa*, *Matthiola arabica*, *Phlomis aurea* and *Achillea fragrantissima*. (Guenther et al., 2005).

Achillea fragrantissima community:

Achillea fragrantissima is dominant species, dominating five stands belonging to four sites out of the 26 studied stands and the ten sites (9 in Elgabal Elahmar, 11, 12 in Elzawitin, 15 in Eltibk and 16 in Selebat) with elevation range between 1776 m asl and 1846 m asl. Associate species of this community in this study are *Stachys aegyptiaca*, *Mentha longifolia* and *Phlomis aurea*. *Achillea fragrantissima* community is dominating high elevated wadi, high elevated plain, low elevated wadi, and fans, at Wadi ElSheikh, Agramia Plain, Wadi Sanad, Rahaba - Nasb, and Wadi Feiran (Abd El- Wahab et al., 2006a). The rocky slopes of the mouth of Wadi El-Raha and the finer runnels of the upstream effluents of Wadi Gharandal are dominated by *Achillea fragrantissima* (Zahran and Willis, 2009). *A. fragrantissima* is a perennial species found in different landforms (Gorges, Slopes, Terraces and Ridges) in St. Katherine area (Ayyad et al., 2000). Soils of this communities are very pale brown, light yellowish brown to brownish yellow gravelly. Soil texture of A.

fragrantissima community is sand. Associate species of this community are *Fagonia mollis*, *Zilla spinosa* (Abd El- Wahab *et al.*, 2006a).

***Erigeron bonariensis* community:**

Erigeron bonariensis is dominant species, dominating five stands belonging to three sites out of the 26 studied stands and the ten sites (2, 4 and 5 in Wadi-Alshaq, 8 in Kharazet-Elshaq and 21 in Farsh Elromana) with elevation range between 1778 m asl and 1828 m asl. Associate species of this community in the present study are *pulicaria undulata*, *Alkanna orientalis*, *Anarrhinum pubescens*, and *Achillea fragrantissima*. A characterizing mountainous habitat (gorge, terraces, farsh, wadi bed). *E. bonariensis* grows in diverse ecological conditions and also is quite variable morphologically (Gubta and Gill, 1983). It is one of the plant species that was recorded in Feiran Oasis with two types of habitat (date palm orchards and crop fields) (Abd El-Ghani and Fahmy, 1998). Plants of this community are also characterizing cultivated lands and canal banks in the Nile Delta Egypt and the associate species of this community are *Polypogon monspeliensis*, *Malva parviflora* (Shehata, 2014).

***Mentha longifolia* community:**

Mentha longifolia is dominant species, dominating three stands belonging to three sites out of the 26 studied stands and the ten sites (1 in Wadi-Alshaq, 7 in Kharazet-Elshaq and 14 in Eltibk) with elevation range between 1772 m asl and 1836 m asl. Associate species of this community in the present study are *Phlomis aurea*, *Stachys aegyptiaca* and *Achillea fragrantissima*. *Mentha longifolia* comprises herbaceous, perennial plants, common in temperate climates in Europe, Australia and South Africa (Lange and Croteau, 1999). *M. longifolia* commonly known as wild mint or horse mint, is a perennial herb that can grow up to 1-2 m height (Okoh and Afolayan, 2011). Traditionally, *M. longifolia* plant has been used for the treatment of diarrhea, dysentery and stomachache and cardiac diseases too (Haq *et al.*, 2011). *M. longifolia* characterizes the mountainous habitat (prefers high elevated wadi and gorge). This plant species may be considered as indicators of high soil quality. Soils of this community are darker in color, and have more silt and clay content than soils of low lands. Soil texture of *Mentha longifolia* community is sand to loamy sand with yellow brown to dark grayish brown gravelly colour. Associate species of this community are

Nepeta septemcrenata, *Adiantum capillus-veneris*, *Crateagus xsinaica*, *Zilla spinosa* and *Juncus rigidus* (Abd El- Wahab *et al.*, 2006 a).

