

# The moss flora of Gebel St. Katherine area (Sinai) with nine new records

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Sixteen moss species representing eleven genera, six families and five orders are reported from Gebel St. Katherine area including nine new records. Mosses known from this area amount to 28 taxa. Diagnostic features, notes on morphology-habitat relations and moss abundance of the 16 taxa are provided and a key for the identification of the mosses known at present from the study area based on gametophytic characters is constructed.

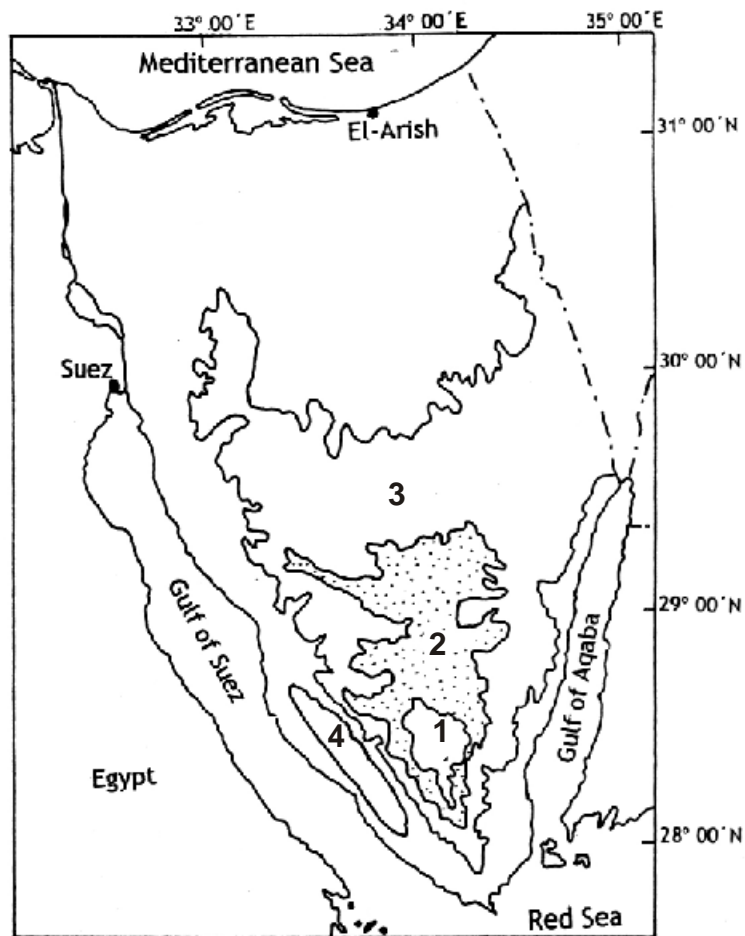
**Key Words:** Egypt, Gebel St. Katherine mountain, Moss flora, Southern Sinai.

## Introduction

Mountainous southern Sinai consists of a complex system of high and very rugged igneous and metamorphic mountains that are dissected by deep wadis (Said, 1990). It is delimited from the north by both Uqma plateau and El-Tih desert, from the southwest by El-Qaa plain and from the east by the shore of El-Aqaba Gulf (Fig. 1). Its central district is more elevated, has mean annual temperature of 9°-15°C, receives more precipitation than any other part of Sinai, but fog and dew are absent. Gebel St. Katherine is one of the prominent features which is located nearly in the center of this district (Fig. 1). This black mountain consists of old volcanic rocks and attains an altitude of 2642 m asl. being the highest in Egypt. It is the coldest area in Sinai; the mean monthly temperature ranges from -1°C to 2°C in winter and 17°C to 19°C in summer. It receives about 65-100 mm of rainfall annually. Precipitation may also occur as snow and hail (Zahran & Willis, 1992).

