

Contributions to a Bryoflora of the United Arab Emirates (UAE).

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Twenty-four out of 26 mosses, recently collected from the United Arab Emirates (UAE), are new records for the country and the total number is raised to 27 entities. Six of these mosses and *Riccia subbifurca* Warnst. ex Croz. are new records to the whole Arabian Peninsula. Upward-growing peculiar aerial rhizoids are recorded in six of the mosses. Reference to sporulation, sexual and asexual reproductive structures are made.

Key words: aerial rhizoids, bryophytes, United Arab Emirates.

Introduction

It was long thought that the Arabian Peninsula is very poor in bryophytes. The report of only two mosses from Yemen (Forsskål, 1775) and a single moss from Oman (Thériot *et al.* 1934) seems to have put more emphasis on this thought rather than eliminate it. Detailed intensive studies on the bryoflora of different countries of the Arabian Peninsula showed, however, that it is not that poor in mosses.

In a series of papers, El-Saadawi (1976, 1978, 1979a-b) enumerated the moss species encountered in Kuwait (Fig.1). He described niches where they grow in desert wadis, gave comments on adaptation, environment and drought resistance shown by some of them and reported for the first time on "peculiar aerial rhizoids" developed by four of these desert mosses (1979b). The report on remarkable persisting structures and drastic changes in the diversity of this desert bryoflora brought about by successive years of drought came in El-Saadawi & Zanaty (1990) and Halwagy & El-Saadawi (1992). Studies on Kuwaiti mosses were even extended to phytochemistry (Al-Hasan *et al.*, 1989)

While trying to interpret the origin of the isolated desert bryoflora of Kuwait, El-Saadawi (1976) pointed out that the distribution of mosses throughout the world is required and that nothing is known of the moss flora of the Saudi Arabia. Frey & Kürschner (1982), started working on the bryoflora of the Arabian Peninsula especially Saudi Arabia. Results of their extensive voluminous work (Jointly with other participants in some cases) have been published in a long series of papers (cf Kürschner, 1997) under a main title of "studies in Arabian bryophytes".

In addition to the above mentioned comprehensive works on Kuwait and Saudi Arabia, other mosses were reported from Yemen (Hepper, 1977; Townsend, 1979;

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Delgadillo, 1982; Ochi & Kürschner, 1988; Whitehouse & Crundwell, 1992; Al-Gifri & Kürschner, 1996; Kürschner, 1996a); from Yemen and Oman (Bruggeman-Nannenga, 1987; Frey & Kürschner, 1991); from Oman (Whitehouse & Crundwell, 1991; Kürschner, 1996b; Arts, 1998) and from The United Arab Emirates (Frey & Kürschner, 1988). Accordingly, more than 150 moss taxa are, at present recorded from the Arabian Peninsula, with the largest number (110 taxa) from Saudi Arabia and the smallest (3 taxa) from U.A.E.

Although Socotra (Fig.1) is a Yemeni territory, yet we did not include its bryoflora with a total of 25 taxa reported by Schweinfurth (1884), Mitten (1888), Müller (1901), Balfour (1903), Townsend (1969), Long (1987), Frey and Kürschner (1988) and Al-Gifri *et al.* (1995). This island and its flora has closer affinities to the African continent. Bryofloristically it belongs to Af2 (see also Hodgetts *et al.*, 1999).

The geomorphology, topography and climate of the UAE (especially the mountains of the northeast), all clearly suggest that plenty more than the 3 recorded mosses would be found there, if a careful survey was undertaken. This makes the aim of the present paper.

Collecting sites

UAE is a small country occupying only *ca.* 83600 Km² of the vast area of the Arabian Peninsula (Fig.1). It is bounded by Saudi Arabia, Oman, Gulf of Oman, Oman (again), Arabian Gulf, and Qatar (Figs.1&2). It is mainly a desert lowland which ranges from 100 to 500 m a.s.l., with a limited mountainous area in the northeast which is 1000- 2000 m (or more) a.s.l.

