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Mosses from Gebel Maghara with new records for Isthmic Desert and Egypt

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Abstract – Thirty-two moss taxa are recorded from Gebel Maghara. Sixteen of them are new records to the Isthmic Desert bringing the total to 47 taxa. Four species are new records to Egypt. About half the Gebel Maghara taxa occur also in the Mediterranean region while only about a quarter in the Nile regions.

Mosses / Isthmic Desert / Sinai / Egypt / North Africa

INTRODUCTION

More than 60 studies have been published on the Egyptian moss flora (El-Saadawi et al., 1999, 2003), about half of which have been on southern Sinai, but only four on northern Sinai (Isthmic Desert; Figs 1-2). The latter four studies reported a total of 31 taxa (of the 175 moss taxa that had been recorded from Egypt; El-Saadawi et al., 2003) from six areas: Ain El-Godyrat and Gebel Libni (Abou-Salama & El-Saadawi, 2001), Ain Qadies and Gebel Dalfa (Refai & El-Saadawi, 2000), Areif El-Naka or El-Naga (Bilewsky, 1974) and Gebel Halal (Shabbara, 1999), which, together represent a rather small portion of the Isthmic Desert (Fig. 2).

The Isthmic Desert is divided into two regions: the area of domes and the desert region. The area of domes (the most favourable for growth of mosses) is a region that covers about 13000 km^2 and is bordered in the north by the Mediterranean coast. Gebel Maghara, Gebel Halal, and Gebel Ya'laq are the most important mountains in this area (Fig. 2). There are no bryological studies of Gebel Ya'laq, and only a limited study of Gebel Halal, where a few interesting taxa have been reported (Shabbara, 1999).

As a contribution to the moss flora of the Isthmic Desert, a survey of a limited area of Gebel Maghara was undertaken in 1995. The results are given in this paper.

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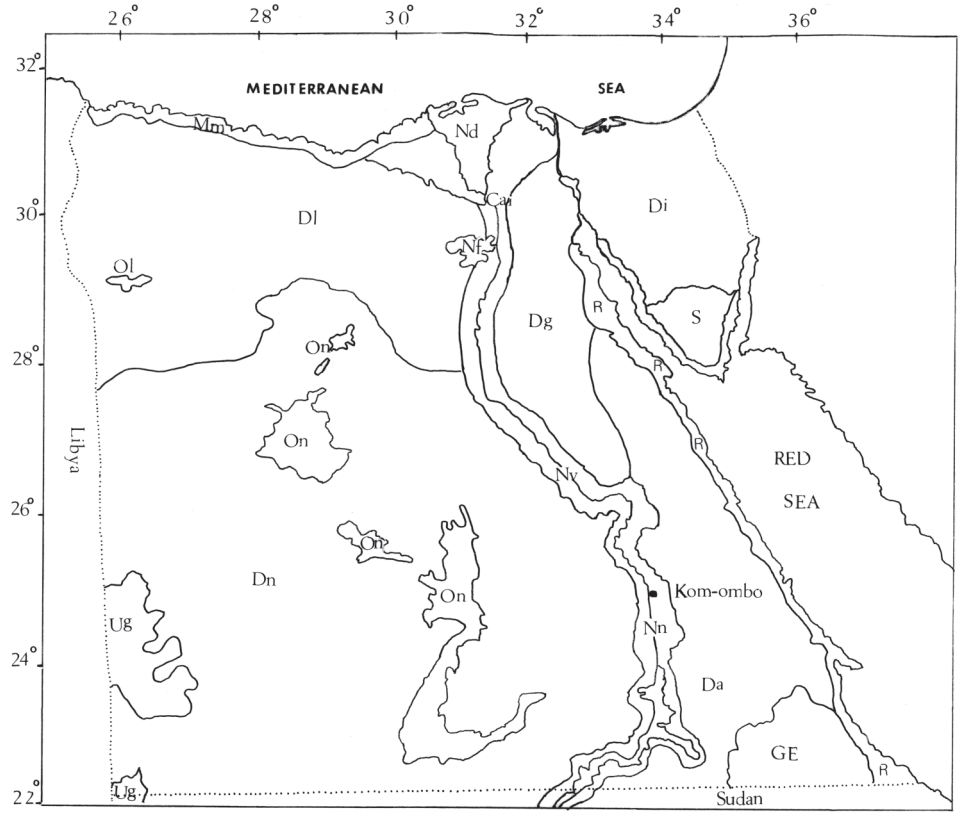