Lorentz (1867), reported from Gebel St. Katherine *Eucladium verticillatum* (Brid.) Bruch, Schimp. & W. Gümbel, *Rhynchostegium riparioides* (Hedw.) Cardot (= *Rhynchostegium rusciforme* Bruch, Schimp. & W. Gümbel) and *Bryum syriacum* Lorentz (= *Webera sinaitica* Lorentz). Out of the nine moss taxa recorded by Hart (1891) from Gebel St. Katherine, seven were new to its flora. These were; *Encalypta vulgaris* Hedw., *Gymnostomum aeruginosum* Sm. (= *Hymenostylium rupestre* Schwägr.), *Grimmia laevigata* (Brid.) Brid. (= *Grimmia leucophaea* Grev.), *Schistidium apocarpum* (Hedw.) Bruch & Schimp. (= *Grimmia apocarpa* L.), *Entosthodon attenuatus* (Dicks.) Bryhn (= *Entosthodon templetonii* Schwägr.), *Bryum turbinatum* (Hedw.) Turner and *Brachythecium velutinum* (Hedw.) Bruch, Schimp. & W. Gümbel (= *Hypnum velutinum* L.). To these, Geheeb (1903) added *Didymodon tophaceus* (Brid.) Lisa, *Syntrichia inermis* (Brid.) Bruch, *Syntrichia rigescens* (Broth. & Geh.) Ochyra, *Tortula kneuckeri* Broth. & Geh. and *Grimmia anodon* Bruch & Schimp. Furthermore, Geheeb (1904) added *Brachymenium exile* (Dozy & Molck.) Bosch & Sande Lac. (incorrectly identified as

*Bryum caespiticium* Hedw. cf. El-Saadawi, *et al.* 1999), *Bryum gemmiparum* De Not. and *Pohlia atropurpurea* (Wahlenb.) Lindb. (= *Bryum atropurpureum* Wahlenb.). *Hymenostylium recurvirostrum* (Hedw.) Dixon (= *Hymenostylium recurvirostre* Hedw.) was reported from Gebel St. Katherine by Bilewsky (1974) bringing the score up to 19 species from this mountain.



**Fig. (1):** Map showing the location of Gebel St. Katherine in Southern Sinai Massif. 1 = Gebel St. Katherine (Igneous & Metamorphic rocks; Basalt & Granite). 2 = Ugma Plateau. 3 = El-Tih Desert. 4 = El-Qaa Plain.

### ***Materials and methods***

Twenty-nine moss samples were collected during May 1993 from wet to nearly dry rock crevices and from the edges and inside walls of a unique freshwater spring called Maayen (Bir) El-Shinnara (1900 m asl.) in Gebel St. Katherine area. This spring is located

in a deep, windless, shaded, wet and very quiet place. Its waters come steadily from inside the rocks as well as percolating through rocks. Mesic and aquatic habitats favouring the luxuriant growth of moss populations are widespread in this part of the Gebel.

Specimens were examined, sectioned according to Abou-Salama (1985) and Wilson (1990), and identified. Voucher specimens are kept in the Herbarium of the Botany Department, Faculty of Science, Ain Shams University (CAIA) and duplicates in the private collection of the author.

Identification was achieved by matching against authentic specimens kept in CAIA and by using keys, descriptions and illustrations in different moss floristic works (e.g. Flowers, 1973; Agnew and Vondracek, 1975; Nyholm, 1975; Smith, 1980 and Zander, 1993) as well as in some comprehensive treatments of specific taxa (e.g. Ochi, 1972). Classification, synonymy and epithets of authorities of plant names were followed as given in the recent updated list of Egyptian mosses (El-Saadawi, *et al.* 1999).

## Results

The 29 collected samples yielded 18 entities, among which 16 entities were fully identified to the specific level. These species belong to eleven genera, six families and five orders, which are listed below (\* = new record to Gebel St. Katherine, (\*\* = new record to Egypt):

Order: Pottiales

Family: Pottiaceae

Subfamily: Trichostomoideae

1. *Eucladium verticillatum* (Brid.) Bruch, Schimp. & W. Gumbel

Subfamily: Merceyoideae

\* 2. *Didymodon luridus* Hornsch.

3. *D. tophaceus* (Brid.) Lisa

\* 4. *Gymnostomum calcareum* Nees & Hornsch

\* 5. *Gyroweisia tenius* (Hedw.) Schimp.