The average annual temperature is 17°-37°c. The coldest month is January and the hottest is August. Rain usually falls between November and May. The annual rainfall is *ca.* 50 mm or less in the desert lowland and ranges from 100 to 250 mm in the mountainous area. The rainfall is sporadic and fluctuates sharply in time and space; half the amount of annual rain may fall during one rainy storm. This is followed by sudden powerful torrents that rush through runnels and drain mainly to the east in the Gulf of Oman, or less frequently to the west in the desert plains. Porosity of rocks is low and water is held for some time under or between rocks, and in rock crevices to form suitable niches for the growth of mosses, annual flowering plants, numerous lichens,etc. (Figs. 3&4).

Mosses and one liverwort were collected (by the second author) in January and February 1998 from 8 mountainous sites (Table 1&Fig. 2), at elevations between 600- 800 m a.s.l.

Details of these sites are as follows:

- Site 1: At rock bases of dry runnels, Khour-fakan, Sharja Emirate, UAE, 29.1.1998.
- Site 2: On mud between inclined rocks; at bases of large boulders, a few kilometers from Fujayrah city, Fujayrah Emirate, UAE, 3.2.1998.
- Site 3: Road Mark Km 4, along Fujayrah-Sharja road, among rocks facing sun almost all day, on the right side of the road, 5.2.1998.
- Site 4: Road Mark Km 10, along Fujayrah-Sharja road, among rocks in runnels, on the right side of the road, 5.2.1998.

Contributions to a Bryoflora of the UAE

- Site 5: Road Mark Km 12, along Fujayrah-Sharja road, on mud among rocks with many runnels converge, in shade, on the left side of the road, 5.2.1998.
- Site 6: Road Mark Km 25, along Fujayrah-Sharja road, among rocks of runnels, in shade in afternoons, on the left side of the road 6, 13.2.1998.
- Site 7: Road Mark Km 39, along Fujayrah-Sharja road, at rock bases of dry runnels, on the right side of the road, 3.2.1998.
- Site 8: Road Mark Km 40, along Fujayrah-Sharja road, on mud between rocks, on the right side of the road, 3.2.1998.

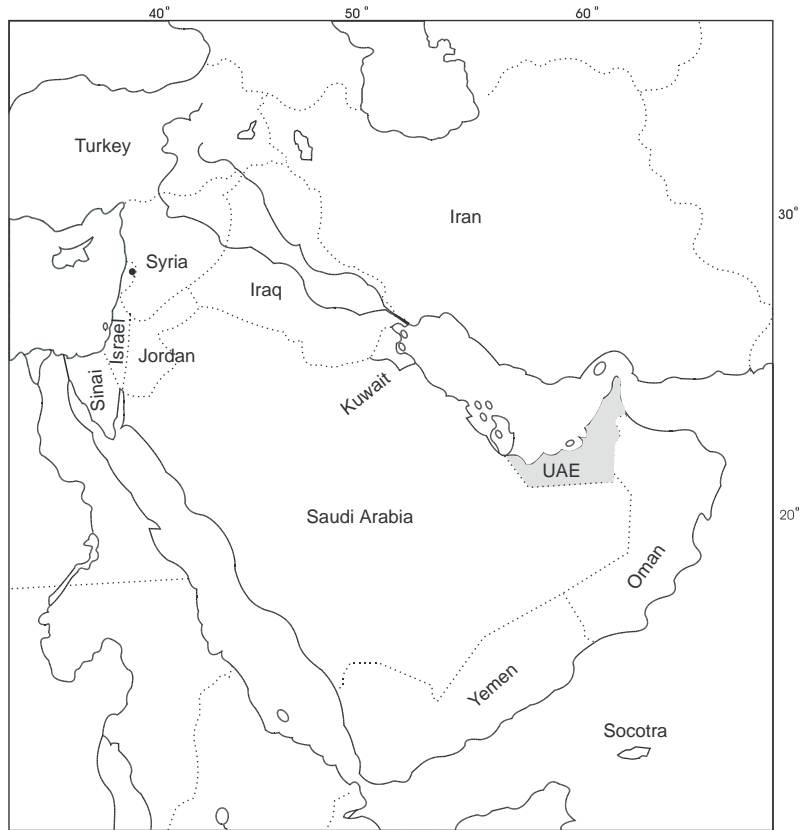


Fig. 1 Location of the United Arab Emirates (UAE)