Fig. 1. Map of Egypt showing its phytogeographical areas (after El-Hadidi, 2000 and El-Saadawi et al., 2003). **Cai**: Cairo region; **Da**: Arabian Desert; **Dg**: Galala Desert; **Di**: Isthmic Desert; **Dl**: Libyan Desert; **Dn**: Nubian Desert; **GE**: Gebel Elba district; **Mm**: Mediterranean coastal land (Mareotic sector); **Nd**: Nile Delta; **Nf**: Nile Faiyum; **Nn**: Nile Nubia, from Kom-Ombo southwards to Egyptian boundaries with the Sudan; **Nv**: Nile Valley, from Cairo to Kom-Ombo; **Ol**: Oases of Libyan Desert; **On**: Oases of Nubian Desert; **R**: Red Sea Coastal Plains; **S**: Southern Sinai Massif (Sinai proper i.e. relatively high mountains, south of Isthmic Desert); **Ug**: Gebel Uweinat and the northerly situated Gilf El-Kebir.

STUDY AREA AND MATERIAL

Gebel Maghara is a mountain area about 20 km long and 15 km wide, and about 300 km^2 in area, situated in the northern part of the Isthmic Desert (Fig. 2). It comprises a principal and several secondary domes, with summits ascending to 500-735 m. The geological structure is essentially anticlinal, in the form of an asymmetrical fold, with subsequent erosion having exposed the most complete, thickest and the largest exposure of Jurassic strata in Egypt (Abu-Al-Izz, 1971). The mountain tops are composed of the oldest strata, whilst erosion has exposed Chalk and Nubian Sandstone of Upper Cretaceous age on the lower slopes and bases of the mountain (Said, 1990).