6. *Hymenostylium recurvirostrum* (Hedw.) Dixon

7. *Tortula kneuckeri* Broth. & Geh.

Order: Grimmiales

Family: Grimmiaceae

8. *Grimmia anodon* Bruch & Schimp.

Order: Bryales

Family: Bryaceae

\* 9. *Bryum caespiticium* Hedw.

\* 10. *B. capillare* Hedw.

\* 11. *B. funkii* Schwägr.

\* 12. *B. pseudotriquetrum* (Hedw.) P. Gaertn.

13. *B. syriacum* Lorentz

Order: Orthotrichales

Family: Orthotrichaceae

\*\* 14. *Orthotrichum rupestre* Schleich. Ex Schwägr.

Order: Hypnales

Family 1: Amblystegiaceae

15. *Amblystegium riparium* (Hedw.) Bruch, Schimp. & W. Gumbel

Family 2: Brachytheciaceae

16. *Rhynchostegium riparioides* (Hedw.) Cardot

Number of pure gatherings, mixed gatherings, herbarium number together with diagnostic features of the identified species recorded from Maayen El-Shinnara are given below.

**1- *Eucaldium verticillatum***

Leaves spreading to erecto-patent rarely patent, linear to linear-lanceolate, long and large towards tip; leaf margin plane, with serrulate cells just above base; leaf base pellucid with large wide rectangular and lax cells; costa usually percurrent, stout, with 2 stereid bands and median guides. Stem without central strand.

Examined specimens: Pure gatherings: U.900, U.905, U.908, U.909, U.910, U.911 and U.913 (CAIA). Mixed gatherings: U.901b, U.902b and U.915b (CAIA).

**2- *Didymodon luridus***

Leaves ovate, crowded at stem apex, widely keeled, quite fragile and with erect bases, papillose or papillose-crenulate recurved apical margins, percurrent or rarely ending below apex costa, leaf cells collenchymatous papillose especially abaxial surface.

Examined specimen: Mixed gathering: U.892b (CAIA).

**3- *Didymodon tophaceus***

Plants olive-green; leaves  $\pm$  crowded above but equidistant below, mostly patent but sometimes erecto-patent to patent, upper leaves with erect base, usually ligulate; margin slightly recurved; apex obtuse to broadly acute; costa mostly ending below apex but occasionally percurrent; cells slightly papillose, clear,  $\pm$  uniform in size all over the leaf but wide rectangular at base near costa.

Examined specimens: Pure gathering: U.891 (CAIA). Mixed gatherings: U.901a and U.902a (CAIA).

**4- *Gymnostomum calcareum***

Leaves erecto-patent to patent from usually erect base, not crowded, apex mostly broadly acute, rarely apiculate, margin plane, costa ending below apex, upper leaf cells usually opaque and densely papillose, basal leaf cells wide rectangular.

Examined specimens: Pure gatherings: U.907, U.917 (CAIA). Mixed gathering: U. 899a (CAIA).

**5- *Gyroweissia tenuis***

Leaves erecto-patent, ligulate, more crowded at apex, apex obtuse, margin plane and slightly papillose, costa ending just below apex, cells of leaf base wide and thin walled.

Examined specimens: Pure gathering: U.906 (CAIA).

**6- *Hymenostylium recurvirostrum***

Lingulate leaves, acute margin, stout costa, collenchymatous and papillose lamina cells, medium guides and the stem with very thick outer cortex and without central strand are the most important characters of this taxon.

Examined specimens: Mixed gathering: U.915c (CAIA).

**7- *Tortula kneuckeri*** (endemic to Southern Sinai; Geheeb, 1903)

Small delicate moss with short oblong soft leaves, slender hair point, delicate costa, smooth thin walled lamina cells, 1-3 rows of ventral guides and small stereid band, some leaves with asymmetrical blade, long perichaetial leaves, short cylindrical capsule and tessellate peristome with short membrane.

Examined specimens: Mixed gathering: U.898a (CAIA).

