

Mosses of the Egyptian conservation areas: II. Omayed Protected Area

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Abstract – Twenty-nine moss taxa are recorded, for the first time, from Khashm El-Aish plateau in Omayed Protected Area (OPA), Mediterranean coast, Egypt. Sixteen of them represent new records to the western Mediterranean coast (Mm) and six [*Aloina brevisrostris* (Hook. et Grev.) Kindb., *Entosthodon* cf. *commutatus* Durieu et Mont., *Didymodon cordatus* Jur., *Tortella flavovirens* (Bruch.) Broth., *Tortula cuneifolia* (Dicks.) Turner, *T. muralis* Hedw. var. *aestiva* (Hedw.) Brid.] to Egypt bringing their totals to 63 and 170 taxa, respectively. OPA represents 0.07% of Egypt's area but sustains over 17% of its moss flora. The most common taxa are species of *Tortella*. The most frequent genera are *Tortella*, *Didymodon* and *Bryum*. The largest genera are *Didymodon*, *Bryum* and *Tortula*. The Pottiaceae represent ca. 76% of the flora and comprise over 70% of taxa recorded with sporophytes. Similarity of the bryoflora of OPA is mainly with Sinai and Isthmic Desert in Egypt.

Bryophyta / distribution / Egypt / Mareotic sector / Mediterranean / North Africa / western Mediterranean coast phytogeographic territory

INTRODUCTION

Omayed Protected Area (OPA) is one of the Managed Resource Protected Areas in Egypt. As it is a part of the north-western Mediterranean coastal belt of Egypt (Mm) (Fig. 1) it represents its habitat and biota diversity.

The site of Omayed is endowed with notable diversity in habitats and microhabitats attributed mainly to the prominent geomorphological, topographic and edaphic spatial variations. These factors also induce diversity in the microclimate within the site. Conceivably, such climatic and habitat diversities have produced a parallel diversity in plant and animal communities (Kassas *et al.*, 2002).

Endemism is represented in the fauna of OPA by four subspecies of birds and one species of rodents. Endangered, threatened and vulnerable animal species include eight species and subspecies of reptiles, three species of invertebrates and a subspecies of rodents (Kassas *et al.*, 2002).

Flora of Omayed comprises 253 species of flowering plants (12% of the flora of Egypt in 0.07% of the country area). Species richness is not the only thing characterizing it, other criteria include: (I) no less than 45 of the species are rare

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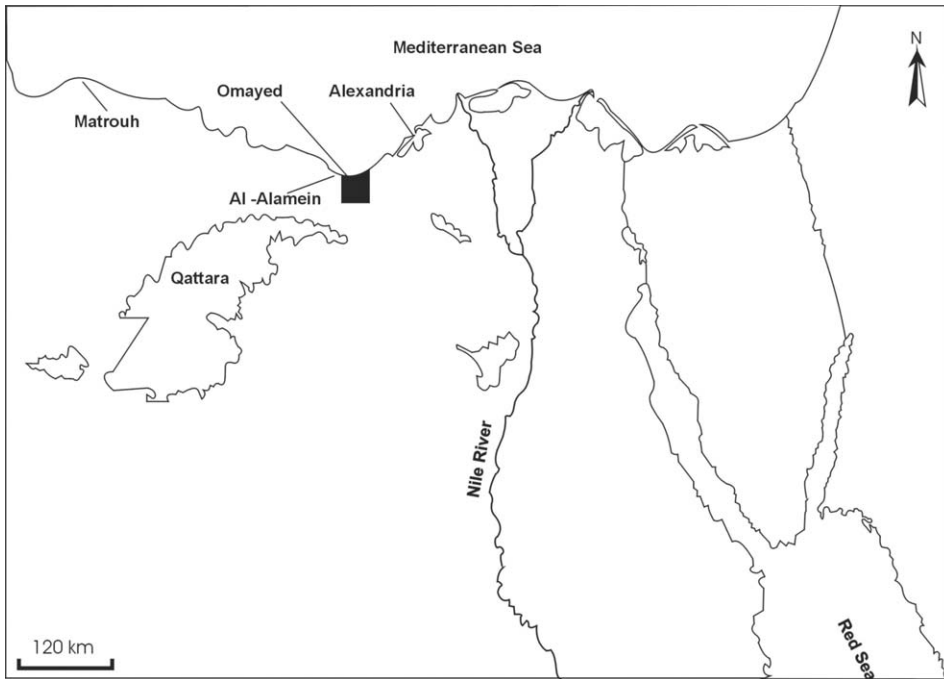


Fig. 1. A map of the northern part of Egypt showing location of Omayed Protected Area on the Mediterranean coastline (after www.ecaa.gov.eg with modification).

or very rare in Egypt, 18 of which are restricted to the Mediterranean coastal strip, (II) 17 of the species in OPA are rated as endangered or threatened and (III) it represents one of the few spots left where two endemic and highly endangered species *Helianthemum sphaerocalyx* Gauba et Janch. and *Zygophyllum aegyptium* Hosny can still be found (Kassas *et al.*, 2002).