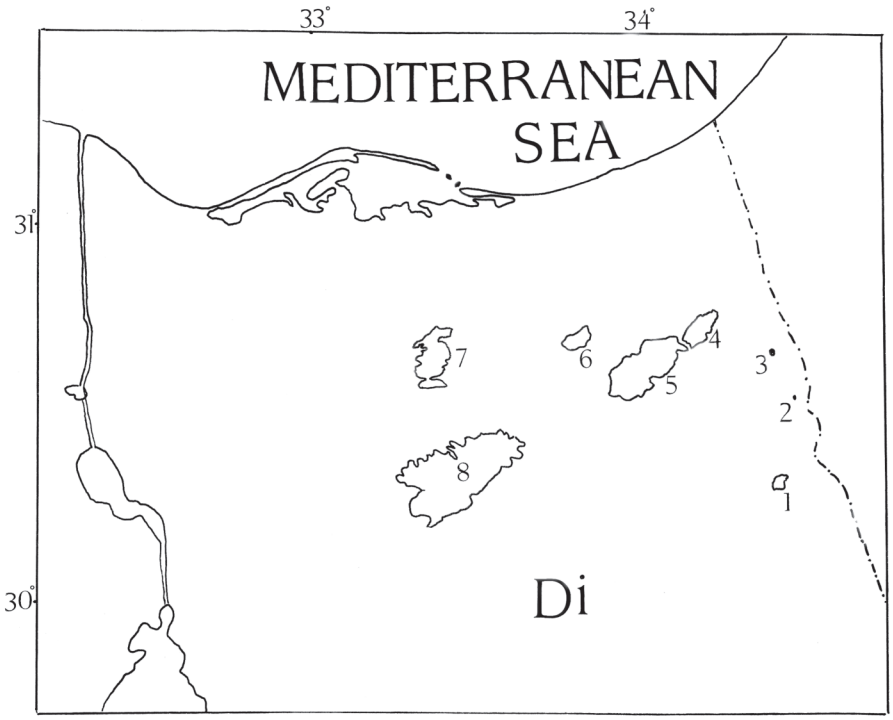

Fig. 2. Map showing the study area (Gebel Maghara) and other mountains in the Isthmic Desert. **1**. Areif El-Naka. **2**. Gebel Qadies including Ain Qadis. **3**. Gebel El-Godyrat including Ain El-Godyrat. **4**. Gebel Dalfa. **5**. Gebel Halal. **6**. Gebel Libni. **7**. Gebel Maghara. **8**. Gebel Ya'laq.

The area of domes which include Gebel Maghara is arid, with a mean annual rainfall of 50-100 mm, though ranging from as little as 30 mm in some years to 300 mm in others (Ayyad & Ghabbour, 1986). Rainwater falling on the mountains runs over the slopes and into narrow deep wadis where it forms seasonal streams or pools. Some of this water percolates into the substratum or becomes stored in rock crevices, which are favourable for sustaining the growth of mosses. The mean annual temperature is 16°-20°C with hot summers and mild winters. Generally the climate varies most strikingly with variations in altitude.

The annual rainfall received by the area allows a fairly good vegetation cover of considerable diversity to grow on the open plains surrounding the mountain, as well as in wadis. The vegetation of Gebel Maghara shows sequential changes in vegetation types with elevation. Dwarf shrubs (*Fagonia*, *Anabasis*) and grasses (*Stipagrostis*, *Panicum*) dominate the vegetation on the gravel-plain. The wadis at the foot of the mountains are dominated by commnities of *Artemisia judaica*, *Hammada elegans*, *Salsola tetrandra*, *Retama raetam*, and some species of *Acacia* (El-Hadidi, 2000). The vegetation on the hills of Maghara includes many Mediterranean relicts, such as *Juniperus phoenicea*, which grows on the north-facing slopes and is confined in Egypt to the higher slopes of Gebel Halal and Gebel Maghara (El-Hadidi, 1969).

All moss samples were collected from Gebel Maghara (30°43'- 30°36' N, 33°20'- 33°26' E) by the second author in 1995. There are 14 in total, WEm 301-314,

collected from two locations: 1) Twelve samples, WEm 301-312, were collected from the mountain area close to road-mark "Gebel Maghara, 14 km", from fine sediments between rocks in runnels on north-facing slopes at 200-225 m alt., 2). Two samples, WEm 313-314, collected 5 km further north close to Sadd-al-Karm (a small dam built to retain water for irrigation), from among rocks on muddy banks behind the dam, 10 m above water level and at 215 m alt.

Moss populations were always mixed and many intermingled with lichens. All samples are kept at CAIA.

RESULTS

Thirty-two taxa are recorded here from Gebel Maghara, 16 of which are new records to the Isthmic Desert and four new to Egypt. This brings the total number of taxa recorded from the Isthmic Desert to 47 and from Egypt to 179.

The taxa recorded from Gebel Maghara are listed below, arranged in family order, an asterisk denoting those new to Egypt. Sample number, altitude and fertility or any reproductive structure are mentioned. Moss associations are tabulated in appendix (1). The distributions of the taxa in the Isthmic Desert and elsewhere in Egypt, as well as in the rest of the world are also given. Abbreviations of the phytogeographical regions of Egypt are explained in Fig 1. The world distributions are based mainly on the following publications: Wijk et al. (1959-1969), El-Saadawi (1979), Frey & Kürschner (1991), Zander (1993), Kürschner (1996), Ros et al. (1999), Kürschner (2000), O'Shea (2003), Cortini Pedrotti (2001), Shabbara & El-Saadawi (2001) and Hébrard (2003).