***Euphorbia obovata* community:**

Euphorbia obovata is dominant species, dominating three stands belonging to three sites out of the 26 studied stands and the ten sites (17 in Selebat, 19 in Farsh Elromana and 25 in Abu Walei) with elevation range between 1394 m asl and 1879 m asl. Associate species of this community in this study are *Zilla spinosa*, *Erigeron bonariensis* and *Pulicaria undulata*. *Euphorbia sanctae-catharinae* Fayed is listed as a synonym to *Euphorbia obovata* Decne. (Boulos, 2009). It is a low shrub endemic plant, grows under extremely severe arid conditions in Saint Katherine protectorate (Moursy *et al.*, 2010). It is found in all habitat types in SKP and the highest number of individual was recorded in Rihibat Nada, while the lowest number of individual was recorded in Selebat (Moursy *et al.*, 2010). Plants of this community occupied most of high altitude representative different habitats in SKP such as wadi bed, terrace, gorge, slope and farsh, the only habitat in which the plant does not occur is the cave habitat (Moursy *et al.*, 2010). *E. obovata* is a perennial species found in different landforms (gorges and Terraces) in St. Katherine area (Ayyad *et al.*, 2000). The altitude of *Euphorbia* sites ranges from 1440 m above sea level in Wadi Ithah area to 2030 m in Keneiset al-Hamar area in Gabal Mousa. Most of the *Euphorbia obovata* populations were small and plants occurred sporadically in space, as little groups or as individuals. This indicates that this species has a small geographical range and wide range of habitats of spatial distribution and presence (Moursy *et al.*, 2010). Associate species of this community are *Artemisia herba-alba*, *Stachys aegyptiaca* and *Origanum syriacum* (Moursy *et al.*, 2010).

***Chiliadenus montanus* community:**

Chiliadenus montanus is dominant species, dominating two stands belonging to two sites out of the 26 studied stands and the ten sites (10 in Elharezy and 13 in Elzawitin) with elevation range between 1867 m asl and 1875 m asl. Associate species of this community in this study are *Plantago afra* and *Hypericum sinaicum*. One of the most collected species for trade because of its medicinal value Assi (2007). This community prefers high terraces with fissures and slope with fissures. It is found in all sites of SKP except Wadi Gragneia. In

this community the altitude is 1813 m. with exposure degree ranging from 20° to 340° (North, North-Western, South-Eastern) and the slope degree is 45.18° (Moustafa *et al.*, 2015). *Chiliadenus montanus* is dominating high slopes and a well-defined wadi bed composed of high sand component (Guenther *et al.*, 2005). The soil of this community is characterized by low organic matter (3.13%), while the other parameters landform, slope degree, exposure degree, elevation, gravel, coarse sand, medium sand, fine sand, silt and clay, pH, electrical conductivity, moisture content, calcium, magnesium, bicarbonate, chloride, and nature of soil surface are moderate in its range. Associate species of this community are *Tucrium polium*, *Stachys aegyptiaca* and *Origanum syriacum* (Moustafa *et al.*, 2015).

Verbascum sinaiticum community:

Verbascum sinaiticum is dominant species, dominating one stand belonging to one site out of the 26 studied stands and the ten sites (24 in Ma'aroffiaa) with elevation 1821 m asl. Associate species of this community in this study are *Pulicaria undulate*, *Mentha longifolia* and *Phlomis aurea*. *Verbascum sinaiticum* is a perennial species found in two types of habitat (gorges and slope) in St. Katherine area (Ayyad *et al.*, 2000). *Verbascum sinaiticum* community is dominating Ain Lousa, surrounding area and Wadi Ba'athran. Landforms supporting this community are the high elevated terraces, gorges and slopes (Abd El- Wahab *et al.*, 2006 b). Associate species of this community are *Artemisia herba-alba*, *Silene schimperiana*, *Galium sinaicum*, *Juncus rigidus*, *Mentha longifolia* and *Phlomis aurea* (Abd El- Wahab *et al.*, 2006 b).