These studies on fauna and flora of flowering plants, though great, are not sufficient to achieve the plan put by the World Commission on Protected Areas in 1998 (see Kassas *et al.*, 2002) for covering the full range of ecosystems and communities found in a particular country.

Mosses represent an important element, which plays an essential role in ecosystems. The known moss flora of Egypt, up till now, consists of 164 taxa (species, subspecies and varieties). These records were reported from 12 out of the 15 phytogeographical territories of Egypt (El-Saadawi *et al.*, 2003). Hitherto, only three of the Egyptian protected areas have been surveyed for mosses, namely: Saint Catherine (Abou Salama, 1985, 2001; Mansi, 1988), Elba (Abou Salama, 2000), and Siwa (Refai, 2001). Mosses have not been studied, at all in the other 24 declared protected areas of Egypt and regarding OPA (which belongs to Mareotic sector of the western Mediterranean coast (Mm) phytogeographic territory of Egypt(there is only a brief mention of the occurrence of two moss species, namely *Bryum bicolor* Dicks. (= *B. dichotomum* Hedw.) and *Aloina bifrons* (De Not.) Delgad. in sandy soil under shade of cultivated olive trees by Kassas *et al.* (2002), who recommended that there is much need for an extensive study of the bryophytes of this protected area.

The aim of this paper is, therefore, to study the bryophytes of OPA as a contribution to the moss floras of protected Areas, Mm, Egypt, North Africa and Mediterranean area.

STUDY AREA AND MATERIAL

OPA lies between long. 29°00'-29°18'E and lat. 30°38'-30°52'N, extending 26 km along the Mediterranean coastline. It extends between km 70 and 100 west of Alexandria city, along the Alexandria-Matrouh road and about 17.5 km east of Al-Alamein city. The area of OPA covers approximately 700 km².

OPA, as being a part of the Mediterranean coastal belt of Egypt, is characterized by sub-desert climate which is summarized by having: average temperature 12.4°C in January and 26°C in August, rainfall annual mean is 140.4-168.9 mm from October to February; relative humidity: 61% (October) – 72% (August); wind: northern; 10.2 km/h (in October) – 16.5 km/h (in March) to western; 18 km/h (in February) – 32 km/h (in December) (weather underground.com, 2011).

Water resources vary between rainfall and wells. The annual rainfall volume over OPA was estimated at approximately 106.26×10^6 m³. Ayyad (1977-1979) mentioned that about 2% of this water volume goes back to the atmosphere during the rainy storms causing minimum losses of evapo-transpiration. The remaining 98% supports the groundwater aquifer system (Ayyad, 1977-1979). Dew is another important water resource especially for plant growth. The total amount of dewfall in 1955 amounted 11.5 mm (Arvidson & Hillstorm, 1955) which in turn increased moisture content by 0.4 to 1.4% of total soil moisture content (Abdel Rahman *et al.*, 1966).

OPA soil has relatively high contents of medium; fine and very fine particles that explain its high water holding capacity (Abdel-Kader, 1980).

According to Ayyad & Le Floc'h (1983), there are three major physiographic systems in OPA, which run parallel to each other and to the seashore. Each of these systems has a number of habitats and microhabitats; each having a characteristic plant cover. These systems are as follows:

- a coastal system at the sea level which covers a small part of the territory;
- ridges and depressions system which constitutes the main part of the territory; the ridges are planted with fig and olive trees;
- the inland plateau system which is close to the inland desert, represented in Khashm El-Aish plateau, attains an elevation of 110 m and its rocks are of Pleistocene origin.

Khashm El-Aish plateau lies between lat. 30°44'20"-30°45'18"N and long. 29°08'23"-29°12'17"E, extending to five km length and 110 m height. It is characterized by shaded and humid microhabitats for having small caves with silted soils between large boulders (named by Bedouins "Al-Agr") (Fig. 2), in addition it is a gathering place for rain floods. It is the place where the only fern, the only gymnosperm and the only semi-succulent angiosperm in OPA exist (Kassas *et al.*, 2002).

