Contribution to the bryophyte flora of Morocco: terricolous and saxicolous bryophytes of the Jbel Bouhalla

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SUMMARY

The terricolous and saxicolous bryophytes of the Jbel Bouhalla (Rif Cordillera, Morocco) have been studied. This mountainous system, characterized by basic geology, contains the largest and best conserved forest of Abies pinsapo subsp. maroccana in Northern Africa. The catalogue is composed of 121 taxa, of which 108 are mosses and 13 liverworts. Of these, nine are new to the African continent (Acaulon mediterraneum, Claopodium whippleanum, Gymnostomum lanceolatum, Hedwigia stellata, Orthotrichum cupulatum var. baldacci, Schistidium brunnescens subsp. griseum, S. crassipilum, Scorpiurium sendméri, Seligeria acutifolia), Ear rhynchium schleicheri is new for mainland Africa, and seven are new records for Morocco (Barbula enderesii, Bryum dunense, Campylia delphus chrysophyllus, Fissidens dautius, Hedwigia ciliata var. leucophaea, Pleuridium acuminatum, Pseudoleskeella catenulata).

KEYWORDS: terricolous and saxicolous bryophyte flora, Jbel Bouhalla, Northern Africa, Morocco.

INTRODUCTION

The bryophytes of the Rif Cordillera have been previously studied only in a fragmentary way, as with the rest of Morocco. Very few publications deal with this Cordillera, which enjoys a very specific climate. Jovet-Ast (1958) was the only bryologist to list mosses from the W. Rif, although none of the mosses reported were collected in the Jbel Bouhalla. More recent papers provide some data for this area, two related to epiphytic mosses. Garilleti, Lara & Mazimpaka (1997a) reported Orthotrichum macrocephalum Lara, Garilleti & Mazimpaka and O. ibericum Lara & Mazimpaka new from the African continent, and Garilleti, Lara & Mazimpaka (1997b) described the new species O. lewinskyae Lara, Garilleti & Mazimpaka from the Jbel Bouhalla. Cano et al. (1999) in a wider work about a new bryophyte community from S. Spain and Morocco, cited some species from the Jbel Bouhalla.

The Rif Cordillera is a mountainous system running parallel to the Mediterranean coast in Northern Morocco. Its mean altitude is about 1500 m and the highest peaks reach 2000 m. The Jbel Bouhalla, also known as Jbel Lakrâa, is situated in the western part of the Rif, within the province of Chefchaouen. The only way to reach these mountains is through the village of Bab-Taza, along a very poor track. The Jbel Bouhalla is formed by a series of escarpments aligned in a N.–S. direction and perpendicular to the coast. The maximum height is 2170 m, which is the second highest in the Rif Cordillera after Jbel Tidhirine (2448 m). The relief is very abrupt, with long slopes and several sharp and deep gullies.

Geologically, the Jbel Bouhalla is formed of mesozoic and cenozoic rocks, in which carbonates dominate. According to Sanz de Galdeano (1997), the stratigraphic series of the Jbel Bouhalla is made of dolomites with marl–limestone intrusions, limestones, sometimes with flints, radiolarites and loamy conglomerates.

Due to the intermediate geographic situation of the Rif Cordillera, midway between the Atlantic Ocean in the W. and the Mediterranean Sea in the N. and N.E., its climate is very distinctive. In general, the Rif Cordillera is an area of high precipitation. In the western part of the Rif, clouds from the Straits of Gibraltar produce rainfall when they come up against the high Moroccan mountains. The only quantitative rainfall data for this area refer to other mountainous systems near the Jbel Bouhalla: e.g. the Jbel Bou Hachem (1094 m) situated on the N.E. face of the Bouhalla receives 2168 mm per year and the Jbel Ouka (1085 m) on the S.W. face of the Bouhalla experiences 1760 mm per year. According to Benabid (1982), the Jbel Bouhalla receives more precipitation than these other two mountains. As in other Mediterranean climates, there are two rainfall maxima, one in winter and the other in spring. Foggy
days are numerous, which is critical for the existence of the *Abies* forest. In spite of a very pronounced summer drought, air humidity remains high. The average annual temperature at the nearest weather station to the study area (Chefchaouen, 630 m) is 16°C, January being the coldest month (9°C) and August the warmest (22°C). The average annual minimum temperature in the higher parts of the Jbel Bouhalla varies from 3.5 to 4.0°C (Ruiz-Laso, 1986).

