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

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ARTICLE INFO

ABSTRACT

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

INTRODUCTION

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

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

Citation: Egypt. Acad. J. Biol. Sci. (H. Botany) Vol.13(1) pp125-139(2022)

DOI: 10.21608/EAJBSH.2022.257570
Vegetation of Saint Katherine has been studied by several authors (Moustafa and Zaghloul, 1996; Ward, et al., 2002; Tan, 2005; Zahran and Willis, 2009). The present study aims at identifying some of the plant communities growing in the eastern sector of the Saint Katherine protectorate and species distribution along the study area.

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

**MATERIALS AND METHODS**

**Study Area:**

The research area is in Saint Katherine High altitude Mountain area (28.518911°N 33.959451°E) (Maps 1). The study period was from March 2011 to March 2012. Mount Saint Katherine is one of the richest and highly diverse in its flora due to its sharp variation in altitude, soil characteristic and geomorphological formations. This mountain consists of a group of huge, volcanic mountains overlapped with each other and forming the two main high peaks (Abu Rumail and Katherine).

Vegetation of Forty-two stands (Map.1), with five quadrats (5×5 m) using The Quadrate Transect Method (Fig.1). The GPS position of each stand was recorded including latitude, longitude, habitat and altitude were recorded (Table 1.), and are represented in Map 1. The floristic composition of each stand was recorded. All plant species existing in each site were listed after complete identification according to Täckholm, (1974); Boulos, (1999-2005). Plant names were updated after Voucher herbarium specimens were prepared and kept in the herbarium of the Department of Botany and Microbiology, Faculty of Science, Al-Azhar University (Boy’s Branch). A checklist of all plant species is given in Table 2. Density (D), percentage of frequency (F), abundance (A), relative density (RD), relative frequency (RF), relative abundance (RA), and importance value (IVI) were calculated for each species in each site; According to the following equations (Braun – Blanquet, 1964).
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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) \times 100

3. **Frequency (F):** Total number of quadrats in which a species occurs / total number of quadrats studied

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

At the species level and from vegetation survey, *Teucrium polium* has the highest presence percentage (34 stand = 81 \%), followed by *Nepeta septemcrenata* and *Phlomis aurea* (32 stand = 76.2 \%), *Chilidium montanum* and *Seriphidium herba-album* (29 stand = 69 \%), *Echinops spinosus* and *Tanacetum sineaicum* (27 stand = 64.3 \%), *Stachys aegyptiaca* (25 stand = 59.5 \%), *Ballota undulata* (24 stand = 57.1 \%), *Achillea fragrantissima* (22 stand = 52.4 \%) (Table 2).
Table 1. GPS position of the studied 42 stands including sites, longitude, latitude and altitude.