Mosses were abundant at Khashm El-Aish plateau only on its northern side, away from direct sun light and facing the prevailing north-westerly cool winds at alt. ranging between 53 m and 91 m and at boundaries between lat.



Fig. 2. Small caves (Al-Agr) at Khashm El-Aish plateau.

30°44'57"-30°45'18"N and long. 29°10'22"-29°12'17"E. They were found to be adjacent to lichens (which prevailed in the area) and associated with filamentous algae especially in winter. In winter moss plants were green, easily noticed, abundant and fruiting while in the dry season they were small, pale green, very hard to be noticed while lichens were conspicuous and abundant in the study area throughout the period of study. Quite a few hepatics grew associated with mosses only in winter.

117 moss samples were collected, through five excursions: April and December 2005, September 2006, February and March 2007 from the northern face of Khashm El-Aish plateau. Other faces of this plateau as well as other localities, in OPA, outside Khashm El-Aish plateau, were barren of mosses in spite of the old record of *Bryum dichotomum* and *Aloina bifrons* (Kassas *et al.*, 2002) at the base of cultivated olive trees in the sandy dunes ridges.

Detailed information about all collected samples is available on herbarium packets kept at CAIA, the main points, however, are included in the results below.

RESULTS

Twenty-nine moss taxa are recorded, here, for the first time from the northern face of Khashm El-Aish plateau between lat. 30°44'57"-30°45'18"N and long. 29°10' 22"-29°12'17"E at an altitude of 53-91 m. Sixteen and six of the taxa

are new records to Mm and Egypt, respectively, which brings the total number of taxa known from Mm to 63 and from Egypt to 170. *Bryum dichotomum* but not *Aloina bifrons* was among the mosses reported, here, from Khashm El-Aish plateau which makes the total number of mosses known from OPA thirty taxa. *A. bifrons* is, however, an old record to Mm (El-Saadawi *et al.*, 2003). It must be mentioned that many more of the investigated mosses (belonging to Bryaceae, Grimmiaceae and Pottiaceae) were imponderable and are left for a future study.

The 29 taxa recorded from Khashm El-Aish plateau in OPA are listed below in family order. Taxa new to Egypt are asterisked and taxa new to Western Mediterranean coast (Mareotic sector: Mm) of Egypt are bold typed. Sample number (sample number is followed by the acronym "SO" where S = Sahar – one of the authors of this paper and O = Omayed), substrate, fertility, any reproductive structure, and distribution in phytogeographic territories of Egypt are all given.

Phytogeographic territories (after El-Saadawi *et al.* 2003) are abbreviated as follows: **Cai**: Cairo area; **Da**: Arabian desert; **Dg**: Galala Desert; **Di**: Isthmic Desert; **DL**: Libyan Desert; **Dn**: Nubian desert; **GE**: Gebel Elba; **Mm**: western Mediterranean coastal land (Mareotic sector); **Nd**: Nile Delta; **Nf**: Nile Fayoum; **Nn**: Nile Nubia, from Kom Ombo southwards to Egyptian boundaries with the Sudan including the areas now inundated by the waters of Lake Naser since 1965; **Nv**: Nile Valley, from Cairo-Giza to Kom Ombo; **On & Ol**: Oasis of the Nubian and Libyan Desert; **R**: Red Sea coastal plains; **S**: Southern Sinai massive (Sinai proper i.e. relatively high mountains, south of Isthmic desert).

List of mosses in Omayed Protected Area

Fissidentaceae

Fissidens bryoides Hedw. – at the middle of Khashm El-Aish plateau, inside a rock groove, facing north, away from direct sun light, sporophytes rare, archegonia and rhizoidal gemmae present, protonema prominent, 15 Dec 2005 (37bSO); in a semi shaded place, between rock and ground, 15 Dec 2005, 49cSO. Distribution in Egypt: Cai, Dg, Nd. **New to Mm.**

F. crispus Mont. – at the middle of Khashm El-Aish plateau, in a semi shaded place, on vertical side of a calcareous rock, facing north away from direct sun light, antheridia, archegonia and thin hyaline paraphyses present, 15 Dec 2005, 43bSO. Distribution in Egypt: Cai, Nv, S. **New to Mm.**

Pottiaceae

Aloina ambigua (Bruch. *et* Schimp.) Limpr. – at the middle of Khashm El-Aish plateau, in the shade of higher plants, sporophytes present, 15 Dec 2005, 33cSO; on semi-shaded soil on an inclined surface of a calcareous rock, 7 Feb 2007, 75bSO; on semi-shaded coarse soil where water flows, 7 Feb 2007, 102aSO. Distribution in Egypt: Di, Mm, S.