The lowest parts of the Jbel Bouhalla that have been studied are occupied by mixed evergreen forests of *Quercus suber* L. and *Q. rotundifolia* Lam., in the so-called thermo- and meso-Mediterranean belts. The last species dominates at about 1000 m in the meso-Mediterranean belt, but it is substituted at greater altitudes by *Q. faginea* Lam. in the more humid parts, and by *Pinus pinaster* Aiton in the drier parts. At about 1500 m the *Quercus* forest disappears and *Abies pinsapo* Boiss. subsp. *maroccana* (Trab). Emb. & Maire appears, but only above 1600 m, in the supra-Mediterranean belt, does the *Abies* forest become very dense. Some isolated specimens of *P. nigra* Arnold subsp. *mauretanica* (Maire & Peyerimh.) Heywood are present from 1500 to 1700 m, in the supra-Mediterranean belt. At about 1800 m *Cedrus atlantica* Manetti appears and starts to supplant the *Abies* forest, which does not ascend above 1900 m. *Cedrus* forms a pure forest above this altitude, in a zone that is still regarded as part of the supra-Mediterranean belt. In the highest parts of the mountains, trees disappear and they are substituted by a xerophytic formation composed of thorny shrubs.

This paper adds to our knowledge of a very interesting Moroccan mountainous area, which is bryologically almost unknown. The epiphytes being studied by bryologists at the Autonomous University of Madrid will form the subject of a separate publication. This paper focuses on the terricolous and saxicolous bryophytes of the Jbel Bouhalla. These were studied along an altitudinal gradient (Fig. 1) that began at 1050 m above sea level and finished at 1800 m. No bryophytes were found above this altitude. Specimens were collected on two expeditions (March and June 1997). They are deposited at MUB, MO and NY. Table 1 lists the sites sampled, all of which belong to the province of Chefchaouen.

**Bryophyte Catalogue**

The terricolous and saxicolous bryophyte catalogue includes 121 bryophytes: 108 mosses and 13 liverworts. After consulting Dirkse, Bouman & Losada-Lima (1993), Wigginton & Grolle (1996), O’Shea (1999) and Ros, Cano & Guerra (1999), nine are identified as new for the African continent, one is new for the African mainland and seven are new for Morocco. For the nomenclature of most taxa, Corley et al. (1981), Corley & Crundwell (1991) and Grolle & Long (2000) were followed, but for the family Pottiaceae and the genus *Schistidium* we have followed Zander (1993) and Blom (1996) respectively, as well as some other recent taxonomical papers mentioned in the text. For each taxon the numbers of the sites where they have been found are given, followed by the description of the habitat occupied in the study area and the previous reports, if any. When the distribution area of a taxon is extended by a discovery in the Jbel Bouhalla, or if the taxon is very rare in the area, some comments about its known distribution are also included. The new records for the African continent and Morocco are summarized in Table 2.

**Mosses**

*Pogonatum aloides* (Hedw.) P.Beauv. 1. Sheltered screes under *Quercus rotundifolia*.

*Fissidens dubius* P. Beauv. 3, 7, 10. Rock crevices with soil. Known from Europe extending east to Ukraine and Crimea, Macaronesia, N. Africa, Turkey, Caucasus, Himalaya, N.E. and S.E. Asia, N. America, Mexico and Haiti (Hill, Preston & Smith, 1992). In N. Africa has only been cited from Algeria (Ros et al., 1999). New for Morocco.

*Fissidens sublimbatus* Grout. 3, 8, 9, 10. Sheltered crevices, in screes and on rocks in evergreen *Quercus* and coniferous forests. It was formerly considered to be an endemic of western North America (Arizona, California, Colorado, Nevada, New Mexico, Oklahoma, Texas, Utah, and Wyoming in the United States, Baja California Norte in Mexico, and Alberta in western Canada; Pursell, 1997), but has recently been discovered in Morocco and the Canary Islands (Ros et al., 2001).