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

| Species Name                                      | Family       | Common Name Arabic                      | Presence of species | % Of P |
|--------------------------------------------------|--------------|-----------------------------------------|---------------------|--------|
| 1. Achillea fragrantissima (Forssk.) Sch.        | Compositae   | قصوص                                | 22                  | 52.4   |
| 2. Alkanna orientalis (L.) Boiss.                | Boraginace   | اللبيد                                | 30                  | 71.4   |
| 3. Anarrhinum pubescens Fresen.                  | Scrophulari  | أرفيج، رفيعة                        | 10                  | 23.8   |
| 4. Andracea aspera Spreng.                       | Euphorbiac   | عود العقرب، عين أم                    | 2                   | 4.8    |
| 5. Asclepias sinaica (Boiss.) Muschl.             | Asclepiad    | حرجل ذي                                    | 8                   | 19.0   |
| 6. Astragalus sieberi DC.                        | Leguminos    | شوك النعاج، صبعم                    | 3                   | 7.1    |
| 7. Atropaphis spinosa L.                         | Polygonace   | سوس، سوسا                           | 1                   | 2.4    |
| 8. Ballota undulata (Fresen.) Benth.             | Labiatae     | الغاصة، رفقة                        | 24                  | 57.1   |
| 9. Buflonia multiceps Decne.                     | Caryophylla  | عذمة                                  | 8                   | 19.0   |
| 10. Capparis spinosa L. var. spinosa             | Capparicae   | لصف، لصفوف، جربة، عورور        | 1                   | 2.4    |
| 11. Centaurea erynyiodes Lam.                    | Compositae   | نحية الندأة، رفان                        | 8                   | 19.0   |
| 12. Centaurea scorpiaria Sieber ex Spreng.       | Composite    | هندية، نهيدة                        | 1                   | 2.4    |
| 13. Chiadenus montanus (Vahl) Brullo.            | Compositae   | زعور، جربة جريبي                      | 1                   | 2.4    |
| 14. Crataegus s x sinaica Boiss.                 | Rosaceae     | حماط، تين البر                         | 2                   | 4.8    |
| 15. Cynodon dactylon (L.) Pers.                   | Gramineae    | حضانة، نين البر                        | 4                   | 9.5    |
| 16. Deverra tortuosa L.                          | Umbellifera  | سكيح، نين البر                        | 6                   | 14.3   |
| 17. Deverra triradiata Poir.                     | Umbellifera  | زوجوم، غرانيا، بريني                  | 7                   | 16.7   |
| 18. Diploaxis harr. (Forssk.) Boiss.             | Cruciferae   | جحاء                                  | 2                   | 4.8    |
| 19. Echinops spinosus L.                         | Composite    | عذمة                                  | 27                  | 64.3   |
| 20. Ephedra pachyclada Boiss.                    | Ephedraceae  | عذمة                                  | 1                   | 2.4    |
| 21. Erodium laciniatum (Boiss.) Batt. &          | ERANIA       | ذهبية، دالية، نيئة، زعورة | 2                   | 4.8    |
| 22. Euphorbia sanctae-cathariniae Fayed.         | Euphorbic    | نيئة، زعورة، جربة جريبي              | 9                   | 21.4   |
| 23. Fagonia arabica var. arabica L.               | Zygophylla   | مجرى، جربة جريبي، نبرشة             | 7                   | 16.7   |
| 24. Fagonia mollis Delile.                       | Zygophylla   | النبات المخلب، الزغفة، جربة            | 17                  | 40.5   |
| 25. Farseta aegyptia Turra                       | Cruciferae   | حمامة، نتين البر، برقي              | 1                   | 2.4    |
| 26. Ficus palmata Forssk.                        | Moraceae     | نبرشة، برقان                        | 4                   | 9.5    |
| 27. Galium sinaicum (Delile ex Decne.)           | Rubiaceae    | عذمة                                  | 10                  | 23.8   |
| 28. Gymnocarpus decandrus Forssk                 | Caryophyll    | جرد                                  | 3                   | 7.1    |
| 29. Hyoscymus hoveanus (Dunal) Asch. &            | Solanaceae  | سكران                                | 1                   | 2.4    |
| 30. Juncus rigidus Desf.                        | Juncaceae    | سكران                                | 5                   | 11.9   |
| 31. Launaea nudicaulis (L.) Hook, F.             | Composita    | حوران                                | 1                   | 2.4    |
| 32. Launaea spinosa (Forssk.) Sch. Bip. Ex       | Composita    | كبابة                                | 4                   | 9.5    |
| 33. Lavandula coronopifolia Poir.                | Labiatae     | زينة                                  | 1                   | 2.4    |
| 34. Matthiola arabica Boiss.                     | Cruciferae   | خمجم                                | 13                  | 31.0   |
| 35. Mentha longifolia (L.) Huds.                 | Labiatae     | حضانة، ضقية، زعورة، مزيز           | 7                   | 17.1   |
| 36. Nepeta septemcrenata Benth.                  | Labiatae     | زعورة، مزيز، جربة جريبي              | 32                  | 76.2   |
| 37. Origanum syriacum (Boiss.) Greater &         | Labiatae     | زعورة، برقان، مزق              | 17                  | 40.5   |
| 38. Peganum harmala L.                           | Zygophylla   | عذمة، حرمل                         | 5                   | 11.9   |
| 39. Phlomis aurea Decne.                        | Labiatae     | عورور، زهرة                        | 32                  | 76.2   |
| 40. Phoenix dactylifera L.                       | Palmae       | شهب، نба نازك، نباه، جزء نازك    | 1                   | 2.4    |
| 41. Plantago sinaica (Barnoum) Decne.            | Plantaginace  | لسان الحمل، زهرة، عملج              | 12                  | 28.6   |
| 42. Pterocephalus sanctus Decne.                 | Dipsacaceae  | علبه، عملجية، جربة جريبي          | 4                   | 9.5    |
| 43. Pulicaria undulata (L.) C. A. Mey.           | Composite    | نبات، نبات، زعورة                | 8                   | 19.0   |
| 44. Scrophularia libanotica Boiss.               | Scrophulari  | جربة جريبي، زعورة، مزيز           | 9                   | 21.4   |
| 45. Seriphidium herba-album (Asso) Sojak.        | COMPOSI      | شبيه                                | 29                  | 69.0   |
| 46. Silene schimpertiana Boiss.                  | Caryophyll   | لصف، نبات، زهرة                      | 9                   | 21.4   |
| 47. Stachys aegyptiaca Pers.                     | Labiatae     | زعور، زهرة، غزاة                | 25                  | 59.5   |
| 48. Tanacetum sinaicum (fresen.) Delile ex       | Composita    | مر، مزق، زعورة                  | 27                  | 64.3   |
| 49. Teucrium polium L.                           | Labiatae     | جرد                                  | 34                  | 81.0   |
| 50. Thymus decussatus Benth.                     | Labiatae     | زعور، غزاة، زهرة              | 7                   | 16.7   |
| 51. Verbascum sinaticum Benth.                   | Scrophulari  | جربة، زهرة                        | 15                  | 35.7   |
| 52. Zilla spinosa (L.) Prantl in Engl. &         | Cruciferae   | زهرة، رغامة، كرمان             | 17                  | 40.5   |
Fig. 2. Family representation of the species recorded in vegetation Survey.