List of mosses in Gebel Maghara

Fissidentaceae

Fissidens arnoldii R.Ruthe – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, sporophytes rare, alt. 210 m, 17/4/1995 (WEm306-1); behind Sadd-al-Karam, among rocks on mud of bank, 10 m above water level, alt. 215 m, 19/4/1995 (WEm314-1). **Distribution**: Gebel Dalfa, Gebel El-Godyrat; Egypt (S, GE); S.-W. Asia (common in Arabian Peninsula); C. Africa (Sudan); Europe; N. America.

F. bryoides Hedw. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, rare, alt. 210 m,17/4/1995 (WEm306-2); behind Sadd-al-Karam, among rocks on mud of bank, 10 m above water level, alt. 215 m, 19/4/1995 (WEm314-2). **Distribution**: **New to Isthmic Desert**; Egypt (Dg, Cai, Nd); S.-W., N. & C. Asia (India, Pakistan, Bangladesh); N. Africa; Europe; N. & S. South America; Australia; Subantarctica (Prince Edward Islands).

F. crassipes Bruch & Schimp. subsp. ***warnstorfii*** (M.Fleisch.) Brugg.-Nann. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, rare, alt. 210 m, 17/4/1995 (WEm306-3). **Distribution**: **New to Isthmic Desert**; Egypt (Nd); S.-W. Asia; N. & C. Africa; Europe.

Pottiaceae subfamily Timmielloideae

Timmiella barbuloides (Brid.) Mönk. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 210 m, 17/4/1995 (WEm 305-1); with sporophytes, (WEm 308-1). **Distribution: New to Isthmic Desert**; Egypt (S, GE); S.-W. & N. Asia (Pakistan, India, Tibet, Caucasus); N. & C. Africa; Europe; N.-W. South America.

Pottiaceae subfamily Merceyoideae

****Didymodon australasiae*** (Hook. & Grev.) R.H.Zander – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 205 m, 17/4/1995 (WEm304-1). **Distribution**: S.-W. Asia; N., C. & S. Africa; Europe; N., C. & S. South America; Australia; New Zealand; Oceania (Galapagos).

D. fallax (Hedw.) R.H.Zander – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 225 m, 17/4/1995 (WEm312-1). **Distribution**: **New to Isthmic Desert**; Egypt (S, On, Nf); S.-W., N. & C. Asia (India, Pakistan); N. Africa; Europe; N., C. & S. America.

****D. haussknechtii*** (Jur. & Milde) Broth – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, archegonia present, alt. 210 m, 17/4/1995 (WEm 305-2). **Distribution**: S.-W. Asia.

D. rigidulus Hedw. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 210 m (WEm 305-3 & WEm306-4), alt. 215 m (WEm309-1) and alt. 225 m (WEm312-2). **Distribution**: Gebel Dalfa, Gebel El-Godyrat, Gebel Libni; Egypt (S, Ol); S.-W., S.-E., N. & C. Asia; N. & C. Africa; Europe; N., C. & S. South America.

D. vinealis (Brid.) R.H.Zander – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 205 m (WEm303-1) and alt. 210 m (WEm306-5 & WEm 308-2). **Distribution**: Gebel El-Godyrat, Gebel Halal; Egypt (S, Mm, On, Cai, Nd, Nf); S.-W., N. & C. Asia; N. Africa; Europe; N., C., S. & N.-W. South America.

Gymnostomum mosis (Lorentz) Jur. & Milde – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, with gemmae, alt. 210 m, 17/4/1995 (WEm307-1). **Distribution**: Ain Qadies, Gebel Dalfa; Egypt (S); S.-W. Asia; Europe.

G. viridulum Brid. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 200 m (WEm301-1), alt. 205 m (WEm304-2) and alt. 210 m (WEm 305-4 & WEm306-6); behind Sadd-al-Karm, among rocks on mud of bank, 10 m above water level, alt. 215 m, 19/4/1995 (WEm313-1 & WEm314-3). **Distribution**: Gebel El-Godyrat, Gebel Libni; Egypt (S, Mm, Dg, Cai, Nv); S.-W. Asia; N. & C. Africa; Europe.

