Significant fern, lichen and bryophyte collections from the UAE and northern Oman, including five new records for the Arabian Peninsula

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Abstract

We present a list of ferns, lichens, mosses, and liverworts collected in the eastern UAE and northern Oman in January 2009. Of the seven fern species reported, *Cosentinia vellea* is confirmed for the UAE and *Asplenium ceterach* is reported for Oman for the second time. We briefly summarise the taxonomic and nomenclatural reasons for using the names *Asplenium ceterach, Cheilanthes acrostica*, and *Cosentinia vellea* for our collections, rather than the frequently used *Ceterach officinarum, Cheilanthes pteridioides*, and *Cheilanthes vellea*, respectively. Of the 12 lichen species reported, seven represent new records for Musandam, seven for Oman, and two for the Arabian Peninsula (*Caloplaca inconnexa* and *Caloplaca pusilla*). For the mosses, we report 13 species: seven new records for Musandam, nine for Oman, and three for Arabia (*Anoectangium handelii, Orthotrichum* cf. *cupulatum*, and *Syntrichia sinensis*). One of the liverworts is new for Oman (*Riccia crozalsii*). We include a brief description of the cryptogam flora of the UAE and northern Oman, the degree to which it is under-explored (five new records for Arabia in the course of extremely modest and relatively casual fieldwork by non-specialists), and avenues for future work.:

Included in this article are records of the following species

FERNS:

Adiantum capillus-veneris L.
Asplenium ceterach L.
Cheilanthes acrostica (Balbis) Tod.
Cosentinia vellea (Ait.) Tod.
Equisetum ramosissimum Desf.
Onychium divaricatum (Poir.) Alston
Pteris vittata L.

LICHENS:

Aspicilia contorta (Hoffm.) Kremp.
Caloplaca inconnexa (Nyl.) Zahlbr.
Caloplaca pusilla (A. Massal.) Zahlbr.
Collema sp.
Collema tenax s.l. (Sw.) Ach.
Diploschistes ocellatus (Vill.) Norman
Gloeoheppia turgida (Ach.) Gyeln.
Lichinella nigritella (Lettau) P.P. Moreno & Egea
Psora decipiens (Hedw.) Hoffm.
Squamarina lentigera (Weber) Poelt
Toninia sedifolia (Scop.) Timdal
Verrucaria cf *calciseda* DC.

MOSSES:

Anoectangium handelii Schiffn.
Barbula indica (Hook.) Spreng.
Barbula cf. *unguiculata* Hedw.
Bryum cf. *nanoapiculatum* Ochi & Kurschner
Didymodon acutus (Brid.) K. Saito
Fissidens arnoldii R.Ruthe
Gyroweisia tenuis (Hedw.) Schimp.
Orthotrichum cf. *cupulatum* Hoffm. ex Brid.
Splachnobryum aquaticum Müll. Hal.
Syntrichia inermis (Brid.) Bruch.
Syntrichia pseudodesertorum (Froehl.) Agnew & Vondr.
Syntrichia sinensis (C. Müller) Ochyra
Timmiella barbuloides (Brid.) Moenk.

LIVERWORTS:
Exormotheca pustulosa Mitt.
Plagiochasma rupestre (Forst.) Steph.
Riccia crenatodentata Volk
Riccia crozalsii Levier.

A January 2009 family vacation to eastern UAE and northern Oman took a serendipitous turn when we (CJR, PRs) decided to see how many fern taxa we could find. This mission was not quite as improbable as it might appear—there are several clades of ferns that are noteworthy for having successfully colonised xeric habitats, including deserts of both the Old and New Worlds, particularly those in the family Pteridaceae (Schuettpelz *et al*. 2007). One of the larger Pteridaceae clades (the one that includes *Cheilanthes* and its relatives) is the focus of research by CJR's labmates at Duke University, North Carolina, which added some impetus to our quest. And, given that we were looking for ferns, it seemed only proper to look for mosses, liverworts and lichens as well.

The UAE and northern Oman boast a documented fern flora of nine species (Miller & Cope 1996; Jongbloed 2003). Some of these are hardy colonists but nonetheless require moderate levels of moisture, and thus are found principally around seeps and wadi pools (e.g., *Adiantum capillus-veneris, Equisetum ramosissimum*). Others are true xeric habitat specialists found in cracks in sheltered rock walls or under the lips of boulders (*Cheilanthes, Cosentinia, Asplenium ceterach*, etc.). Only one — *Ophioglossum polyphyllum* — is found in open sand habitats.

In comparison, relatively little is known about the lichen flora of much of the Arabian Peninsula. Studies are fragmentary and it is difficult to extrapolate to the Peninsula as a whole. Based on our literature search, we estimate that there are 267 reported species from the Peninsula and 247 from Socotra. Most species (~100) have been recorded from Saudi Arabia (Abuzinada & Hawksworth 1975; Abuzinada *et al.* 1986; Kürschner 1984; Bokhary *et al.* 1993). Thirty-eight lichen species have been reported from Kuwait by Brown (1998) and Schultz *et al*. (2000).

Fig 1. Wadi Tiwi, a study in contrast.

Lamb (1936) and Mandeel & Aptroot (2004) recorded some species from Bahrain, and Babikir & Kürschner (1992) from Qatar. About 73 species have been reported from mainland Yemen (Acharius 1810; Müller Argau 1893; Steiner 1907; Schultz 1998; Schultz 2004; Sipman 2002) and nearly 250 from the Socotra Archipelago (Steiner 1907; Mies 1994a, b; Mies 2001; Mies *et al.* 1994; Mies *et al.* 1995; Mies & Printzen 1997; Schultz *et al.* 1999; Schultz & Mies 2003; Mies & Schultz 2004; Schultz 2002, 2003, 2005). Lichen records from adjacent areas (Iran, Syria, Lebanon, Israel, Turkey, etc.) have been given by Steiner (1916, 1921), Szatala (1940, 1957), Galun (1970), Marton & Galun (1981), Insarov & Insarov (1995), and John (1996).

Even in the context of the Peninsula, our knowledge of the lichen flora of UAE and Oman is incomplete. To date, approximately 55 species have been recorded from Oman (Mandaville 1977; Krog 1983; Cope 1988; Ghazanfar & Rappenhoner 1994; Ghazanfar & Gallagher 1998; Kürschner & Ghazanfar 1998; Brown *& al.* 2002); comparable studies in the UAE are in their infancy (Brown & Sakkir 2004; Brown 2005). These numbers certainly under-represent the lichen richness present, as demonstrated in this paper: of 12 collections, seven are new species records for Oman and two for the Arabian Peninsula. Four of the 12 species are cyanobacterial lichens, which are particularly abundant in arid climates with scarce vegetation, on soil crust in savannas, deserts or semi-deserts, where they play important ecological roles.

Kürschner (2000) reports 224 bryophyte species (one hornwort, 50 liverworts and 173 mosses) from the Arabian Peninsula and Socotra. Of these, Oman is represented with 16 liverworts and 41 mosses, and the UAE has seven liverworts and 14 mosses. It is, thus, not surprising that a great number of the bryophyte records presented here are new records for Oman (nine new mosses and one liverwort out of 17 species collected) and even for the Arabian Peninsula (three new mosses). The bryophyte flora of the Arabian Peninsula is composed of taxa with a mix of (Sub)cosmopolitan, Northern-Temperate, Xerotherm-Pangaean, Circum-Tethyan, and Tropical distributions, aside from a number of local endemics (Kürschner 2008).

In general, we were surprised by the ease of finding ferns, given the limited time we had available to search and our lack of familiarity with the areas we visited. Having a search image for the appropriate microhabitats (generally sheltered pockets under boulders or around rock outcrops) was very helpful, as was getting to elevation. The drier hotter areas at low elevations were largely fern-free.

In contrast, we had difficulty finding lichens (especially rock lichens) and, to a lesser extent, bryophytes. These are groups with which we are less familiar, so might have not been as effective in our

searching. Nonetheless, even in glorious rocky habitats like those of Ru'us al-Jibal, rock lichens were scarce; comparable habitats in North America would have been covered with lichens.

Our collections of both lichens and bryophytes are likely to be strongly under-representative of the diversity present. We (CJR, PRs) did not know either group well enough to identify them in the field, and were hesitant to collect multiple samples that appeared superficially similar. Subsequently, however: a) most of our collections were determined to be of different species; b) mixed in with our liverwort collections were interesting mosses that we didn't notice in the field; and c) the things that we collected without even being sure that they were lichens in fact were, and interesting ones at that! Clearly, much awaits interested students of these groups.