**A. brevis* (Hook. *et* Grev.) Kindb. – at the middle of Khashm El-Aish plateau, inside rock crevices archegonia, sporophytes and rhizoidal gemmae present, 8 Apr 2005, 7bSO, 7 Feb 2007, 95bSO and 15 Mar 2007, 116aSO; on semi-shaded coarse soil where water flows, 87cSO; on soil in a small cave, 7 Feb 2007, 93bSO, 97aSO & 95aSO.

Crossidium laevipilum Thér. et Trab. – at the middle of Khashm El-Aish plateau, on semi-shaded soil between rock and ground, 7 Feb 2007, 107bSO. Distribution in Egypt: Di, Mm.

C. laxefilamentosum W.Frey et Kürschner – at the Middle of Khashm El-Aish plateau, on semi-shaded soil between rock and ground, archegonia, antheridia and sporophytes present, 7 Feb 2007, 107cSO. Distribution in Egypt: Di. **New to Mm.**

Didymodon acutus (Brid.) K.Saito – at the middle of Khashm El-Aish plateau, in shade of a higher plant, facing north, 15 Dec 2005, 33aSO. Distribution in Egypt: Mm, S.

**D. cordatus* Jur. – at the middle of Khashm El-Aish plateau, in a semi-shaded site, on vertical side of a calcareous rock, 15 Dec 2005, 54SO.

D. fallax (Hedw.) R.H.Zander – at the middle of Khashm El-Aish plateau, in rock crevices 8 Apr 2005, 7aSO; in a semi-shaded place between rock and ground, 4 Sep 2006, 67SO; on coarse soil where water flows, 7 Feb 2007, 84dSO & 102cSO; in a semi-shaded site on inclined surface of a rock, 7 Feb 2007, 88dSO & 98bSO; on rock surfaces, 7 Feb 2007, 94SO. Distribution in Egypt: Nf, O, S. **New to Mm.**

D. luridus Spreng. – at the middle of Khashm El-Aish plateau, inside a calcareous rock groove, 7 Feb 2007, 82bSO. Distribution in Egypt: Mm.

D. rigidulus Hedw. – at the middle of Khashm El-Aish plateau, on semi-shaded coarse soil where water flows, 7 Feb 2007, 104aSO; in a semi-shaded site between rock and ground, 7 Feb 2007, 107aSO. Distribution in Egypt: Di, O, S. **New to Mm.**

D. tophaceus (Brid.) Lisa – at the east of Khashm El-Aish plateau, inside rock crevices, 15 Mar 2007, 109aSO. Distribution in Egypt: Cai, Dg, Mm, Nd, Nf, Nn, Nv, O, S.

D. vinealis (Brid.) R.H.Zander – at the middle of Khashm El-Aish plateau, on semi-shaded coarse soil where water flows, antheridia present, 15 Dec 2005, 51bSO, 26bSO and 7 Feb 2007, 78bSO; inside rock crevices, 15 Dec 2005, 30SO; inside a rock groove, 7 Feb 2007, 83SO; on semi-shaded coarse soil where water flows, 7 Feb 2007, 85bSO; on soil in a small cave, 7 Feb 2007, 93bSO. Distribution in Egypt: Cai, Di, Mm, Nd, Nf, O, S.

Gymnostomum viridulum Brid. – at the middle of Khashm El-Aish plateau, inside rock crevices, usually with propagules crowded at stem apex and rhizoidal gemmae, 8 Apr 2005, 13cSO; in the shade of higher plants, 15 Feb 2005, 33bSO; inside a rock groove, 7 Feb 2007, 82cSO; on rock surfaces, 7 Feb 2007, 99aSO & 105dSO; on semi-shaded coarse soil where water flows, 7 Feb 2007, 102fSO. Distribution in Egypt: Cai, Dg, Di, Mm, Nv, S.