Pseudocrossidium hornschuchianum (Schultz) R.H.Zander – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 210 m, 17/4/1995 (WEm 305-5). **Distribution**: **New to Isthmic Desert**; Egypt (S, Mm, Nv); S.-W. Asia, India; N., C. & S. Africa; Europe; N. & S. America, Chile; Australia.

Pottiaceae subfamily Pottioideae

Aloina aloides (Schultz) Kindb. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 200 m (WEm301-2), alt. 210 m (WEm306-7) and alt. 215 m (WEm310-1 & WEm311-1); behind Sadd-al-Karm, among rocks on mud of bank, 10 m above water level,

alt. 215 m, 19/4/1995 (WEm314-4), sporophytes present in all samples. **Distribution**: Ain Qadies; Egypt (S, Mm); S.-W., N. & C. Asia; N. Africa; Europe; N. America.
A. ambigua (Bruch & Schimp.) Limpr. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 205 m (WEm304-3), alt. 210 m (WEm306-8) and alt. 215 m (WEm310-2 & WEm311-2); among rocks on mud of bank behind Sadd-al- Karm, 10 m above water level, alt. 215 m, 19/4/1995 (WEm314-5), sporophytes present in all samples. **Distribution**: Gebel Dalfa, Gebel El-Godyrat; Egypt (S, Mm); S.-W., N. & C. Asia; N. Africa; Europe; N. & C. America; Australia.
A. bifrons (De Not.) Delgad. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 225 m., 17/4/1995 (WEm312-3). **Distribution**: Ain Qadies, Gebel Dalfa, Gebel El-Godyrat; Egypt (Mm); S.-W., N. & C. Asia; N. & S. Africa; Europe; N., C. & S. America.
A. rigida (Hedw.) Limpr. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 200 m (WEm301-3), alt. 205 m (WEm303-2) and alt. 210 m (WEm306-9); alt. 215 m, sporophytes present (WEm310-3). **Distribution**: **New to Isthmic Desert**; Egypt (Mm, Ol); S.-W., N. & C. Asia; N., C. & S. Africa; Europe; N. & C. America; Australia.
Crossidium aberrans Holz. & E.B.Bartram – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 200 m (WEm301-4) and alt. 210 m (WEm305-6 & WEm307-2). **Distribution**: Gebel Halal; Egypt (S, Mm); S.-W. & E. Asia; N. Africa; Europe; N. & C. America.
C. crassinerve (De Not.) Jur. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 210 m, 17/4/1995 (WEm305-7). **Distribution**: **New to Isthmic Desert**; Egypt (Mm, Ol); S.-W. Asia (India, Pakistan); N. & C. Africa; Europe; N. & C. America.
C. geheebii (Broth.) Broth. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, with sporophytes, alt. 215 m, 17/4/1995 (WEm310-4). **Distribution**: **New to Isthmic Desert**; Egypt (S); S.-W. Asia; N. Africa (Canary Islands); Europe; Australia; New Zealand.
C. laevipilum Thér. & Trab. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 210 m (WEm307-3) and alt. 215 m (WEm310-5), sporophytes present in all samples. **Distribution**: Ain Qadies, Gebel Dalfa, Egypt (Mm); S.-W. Asia; N. & C. Africa; Europe.
****C. laxefilamentosum*** W. Frey & Kürschner – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 210 m, 17/4/1995 (WEm305-8). **Distribution**: S.-W. Asia; N. Africa; Europe.
C. squamiferum (Viv.) Jur. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 215 m, 17/4/1995 (WEm310-6). **Distribution**: Ain Qadies, Arif El-Naka, Gebel Dalfa, Gebel El-Godyrat; Egypt (S, Ol); S.-W., N. & C. Asia; N. & C. Africa; Europe; N. & C. America; New Zealand.
****Microbryum davallianum*** (Sm.) R.H.Zander – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, with sporophytes, 17/4/1995, alt. 205 m (WEm303-3), alt. 210 m (WEm305-9 & WEm307-4) and alt. 215 m (WEm310-7). **Distribution**: S.-W. Asia; N. & S. Africa; Europe; N. & C. America; Australia.
M. starckeanum (Hedw.) R.H.Zander – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995,

alt. 200 m (WEm302-1), alt. 205m (WEm303-4), alt. 210 m (WEm305-10 & WEm306-10), alt. 215 m (WEm311-3) and alt. 225 m (WEm312-4), sporophytes present in all samples. **Distribution**: Gebel El-Godyrat; Egypt (S, Mm); S.-W. Asia; N. Africa; Europe; N. & C. America; Australia; New Zealand.