We learned subsequently that one of the common techniques for collecting desert lichens and bryophytes is to bring water with you in the field, spray down promising looking spots, wait a few minutes for the lichens to rehydrate and the mosses to green-up, and then make your collections. Otherwise it is easy for even experts to overlook many of these taxa.

FERNS:

Asplenium ceterach L. *sensu* Miller & Cope (1996; as *Ceterach officinarum*). (Aspleniaceae).

- Sultanate of Oman; **Musandam Peninsula**. Khasab to Jebel Harim Road, second major wadi above the Sayh plain. Elevation: 1400 m. Rare in crevices in NE-facing wadi wall cliff-face, with *Onychium divaricatum, Cheilanthes acrostica*, blue-green thalloid liverwort, mosses, etc. January 22, 2009. C.J. Rothfels #2755, with Paul Rothfels. Specimens to DUKE. Identified by C.J. Rothfels. For Miller and Cope (1996), in Arabia, this species was unknown north of southwestern Saudi Arabia. Since then, however, it has been discovered in Musandam (Jongbloed 2003); our's may be the second record for Oman. *Ceterach*, and virtually all other asplenioid segregate genera, have been shown by molecular phylogenetic analysis to be nested well within *Asplenium* itself (Schneider *et al*. 2004; Smith *et al*. 2006).

Equisetum ramosissimum Desf. *sensu* Miller & Cope (1996). (Equisetaceae).

- Sultanate of Oman; **Sharqiyah Region**. Wadi Tiwi, approximately 3km up. Elevation: 30 m. Two dense patches seen, in our limited explorations. On flat sections of wet sand or shallow standing water, at the edge of the wadi pool, with *Bacopa*, Cyperaceae, etc. No fertile plants seen. Many of the sporophytes were simple, and tangled. Only the larger ones had lateral branches. January 29, 2009. C.J. Rothfels #2757, with Peter Rothfels, Paul Rothfels, M. Almack. Identified by C.J. Rothfels.

Horsetails, of which *E. ramosissimum* is the only representative in Arabia, are ferns (rather than "fern allies", etc.), despite their odd appearance (Pryer *et al*. 2001). Miller and Cope (1996) show two isolated records for this species in the Hajar Mountains, presumably including Wadi Tiwi, where we found it; the next nearest Arabian records are in southern Yemen, against the Red Sea (Miller & Cope 1996). This may reflect its preference for relatively damp habitats; if so, it could yet be found in the Salalah area.

Fig. 2. A tangled patch of *Equisetum ramosissimum*, mixed with other thin-leaved wetland plants, in a depresssion along Wadi Tiwi, Sultanate of Oman; Sharqiyah Region. C.J. Rothfels, January 29, 2008

Adiantum capillus-veneris L. *sensu* Miller & Cope (1996). (Pteridaceae).

- Sultanate of Oman; **Dhahirah Region; Wilayat Mahdhah**. South of Al Madam on Highway E44. Elevation: 400 m. Two patches ~15m apart. Each ~3m long, 20cm high, and densely packed with plants (living and dead leaves). Plants were on the vertical wadi wall, slightly overhung, right at the edge of the wet sand or standing water, with *Nerium oleander*, etc.

Fig. 3. *Adiantum capillus-veneris*, showing the small average plant size, and the mix of deeply and shallowy incised leaflets. Sultanate of Oman; Dhahirah Region; Wilayat Mahdhah. C.J. Rothfels, January 19, 2009.

Fig. 4. *Adiantum capillus-veneris* growing at the water's edge, under overhanging wadi wall. Note the small average plant size, and the mix of deeply and shallowy incised leaflets. Sultanate of Oman; Dhahirah Region; Wilayat Mahdhah. C.J. Rothfels, January 19, 2009.

Fig. 6. Robust clumps of *Adiantum capillus-veneris,* on conglomerate wadi bank. United Arab Emirates; Ra's al-Khaimah Emirate. C.J. Rothfels, January 20, 2009.

The wadi was narrow, with steep walls, and at least semi-permanent clear flowing water and many toads. Plants seemed dimorphic—some leaves had deeply divided finger-like pinnae, others had more circular pinnae. January 19, 2009. C.J. Rothfels #2720, with Peter Rothfels, Paul Rothfels, M. Almack. Identified by C.J. Rothfels.

Fig. 5. Robust clumps of *Adiantum capillus-veneris,* on conglomerate wadi bank. United Arab Emirates; Ra's al-Khaimah Emirate. C.J. Rothfelds, January 20, 2009.

- United Arab Emirates; **Ra's al-Khaimah Emirate**. Diftah (southeast of Masafi). Up the wadi on the east side of Highway E89. Elevation: 350 m. aLocally common on steep, undercut, seepy conglomerate wadi bank in ophiolite bedrock. January 20, 2009. C.J. Rothfels #2721, with Paul Rothfels. Identified by C.J. Rothfels.

- **Sultanate of Oman**; **Sharqiyah Region**. Wadi Tiwi, approximately 3km up. Elevation: 30 m. Common in seeps and damp shaded spots along wadi, with *Pteris vittata* (CJR 2756, 2760), *Splachnobryum aquaticum* (CJR 2758), etc. This collection is from a large patch in shelter of boulders, on wet sand. The species seemed to be fairly morphologically uniform at this site—the more highly divided forms (see CJR 2720) were rare or absent. January 29, 2009. C.J. Rothfels #2759, with Peter Rothfels, Paul Rothfels, M. Almack. Identified by C.J. Rothfels.

Adiantum capillus-veneris, as it is most often treated, is one of the most widespread fern species in the world. Not only is it one of the two most common ferns in the UAE and Oman (with *Onychium divaricatum*), but it also occurs across Europe, and through much of North and South America, Africa, and the West Indies (Paris 1993). Whether or not all these populations should be treated within a single species is not yet determined. European plants examined thus far are diploid (two sets of chromosomes) whereas some North American populations are tetraploid (four sets), which suggests that multiple distinct lineages are present within the species (Manton 1950; Wagner 1963; Paris 1993).

We anticipated that the Arabian plants would be diploid, based on their proximity to the European populations. However, spore size data suggest otherwise. Twenty spores from a single sporangium

(64 spores per sporangium) of one plant yielded an average size of 45.3 µm, with a standard deviation of 3.34 µm, and five spores from another population had an average size of 39.8 +/-2.88 µm. These values fit the range of 40–50 microns cited for the tetraploid North American plants (Paris 1993), and suggest that the Arabian plants may also be tetraploid, which would be the first report of non-diploid *Adiantum capillus-veneris* outside of North America. Chromosome counts are necessary to confirm this hypothesis.

Cheilanthes acrostica (Balbis) Tod. *sensu* Jermy & Paul (1993). (Pteridaceae).

- Sultanate of Oman; **Musandam Peninsula**. Sahasa area, along the road from Khasab to Jebel Harim, between the Sayh plain and the pass.

Fig. 7. *Cheilanthes acrostica,* growing from crack roadside limestone rock face. Sultanate of Oman; Musandam Peninsula. Sahasa area, along the road from Khasab to Jebel Harim, between the Sayh plain and the pass. C.J. Rothfels, January 22, 2009.

Elevation: 1400 m. Locally common in sheltered cracks in E-facing roadcut wall. In hard, sharp, fractured, limestone, with mosses, *Onychium*, etc. This species was uncommon to common in the vicinity of the diesel generator area, but usually as smaller plants (see CJR 2753), and usually deep in crevices in north-facing rock faces. January 22, 2009. C.J. Rothfels #2735, with Paul Rothfels. Identified by C.J. Rothfels.

- Sultanate of Oman; **Musandam Peninsula**. Sahasa area, along the road from Khasab to Jebel Harim, around the military complex just below the pass. Elevation: 1600 m. Uncommon, widespread, as scattered small individuals, in silt-packed crevices in W-facing limestone faces, with liverworts (CJR 2750, 2751), mosses, etc. *Cosentinia vellea* was also collected at this site (CJR 2749). January 22, 2009. C.J. Rothfels #2753, with Paul Rothfels. Identified by C.J. Rothfels.