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

**Site 1: Shaq El Gragnia.**

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

**Stand (1) “Phlomis aurea Decne. community”**

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

**Stand (2): ‘Origanum syriacum L.community’**

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

**Stand (3): “Nepeta septemcrenata Benth. community”**

Eight plant species have been recorded during the survey of this stand, where representing the dominant species Nepeta septemcrenata Benth with (I.V.I. = 66.71),
Phlomis aurea Decne representing the co-dominant species with (I.V.I. = 62.21) while the other associated species have a lower Important Value Index.

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

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

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

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

**Site 2: Shak Mosa.**

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

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

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

**Site 3: Gabal Musa.**

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

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

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

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

Ten species have been recorded in this stand; the characteristic species of this community are Tanacetum sinaicum (fresen.) Delile ex Bremer & humphries. (I.V.I.=
43.61), co-dominant is *Seriphidium herba-album* (Asso) Sojak. (I.V.I.= 38.57), *Verbascum sinaicum* (I.V.I.= 33.52). The other species with low Important Value Index.

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

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

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

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

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

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

**Site 4. Farsh Ellia.**  

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

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

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

**Site 5. Farsh Elloza.**  

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

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

Twelve species have been recorded in this stand during the survey and the most characteristic species representing this community is: the dominant species *Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries. with (I.V.I.= 120.21), the co-dominant species is *Nepeta septemcrenata* Benth. with (I.V.I.= 29.34), *Peganum harmala* L. &
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Alkanna orientalis (L.) Boiss. (I.V.I.= 23.96). The other species recorded a lower Important value Index