Diploaxis harra community:

Diploaxis harra is dominant species, dominating one stand belonging to one site out of the 26 studied stands and the ten sites (6 in Wadi-Alshaq) with elevation 1835 m asl. Associate species of this community in the present study are *Verbascum sinaiticum* and *Erigeron bonariensis*. *Diploaxis harra* is a perennial species found in two types of habitat (gorges and slope) in St. Katherine area (Ayyad *et al.*, 2000). *D. harra* may be present in two types of habitat, rill-runnels across rocky slopes (In years of good rainfall) and long shallow runnels. Among the species characteristic of the slopes on the wadi sides of the Egyptian deserts is *Diploaxis harra*.

Grazing activity is moderate with *Diploaxis harra* in Saint Katherine Mountains (Moustafa, 2000). *D. harra* is better favoured on the limestone than on the gravel. Associate species of this community are *Fagonia mollis*, *Gymnocarpos decander*, *Limonium pruinosum*, *Reaumuria hirtella* (Zahran and Willis, 2009).

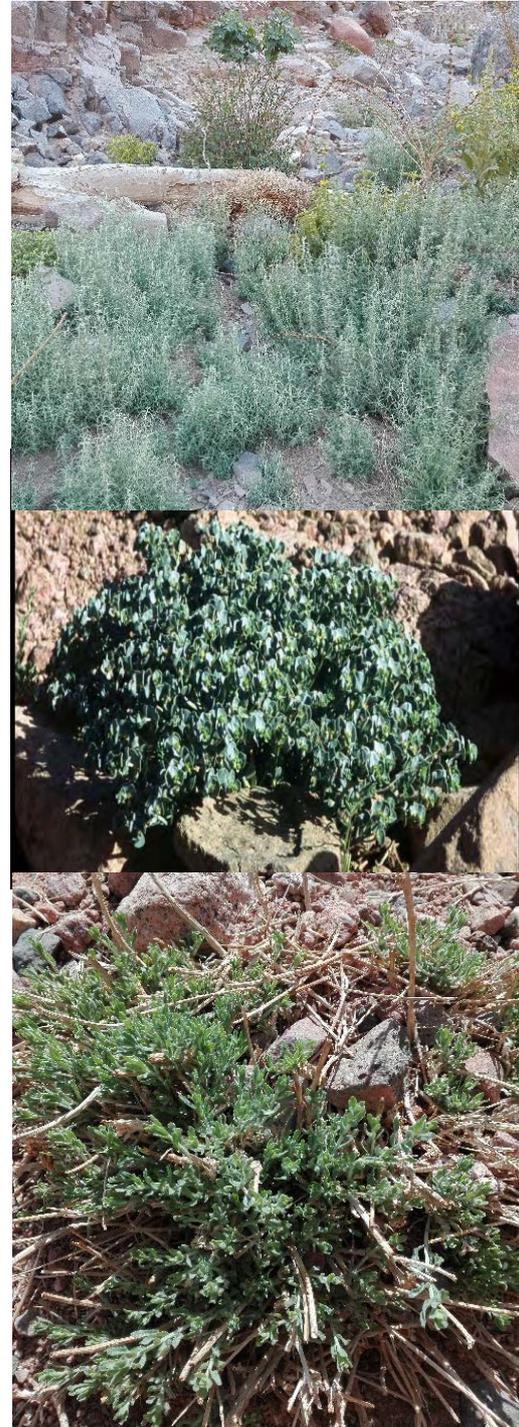


Fig 2. Showing different plant communities of the 26 studied stands (A: *Mentha longifolia*, B: *Euphorbia obovata*, C: *Achilla fragrantissima*)



Fig 3. Showing different plant communities of the 26 studied stands (A: *Verbascum sinaiticum*, B: *Diplotaxis harra* C: *Pulicaria undulate*).

Conclusion

Ten sites including 26 stands were studied and eight plant communities have been identified. The present work is a contribution to the vegetation of Saint Katherine Protectorate. Further studies to investigate vegetation-soil relationships is highly recommended in order to understand the composition of the different ecosystems inhabiting St. Katherine protectorate.

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