**8- *Grimmia anodon***

Plants usually form hoary, dark green and usually pure cushions (or sometimes small mats), turn blackish when dry; Leaves crowded, erecto-patent, keeled, with long multiseriate decurrent down apices and margins of lamina hyaline hair point (especially upper leaves), lamina cells bistratose especially towards leaf apex and obviously incrassate.

Examined specimens: Pure gatherings: U.894 and U.895 (CAIA).

**9- *Bryum caespiticium***

Leaves small, up to 1.0 mm long, crowded especially at apex, imbricate, erect, strongly concave, ovate above but lanceolate below; costa excurrent to a long or short point; apex pointed outwards.

Examined specimens: Mixed gatherings: U.897b and U.899b (CAIA).

**10 - *Bryum capillare***

Plants autoecious, with papillose rhizoids, rhizoidal gemmae  $\pm$  spheroidal, leaves more crowded at apices, broadest part of leaf above mid-leaf, margin usually serrulate at apex and bordered, costa excurrent to a long  $\pm$  stout point, base especially in old leaves usually with red colour.

Examined specimens: Mixed gatherings: U.893a, U.896a and U.898b (CAIA).

**11- *Bryum funkii***

Leaves imbricate, strongly concave, short ovate or ovate-orbicular, equally spaced and crowded, stem jellylike, costa excurrent to a short point in apical leaves but ending below apex in lower leaves.

Examined specimens: Pure gathering: U.914 (CAIA). Mixed gatherings: U.897a and U.916b (CAIA).

**12- *Bryum pseudotriquetrum***

Leaves crowded at stem apex, ovate to lanceolate, large, up to 3.0 mm long; with strongly bordered bistratose margin, apex acute; costa percurrent rarely very short excurrent especially in old leaves sometimes ending below apex in lower leaves, slightly pointed outwards.

Examined specimen: Pure gathering: U.918 (CAIA).

**13- *Bryum syriacum***

Female plants were recorded, leaves bent to one direction, oblong ovate to long lanceolate, large, up to 3.0 mm long, apex acute, costa in upper leaves percurrent but in lower leaves ending below apex, lanceolate to ovate, margin bordered bi- and tri- stratose.

Examined specimens: Pure gathering: U.890 (CAIA). Mixed gatherings: U.892a, U.896c, U.901c, U.903b and U.916a (CAIA).

**14- *Orthotrichum rupestre***

Plant autoecious; leaves fragile, crowded, erecto-patent and patent, lanceolate-ligulate; apex obtuse-acute with soft apiculus; costa ending below apex; margin recurved; leaf cells collenchymatous, upper cells irregularly rounded and slightly papillose but rectangular and smooth below.

Examined specimen: Mixed gathering: U.901d (CAIA).

**15- *Amblystegium riparium***

Stem with indistinct central strand; leaves crowded and  $\pm$  equidistant, vary in sizes forming alternate zones of small and large leaves, ovate, sometimes with asymmetrical blade,  $\pm$  slightly concave, mostly patent to spreading; apex acuminate to acute, mostly secund; margin serrulate especially towards leaf apex, plane, unbordered; costa usually percurrent, distinctly undulate at upper leaf part, slender, homogenous; cells obviously incrassate, rhomboidal rectangular pentagonal and hexagonal.

Examined specimens: Mixed gatherings: U.896b and U.903a (CAIA).

**16- *Rhynchostegium riparioides***

Aquatic creeping robust moss with vigorously pinnately branched stem, leaves crowded and vary in sizes in alternate zones, serrulate apical leaf margin, costa so delicate and vanishing distinctly below apex, linear to vermicular lamina cells turning wide at base.

Examined specimen: Mixed gathering: U.915a (CAIA).

**Discussion**

From the results that have been presented, *Eucladium verticillatum* was found to be the most frequent taxon in the study area, being represented in ten samples. This is due to the fact that this moss exhibited a wide spectrum of morphological features that enables it to inhabit diverse habitats not only in Gebel St. Katherine but in the whole area of St. Katherine protectorate (Abou-Salama, 1991). The second most frequent taxon is *Bryum syriacum* being represented in six samples. On the other hand, seven taxa are represented

in only one sample each, while seven others are represented in two or three samples each. Furthermore, three taxa occur in pure samples, eight in mixed samples while five in both pure and mixed ones.