This species, which belongs to the large "hemionitid" group of cheilanthoid ferns (see Windham *et al.* 2009), is part of the *C. pteridioides* complex. There appear to be two main players of relevance to Arabian workers: a diploid with entire false indusia, and an allotetraploid with fringed false indusia (Vida *et al.* 1971, 1983). The diploid has long been referred to as *C. maderensis* Lowe, but the lectotype of *C. pteridioides* turns out to be that taxon, and the name *C. pteridioides* has priority (Nardi & Reichstein 1985). So the diploid has to be called *C. pteridioides*, leaving that name unavailable for the taxon to which it had historically been applied: the tetraploid. The tetraploid, then, gets the name *C. acrostica* (Balbis) Tod. A proposal to simplify the matter by throwing out the name *C. pteridioides* as ambiguous and confusing (Nardi & Reichstein 1986), which would leave the unambiguous name *C. maderensis* available for the diploid, was not accepted (Pichi Sermolli 1987). The

Fig.8. *Cosentinia vellea,* wedged deeply in sheltered crack in limestone. Sultanate of Oman; Musandam Peninsula. Sahasa area, along the road from Khasab to Jebel Harim, around the military complex. C.J. Rothfels, January 22, 2009.

specimens here have fringed false indusia, and thus are the presumed tetraploid *C. acrostica*, although Arabian floras (e.g. Miller & Cope 1996; Jongbloed 2003) still use the name *C. pteridioides*. We know of no records of true *C. pteridioides* from Arabia. Some recent European publications (e.g., Jermy & Paul 1993) continue to use *C. maderensis*, in apparent contradiction to the Code of Nomenclature, but without explanation.

Cosentinia vellea (Ait.) Tod. *sensu* Miller & Cope (1996; as *Cheilanthes vellea*). (Pteridaceae).

- United Arab Emirates; **Ra's al-Khaimah Emirate**. Diftah (southeast of Masafi). Up the wadi on the east side of Highway E89. Elevation: 400 m. Rare, local - five plants seen. On steep NW-facing jebel slope above steep-walled wadi. Plants were in pockets of silt in sheltered cracks among fractured ophiolite rocks, with scattered angiosperms, *Riccia crenatodentata* (CJR 2725) and *Timmiella barbuloides* (CJR 2727). January 20, 2009. C.J. Rothfels #2724, with Paul Rothfels. Identified by C.J. Rothfels.

- Sultanate of Oman; **Musandam Peninsula**. Sahasa area, along the road from Khasab to Jebel Harim, around the military complex. Elevation: 1600 m. Local, in crevices in W-facing hard limestone face, with *Cheilanthes acrostica* (CJR 2753), etc. This species was locally more abundant than *C. acrostica*, although *C. acrostica* was much the more common species in the broader area. Plants were wedged deeply in crevices, and were very hard to collect. January 22, 2009. C.J. Rothfels #2749, with Paul Rothfels. Identified by C.J. Rothfels.

Contrary to its general appearance and its long history of treatment under *Cheilanthes* or *Notholaena*, this species is not closely related to *Notholaena* or any *Cheilanthes* group (Rothfels & al. 2008). Rather, it is closer to species of *Anogramma* and *Pteris* (Nakazato & Gastony 2003). Conversely, the superficially similar *Cheilanthes acrostica* is more closely related (evolutionarily) to *Adiantum* than it is to *Cosentinia*. The two *Cosentinia* collections above are from very different substrates (limestone vs. ophiolite) and elevations (1600m vs. 400m). There is only one species in the genus, however, with two subspecies (Pichi Sermolli 1985; Badré & Reichstein 1983) that differ in their ploidy levels. The nominate (tetraploid) subspecies can be distinguished from the diploid *Cosentinia vellea* Tod. subsp. *bivalens* (Reichstein) Rivas Mart. & Salvo (1984) by spore size: spores of the tetraploid range from (53-)57-66(-75) µm, whereas spores of the diploid are smaller: (42-)51-57(-60) µm (Badré & Reichstein 1983).

Our collections have spore sizes that overlap the boundary. From the UAE collection, we measured spores from four sporangia with the following average sizes and standard deviations: 52.5+/-2.90 µm (n=13 spores counted); 57.4+/-1.96 µm (n=24); 57.0+/-2.59µm (n=18); 55.8+/-2.90 µm (n=22). Similarly, three sporangia from the Oman collection had the following spore sizes: 58.8+/-2.26 µm (n=8); 57.9+/-2.01 µm (n=14); 52.2 +/-1.95 µm (n=6). The last sporangium has spores significantly smaller than the other two, and, interestingly, a mixture of spores from the UAE specimen (not taken from individual sporangia) had a bimodal size distribution, with some spores larger (~63 µm), darker, and more strongly and evenly tetragonal than the others (which were ~49 µm in diameter, more transparent, and irregularly shaped). Perhaps those spores, and those of the third sporangium of the Oman plant, were incompletely formed, or suffered from an error at some stage of sporogenesis. Regardless of whether these smaller spores are included, however, our mean spore sizes span the boundary supposedly separating the diploid from the tetraploid taxon; chromosome counts will be necessary to conclusively determine the subspecies involved. All the sporangia we measured spores from had 32 spores per sporangium, a condition that typically indicates apomixis (asexuality), but apparently not so in *Cosentinia* (Badré & Reichstein 1983).

Miller and Cope (1996) show records of *Cosentinia* only from Oman (several from the Hajar mountains and one from the vicinity of Khasab). More recently, it has been found in the Hajar mountains and in the Musandam of the UAE (Feulner 2011).

Onychium divaricatum (Poir.) Alston *sensu* Miller & Cope (1996). (Pteridaceae).

- Sultanate of Oman; **Musandam Peninsula**. On the road from Khasab to Jebel Harim, between Wadi Khasab and the Sayh plain. Elevation: 650 m. Fairly common, scattered individuals. In pockets of silt in crevices under boulders on north-facing limestone boulder slope, with *Morus* cf. *johannis*, *Timmiella barbuloides* (CJR 2731), *Bryum* cf. *nanoapiculatum* (CJR 2732), *Plagiochasma rupestre* (CJR 2733), etc. We saw this species frequently on the subsequent day, between 1200m and 1500m, but there it was mostly just fiddleheads (few fully expanded leaves). January 21, 2009. C.J. Rothfels #2730, with Paul Rothfels, M. Almack, Colin Rothfels. Identified by C.J. Rothfels.

Onychium was locally common in Musandam, in accord with the records of Miller and Cope (1996) and Jongbloed (2003), who record it as widespread in the Hajar Mountains as well. Otherwise on the Arabian Peninsula it is only found along the Red Sea in southern Yemen and western Saudi Arabia. It reappears on both sides of the peninsula, in northern Africa, and in Iran, and extends east into East Asia (Miller & Cope 1996).

Pteris vittata L. *sensu* Miller & Cope (1996). (Pteridaceae).

- Sultanate of Oman; **Sharqiyah Region**. Wadi Tiwi, approximately 3km up. Elevation: 30 m. Common in seeps and sheltered spots (under rocks, etc.) along wadi, with *Adiantum capillus-veneris* (CJR 2759), *Splachnobryum*, etc. Most plants were largish, although a dwarf form occurred in exposed rock crevices. January 29, 2009. C.J. Rothfels #2756, #2760, with Peter Rothfels, Paul Rothfels, M. Almack. Identified by C.J. Rothfels.

Fig.9. *Pteris vittata* perched over the clear pools of Wadi Tiwi. Sultanate of Oman; Sharqiyah. Region C.J. Rothfels, January 22, 2009.

Our collection is in accord with Miller and Cope (1996), who show a smattering of records in northern Oman, a few from the Salalah area, and then a dense series of collections from southern Yemen and extreme southwestern Saudi Arabia. A single site is known from Musandam, at 'Ayn as-Sih, a large seep that is the only Musandam site for several other hygrophilous plant species as well (Feulner 2011). Originally African, this species is generally weedy, and is found far from its native range (e.g., Mickel & Smith 2004). It has attracted considerable attention as a hyperaccumulator of heavy metals, with potential applications for phytoremediation of contaminated sites (Chen *et al*. 2002).

LICHENS:

Toninia sedifolia (Scop.) Timdal (Catillariaceae).