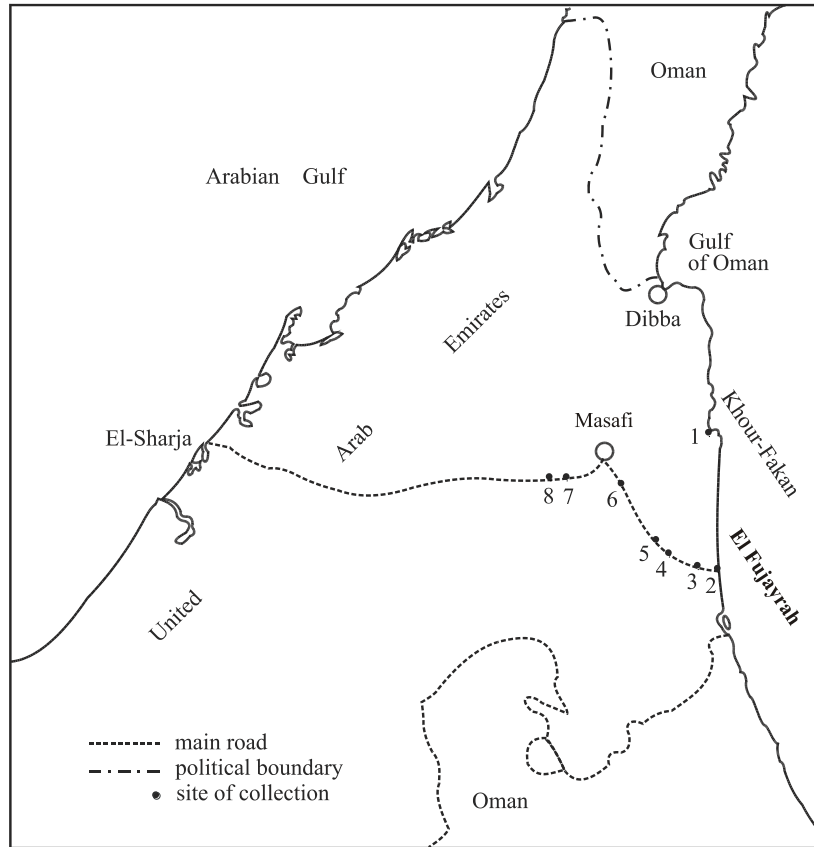


Fig. 2. Map of part of UAE showing locations of the eight sites of collection

Observations and results

Investigation of the collected samples (all kept at Ain Shams University Herbarium CAIA) proved that they include *Riccia subbifurca* Warnst. ex Croz. (a hepatic, site 4) and 26 mosses. Names of the mosses, other details as: distribution of each moss in the sites of collection, number of samples collected from each site, presence of sporophytes, sex organs, gemmae and aerial rhizoids are given in Table 1.



Fig. 3: Vegetation growing in runnels and slopes of one of the mountains located along Fujayrah-Sharja main road, 3.2. 1998



Fig. 3: *Entosthodon attenuatus* (with green unrip capsules) growing among rocks with herbaceous flowering plants, site 6, 6. 2. 1998.

Table1: Data of the recorded taxa: sites of collection, no. of samples; presence of sporophytes (f), archegonia (c), antheridia (t), axillary gemmae (a.g.), aerial rhizoids (a.r.), rhizoidal gemmae (r.g.); * = new record; # = new to Arabian Peninsula; + = present