Syntrichia inermis (Brid.) Bruch – At road-mark "14 km Gebel Maghara" on fine sediments between rocks in runnels, on north-facing slopes, a few individuals, alt. 210 m, 17/4/1995 (WEm306-11). **Distribution**: **New to Isthmic Desert**; Egypt (S); S.-W. & N. Asia (India, Pakistan); N. Africa; Europe; N. & C. America.

Tortula atrovirens (Sm.) Lindb. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 200 m (WEm302-2) and alt. 210 m (WEm305-11 & WEm307-5); among rocks on mud of bank behind Sadd-al-Karm, 10 m above water level, with sporophytes, alt. 215 m, 19/4/1995 (WEm314-6). **Distribution**: Ain Qadies, Gebel Dalfa, Gebel El-Godyrat; Egypt (S, Mm); S.-W. & S.-E. Asia; N., C. & S. Africa; Europe; N. & C. America (West Indies); S. & N.-W. South America; Australia; New Zealand; Oceania (Hawaii).

Funariaceae

Entosthodon durieui Mont. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, with sporophytes, alt. 210 m, 17/4/1995 (WEm305-12); behind Sadd-al-Karm, among rocks on mud of bank, 10 m above water level, with sporophytes, alt. 215 m, 19/4/1995 (WEm313-2). **Distribution**: **New to Isthmic Desert**; Egypt (S, Cai, GE); S.-W. & N. Asia; N. & C. Africa; Europe.

E. fascicularis (Hedw.) Müll.Hal. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, with sporophytes, alt. 210 m, 17/4/1995 (WEm308-3). **Distribution**: Gebel Dalfa; Egypt (Cai); S.-W. Asia; N. & C. Africa (Socotra); Europe.

Bryaceae

Brachymenium exile (Dozy & Molk.) Bosch & Sande Lac. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 210 m, 17/4/1995 (WEm308-4). **Distribution**: **New to Isthmic Desert**; Egypt (S, Mm, On); S.-W., C., S.-E. & E. Asia; N., C. & S. Africa; Oceania (Galapagos, Hawaii).

Bryum caespiticium Hedw. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, 17/4/1995, alt. 200 m (WEm302-3), alt. 205 m (WEm303-5), (WEm304-4), alt. 210 m (WEm305-13 & WEm306-12), alt. 215 m (WEm309-2) and alt. 225 m (WEm312-5). **Distribution**: Gebel Dalfa, Gebel El-Godyrat; Egypt (S, Mm, Ol, On, Cai, Nd); N. & S.-W. Asia; N., C. & S. Africa; Europe; N., C. & S. South America; Australia; New Zealand.

Bryum dichotomum Hedw. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, with bulbils, 17/4/1995, alt. 205 m (WEm303-6) and alt. 210 m (WEm305-14); with bulbils and rhizoidal gemmae, alt. 210 m (WEm307-6), alt. 215 m (WEm311-4) and alt. 225 m (WEm312-6). **Distribution**: Ain Qadies, Gebel Dalfa, Gebel El-Godyrat, Gebel Libni; Egypt (S, Mm, Ol, On, Dg, Cai, Nd, Nf, Nv); S.-W., N. & C. Asia; N., C. & S. Africa; Europe; N. & S. America; Australia; New Zealand; Subantarctica; Antarctica.

B. radiculosum Brid. – At road-mark "Gebel Maghara, 14 km" on fine sediments between rocks in runnels, on north-facing slopes, alt. 225 m (WEm312-7). **Distribution**: **New to Isthmic Desert**; Egypt (S, Mm, On, Cai, Nd); S.-W. & S.-E. Asia; N., C. & S. Africa; Europe; Australia.