*Fissidens taxifolius* Hedw. 5, 9. Screes and rock hollows with accumulated soil.

*Dicranella howei* Renault & Cardot. 1, 2. Screes sheltered by *Quercus rotundifolia* and *Q. suber*.

*Dicranella varia* (Hedw.) Schimp. 9. Scree at the edge of a path.

*Ceratodon purpureus* (Hedw.) Brid. 1, 9. Annual grasslands over exposed acid soils. Previously found in the study area by Cano et al. (1999).

*Pleuridium acuminatum* Lindb. 1, 2. Exposed acid soils and screes under *Quercus rotundifolia* and *Q. suber*. Known from nearly all Europe, Turkey, W. Russia, Macaronesia, Algeria, E. China, N. America (Hill et al., 1992). Its presence in N. Africa was considered doubtful by Ros et al. (1999), but it is now confirmed by this new record. New for Morocco.

*Distichium capillaceum* (Hedw.) Bruch, Schimp. & W. Gümbel 4, 7, 9, 10, 11, 12. Humid and sheltered screes, rock crevices and hollows with soil.

*Encalypta streptocarpa* Hedw. 3, 7, 8, 9, 10, 11. Crevices, ledges and rock bases, sometimes with soil.

*Encalypta vulgaris* Hedw. 3, 7, 9. Rock fissures and ledges, also in grasslands.

*Tortula canescens* Mont. 1, 2. Dry and exposed soils. Also on screes under *Quercus rotundifolia*. 
**Tortula muralis** Hedw. 3, 4, 6, 9. On exposed rocks and fissures with soil.


**Syntrichia calcicola** J.J.Amann. 6, 7, 9. Skeletal and deep soils in *Abies pinsapo* subsp. *maroccana* woods. Also in grasslands.

**Syntrichia handelii** (Schiffn.) Agnew & Vondr. 6, 9. Rock ledges under *Quercus rotundifolia*.

**Syntrichia inermis** (Brid.) Bruch. 3, 6, 9. On exposed and sheltered rocks and scree under shrubs.

**Syntrichia intermedia** Brid. 3, 4, 5, 10. Rocks and fissures with soil.

**Syntrichia princeps** (De Not.) Mitt. 5. Limestone in *Quercus rotundifolia* wood.
Table 1. Details of the study sites. Forest formation: AM = Abies pinsapo subsp. maroccana, CA = Cedrus atlantica, PM = Pinus nigra subsp. mauretanica, PP = Pinus pinaster, QF = Quercus faginea, QR = Q. rotundifolia. QS = Q. suber. Vegetation belt: m-M = meso-Mediterranean, s-M = supra-Mediterranean.