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

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

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

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

**Site 6. Farsh Shoeibi.**

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

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

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

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

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

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

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

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

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

**Site 7. Wadi Elfaraa.**

Wadi Elfaraa is located at 28.536204°N 33.968113°E, 28.553065°N 33.957832°E. with an Altitude range of 1815-1880 (m asl). The soil texture of Wadi Elfaraa contains 10% bolder, 45% rocks, 35% gravel and 10% sand. It has High human activity and High grazing pressure. This wadi consists of rocks and gravel substrate with pink granitic geology. The footpath in the area comes down from Safsafa Mountain and leads down to Wadi Arbaein.
Wadi starts from the end of Wadi Alarbein and terminates by Wadi Shoreage. Wadi has a concave topography with West to Northeast slope exposure. The steepness of the wadi ranges from 5°-15° while the steepness of slope ranges from 45°- 60°. The wadi has an approximate width range from 50-150 meters; Wadi length is approximately 2.4 km. The distance from Saint kathreine city is about 2.4 km (Stands 20, 21, 22, 23, 24).

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

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

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

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

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

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

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

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

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

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

**Site 8. Wadi Alarbein.**

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

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

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

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

Fourteen species have been recorded in this stand; the most characteristic species are *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V. I= 57.30), co-dominant is *Seriphidium*
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herba-album (Asso) Sojak. (I.V.I= 35.16), Stachys aegyptiaca Pers. & Alkanna orientalis (L.) Boiss. (I.V.I= 27.18). The other species with lower important value index.

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

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

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

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

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

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

Site 9. Wadi Itlah.

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

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

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

Stand (31): Euphorbia sanctae-catharinae Fayed.

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

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

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

Stand (33): Euphorbia sanctae-catharinae Fayed.

Nineteen species have been recorded within the stand and the most characteristic species representing the community are Euphorbia sanctae-catharinae Fayed. (I.V.I.
38.23) which represent the dominant species, the co-dominant species is *Juncus rigidus* Desf. & *Stachys aegyptiaca* Pers. (I.V.I. = 24.55), *Pulicaria undulata* (L.) C. A. Mey. (I.V.I. = 23.28). The other associated species with lower Important Value Index.

**Site 10. Wadi Eltalaa.**

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

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

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

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

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

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

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

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

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

**Site 11. Abo Waleie.**

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

**Stand (38): Achillea fragrantissima (Forssk.) Sch. Bip. Community.**
In this stand, seventeen species have been recorded during the survey and the most characteristic species representing this community is: the dominant species *Achillea fragrantissima* (Forssk.) Sch. Bip. with (I.V.I. = 94.98), the co-dominant species is *Euphorbia sanctae-catharinae* Fayed with (I.V.I. = 22.34), *Alkanna orientalis* (L.) Boiss.; *Origanum syriacum* L. & *Verbascum sinaiticum* Benth. (I.V.I. = 21.15). The other species recorded a lower Important value Index.  
**Stand (39): Euphorbia sanctae-catharinae** Fayed. Community.  
Eight species have been recorded within this stand and the most Characteristic species recorded in this community are *Euphorbia sanctae-catharinae* Fayed. (I.V.I. = 104.63) as dominant species, *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I. = 60.32) as co-dominant, *Centaurea eryngioides* Lam. (I.V.I. = 41.86). The other associated species have a lower Important Value Index.  
**Stand (40): Euphorbia sanctae-catharinae** Fayed. community  
Thirteen species have been recorded in this stand, and the characteristic species of this community are *Euphorbia sanctae-catharinae* Fayed. (I.V.I. = 99.17) as the dominant species, the co-dominant species is *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 53.98) and *Plantago sinaica* (Barneoud) Decne. (I.V.I.=31.02). The other associated species have a lower important value index.  
**Site 12. Elzawitin.**  
Elzawitin is located at 28.539435°N 33.922390°E, 28.536107°N 33.915695°E. with an Altitude range of 1920-1945 (m asl). The soil texture of Elzawitin contains 15% bolder, 25% rocks, 45% gravel and 15% sand. It has High human activity and High grazing pressure. This Wadi bed consists of a course sand substrate with granite geology. Wadi has a concave topography with a southwestern slope exposure. The steepness of the wadi ranges from 5°-25°. The wadi bed is approximately 25 meters wide while wadi length is approximately 930 m. The distance from Saint Kathreine city is about 3.3 km. There is high diversity and cover of species in this wadi. Feral donkeys are the biggest threat in this area. Wadi bed is adjacent to Bedouin garden with a footpath along the top of wadi channel (Stans 41, 42).  
**Stand (41): Euphorbia sanctae-catharinae** Fayed. Community.  
Fourteen species have been recorded in this stand, and the characteristic species of this community are *Euphorbia sanctae-catharinae* Fayed. (I.V.I.= 81.26) as the dominant species, the co-dominant species is *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 63.20) and *Stachys aegyptiaca* Pers. (I.V.I.=33.67). The other associated species have a lower important value index.  
**Stand (42): Achillea fragrantissima** (Forssk.) Sch. Bip. Community.  
Ten species have been recorded in this stand; the Characteristic species of this community are: *Achillea fragrantissima* (Forssk.) Sch. Bip. (I.V.I.= 90.61) dominant species, co-dominant is *Teucrium polium* L. (I.V.I.= 41.50) and *Pterocephalus sanctus* Decne. (I.V.I. = 31.53). The other species with lower Important Value Index.