Appendix 1. Association of moss taxa recorded in Gebel Maghara with one another expressed by the frequency of association (number of samples in which they occur together).

Taxa	*Fissidens arnoldii*	*Fissidens bryoides*	*Fissidens crassipes*	*Timmiella barbuloides*	*Didymodon australasiae*	*Didymodon fallax*	*Didymodon haussknechtii*	*Didymodon rigidulus*	*Didymodon vinealis*	*Gymnostomum mosis*	*Gymnostomum viridulum*	*Pseudocrossidium hornsch.*	*Aloina aloides*	*Aloina ambigua*	*Aloina bifrons*	*Aloina rigida*	*Crossidium aberrans*	*Crossidium crassinerve*	*Crossidium geheebii*	*Crossidium laevipilum*	*Crossidium laxeflament.*	*Crossidium squamiferum*	*Microbryum davallianum*	*Microbryum starckeanum*	*Syntrichia inermis*	*Tortula atrovirens*	*Entosthodon durieui*	*Entosthodon fascicularis*	*Brachymenium exile*	*Bryum caespiticium*	*Bryum dichotomum*	*Bryum radiculosum*
Fissidens arnoldii		2	1								2		2	2		1								1	1				1			
Fissidens bryoides	2		1								2		2	2		1													1			
Fissidens crassipes subsp. *warnstorfii*	1	1									1		1	1		1								1	1					1		
Timmiella barbuloides							1	1	1		1	1					1	1			1				1		1	1		1	1	
Didymodon australasiae											1			1																		
Didymodon fallax								1							1									1						1	1	1
Didymodon haussknechtii				1				1			1	1					1	1			1		1	1						1	1	
Didymodon rigidulus	1	1	1	1		1	1				2	1					1	1					1	3	1	1	1			4	2	1
Didymodon vinealis	1	1	1	1				1			1		1	1		2							1	2	1			1	1	2	1	
Gymnostomum mosis																	1			1			1			1					1	
Gymnostomum viridulum	2	2	1	1	1		1	2	1			1	3	3		2	2	1			1		1	2	1	2	2			3	1	
Pseudocrossidium hornschuchianum				1			1	1			1						1	1			1		1	1		1	1			1	1	
Aloina aloides	2	2	1					1	1		3		4			3	1		1	1		1	1	2	1	1				1	1	
Aloina ambigua	2	2	1		1			1	1		3		4			2			1	1		1	1	2	1	1				2	1	
Aloina bifrons						1		1																1						1	1	1
Aloina rigida	1	1	1						2	2		3	2			1			1	1		1	2	2	1					2	1	

Appendix 1. Association of moss taxa recorded in Gebel Maghara with one another expressed by the frequency of association (number of samples in which they occur together). *(suite)*