*Tortula knueckeri*, *Orthotrichum rupestre* and *Bryum capillare* were recorded with both kinds of sex organs and the first was the only fruiting moss. It is worthy to mention that the present find of the endemic *Tortula knueckeri* is the second since the record of the type material by Geheeb (1903).

*Orthotrichum rupestre* is a new record to the bryoflora of Egypt. A single individual plant of this taxon was found in a mixed sample containing *Eucladium verticillatum*, *Didymodon tophaceus* and *Bryum syriacum*. More search in the area for niches accomodating populations of this newly recorded moss is recommended. It is a widespread taxon being reported from: Eur; Afr1, 2, 4; As2, 3, 5; Am1, 2, 6 and Aust1, 2. (Wijk, *et al.* 1964).

*Didymodon luridus*, *Gymnostomum calcareum*, *Gyroweissia tenuis*, *Bryum caespiticium*, *B. capillare*, *B. funkii*, *B. pseudotriquetrum*, *Orthotrichum rupestre* and *Amblystegium riparium* are new records to the moss flora of Gebel St. Katherine. These bring the total number of mosses known from this area to 28 taxa.

These 28 taxa are included in 18 genera, eight families and seven orders, with Pottiaceae as the largest family. It is represented by ten taxa included in seven genera. *Bryum* is the most common as well as the largest genus being represented by seven taxa.

Due to rarity of fruiting, the following key is constructed based on the gametophytic characters of the 28 mosses. This would help for fast and easy identification for mosses known at present from this area.

- 1.a. Leaves with honeycomb areolation bryoid pattern with prosenchymatous cells at apical and middle leaf parts, costa with ventral guides, leaf cells smooth, stem pentagonal in T. S. .... 2
- b. No such combination of characters..... 9
- 2.a. Leaf margin distinctly bordered, 2-3 rows ..... 3
- b. Leaf margin unbordered..... 6
- 3.a. Marginal apical cells serrulate, costa excurrent to a long point, broadest leaf part above mid-leaf..... *Bryum capillare* 4
- b. No such combination of characters ..... 4
- 4.a. Margin unistratose..... *B. turbinatum*
- b. Margin bi- or tristratose ..... 5
- 5.a. Leaves crowded at stem apex, costa in old leaves short excurrent ..... *B. pseudotriquetrum*
- b. Leaves equidistant, costa in old leaves ending below apex ..... *B. syriacum*
- 6.a. Costa percurrent throughout ..... *B. gemmiparum*
- b. Costa excurrent at least in apical leaves..... 7
- 7.a. Leaves short ovate or ovate-orbicular, strongly concave, costa excurrent in apical leaves but ending below apex in lower ones ..... *B. funkii*
- b. Leaves ovate or lanceolate, costa excurrent throughout ..... 8
- 8.a. Basal leaf cells rectangular ..... *B. caespiticium*
- b. Basal leaf cells quadrangular ..... *Brachymerium exile*
- 9.a. Presence of hair point at least in upper leaves ..... 10
- b. Hair point absent ..... 14