**DISCUSSION**

The southern part of Sinai is relatively floristically rich compared to the rest of Sinai. In agreement with Danin (1978 &1983), Moustafa and Klopatek, (1995) the nature of the soil surface is one of the most important factors influencing the floristic richness of the landforms along with the climatic variations due to orographic influences. The present study aimed to identify major plant communities dominating the 42 studied stands from Saint Katherine protectorate. Results showed the presence of Twelve plant communities along the Twelve sites of the study area. The major plant communities were *Teucrium polium* has the highest presence percentage (34 stand = 81 %), followed by *Nepeta septemcrenata* and
Phlomis aurea (32 stand = 76.2 %), Chiliadenus montanus and Seriphidium herba-album (29 stand = 69 %), Echinops spinosus and Tanacetum sinaicum (27 stand = 64.3 %), Stachys aegyptiaca (25 stand = 59.5 %), Ballota undulata (24 stand = 57.1 %), Achillea fragrantissima (22 stand = 52.4 %).

In agreement with (Moustafa and Klopatek, 1995) the flora of the Saint Catherine area is composed of a ‘skeleton’ of very common species (Seriphidium herba-alba, Gymnocarpos decandrum, Artemisia judaica, Tanacetum sinaicum, Achillea fragrantissima and Fagonia mollis) that cover most of the area and dominate many of the sub-shrub communities. Also, many rare species have a limited distribution in the Saint Catherine area. There are rare species that are local endemics (Primula boveana, and Rosa arabica) and the species where scarcity is brought on by overgrazing and overcutting. The Saint Catherine Mountains are a centre of endemism (Zohary, 1973; Shmida, 1984; Moustafa, 1990). Danin (1986) estimated 28 endemic species, 3.2% of its total flora. More than 50% of these species are found in the study area growing in the floristically rich landform types (gorges, springs, and high terraces) that have a wetter microclimate than other habitats of the Sinai. Previous work by Danin (1972 &1978, 1986); Moustafa (1986&1990); Boulos and Gibali (1995) indicate that the Saint Catherine flora area is represented mainly by Irano–Turanian elements. Most of the endemic species in Sinai are confined to the mountain region (El-Hadidi, 1967). Eleven threatened and endemic species and four near endemics Based on the list of Boulos (2009) of rare species in southern Sinai and our data, more than 61 rare species are threatened due to overcutting and livestock grazing. The results of these disturbances are (1) disappearance of palatable plant species, rare species and endemic species; (2) wadis and ridge habitats being dominated by pure communities of plants such as Artemisia judaica, Anabasis articulata, and Fagonia mollis; (3) changes in the soil surface and moisture retention ability; and, (4) a reduction of the total plant cover that protects the soil surface, slow down erosion and stabilizes the relief. It is noticed, in certain plant communities, that the most common species is the least grazed.

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

Conclusion

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

Acknowledgement: I wish to express my deepest gratitude to Mr. Esmail Hatab, General Manager of Saint Katherine protectorate. I would also to express my deepest gratitude to the botanical team in Saint Katherine protectorate.

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