Microbryum davallianum (Sm.) R.H.Zander – at the middle of Khashm El-Aish plateau, in a semi-shaded site on an inclined surface of a rock, archegonia and sporophytes present, 7 Feb 2007, 88aSO. Distribution in Egypt: Di. **New to Mm.**

M. starckeanum (Hedw.) R.H.Zander - at the middle of Khashm El-Aish plateau, on rock surfaces, archegonia, antheridia and sporophytes present, 7 Feb 2007, 80bSO; in a semi-shaded site on vertical side of a dam, 15 Mar 2007, 113SO & 117bSO. At the east of Khashm El-Aish plateau, between rocks, sporophytes and antheridia present, 15 Mar 2007, 110aSO; in a semi-shaded site on an inclined slope of a rocky dam, 15 Mar 2007, 111aSO; in rock crevices, 7 Feb 2007, 90SO. Distribution in Egypt: Di, Mm, Nf, S.

Pseudocrossidium hornschurchianum (Schultz) R.H.Zander – at the middle of Khashm El-Aish plateau, on semi-shaded soil on an inclined surface of a calcareous rock, 7 Feb 2007, 88bSO; on soil in a small cave, 7 Feb 2007, 93cSO. Distribution in Egypt: Mm, Nv, S.

**Tortella flavovirens* (Bruch.) Broth. – at the middle of Khashm El-Aish plateau, inside a rock groove, facing north away from direct sun light, archegonia present, sporophytes absent, 8 Apr 2005, 3SO, 15 Dec 2005, 37bSO & 46bSO and 4 Sep 2006, 64SO; in a semi-shaded place on the vertical side of a rock, 8 Apr 2005, 15aSO & 20SO and 15 Dec 2005, 44aSO; on semi-shaded coarse soil, 8 Apr 2005, 18SO; between rocks, 4 Aug 2005, 24SO, 15 Dec 2005, 26aSO, 4 Sep 2006, 61SO and 7 Feb 2007, 99dSO; in rock crevices, 15 Dec 2005, 28SO and 4 Sep 2006, 63SO; between rock and ground, 15 Dec 2005, 49bSO & 50SO.

T. nitida (Lindb.) Broth. – at the middle of Khashm El-Aish plateau, on inclined side of a rock, facing north away from direct sun light, sporophytes absent, 8 Apr 2005, 11SO and 15 Dec 2005, 47SO; between rocks where water flows, 8 Apr 2005, 22SO & 23SO, 15 Dec 2005, 25aSO & 32SO, 4 Sep 2006, 56SO & 59SO, 7 Feb 2007, 78aSO & 105aSO; inside rock grooves, 8 Apr 2005, 23SO; in rock crevices, 15 Dec 2005, 29SO & 41SO, 7 Feb 2007, 68SO & 91SO and 15 Mar 2007, 115aSO; in a semi-shaded place beside a rocky dam, 15 Dec 2005, 35SO and 15 Mar 2007, 114aSO; on semi-shaded coarse soil, 15 Dec 2005, 51aSO & 52SO and 7 Feb 2006, 81SO & 104bSO. Distribution in Egypt: GE, & Mm, NV.

Tortula brevissima Schiffn. – at the middle of Khashm El-Aish plateau, in rock crevices, archegonia and sporophytes present, 15 Dec 2005, 53aSO; on rock surfaces, 7 Feb 2007, 71aSO; between rocks, 7 Feb 2007, 79aSO; on vertical side of a rocky dam. Distribution in Egypt: S. **New to Mm.**

**T. cuneifolia* (Dicks.) Turner – at the middle of Khashm El-Aish plateau, in a semi-shaded site on an inclined surface of a rock, archegonia and antheridia present, 7 Feb 2007, 98aSO.

T. muralis Hedw. – at the middle of Khashm El-Aish plateau, on semi-shaded moist soil beside a dam, archegonia and sporophytes present, 15 Dec 2005, 35bSO; inside rock crevices, 15 Dec 2005, 42SO and 7 Feb 2007, 89bSO. Distribution in Egypt: Cai, Dg, Di, Nd, Mm.

**T. muralis* var. *aestiva* (Hedw.) Brid. – at the middle of Khashm El-Aish plateau, on an inclined surface of a rock, archegonia and sporophytes present, 7 Feb 2007, 96aSO.

Trichostomum crispulum Bruch. – at the middle of Khashm EL-Aish plateau, inside rock crevices, 4 Sep 2006, 57SO and 15 Mar 2007, 115bSO. Distribution in Egypt: Di, S. **New to Mm.**

Funariaceae

**Entosthodon* cf. *commutatus* Durieu et Mont. – at the middle of Khashm El-Aish plateau, on semi-shaded soil on an inclined surface of a rock, archegonia and sporophytes (not in a good condition) present, 15 Dec 2005, 38SO; inside rock crevices, 4 Sep 2006, 65cSO; inside a rock groove, 7 Feb 2007, 92SO.