- 10.a. Hair point delicate, lamina cells unistratose ..... *Tortula kneuckeri*  
 b. Hair point long and hyaline or leaf tip hyaline, lamina cells partly or totally  
 bistratose especially towards leaf apex ..... 11
- 11.a. Leaf shape lingulate, not keeled ..... *Syntrichia rigescens*  
 b. Leaf shape long triangular to lanceolate, keeled ..... 12
- 12.a. leaf apex with or without quite short hyaline smooth to  
 spinulose hair point, margin recurved on at least one  
 side ..... *Schistidium apocarpum*  
 b. Leaf with long hyaline spinulose hair point, margin plane ..... 13
- 13.a. Costa thickened towards apex ..... *Grimmia anodon*  
 b. Costa widened towards base ..... *G. laevigata*
- 14.a. Leaves lanceolate to ovate or obovate, costa usually ending below apex,  
 slender, leaf cells elongated hexagonal or rectangular, smooth, not  
 chlorophyllose, central strand present at least above ..... 15  
 b. No such combination of characters ..... 16
- 15.a. Plants long or median sized, leaves numerous, margin  
 denticulate above, cells narrowly hexagonal not  
 prosenchymatous, slightly incrassate ..... *Pohlia atropurpurea*  
 b. Plants small, leaves few, margin usually entire or with  
 smoothly protruded cells, cells wide rectangular, thin  
 walled and usually lax especially below ..... *Entothodon attenuatus*
- 16.a. Marginal leaf cells above base serrulate, basal leaf  
 cells lax, central strand absent ..... *Eucladium verticillatum*  
 b. No such combination of characters ..... 17.
- 17.a. Apical marginal cells serrulate, costa homogenous with a few stereids ..... 18  
 b. Apical marginal cells smooth or papillose, costa with ventral or median  
 guides ..... 20
- 18.a. Costa percurrent, leaf cells rhomboidal, rectangular or  
 hexagonal ..... *Amblystegium riparium*  
 b. Costa vanishing far below apex, leaf cells vermicular or long rhomboidal .... 19
- 19.a.. Leaves lanceolate-triangular, apex with long  
 acumen ..... *Brachythecium velutinum*  
 b. Leaves ovate or lanceolate, apex acute ..... *Rhynchostegium riparioides*
- 20.a. Margin recurved..... 21  
 b. Margin plane ..... 24
- 21.a. Leaf cells pluripapillate, leaves flaccid ..... *Syntrichia inermis*  
 b. Leaf cells papillose or mamilllose, leaves not flaccid or fragile ..... 22
- 22.a. Leaf apex apiculate ..... *Orthotrichum rupestre*  
 b. Leaf apex without apiculus ..... 23
- 23.a. Leaves ligulate, apex mostly obtuse, leaf cells clear ..... *Didymodon topiaceus*  
 b. Leaves lanceolate or long ovate or long triangular, apex mainly  
 acute, leaf cells opaque ..... *D. luridus*
- 24.a. Leaf apex acute, cells collenchymatous ..... 25  
 b. Leaf apex obtuse, cells not collenchymatous ..... 27
- 25.a. Costa percurrent, stout, with median guides,  
 stem without central strand ..... *Hymenstylidium recurvirostrum*



- b. Costa ending below apex, usually homogenous, stem with central strand ..... 26
- 26.a. Leaves linear, costa  $\pm$  uniform throughout, leaf cells collenchymatous ..... *Gymnostomum aeruginosum*
- b. Leaves lanceolate or ovate, costa weakened below, cells not collenchymatous ..... *G. calcareum*
- 27.a. Leaf cells pleuripapillate, costa percurrent or excurrent to a very short mucro, leaf base distinctly hyaline ..... *Encalypta vulgaris*
- b. Leaf cells smooth, costa ending below apex, leaf base not hyaline ..... *Gyrowesia tenuis*

### **Concluding Remarks**

Bryolofloristical works on Egypt that began about two centuries ago were recently reviewed and updated by El-Saadawi, *et al.* (1999), revealing the presence of 168 moss taxa in the country. New records were added by Refai and El-Saadawi (2000), one taxon by Abou-Salama and El-Saadawi (2001a), another taxon by Abou-Salama and El-Saadawi (2001b) four taxa and the present work added one taxon; raising the number of mosses, hitherto, known from Egypt to 175 taxa. These were recorded in 12 (out of 15) phytogeographical territories (El-Hadidi & Fayed, 1994/95) and the share of Sinai Massif territory was 85 taxa.

Although the site of Maayen El-Shinnara in Gebel St. Katherine is located at 1900 m a.s.l, yet its mosses share characters with those growing in deep Wadi beds. These characters include, the abundance of mixed samples, absence of or weakly formed central strand, rarity of fertility and fruit, abundance of mesic taxa (12 entities recorded), presence of aquatic mosses (*Amblystegium riparium* and *Rhynchostegium riparioides*) and rarity of xeric taxa (the ephemeral *Tortula kneuckeri* and the dark hoary *Grimmia anodon*).

### **Acknowledgement**

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