<table>
<thead>
<tr>
<th>Site number</th>
<th>Altitude in metres above sea level</th>
<th>Geographic coordinates and U.T.M. square</th>
<th>Vegetation belt</th>
<th>Forest formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1050</td>
<td>35°04'34&quot;N, 5°10'45&quot;W (U.T.M.: 30S0183)</td>
<td>m-M, subhumid</td>
<td>QS, QR</td>
</tr>
<tr>
<td>2</td>
<td>1220</td>
<td>35°05'26&quot;N, 5°09'47&quot;W (U.T.M.: 30S0285)</td>
<td>m-M, subhumid</td>
<td>QS, QR</td>
</tr>
<tr>
<td>3</td>
<td>1275</td>
<td>35°05'58&quot;N, 5°08'56&quot;W (U.T.M.: 30S0385)</td>
<td>m-M, subhumid</td>
<td>QS, QR</td>
</tr>
<tr>
<td>4</td>
<td>1300</td>
<td>35°06'20&quot;N, 5°08'48&quot;W (U.T.M.: 30S0486)</td>
<td>s-M, subhumid</td>
<td>QS, QR</td>
</tr>
<tr>
<td>5</td>
<td>1400</td>
<td>35°06'58&quot;N, 5°08'22&quot;W (U.T.M.: 30S0588)</td>
<td>s-M, hummid</td>
<td>QS, QR, PP, AM</td>
</tr>
<tr>
<td>6</td>
<td>1500</td>
<td>35°07'31&quot;N, 5°08'10&quot;W (U.T.M.: 30S0589)</td>
<td>s-M, hummid</td>
<td>QS, QR, PP, AM</td>
</tr>
<tr>
<td>7</td>
<td>1500</td>
<td>35°07'10&quot;N, 5°08'03&quot;W (U.T.M.: 30S0588)</td>
<td>s-M, hummid</td>
<td>QR, AM</td>
</tr>
<tr>
<td>8</td>
<td>1595</td>
<td>35°08'32&quot;N, 5°08'27&quot;W (U.T.M.: 30S0490)</td>
<td>s-M, hummid</td>
<td>AM, PM</td>
</tr>
<tr>
<td>9</td>
<td>1600</td>
<td>35°08'17&quot;N, 5°08'20&quot;W (U.T.M.: 30S059)</td>
<td>s-M, hummid</td>
<td>AM, PM</td>
</tr>
<tr>
<td>10</td>
<td>1700</td>
<td>35°08'36&quot;N, 5°08'42&quot;W (U.T.M.: 30S0491)</td>
<td>s-M, hummid</td>
<td>AM, PM</td>
</tr>
<tr>
<td>11</td>
<td>1700</td>
<td>35°08'09&quot;N, 5°08'27&quot;W (U.T.M.: 30S0490)</td>
<td>s-M, hummid</td>
<td>AM</td>
</tr>
<tr>
<td>12</td>
<td>1800</td>
<td>35°08'33&quot;N, 5°08'48&quot;W (U.T.M.: 30S0491)</td>
<td>s-M, hummid</td>
<td>AM, CA</td>
</tr>
</tbody>
</table>

Table 2. Notable range extensions represented by the recent discoveries in the Jbel Bouhalla.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Range extension</th>
<th>Previous distribution in Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acaulon mediterraneum</td>
<td>Africa</td>
<td>–</td>
</tr>
<tr>
<td>Barbula enderesii</td>
<td>Morocco</td>
<td>Algeria</td>
</tr>
<tr>
<td>Brynum dumense</td>
<td>Morocco</td>
<td>Algeria, Tunisia</td>
</tr>
<tr>
<td>Campyladelphus chrysophyllus</td>
<td>Morocco</td>
<td>Chad</td>
</tr>
<tr>
<td>Cladopodium whippleanum</td>
<td>Africa</td>
<td>–</td>
</tr>
<tr>
<td>Euryhynchium schleicheri</td>
<td>Africa mainland</td>
<td>Canary Islands</td>
</tr>
<tr>
<td>Fissidens dubiass</td>
<td>Morocco</td>
<td>Algeria</td>
</tr>
<tr>
<td>Gymnostomum lanceolatum</td>
<td>Africa</td>
<td>–</td>
</tr>
<tr>
<td>Hedwigia ciliata var. leucophaea</td>
<td>Morocco</td>
<td>Algeria, Tunisia</td>
</tr>
<tr>
<td>Hedwigia stellata</td>
<td>Africa</td>
<td>–</td>
</tr>
<tr>
<td>Orthotrichum cupulatum var. baldacci</td>
<td>Africa</td>
<td>–</td>
</tr>
<tr>
<td>Pleuridium acuminatum</td>
<td>Morocco</td>
<td>–</td>
</tr>
<tr>
<td>Pseudoleskeella catenulata</td>
<td>Morocco</td>
<td>No country cited</td>
</tr>
<tr>
<td>Schistidium brunnescens subsp. griseum</td>
<td>Africa</td>
<td>–</td>
</tr>
<tr>
<td>Schistidium crassispilos</td>
<td>Africa</td>
<td>–</td>
</tr>
<tr>
<td>Scorpiurium sendrei</td>
<td>Africa</td>
<td>–</td>
</tr>
<tr>
<td>Seligeria acutifolia</td>
<td>Africa</td>
<td>–</td>
</tr>
</tbody>
</table>

Aloina aloides (Schultz) Kindb. 6, 11. Dry soils, partially sheltered.