Bryaceae

Bryum argenteum Hedw. – at the middle of Khashm El-Aish plateau, on semi-shaded soil beside a dam where water aggregates, with rhizoidal gemmae and protonema, 15 Dec 2005, 34SO. Distribution in Egypt: Cai, Di, Mm, S.

B. dichotomum Hedw. – at the middle of Khashm El-Aish plateau, rhizoidal gemmae, axillary bulbils, archegonia and sporophytes present, in rock crevices, 15 Dec 2005, 40SO & 53bSO; on a layer of soil on the vertical side of a rock, semi-shaded, 15 Dec 2005, 44bSO; on semi-shaded coarse soil where water flows, 7 Feb 2007, 72a,bSO, 86a-bSO, 87a-bSO & 103bSO; on rock surfaces, 7 Feb 2007, 105cSO; on semi-shaded soil on the vertical side of a rocky dam, 15 Mar 2007, 111bSO, 112SO & 117cSO; in rock crevices, 15 Mar 2007, 116bSO. At the east of Khashm El-Aish plateau, on the inclined surface of a rock, 15 Mar 2007, 108SO; in rock crevices, 15 Mar 2007, 109bSO; between rocks, 15 Mar 2007, 110bSO and 7 Feb 2007, 89aSO. Distribution in Egypt: Cai, Dg, Di, Mm, Nd, Nf, Nv, O, S.

B. gemmiparum De Not. – at the middle of Khashm El-Aish plateau, on semi-shaded coarse soil where water flows, with axillary bulbils and rhizoidal gemmae, 7 Feb 2007, 73SO. Distribution in Egypt: Cai, Nf, O, S. **New to Mm.**

B. radiculosum Brid. – at the middle of Khashm El-Aish plateau, between rocks, with rhizoidal gemmae, 7 Feb 2007, 77cSO; in rock crevices, 7 Feb 2007, 95cSO; on the inclined surface of a rock, 7 Feb 2007, 96bSO. Distribution in Egypt: Cai, Mm, Nd, O, S.

FLORISTIC REMARKS

The largest family, in OPA, is Pottiaceae (23/30 taxa) followed by Bryaceae (4/30 taxa), while Fissidentaceae and Funariaceae are poorly represented. Out of the 12 reported genera the largest are: *Didymodon* (7 species), *Bryum* (4 species), *Tortula* (3 species and 1 variety), while nine genera are represented by one or two species each.

The flora of OPA (30 taxa) represents over 17% that of the whole country (170 taxa) although its area is only 0.07% that of Egypt; Khashm El-Aish plateau, which really sustains the mosses is, of course, even much less in area being a small fraction of that of OPA. Relatively high diversity in OPA may be attributed to its topographic relief. Diversity of taxa was best expressed in the cool rainy winter and least at the end of the dry hot summer, thus a majority of the taxa were reported in February 2007 compared to a minority in September 2006. The taxa dominating in the hot dry season are the more adaptive taxa (*Tortella flavovirens*, *T. nitida* and *Trichostomum crispulum*) which then grew pure as competition decreased. One of these taxa namely *Tortella flavovirens* has highly fragile leaves which break into fragments that endure stress periods; a behaviour known as “Tolerance”. While in most taxa of OPA the green aerial shoots die off in the dry hot summer leaving their stress tolerant propagules in the soil till next rainy season, thus, showing the “Avoidance life strategy” (see Grime, 1974; Stearns, 1976).

The relatively high diversity of the moss flora at OPA is coupled with very low frequency of taxa (measured as number of samples collected), thus over

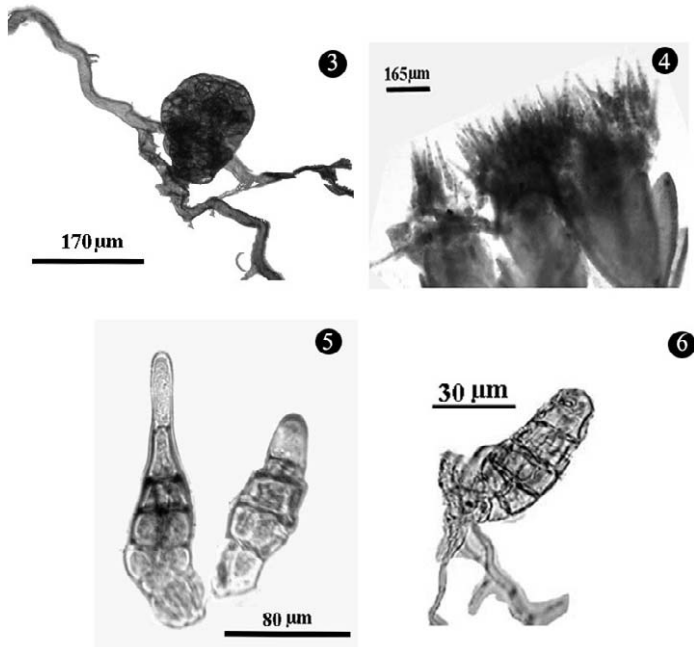
40% of the recorded taxa were met with only once, throughout the period of study, which may be attributed to strong competition between the large number of taxa upon the limited available substrate and nutrition. The most frequent taxa were the two *Tortella* species.