- Sultanate of Oman; **Musandam Peninsula**. Sahasa area, along the road from Khasab to Jebel Harim. Elevation: 1550 m. In sheltered cracks between limestone boulders and rocks on gentle NE-facing slope. With *Collema tenax* s.l. (CJR 2736), *Squamarina lentigera* (CJR 2737, 2738), *Collema* sp. (CJR 2742), *Didymodon acutus* (CJR 2741), scattered *Cheilanthes acrostica* (see CJR 2735), *Ephedra pachyclada*, grasses, misc. spiny angiosperms, etc. Could also be *T.opuntioides* (thin layer chromatography would be needed for confirmation). January 22, 2009. C.J. Rothfels #2739, with Paul Rothfels. Identified by E. Gaya.

First record for Oman. Otherwise, it is recorded from Yemen (Müller 1893, as *Thalloidima caeruleo-nigricans*; Sipman 2002), Kuwait (Brown 1998), and Jordan (El-Oqlah & Lahham 1985, as *Toninia coeruleonigricans*; El-Oqlah 1992). This is a widespread holarctic lichen, with a broad altitudinal and latitudinal range, found on soil and weathered typically calcareous rocks; it prefers well-lit horizontal surfaces in arid regions. *Toninia sedifolia* can be identified by the presence of whitish to bluish-grey (green-olive when hydrated) convex to swollen squamules, by the blackish apothecia without pruina (although sometimes with dense bluish-grey pruina), and by the flat to slightly convex disks. The spores are bicellular and fusiform. No diagnostic chemical reactions are known.

Collema sp. (Collemataceae).

- Sultanate of Oman; **Musandam Peninsula**. Sahasa area, along the road from Khasab to Jebel Harim. Elevation: 1550 m. In sheltered cracks between limestone boulders and rocks on gentle NE-facing slope. With *Collema tenax* s.l. (CJR 2736), *Squamarina lentigera* (CJR 2737, 2738), *Toninia sedifolia* (CJR 2739), *Didymodon acutus* (CJR 2741), scattered *Cheilanthes acrostica* (see CJR 2735), *Ephedra pachyclada*, grasses, misc. spiny angiosperms, etc. Globose isidia, apothecia sunken in lobes. January 22, 2009. C.J. Rothfels #2742, with Paul Rothfels. Identified by E. Gaya.

No *Collema* species have been reported from Oman so far, and only one (*Collema coccophorum*) from the UAE (Brown & Sakkir 2004). Several species have been recorded for mainland Yemen and Socotra (Schultz 1998; Schultz & Mies 2003) as well as Saudi Arabia and Kuwait (Abuzinada *et al*. 1986; Kürschner 1984; Abokhatwa 1989; Frey 1989; Bokhary *et al*. 1993; Schultz *et al*. 2000). Unfortunately, this specimen, with globose isidia and apothecia sunken in lobes, is too small to identify to the species level.

Collema tenax s.lat. (Sw.) Ach. (Collemataceae).

- Sultanate of Oman; **Musandam Peninsula**. Sahasa area, along the road from Khasab to Jebel Harim. Elevation: 1555 m. In sheltered cracks between limestone boulders and rocks on gentle NE-facing slope. With *Squamarina lentigera* (CJR 2737, 2738), *Toninia sedifolia* (CJR 2739) *Collema* sp. (CJR 2742), *Didymodon acutus* (CJR 2741), scattered *Cheilanthes acrostica* (see CJR 2735), *Ephedra pachyclada*, grasses, misc. spiny angiosperms, etc. January 22, 2009. C.J. Rothfels #2736, with Paul Rothfels. Identified by E. Gaya.

First record for Oman. Reported from Yemen, Socotra (Schultz & Mies 2003), growing in a soil crust over calcareous rock, Jordan (El-Oqlah *et al*. 1986) as var. *ceranoides* (Borr.) Degel, and Saudi Arabia (Abuzinada *et al*. 1986; Bokhary *et al*. 1993). This cyanobacterial lichen is mainly terricolous, with a thick thallus and submural spores.

Gloeoheppia turgida (Ach.) Gyeln. (Gloeoheppiaceae).

- United Arab Emirates; **Ra's al-Khaimah Emirate**. Diftah (southeast of Masafi). Up the wadi on the east side of Highway E89. Elevation: 400 m. Uncommon, local? On steep NW-facing jebel slope above steep-walled wadi. In sheltered pockets of silt among fractured ophiolite rocks. Also collected here were *Riccia crenatodentata* (CJR 2725) and *Timmiella barbuloides* (CJR 2727). January 20, 2009. C.J. Rothfels #2728, with Paul Rothfels. Identified by E. Gaya.

This is a common species with a widespread occurrence throughout Arabia. It has been reported from mainland Oman by Brown *et al*. (2002), from Masirah island by Ghazanfar & Rappenhöner (1994) and Ghazanfar & Gallagher (1998), and from the UAE by Brown and Sakkir (2004) and Brown (2005). *Gloeoheppia turgida* grows mainly on calcareous soil and rock, also in shaded, sand-filled clefts between limestone boulders from coastal to mountainous regions in the Mediterranean, Macaronesian and Saharo-Arabian regions. Another *Gloeoheppia* species known from Oman is *Gloeoheppia erosa* (J. Steiner) Marton, recorded by Brown *et al.* (2002), and from the UAE by Brown and Sakkir (2004). *Gloeoheppia turgida* is one of the few species able to withstand the harsh, dry climate of the coastal plains of southern Yemen.

This is another cyanobacterial lichen, widespread and conspicuous, which can form large populations. Characteristic features of *G. turgida* are the inflated squamules with rounded margins and the smooth surface. The species is rather variable in habit. The squamules can be convex, concave or convoluted, erect and elongated or flat and ± distinctly peltate, brown, olivaceous or blackish, matt, glossy or often covered by a bluish white pruina; the apothecia remain completely immersed or are secondarily raised above the thallus surface and then surrounded by a thalline margin. Old thalli can be pruinose and develop minute cracks, often with dark-brown or blackish, ± urceolate apothecia.

Lichinella nigritella (Lettau) P.P. Moreno & Egea (Lichinaceae).

- Sultanate of Oman; **Musandam Peninsula**. Sahasa area, along the road from Khasab to Jebel Harim, between Wadi Khasab and the Sayh plain. Elevation: 650 m. Locally common on vertical limestone face, by N-facing limestone boulder slope. *Onychium* (CJR 2730), *Morus* cf *johannis*, liverwort (CJR 2733), *Timmiella barbuloides* (CJR 2731), *Bryum* cf. *nanoapiculatum* (CJR 2732), etc., in vicinity. January 21, 2009. C.J. Rothfels #2734, with Paul Rothfels, M. Almack, Colin Rothfels. Identified by E. Gaya.

Recorded from Oman by Brown *et al.* (2002), it is elsewhere known from Europe and North America. In the Arabian Peninsula, apart from Oman, it has been reported from Socotra by Schultz & Mies (2003), and Saudi Arabia by Abuzinada *et al.* (1986, as *Thyrea nigritella*) and Bokhary *et al.* (1993, as *Thyrea nigritella*). Other *Lichinella* species recorded from Oman are *L. cribellifera* (Nyl.) P. Moreno & Egea, *L. iodopulchra* (Crozals) P. Moreno & Egea, *L. sinaica* (Galun & Marton) P. Moreno & Egea, and *L. stipatula* Nyl. (Brown *et al.* 2002). *Lichinella nigritella* is a cyanobacterial lichen characterised by a foliose-fruticose thallus with deeply branched, erect, ± strap-like lobes usually densely covered by globose isidia; fruiting bodies are rarely formed. It has been reported growing on both calcareous and silicate rocks.

Aspicilia contorta (Hoffm.) Kremp. (Megasporaceae).

- Sultanate of Oman; **Musandam Peninsula**. West of the Sahasa area, off the road from Khasab to Jebel Harim. Elevation: 1700 m. On rock, in moist, shallow, north-facing "cave" in hard sharp limestone, on moderate rocky slope. With *Caloplaca pusilla, Caloplaca inconnexa, Aspicilia contorta* (CJR 2743, 2744, 2770), *Psora decipiens* (CJR 2748), *Syntrichia inermis* (CJR 2745,2747), and *Syntrichia sinensis* (CJR 2746). The site is apparently very close to the international border, and it may be that this record should equally be credited to the UAE (Ra's al-Khaimah emirate). January 22, 2009. C.J. Rothfels #2770, with Paul Rothfels. Identified by E. Gaya.