Recorded taxa	No. of samples collected from each of the 8 sites								Total number of:	
	1	2	3	4	5	6	7	8	Sites	Samples
Fissidentaceae:										
*1 <i>Fissidens arnoldii</i> R. Ruhe				2					1	2
Pottiaceae :										
#2 <i>Anoetangium handelii</i> Schiffn.				1					1	1
*3 <i>Crossidium crassinerve</i> (De Not.) Jur.				2				1f	2	3
*4 <i>Gymnostomum aeruginosum</i> Sm.				1					1	1
*5 <i>G. mosis</i> (Lorentz) Jur. & Milde				1a.g.					1	2
*6 <i>G. viridulum</i> Brid.				1		1			2	2
7 <i>Gyroweisia reflexa</i> (Brid.) Schimp.				1		1t 2c			2	4
*8 <i>Microbryum davallianum</i> (Sm.) R.H. Zander				1f	1	3f		2f	4	7
#9. <i>M. davallianum</i> var. <i>conicum</i> (Schleich. ex Chwaegr.) R.H. Zander				2f	1f	1f			3	4
#10. <i>M. davallianum</i> var. <i>commutatum</i> (Limpr.) R.H. Zander						1f		1f	2	2
*11. <i>M. starckeanum</i> var. <i>starckeanum</i> (Hedw.) R.H. Zander		1f, a.r.		1f	4f	6f	1f	1f	6	14
#12. <i>M. starckeanum</i> var. <i>brachyodus</i> (Bruch, Schimp. & W. Gumbel) R. H. Zander	1f, a.r.				1f				2	2
*13. <i>Pseudocrossidium prophyroneura</i> (Müll. Hal. ex Vent.) R.H. Zander				1					1	1
14. <i>Timmella barbuloides</i> (Brid.) Mönk.				1					1	1
*15 <i>Tortella inclinata</i> (Hedw.) Limpr.	1a.r.							2a.r	2	3
*16 <i>Tortula lanceolata</i> R.H. Zamder					2f			1f	2	3
*17 <i>Trichostomum brachydontium</i> Bruch		1r.g., a.r., c,t							1	1
*18 <i>T. crispulum</i> Bruch						1f			1	1
*19 <i>Weissia condensa</i> (Voit) Lindb.				1			1f, a.r		2	2
*20 <i>W. latuiscula</i> Müll. Hal.	1c,t	1		2	1	1	1	1a.r	7	8
*21 <i>W. rutilans</i> (Hedw.) Lindb.			1						1	
Funariaceae:										
*22 <i>Entosthodon attenuatus</i> (Dicks.) Bryhn				2f	1f	6f	1f	2f	5	12
*23. <i>Funaria muhlenbergii</i> Turner				1					1	1
*24 <i>F. pulchella</i> H. Philib.				3t	1t	2			3	6
Bryaceae:										
*25 <i>Bryum bicolor</i> Dicks.				2t, r.g.	1 r.g	3		1 r.g	4	7
#26 <i>B. pseudotriquetrum</i> (Hedw.) P. Gaertn., G. Mey. & Scherb.				1		3		1	3	5
Hepaticae :										
# <i>Riccia subbifurca</i> Warnst. ex Croz.				+						

Table 1 shows that the most widespread and most frequent taxa are: *Weissia latuiscula* (7 sites, 8 samples), *Microbryum starckeanum* var. *starckeanum* (6 sites, 14

samples), *Entosthodon attenuatus* (5 sites, 12 samples), *Bryum bicolor* and *Microbryum davallianum* (4 sites, 7 samples each). The other 21 taxa exist in 1-3 sites and are represented by 1-6 samples each. *Weissia rutilans* is the only moss recorded in site 3; a site distinct by being exposed to sun almost all day round. This moss has not been recorded in any other site.

Most of the collected taxa seem to be well established in the study area, then 10 taxa carried sporophytes, three taxa had archegonia and antheridia, two taxa had only antheridia, two taxa carried rhizoidal gemmae and one taxon carried axillary gemmae. Five out of the 10 sporulated taxa belong to *Microbryum*, i.e. all entities of this genus were sporulated. Almost all collected samples of the four genera; *Microbryum*, *Entosthodon*, *Tortella* and *Tortula* were sporulated.

Six of the recorded taxa (in sites 1, 2, 7, 8) showed the “peculiar phenomenon” referred to only once before in desert mosses from Kuwait by El-Saadawi (1979b). These six taxa were found to have developed among their upper leaves, upward growing, unbranched, straight, rigid, needle-like, deep-red rhizoids.