The majority of the taxa were found in mixed samples while a minority was found growing alone in pure samples. Some taxa grew in pure as well as in mixed samples. Associations, at specific level, were insignificant. At generic level, however, the most significant associations were between: *Bryum* and *Didymodon*, *Bryum* and *Tortula* and *Tortella* and *Didymodon*.

About 38% of the recorded taxa of OPA developed sporophytes. This is a relatively high percentage compared to the whole of Egypt (about 20%) but is about the same as in Gebel Maghara (Isthmic Desert, Di) (about 37%). The fruiting taxa were mainly (like in Gebel Mghara) members of subfamily Pottioideae (Shabbara & El-Saadawi, 2006).

Taxa that did not produce sporophytes (18 taxa) either carried antheridia and archegonia or only archegonia or only antheridia or were entirely without developed sex organs.

Regarding asexual reproductive structures; some taxa (all Bryaceae) produced bulbils, other taxa (including Bryaceae) produced rhizoidal gemmae (Figs 3, 6), but propagules clustered at stem or branch tips and protonemata were rare. February 2007 was the richest month in all recorded sexual and asexual reproductive structures.



Figs 3-6. **3.** *Aloina brevirotis*; a rhizoidal gemma about 170 μm long \times 140 μm widest. **4.** *Gymnostomum viridulum*; apical part of three stems with clustered propagules. The longest are about 165 μm each. **5.** *Gymnostomum viridulum*; two of the apical propagules, the larger one is 165 μm long. **6.** *Gymnostomum viridulum*; a rhizoidal gemma, about 60 μm long.

As far as the authors are aware the present report of rhizoidal gemmae in *Aloina brevirostris* and of propagules, clustered at stem and brach tips, in *Gymnostomum viridulum* is the first in the literature for these species and, therefore, merit description and illustration here. Rhizoidal gemmae of *A. brevirostris* are pear-shaped, reddish on brown rhizoids, about $170 \times 140 \mu\text{m}$ in size each, and consist of numerous cells (Fig. 3).

Apical propagules clustered at stem and branch tips of *Gymnostomum viridulum* (Fig. 4) are of brownish green colour, more or less fusiform in shape, a gemma is up to $165 \mu\text{m}$ in length, consisting of a relatively small number of cells (Fig. 5). Smaller brown gemmae of more or less the same structure, as the apical propagules were borne on the rhizoids of *G. viridulum* (Fig. 6). It must be mentioned that Dr. M. Cano (pers. com.) stated that the Egyptian specimen (No *I3cSO*) seems to be *G. viridulum* but is a little different from Spanish samples. The gemmae do not have a tapering apex of various cells as Egyptian material and the leaf is orange in KOH (usually known to be more yellow in this species).

Mosses already known from the Mareotic sector of the western Mediterranean coastal land of Egypt (i.e. Mm) or the phytogeographic territory to which OPA belongs are 47 taxa (El-Saadawi *et. al.* (2003), 14 of which are restricted, in Egypt, to this territory (Mm). The present work increased the number of mosses known from Mm to 63 (47 old + 16 new) taxa of which 6 are new records to Egypt which brings the total number restricted to Mm to 20 taxa (14 old + 6 new).

Sinai (Southern Sinai) and Isthmic Desert (Northern Sinai) are the two phytogeographic territories which have a relatively considerable number of taxa in common with OPA compared to the other phytogeographic territories of Egypt.

Out of the 30 taxa of OPA, *Bryum dichotomum*, *Didymodon tophaceus* and *D. vinealis* are the most widespread in Egypt being present in at least seven of the phytogeographical territories of the country.