Taxa	*Fissidens arnoldii*	*Fissidens bryoides*	*Fissidens crassipes*	*Timmiella barbuloides*	*Didymodon australasiae*	*Didymodon fallax*	*Didymodon haussknechtii*	*Didymodon rigidulus*	*Didymodon vinealis*	*Gymnostomum mosis*	*Gymnostomum viridulum*	*Pseudocrossidium hornsch.*	*Aloina aloides*	*Aloina ambigua*	*Aloina bifrons*	*Aloina rigida*	*Crossidium aberrans*	*Crossidium crassinerve*	*Crossidium geheebii*	*Crossidium laevipilum*	*Crossidium laxefilament.*	*Crossidium squamiferum*	*Microbryum davallianum*	*Microbryum starckeanum*	*Syntrichia inermis*	*Tortula atrovirens*	*Entosthodon durieui*	*Entosthodon fascicularis*	*Brachymenium exile*	*Bryum caespiticium*	*Bryum dichotomum*	*Bryum radiculosum*
Crossidium aberrans				1			1	1		1	2	1	1			1		1		1	1		2	1		2	1			1	2	
Crossidium crassinerve				1			1	1			1	1					1				1		1	1		1	1			1	1	
Crossidium geheebii													1	1		1				1		1	1									
Crossidium laevipilum										1			1	1		1	1		1			1	2			1					1	
Crossidium laxefilamentosum				1			1	1			1	1					1	1					1	1		1	1			1	1	
Crossidium squamiferum													1	1		1			1	1			1									
Microbryum davallianum				1			1	1	1	1	1	1	1	1		2	2	1	1	2	1	1		2		2	1			2	3	
Microbryum starckeanum	1	1	1	1		1	1	3	2		2	1	2	2	1	2	1	1			1		2		1	2	1			5	4	1
Syntrichia inermis	1	1	1					1	1		1		1	1		1								1						1		
Tortula atrovirens	1	1		1			1	1		1	2	1	1	1			2	1		1	1		2	2			1			2	2	
Entosthodon durieui				1			1	1			2	1					1	1			1		1	1		1				1	1	
Entosthodon fascicularis				1					1																				1			
Brachymenium exile				1					1																			1				
Bryum caespiticium	1	1	1	1	1	1	1	4	2		3	1	1	2	1	2	1	1			1		2	5	1	2	1				3	1
Bryum dichotomum				1		1	1	2	1	1	1	1	1	1	1	1	2	1		1	1		3	4		2	1			3		1
Bryum radiculosum						1		1							1									1						1	1	

CONCLUDING REMARKS

The results show that, although the area of study and range of altitude are small, there was a diversity in taxa recorded. The number of taxa recorded here from Gebel Maghara (32 taxa) exceeds that (31 taxa) recorded from the six areas studied earlier from Isthmic desert. The taxa recorded from Gebel Maghara belong to four families, the Fissidentaceae, Pottiaceae, Funariaceae and Bryaceae. The Pottiaceae is represented by its three subfamilies (already known from Egypt), the Timmielloideae, Merceyoideae and Pottioideae. The latter subfamily is well represented in Gebel Maghara and eight out of its 14 recorded taxa carried sporophytes. The high percentage of fruiting among Pottioideae taxa in Gebel Maghara (over 60% of fruiting taxa) was similar to that which has been found in Mediterranean coastal land, Oases and Sinai in Egypt (El-Saadawi et al., 2003). Of the 12 Gebel Maghara taxa that carried sporophytes, 11 have been previously noted with sporophytes from Egypt, and sterile plants of *Timmiella barbuloides* have been reported from Sinai and Gebel Elba (Abou Salama, 1991and 2000).

The Pottioideae (14 taxa) is also the largest subfamily in Gebel Maghara, comprising Crossidium (6 species), Aloina (4), Microbryum (2), Tortula atrovirens and Syntrichia inermis. The occurrence of species belonging to these genera in a small area in Gebel Maghara (and in a limited area in Bramley's Grotto; Shabbara, 1990) confirms the evolutionary relationship between these genera indicated by many bryologists (e.g., Delgadillo, 1975). Furthermore, the occurrence of 50 % of the world's accepted *Crossidium* species (having different phylogenetic relationships, Delgadillo, 1975) in Gebel Maghara may deserve more thoughts about the exact centre of evolution of this genus (cf. Frey & Kürschner, 1987).

The most frequent associations shown in Appendix 1 were: *Microbryum starckeanum* with *Bryum caespiticium* (5 samples), *B. dichotomum* (4) and *Didymodon rigidulus* (3); *Didymodon rigidulus* with *Bryum caespiticium* (4); *Aloina aloides* with *A. ambigua* (4) and *A. rigida* (3). The latter three *Aloina* taxa were found in association in 2 samples.

A comparison of the, hitherto, known moss flora of Gebel Maghara with the moss flora of other parts of Egypt shows that it more closely, resembles that of the Mediterranean coastal land (Mm) than that of the Nile regions (Nn, Nv, Nd): about half the Gebel Maghara taxa are also found in the Mediterranean region and about a quarter in the Nile regions.

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