The 26 recorded mosses belong to four families and 15 genera. The largest family is **Pottiaceae** (20 taxa), followed by **Funariaceae** (3 taxa), **Bryaceae** (2 taxa) and **Fissidentaceae** (one taxon). The largest genus is *Microbryum* (5 entities) followed by *Gymnostomum* and *Weissia* (3 entities each) then *Trichostomum* and *Funaria* (2 entities each). The other 11 genera are represented by one entity each.

Old and new records

The two hepatics: *Cyathodium africanum* Mitt. and *Exormotheca pustulosa* Mitt., reported earlier (cf. Long, 1987; Frey & Kürschner, 1988) from montane sites near Masafi and Fujayrah respectively (Fig.2), were not encountered in this work, so also the moss *Splachnobryum procerinum* Dix. et P.Varde which was reported from montane sites between Dibba and Masafi. These places were not visited for this work (see Fig.2). Other old records made by Frey & Kürschner (1988) namely: *Gyroweisia reflexa* and *Timmiella barbulooides* (both from near Masafi) have been collected in this work.

On the other hand 24 out of the 26 collected mosses represent new records to UAE, six to the Arabian Peninsula and one (*Weissia rutilans*) to AS5.

The single hepatic *Riccia subbifurca* recorded in this work is not only a new record to UAE but also to the whole area of the Arabian Peninsula.

Aeronemata

As to the upward-growing peculiar rhizoids reported here for six taxa and earlier by El-Saadawi (1979b) from Kuwait, in four other taxa; it is plausible to think that they are a means of survival against the probable destructive effect of increased humidity associated with decreased light intensity brought about by comparatively large number of cloudy and rainy days.

Increased humidity associated with low porosity of rocks causes gathering of rain water to be held for some time in relatively sheltered microhabitats (e.g. rock crevices) in amounts sufficient to submerge the tiny mosses dwelling in such niches. This apparently triggers the development of the aerial rhizoids by which means the endangered mosses

can escape the fate of being soaked in (or submerged under) water for comparatively long periods of time. That these aerial rhizoids readily develop chloronemata that naturally propagate the moss, has been discussed by El- Saadawi (1979b).

Observations common to mosses with aerial rhizoids in Kuwait and in UAE which led to the above understanding are:

1- the aerial rhizoids were reported in the season which witnessed the largest number of cloudy and rainy days. The factor which seems to trigger the development of aerial rhizoids is the rains that are not interrupted by long dry spells (cf. Halwagy & El-Saadawi, 1992). This was the case in Kuwait in the 1975/76 season which coincided with the largest amount of annual rainfall ever recorded in Kuwait viz. 260.2 mm, compared to 171.2 mm in 1974/75 and 43.5 mm in 1976/77 (cf. Halwagy & El- Saadawi, 1992). In UAE the aerial rhizoids were reported also in the good rainy season of 1997/98. In this season many of the days were cloudy and light or heavy showers fell most of the time. For example during the period of collection from 23 Jan. to 13 Feb. 1998 the amount of rainfall in only one day (the 26th of Jan.) was 17.2 mm in Fujayrah, 16.3 mm in Masafi, 9 mm in Khour-fakan and ranged from 3 to 45.2 mm in other parts of the Emirates. And the amount of rainfall for the 1997/98 season (October- April) was 149.1 mm while it was only 40.5 mm for the same period in 1998/99 (Fujayrah Meteorological Office).

2- The aerial rhizoids are developed by fruiting and nonfruiting mosses growing in relatively sheltered sites and never by mosses growing on exposed rocks (where light is more bright and water cannot be held for long periods).

The strong negative geotropism shown by these aerial rhizoids finds parallel in the vertical upward growth of secondary caulonemata that form when moss gametophores are placed in the dark for several days (cf. Chaban *et al.* 1998). Therefore, upward growing of aerial rhizoids and secondary caulonemata are survival means developed by mosses endangered by continual increased moisture content or prolonged darkness respectively.

The aerial rhizoids being developed in 10 different mosses (8 **Pottiaceae**, one **Bryaceae** and one **Fissidentaceae**) in different parts of the Arabian Peninsula renders it a phenomenon that may warrant calling them "aeronemata".

It has to be said in conclusion that although the present study added a considerable number of new records, yet there is still a good opportunity to have many new records from the vast montane areas that have not been yet visited.

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