This is a first record for Oman. *Aspicilia contorta* has also been found in Iran (Szatala 1957, as *A. viridescens*), Saudi Arabia (Abuzinada & Hawksworth 1974, as *Lecanora contorta*), Abuzinada *et al.* (1986), and in Kuwait (Brown 1998, as *Aspicilia contorta* (Hoffm.) Kremp. subsp. *hoffmanniana* S. Ekman & Fröberg). Another *Aspicilia* species that seems to be common in the Arabian Peninsula is *A. circummunita*. *Aspicilia contorta* is easily recognised by the scattered areoles, convex, grey and more or less pruinose, and by the sunken apothecia. It is typically found on limestone.

Psora decipiens (Hedw.) Hoffm. (Psoraceae).

- Sultanate of Oman; **Musandam Peninsula**. West of the Sahasa area, off the road from Khasab to Jebel Harim. Elevation: 1700 m. On pocket of soil, in moist, shallow, north-facing "cave" in hard sharp limestone, on moderate rocky slope. With *Caloplaca pusilla, Caloplaca inconnexa, Aspicilia contorta* (CJR 2743, 2744, 2770), *Syntrichia inermis* (CJR 2745,2747), and *Syntrichia sinensis* (CJR 2746). The site is apparently very close to the international border, and it may be that this record should equally be credited to the UAE (Ra's al-Khaimah emirate). January 22, 2009. C.J. Rothfels #2748, with Paul Rothfels. Identified by E. Gaya.

Recorded from Oman by Brown *et al.* (2002), Ghazanfar & Gallagher (1998) and Mandaville (1977), and from the UAE by Brown and Sakkir (2004), where it can be common (Brown 2005). Ghazanfar & Gallagher (1998) state that the species is common throughout the northern and southern mountains of Oman above 1500 m. According to Brown *et al.* (2002), this species is probably widespread in suitable high elevation locations throughout the Arabian Peninsula, as implied by the records from various countries. It has been recorded also from Jordan (El-Oqlah & Lahham 1985; El-Oqlah 1992), Kuwait (Brown 1998), Saudi Arabia (Abuzinada & Hawksworth 1974, as *Lecidea decipiens*; Abuzinada *et al.* 1986; Bokhary *et al.* 1993), and Yemen (Schultz 1998; Sipman 2002). This lichen can be easily spotted by the pinkish or reddish rounded squamules (specially conspicuous when wet), in general with white margins, with rounded divisions or crenulate, concave, flat to irregular, with a whitish lower surface, and black apothecia. It is typically found on thin soils in carbonate areas, often with *Fulgensia fulgens* and *Toninia sedifolia*.

Squamarina lentigera (Weber) Poelt (Stereocaulaceae).

- Sultanate of Oman; **Musandam Peninsula**. W of the Sahasa area, off the road from Khasab to Jebel Harim. Elevation: 1550 m. In sheltered cracks between limestone boulders and rocks on gentle NE-facing slope. With *Collema tenax* s.l. (CJR 2736), *Toninia sedifolia* (CJR 2739), *Collema* sp. (CJR 2742), *Didymodon acutus* (CJR 2741), scattered *Cheilanthes*

Fig.10. Two large individuals of *Squamarina lentigera,* surrounded by a mixed community of *Collema* (the black lichen), and mosses. Sultanate of Oman; Musandam Peninsula. Sahasa area, along the road from Khasab to Jebel Harim, between Sayh plain and pass. C.J. Rothfels, January 22, 2009.

acrostica (see CJR 2735), *Ephedra pachyclada*, grasses, misc. spiny angiosperms, etc. January 22, 2009. C.J. Rothfels #2737, 2738, with Paul Rothfels. Identified by E. Gaya.

Recorded from Oman, in the Musandam mountains, by Ghazanfar & Gallagher (1998). Also known from Kuwait (Brown 1998). This is a squamulose, soil-growing lichen, forming whitish rosettes, with pruinose lobules lifted at the margins, and light brown discoid apothecia. On limestone and chalky soils, sunny, with superficial crust. Common in areas of scarce rain in the Mediterranean region, occasionally on sandy or hard soils. Part of the terricolous communities of bright colours. Often found with *S. cartilaginea*, *Psora decipiens*, *Toninia sedifolia*, *Fulgensia* spp., and *Catapyrenium* spp.

Caloplaca inconnexa (Nyl.) Zahlbr. (Teloschistaceae).

- Sultanate of Oman; Musandam Peninsula.

W of the Sahasa area, off the road from Khasab to Jebel Harim, on the Khasab side of the pass. Elevation: 1700 m. On rock, in moist, shallow, north-facing "cave" in hard sharp limestone, on moderate rocky slope. With *Caloplaca pusilla*, *Caloplaca inconnexa*, *Aspicilia contorta* (CJR 2743, 2744, 2770), *Psora decipiens* (CJR 2748), *Syntrichia inermis* (CJR 2745,2747), and *Syntrichia sinensis* (CJR 2746). The *Caloplaca inconnexa* is growing on the *Aspicilia*. The site is apparently very close to the international border, and it may be that this record should equally be credited to the UAE (Ra's al-Khaimah emirate). January 22, 2009. C.J. Rothfels #2743, 2744 with Paul Rothfels. Identified by E. Gaya.

First record for Oman, and probably for the Arabian Peninsula. It was found growing on *Aspicilia*. *Caloplaca inconnexa* may be more common in the area than records indicate, due to mis-identification as *C. holocarpa* (Hoffm.) Wade, a species reported from all over the Peninsula, but with a complex taxonomy that has been recently clarified by Arup (2009).

Caloplaca pusilla (A. Massal.) Zahlbr. (Teloschistaceae).

- Sultanate of Oman; Musandam Peninsula.

W of the Sahasa area, off the road from Khasab to Jebel Harim. Elevation: 1700 m. On rock, in moist, shallow, north-facing "cave" in hard sharp limestone, on moderate rocky slope. With *Caloplaca pusilla*, *Caloplaca inconnexa*, *Aspicilia contorta* (CJR 2743, 2744, 2770), *Psora decipiens* (CJR 2748), *Syntrichia inermis* (CJR 2745,2747), and *Syntrichia sinensis* (CJR 2746). The site is apparently very close to the international border, and it may be that this record should equally be credited to the UAE (Ra's al-Khaimah emirate). January 22, 2009. C.J. Rothfels #2743, 2744 with Paul Rothfels. Identified by E. Gaya.

This is a first record for Oman and the Arabian Peninsula. *Caloplaca pusilla* is a widely distributed species, probably cosmopolitan, known mainly from Europe, North Africa and North America. Coniophilous and ornithocoprophilous, this is a typical taxon from eutrophic microenvironments. Found at varying altitude and exposure, *C. pusilla* is a very common species and one of the most easily identifiable taxa of the *C. saxicola* group (Gaya 2009). With (relatively) large thalli, this species has a characteristic ochraceous-yellow (the form observed here) to salmon pigmentation, reacting K+ purple. Almost always pruinose, it can be whitish in the central part of the rosettes and suffer necrosis. Apothecia are dark, orange to red, and the spores are wide ellipsoid. *Caloplaca pusilla* is a taxon that has been, and still is, frequently confused with typical *C. saxicola*. There are records of the latter species from Jordan (El-Oqlah & Lahham 1985; El-Oqlah 1992).

Diploschistes ocellatus (Vill.) Norman (Thelotremataceae).

- Sultanate of Oman; Musandam Peninsula. Sahasa area, on the road from Khasab to Jebel Harim, around the military complex. Elevation: 1600 m. Rare in silt-packed crevices in west-facing limestone faces, with *Cheilanthes acrostica* (CJR 2753), a big thalloid liverwort (CJR 2750), mosses, etc. January 22, 2009. C.J. Rothfels #2752, with Paul Rothfels. Identified by E. Gaya.

Recorded from Oman by Mandaville (1977) and Ghazanfar & Gallagher (1998), and from UAE by Brown (2005). Known also from Kuwait (Brown 1998), Saudi Arabia (Abuzinada *et al*. 1986; Bokhary *et al*. 1993), and Yemen (Schultz 1998; Sipman 2002), this species has a thick white thallus, which can cover large areas (extending 10-20 cm or more), and convex areoles, with big apothecia slightly sunken in the thallus. In the Mediterranean region it prefers sunny carbonate rocks and soil. It often occurs with *Toninia tumidula*.