Aloina ambigua (Bruch & Schimp.) Limpr. 6. Scree between rocks.

Acaulon mediterraneum Limpr. 1. Dry and exposed, acid soils. It is known from nearly all European countries and Turkey (Düll, 1984, 1992). New to the African continent.

Barbula convoluta Hedw. 3, 9, 10, 11, 12. Scree, crevices of rocks with skeletal or sandy soils.


Barbula unguiculata Hedw. 7, 11. Ledges of rocks with accumulated soil.


Didymodon fallax (Hedw.) R.H.Zander. 3, 4, 8. Rock fissures and sandy soils.

Didymodon tophaceus (Brid.) Lisa. 9, 11. Scree where water seeps, with or without soil.
Didymodon vinealis (Brid.) R.H.Zander. 7, 9. Exposed limestones with soil and screes at the edge of a path. Var. flaccidus (Bruch & Schimp.) R.H.Zander. 1, 2, 3, 4, 5, 6, 7, 8, 9,10, 11, 12. Rock fissures, ledges and crevices with soil, sometimes at the base of rocks, usually in sheltered places.

Bryoerythrophyllum recurvirostrum (Hedw.) P.C.Chen. 9, 11. Rock fissures, ledges and crevices with soil, sometimes at the base of rocks, usually in sheltered places.

Gymnostomum calcareum Nees & Hornsch. 8, 11. Humid screes. Until now it was known only from the S.E. of the Iberian Peninsula, in Almeria and Alicante provinces (Cano, Ros & Guerra, 1994). Recently it has been found on the Balearic Islands (Cano et al., 2001), and in Turkey and Croatia (Kuçera, 1998). New to the African continent.

Gymnostomum viridulum Brid. 7. Ledge of rock with soil.


Schistidium singarense (Schiffn.) Laz. 3, 4, 6, 7, 8, 10, 12. In the same habitats as the preceding species. These two are the commonest species of the genus Schistidium in the Mediterranean area.

Grimmia laevigata (Brid.) Brid. 2. Partially sheltered limestone.

Grimmia lisae De Not. 1, 2. Bare limestone rock fissures, more or less sheltered.

Grimmia pulvinata (Hedw.) Sm. 3, 5, 6, 7, 10. Exposed limestones.

Grimmia trichophylla Grev. 3, 4, 5, 6, 7, 9, 10, 11. Shaded and exposed limestones.

Seligeria acutifolia Lindb. 3, 4, 9. Sheltered limestones and fissures. It is present in Europe, Caucasus, Turkey, Japan and N. America (Hill et al., 1992). New to the African continent.

Funaria hygrometrica Hedw. 3. Sandy soil.

Bryum alpinum Huds. ex With. 8. Scree on a dry river bank.

Bryum argenteum Hedw. 1, 9. Soils at the edge of a path. It was previously recorded in the Jbel Bouhalla by Cano et al. (1999).

Bryum dichotomum Dicks. 1, 2, 3. Sandy soils in clearings between bushes.

Bryum donianum Grev. 5. Rock crevices with soil.

Bryum dunense A.J.E.Sm. & H.Whitehouse. 9. Sandy soil. It is present in Europe and Turkey (Hill, Preston & Smith, 1994). In N. Africa it was known from Algeria and Tunisia (Ros et al., 1999). New for Morocco.

Bryum gemmilucens R.Wilczek & Demaret. 1, 2. Exposed soils.

Bryum pseudotriquetrum (Hedw.) P.Gaertn., B.Mey. & Scherb. 8. Scree on a dry river bank.

Bryum torquescens Bruch ex De Not. 1, 3, 12. Sheltered rocks and screes.

Bartramia pomiformis Hedw. 1. Scree under Quercus rotundifolia.

Bartramia stricta Brid. 1. Bare and exposed rocks, and screes sheltered by Quercus rotundifolia.

Timmia bavarica Hessl. 5, 9, 11. Bases of rocks with soil and rock fissures. It is found in all the major mountain areas of the
N. Hemisphere (Brassard, 1984). It was previously known from Algeria and Morocco (Ros et al., 1999), but it is a rare species in N. Africa.