Acknowledgements. Special thanks to Prof. Dr. Mohammed Kassas (passed away on 21 March 2012) for interest and being so kind making his library available to us and providing us with some relevant references. Thanks are also to Geologist Mohammed Ibrahim, consultant at managing centre for protected areas in Egypt, for his kind help and facilities offered to visit the protectorate. All gratitude to site manager, agriculture engineer Mohammed Essawi for guidance to Khashm El-Aish plateau and through the rest of the protectorate and for supplying useful and important publications about the protectorates of Egypt. And to ecological researchers Ahmed Gad and Wessam Emeil for guidance in the protectorate during the Excursions. Thanks to Dr. Mahmoud El-Refai for kind help with preparation of the map. We are greatly indebted, with regard to confirming or correcting the identity of moss specimens to Drs M. Cano and M. Gallego, Murcia, Spain (*Aloina brevirostris*, *Microbryum*, *Tortella*, *Tortula muralis*), Dr M.Cano (*Gymnostomum viridulum*), Mr. T.L Blockeel, Dore, UK (*Bryum radiculosum* and some other specimens), Dr M. Brugués, Barcelona, Spain (*Entosthodon*) and Dr R.H. Zander, St. Louis, USA (*Didymodon luridus*, *D. vinealis*). Thanks are due to three reviewers whose valuable comments added positively to the article, therefore, highly acknowledged.

REFERENCES

- ABDEL-KADER F., 1980 — Soil erosion. In: Ayyad M. A. (ed.), *Regional Environmental Management of Desert Ecosystems in Northern Egypt. Progress Report No. 1, 3* (cf. Kassas *et al.*, 2002, cited below).

- ABDEL-RAHMAN A.A., AYAAD M.A. & EL-MONAYARI M.M., 1966 — Hydroecology of the sand dunes habitat at Burg El-Arab. *Bulletin of faculty of sciences, university of Cairo* 40: 29-54.
- ABOU SALAMA U.Y., 1985 — *Morphological studies on some Egyptian bryophytes in southern Sinai*. M.Sc. Thesis, Dept. Bot., Fac. of Sci., Ain shams univ., Cairo. 162 p.
- ABOU SALAMA U.Y., 2000 — Mosses of the Egyptian conservation areas: I. Gebel Elba protectorate. *Phytomorphology* 50: 47-58.
- ABOU SALAMA U.Y., 2001 — The moss floras of Gebel St. Katherine (Sinai) with nine new records. *Taeckholmia* 21: 81-90.
- ARVIDSON I. & HILLSTORM B., 1955 — A note on dew in Egypt. *Bulletin of the institute. Inst. Hydraul.*, Royal Institute of Technology, Stockholm, 48: 416-426.
- Ayyad M.A., 1977–1979 — Systems analysis of Mediterranean desert ecosystems of northern Egypt (SAMDENE). Unpublished progress reports Nos. 1-5 (cf. Kassas *et al.*, 2002, cited below).
- AYYAD M.A. & LE FLOCH E., 1983 — *An ecological assessment of renewable resources for rural agricultural development in the western Mediterranean coastal region of Egypt. (Case study: El Omayed Test-area)*. Alexandria, Academy of Scientific Research and Technology, REMDENE Project. Alexandria University, Egypt. 104 p.
- EL-SAADAWI W., SHABBARA H.M., REFAI M.S. & ABOU-SALAMA U.Y., 2003 — Mosses of different phytogeographical territories of Egypt. *Bocconea* 16: 133-146.
- GRIME J.P., 1974 — Vegetation classification by reference to strategies. *Nature* 250: 26-31.
- KASSAS M. & AL., 2002 — *Management plan for Omayed Protected Area*. Township Med Wet Coast, Global Environment Facility & Egyptian Environment Affairs Agency. 130 p.
- MANSI M.A., 1988 — *Studies on the bryoflora of Southern Sinai*. M.Sc. Thesis, Department of Botazny, Faculty of Science, Suez Canal University, Egypt. 165 p.
- REFAI M.S., 2001 — Contributions to the moss flora of the Egyptian Oases. 2- Siwa Oasis. *Taeckholmia* 2: 291-302.
- SHABBARA H.M. & EL-SAADAWI W., 2006 — Mosses from Gebel Maghara with new records for Isthmic Desert and Egypt, *Cryptogamie, Bryology* 27: 91-102.
- STEARNS S.C., 1976 — Life history tactics: a review of the ideas. *Quarterly review of biology*. 51: 3-47.
- WEATHER UNDERGROUND.COM, 2011.