Verrucaria cf. *calciseda* DC. (Verrucariaceae).

- Sultanate of Oman; Musandam Peninsula. Along the road from Khasab to Jebel Harim, around the military complex. Elevation: 1600 m. Rare on west-facing limestone face. *Cheilanthes acrostica* (CJR 2753), mosses, *Cosentinia vellea* (CJR 2749), liverworts (CJR 2750, 2751), etc., were all in the vicinity. January 22, 2009. C.J. Rothfels #2754, with Paul Rothfels. Identified by E. Gaya.

This is the first record of *Verrucaria* for Oman. *Verrucaria calciseda* has been reported from mainland Yemen (Schultz 2004). This is an endolithic lichen that leaves only a white stain on the rock, with dot-like perithecia, eating away depressions in limestone substrate, giving the rock a pitted appearance. The specimen was found on exposed limestone rock. It is too small to confirm a species-level identification.

MOSSES:

Bryum cf. *nanoapiculatum* Ochi & Kurschner (Bryaceae).

- Sultanate of Oman; **Musandam Peninsula**. Along the road from Khasab to Jebel Harim, between Wadi Khasab and the Sayh plain. Elevation: 650 m. In pockets of silt in crevices under boulders on north-facing limestone boulder slope, with *Onychium* (CJR 2730), cf *Morus johannis*, liverwort (CJR 2733), *Timmiella barbuloides* (CJR 2731), etc. January 21, 2009. C.J. Rothfels #2732, with Paul Rothfels, M. Almack, Colin Rothfels. Identified by John Spence.

First record for Oman. *Bryum nanoapiculatum* was first described by Ochi and Kürschner (1998) from Yemen. It is, to date, known only from the Arabian Peninsula and, according to Kürschner (2008), belongs in a complex of more than 50 "desert bryophytes" restricted to the arid regions of SW Asia that have a "circum-Tethyan and xerotherm-Pangaean" origin.

Fissidens arnoldii R.Ruthe sensu Heyn & Herrnstadt 2004. (Fissidentaceae).

- Sultanate of Oman; Musandam Peninsula. Road from Khasab to Jebel Harim, around the military complex. Elevation: 1600 m. In silt-packed crevices in west-facing limestone faces, with *Cheilanthes acrostica* (CJR 2753), *Plagiochasma rupestre* (CJR 2750), *Anoectangium handelii* (CJR 2768), etc. This specimen was originally collected for the liverwort; P. Majestyk recognised and extracted the moss. C.J. Rothfels #2751, with Paul Rothfels. Identified by R. Pursell.

First record for the Musandam Peninsula, although not unexpected. "This species is found in Europe and various areas of the Middle East (see Heyn & Herrnstadt 2004). *Fissidens arnoldii* is often confused with the North American *F. obtusifolius* Wilson" (R.Pursell, *pers. comm*. 2009). In the Arabian Peninsula, this species is known from Kuwait, Saudi Arabia, Yemen and Oman (El-Oqlah 1988, Frey & Kürschner 1988, Kürschner 2000, Ros *et al*. 2001).

Anoectangium handelii Schiffn. (Pottiaceae).

- Sultanate of Oman; Musandam Peninsula. Road from Khasab to Jebel Harim, around the military complex. Elevation: 1600 m. In silt-packed crevices in west-facing limestone faces, with *Cheilanthes acrostica* (CJR 2753), *Plagiochasma rupestre* (CJR 2750), *Fissidens arnoldii* (CJR 2751) etc. This specimen was originally collected for the liverwort; P. Majestyk recognised and extracted the moss, etc. January 22, 2009. C.J. Rothfels #2768, with Paul Rothfels. Identified by R. Zander.

First record for Oman and the Arabian Peninsula. This rare species is previously known from Turkish Kurdistan, where it was first described (Schiffner 1913), Israel and Palestine (Heyn & Herrnstadt 2004),

the Crimean Peninsula (Hill *et al*. 2006), Spain (Casas *et al*. 1976), and Colorado, USA (Zander & Weber 2005).

Barbula cf. *unguiculata* Hedw. (Pottiaceae).

- Sultanate of Oman; Sharqiyah Region. Small wadi between Fins and Ash Shab. Elevation: 20 m. Hardpacked sand at base of steep dry wadi walls. This specimen was mixed in with *Exormotheca pustulosa* (CJR 2764); P. Majestyk recognised and extracted the moss. January 29, 2009. C.J. Rothfels #2765. Identified by R. Zander.

First record for Oman. *Barbula unguiculata* is a sub-cosmopolitan species (Smith 2004) known from N Africa, i.e. the Nile Delta (El-Saadawi *et al*. 1986), and SW Asia, i.e., Turkey (Heyn & Herrnstadt 2004).

Barbula indica (Hook.) Spreng. (Pottiaceae).

- Sultanate of Oman; Sharqiyah Region. Wadi Tiwi, approximately 3km up. Elevation: 30 m. Sheltered hard-packed north-facing earthen bank, by wadi pool. *Orthotrichum* cf. *cupulatum*, *Gyroweisia tenuis*, and *Barbula indica* co-occur at this site (CJR 2761-2763). January 29, 2009. C.J. Rothfels #2763, with Peter Rothfels, Paul Rothfels, M. Almack. Identified by R. Zander.

First record for Oman. Broadly distributed across new and old world tropics (Kürschner 2008). Previously recorded in Saudi Arabia, Yemen and Socotra (Kürschner 2000).

Didymodon acutus (Brid.) K. Saito (Pottiaceae).

- Sultanate of Oman; Musandam Peninsula. W of Sahaha area, off the road from Khasab to Jebel Harim. Elevation: 1550 m. In sheltered cracks between limestone boulders and rocks on gentle NE-facing slope. With *Collema tenax* s.l. (CJR 2736), *Squamarina lentigera* (CJR 2737, 2738), *Toninia sedifolia* (CJR 2739) *Collema* sp. (CJR 2742), scattered *Cheilanthes acrostica* (see CJR 2735), *Ephedra pachyclada*, grasses, misc. spiny angiosperms, etc. January 22, 2009. C.J. Rothfels #2741, with Paul Rothfels. Identified by R. Zander (under the synonym *Didymodon rigidulus* var. *gracilis* (Hook. & Grev.) Zander).

First record for Oman. *Didymodon acutus* is a xerophyte previously known from the Fartak Mountains in Yemen (Kürschner 2008).

Gyroweisia tenuis (Hedw.) Schimp. (Pottiaceae).

- Sultanate of Oman; Sharqiyah Region. Wadi Tiwi, approximately 3km up. Elevation: 30 m. Sheltered hard-packed N-facing earthen bank, by wadi pool. *Orthotrichum* cf. *cupulatum*, *Gyroweisia tenuis*, and *Barbula indica* co-occur at this site (CJR 2761-2763). January 29, 2009. C.J. Rothfels #2762, with Peter Rothfels, Paul Rothfels, M. Almack. Identified by R. Zander.

First record for Oman. This is a temperate species found in Europe north to Scandinavia, Turkey, Syria, Iran, China, Tunisia, and N America (Smith 2004). In the Arabian Peninsula, it is known from Saudi Arabia (Frey & Kürschner 1988).

Orthotrichum cf. *cupulatum* Hoffm. ex Brid. (Pottiaceae).

- Sultanate of Oman; Sharqiyah Region. Wadi Tiwi, approximately 3km up. Elevation: 30 m. Sheltered hard-packed N-facing earthen bank, by wadi pool. *Orthotrichum* cf. *cupulatum*, *Gyroweisia tenuis*, and *Barbula indica* co-occur at this site (CJR 2761-2763). January 29, 2009. C.J. Rothfels #2761, with Peter Rothfels, Paul Rothfels, M. Almack. Identified by R. Zander.

First record for Oman and the Arabian Peninsula. This taxon is a Eurosiberian Temperate moss known from Europe, Macaronesia, N Africa, W and N Asia, N America, Australia, and New Zealand, as well as SW Asia (Iraq, Syria, and Turkey; Smith 2004). Most probably this is *O. cupulatum* var. *bistratosum*.

Syntrichia sinensis (C. Müller) Ochyra (Pottiaceae).

- Sultanate of Oman; Musandam Peninsula. West of the Sahasa area, off the road from Khasab to Jebel Harim, on the Khasab side of the pass. Elevation: 1700 m. On pocket of soil, in moist, shallow, north-facing "cave" in hard sharp limestone, on moderate rocky slope. With *Caloplaca pusilla*, *Caloplaca inconnexa*, *Aspicilia contorta* (CJR 2743, 2744, 2770), *Psora decipiens* (CJR 2748), and *Syntrichia inermis* (CJR 2745, 2747). The site is apparently very close to the international border, and it may be that this record should equally be credited to the UAE (Ra's al-Khaimah emirate). C.J. Rothfels #2746, with Paul Rothfels. Identified by R. Zander (as *Syntrichia alpina* (B.S.G.) Jur., an invalid name).

First record for Oman and the Arabian Peninsula. This taxon, placed in *Syntrichia* by Ochyra (1992), is rare in Europe and more common in Asia.

Syntrichia pseudodesertorum (Froehl.) Agnew & Vondr. (Pottiaceae).

- Sultanate of Oman; Musandam Peninsula. W of the Sahasa area, off the road from Khasab to Jebel Harim. Elevation: 1550 m. In sheltered cracks between limestone boulders and rocks on gentle NE-facing slope. With *Collema tenax* s.l. (CJR 2736), *Squamarina lentigera* (CJR 2737, 2738), *Toninia sedifolia* (CJR 2739), *Collema* sp. (CJR 2742), *Didymodon acutus* (CJR 2741), scattered *Cheilanthes acrostica* (see CJR 2735), *Ephedra pachyclada*, grasses, misc. spiny angiosperms, etc. January 22, 2009. C.J. Rothfels #2740, with Paul Rothfels. Identified by R. Zander.

First record for Oman. There is nomenclatural confusion around the name "*Syntrichia pseudodesertorum*." Some treat it as a synonym of *Syntrichia caninervis* Mitten var. *pseudodesertorum* (Vondr.) M.T. Gallego (Gallego *et al*. 2002), while to others it is a synonym of *S. pseudohandelii* (Fröhlich) Agnew & Vondracek (Zander 1993). In SW Asia, the former species is known from Iran, Afghanistan and Turkey; the latter from Iraq. They all belong to the larger *Syntrichia caninervis* complex. *Syntricha caninervis*, *sensu stricto*, is recorded from northern Saudi Arabia, but not from Oman.

***Timmiella barbuloides* (Brid.) Moenk. (Pottiaceae).**

- United Arab Emirates; Ra's al-Khaimah Emirate. Diftah (southeast of Masafi). Up the wadi on the east side of Highway E89. Elevation: 400 m. Uncommon, local? On steep NW-facing jebel slope above steep-walled wadi. In sheltered pockets of silt among fractured ophiolite rocks. Also collected here were *Riccia crenatodentata* (CJR 2726) and *Gloeoheppia turgida* (CJR 2728). January 20, 2009. C.J. Rothfels #2727, with Paul Rothfels. Identified by R. Zander.

- Sultanate of Oman; Musandam Peninsula. Along the road from Khasab to Jebel Harim, between Wadi Khasab and the Sayh plain. Elevation: 650 m. Uncommon? In pockets of silt in crevices under boulders on north-facing limestone boulder slope, with *Onychium* (CJR 2730), cf *Morus johannis*, *Plagiochasma rupestre* (CJR 2733), *Bryum* cf. *nanoapiculatum* (CJR 2732), etc. January 21, 2009. C.J. Rothfels #2731, with Paul Rothfels, M. Almack, Colin Rothfels. Identified by R. Zander.

Frey & Kürschner (1988) and Kürschner (2000) report this species both from the UAE and Oman, including records from Musandam.

***Syntrichia inermis* (Brid.) Bruch. (Pottiaceae).**

- Sultanate of Oman; Musandam Peninsula. W of the Sahasa area, off the road from Khasab to Jebel Harim. Elevation: 1700 m. In pocket of soil, in moist, shallow, N-facing "cave" in hard sharp limestone, on moderate rocky slope. With *Caloplaca pusilla*, *Caloplaca inconnexa*, *Aspicilia contorta* (CJR 2743, 2744, 2770), *Psora decipiens* (CJR 2748), and *Syntrichia sinensis* (CJR 2746). The site is apparently very close to the international border, and it may be that this record should equally be credited to the UAE (Ra's al-Khaimah emirate). January 22, 2009. C.J. Rothfels #2745, 2747, with Paul Rothfels. Identified by R. Zander (as *Tortula inermis* (Brid.) Mont.).

First record for the Musandam Peninsula. This species is known from Saudi Arabia, Iraq, Kazakhstan, and Egypt, and may also occur in southwestern USA. It has previously been found in Oman (Frey & Kürschner 1988).

***Splachnobryum aquaticum* Müll. Hal. (Splachnobryaceae).**

- Sultanate of Oman; Sharqiyah Region. Wadi Tiwi, approximately 3km up. Elevation: 30 m. Formed dense pillows on south-facing rocks around a small trickle leading down to the wadi pool. Close to the water's edge, with *Pteris vittata*, *Adiantum capillus-veneris*, and a squishy white deposit. Carbonate bedrock. Mosses were common, but local, at this general location. January 29, 2009. C.J. Rothfels #2758, with Peter Rothfels, Paul Rothfels, M. Almack. Identified by P. Majestyk.

In Kürschner (2000) this species is given as *Splachnobryum procerrium*, but *S. aquaticum* is the currently accepted name. It is previously known from both the UAE and Oman. It is also known from Somalia and South Asia (Arts 2001).

Fig.11. Pillows of *Splachnobryum aquaticum* hanging off the rock walls around the Wadi Tiwi channel, with lots of carbonate mineral crusts. Sultanate of Oman; Sharqiyah Region. C.J. Rothfels, January 29, 2009.

Fig.12. Close-up of *Splachnobryum aquaticum* at Wadi Tiwi. Sultanate of Oman; Sharqiyah Region. C.J. Rothfels, January 29, 2009.

LIVERWORTS:

Plagiochasma rupestre (Forst.) Steph. (Aytoniaceae).

- Sultanate of Oman; Musandam Peninsula. On the road from Khasab to Jebel Harim, between Wadi Khasab and the Sayh plain. Elevation: 650 m. Uncommon? In pockets of silt in crevices under boulders on north-facing limestone boulder slope, with Onychium (CJR 2730), cf. *Morus johannis*, *Timmiella barbuloides* (CJR 2731), *Bryum* cf. *nanoapiculatum* (CJR 2732), etc. January 21, 2009. C.J. Rothfels #2733, with Paul Rothfels, M. Almack, Colin Rothfels. Identified by D. Long.

- Sultanate of Oman; Musandam Peninsula. Road from Khasab to Jebel Harim, around the military complex. Elevation: 1600 m. Common in silt-packed crevices in W-facing limestone faces, with *Cheilanthes acrostica* (CJR 2753), mosses, etc. January 22, 2009. C.J. Rothfels #2750, with Paul Rothfels. Identified by D. Long.

According to Kürschner (2008) this taxon is a typical example of the Xerotherm-Pangaean element commonly found in the Arabian peninsula. It has been recorded in Socotra (Kürschner 2003), Saudi Arabia, Yemen and Oman (Kürschner 2000). Previous records from Oman include the Musandam peninsula.

Exormotheca pustulosa Mitt. (Exormothecaceae).

- Sultanate of Oman; Sharqiyah Region. Small wadi between Fins and Ash Shab. Elevation: 20 m. Hardpacked sand at base of steep dry wadi walls. January 29, 2009. C.J. Rothfels #2764. Identified by D. Long.

This is another Xerotherm-Pangaean element common in the Arabian Peninsula (Kürschner 2008). It is known from Socotra (Kürschner 2003), Saudi Arabia, Yemen, UAE, and Oman (Kürschner 2000). In Oman it was previously known from the Batinah region and from Musandam but not from Sharqiyah.

Riccia crenatodentata Volk (Ricciaceae).

- United Arab Emirates; Ra's al-Khaimah Emirate. Diftah (southeast of Masafi). Up the wadi on the east side of Highway E89. Elevation: 400 m. Rare, local? On steep NW-facing jebel slope above steep-walled wadi. In sheltered pockets of silt among fractured ophiolite rocks. Also collected here was *Timmiella barbuloides* (CJR 2727), and *Gloeoheppia turgida* (CJR 2728). January 20, 2009. C.J. Rothfels #2725, with Paul Rothfels. Identified by D. Long.

Endemic to SW Asia (Kürschner 2008). In the Arabian peninsula, it is known from Saudi Arabia, Oman and UAE (Kürschner 2000). Previous records of this taxon in the UAE are from south of the Musandam peninsula, in the area between Diftah and Musandam (Kürschner & Böer 1999).

Riccia crozalsii Levier (Ricciaceae).

- Sultanate of Oman; Sharqiyah Region. Small wadi between Fins and Ash Shab. Elevation: 20 m. Hardpacked sand at base of steep dry wadi walls. See CJR 2766 — *Exormotheca pustulosa*. January 29, 2009. C.J. Rothfels #2766. Identified by D. Long.

First record for Oman. Within the Arabian Peninsula, this taxon of circum-Mediterranean origin has only been recorded in Yemen (Al-Gifri & Kürschner 1996).

Fig.13. Paul Rothfels enjoying some much deserved rest in the company of *Pteris vittata*, *Adiantum capillus-veneris* and *Splachnobryum acquaticum*, at Wadi Tiwi. Sultanate of Oman; Dhahirah Region; Wilayat Mahdhah.

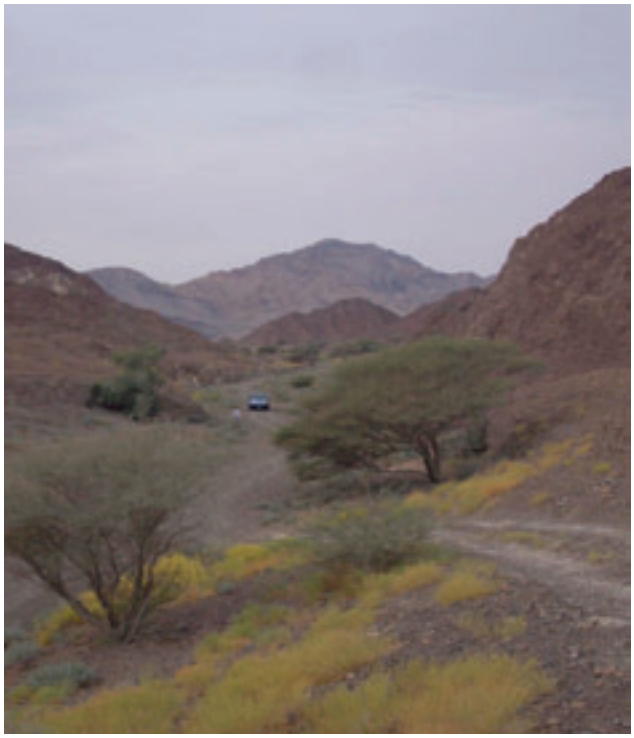

Fig.14. Returning from some *Adiantum* hunting, Sultanate of Oman; Dhahirah Region; Wilayat Mahdhah.

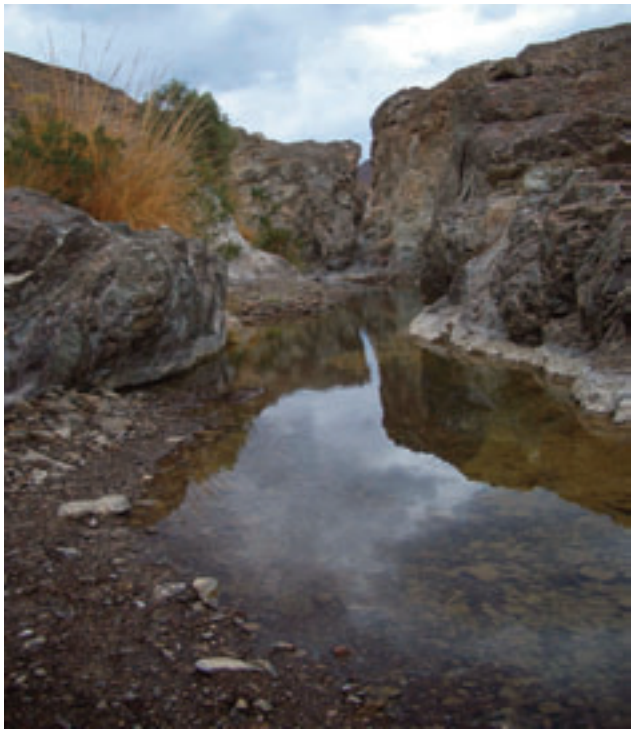

Fig.15. Wadi with standing water (and *Adiantum* along its edges), Sultanate of Oman; Dhahirah Region; Wilayat Mahdhah.

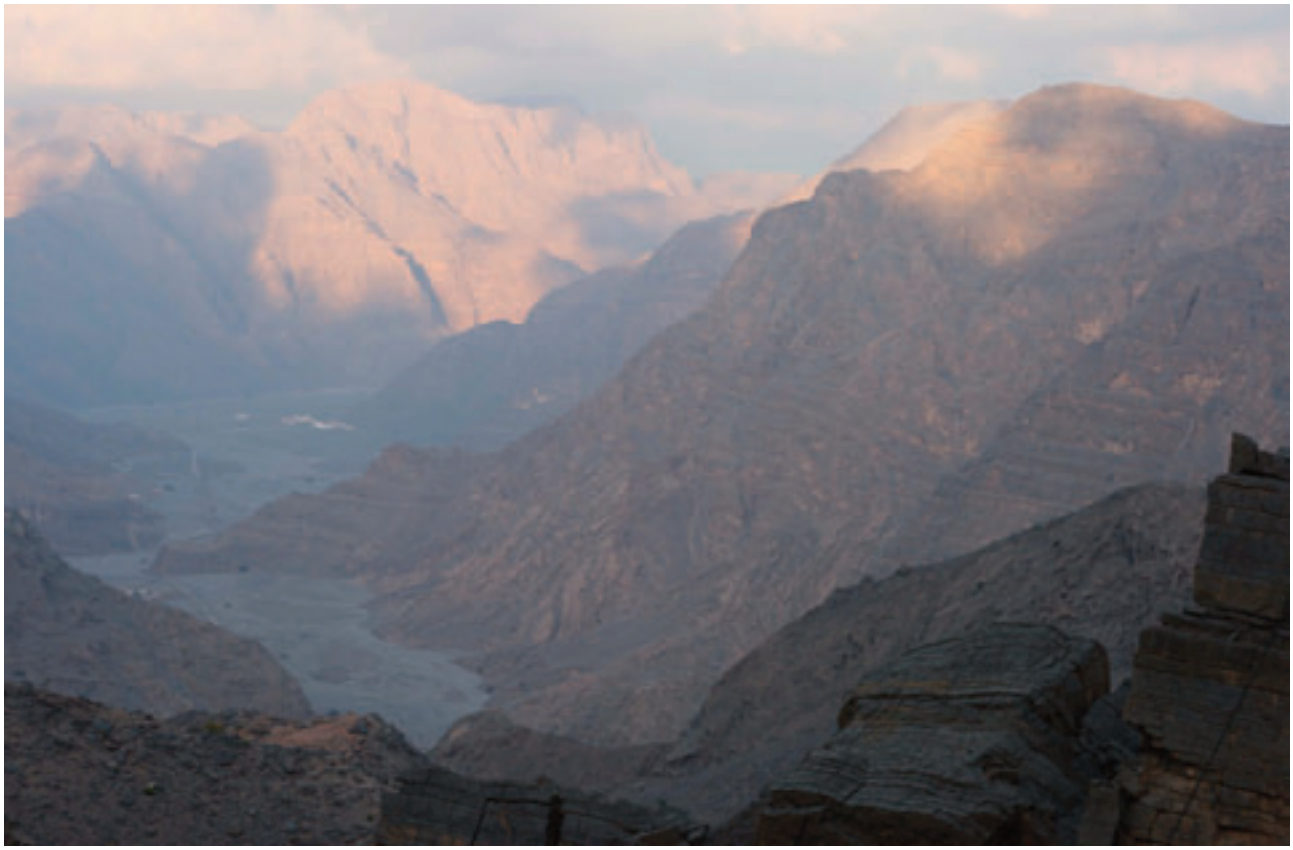

Fig.16. Musandam - an inhospitable environment for ferns and mosses. C.J Rothfels, January 22, 2009.

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