**Orthotrichum anomalum** Hedw. 3, 6. Exposed and shaded limestones.

**Orthotrichum cupulatum** Brid. 3, 4, 5, 6, 7, 9, 10, 11, 12. More or less sheltered limestones.

**Orthotrichum cupulatum** var. **baldacci** (Bott. & Venturi) Piccioli. 3, 7. Bare limestones. It is known from the Iberian Peninsula and former Yugoslavia (Düll, 1984). New to the African continent.

**Orthotrichum rupestrum** Schleich. ex Schwägr. 2, 3, 6. Rocks, sometimes sheltered by trees.

**Hedwigia** **ciliata** var. **leucocephata** Bruch, Schimp. & W. Gümbel 1. Exposed rock. It is known from Europe, Asia Minor and N. America (Wijk, Margadant & Florschütz, 1964) and China (Redfearn & Wu, 1986). In Africa it was only cited in Algeria and Tunisia. New for Morocco.

**Hedwigia** **stellata** Hedenäs. 1. Acid and exposed rock. After the description of the species by Hedenäs (1994) with material from N. Europe, it has been recognized in several areas of Europe (Frahm, 1995; Casas & Sérgio, 1996; Buck & Norris, 1996) and N. America (Buck & Norris, 1996). New to the African continent.

**Leucodon** **sciuroides** (Hedw.) Schwägr. 4, 5. Exposed and sheltered rocks, sometimes with soil.

**Antitrichia** **californica** Sull. 1, 3, 4, 5, 6, 7. On rocks, usually sheltered and with soil.

**Pterogonium** **gracile** (Hedw.) Sm. 1, 3, 4, 5, 6, 7. Rocks with or without soil, sometimes in sheltered places.

**Leptodon** **smithii** (Hedw.) F. Weber & D. Mohr. 3, 4, 7, 9, 11. Limestones, more or less sheltered.

**Metaneckera** **menziesii** (Drumm.) Steere. 3, 4, 5, 9. Rocks and limestone fissures with or without accumulated soil.

**Fabronia** **pusilla** Raddi. 3, 4. Exposed rocks and shady hollow.

**Pseudoleskea** **catenulata** (Bridd. ex Schrad.) Kindb. 9. Sheltered rock with protosol. It is present in the mountains of W., central and N. Europe (Hill et al., 1994). According to Wilson & Norris (1989), the species only grows in Europe and records from outside Europe apparently refer to other taxa, although these authors did not study African specimens. In N. Africa it was known from Algeria. New to Morocco.

**Pseudoleskea** **incurvata** (Hedw.) Loeske. 12. Rock ledge with soil.

**Thamnobryum** **alopecurum** var. **maderense** (Kindb.) Stech. Ros & Werner. 3, 5. Dry basic rocks in very sheltered places, sometimes with a skeletal soil in a Quercus rotundifolia and Q. faginea forest, sometimes mixed with Abies pinsapo subsp. maroccana. It is known from the Macaronesian Islands: Azores, Canary Islands (Tenerife) and Madeira (Hedenäs, 1992), and Portugal (Blockeel et al., 2000). It has recently been found in Morocco, in several localities of the Rif Cordillera (Jbel Bouhalla, Jbel Bessoui and Gorges of Ouazzanne) and in Southern Spain, in Cadiz province (Jiménez et al., 2000). Molecular studies carried out by Stech, Ros & Werner (2001) have shown the close genetic similarity of Thamnobryum alopecurum and T. maderense, which are only distinguishable by small morphological and ecological differences.

**Craepephyllum whippleanum** (Sull.) Renaudl. & Cardot. 1. Humid scree under Quercus rotundifolia. It presents a disjunct distribution in Europe and America. It is known from some countries and islands of S.W. Europe and N.W. America (Düll, 1985, 1992). It is new to the African continent.

**Cratoneuron** **filicinum** (Hedw.) Spruce. 8. Scree in a dry river bank.

**Campyliadelphus** **chrysophyllus** (Bridd.) Kanda. 4. Very shaded and sheltered limestone. It is widespread in the Northern Hemisphere, from the Arctic south to N. Africa, Turkey, C. Asia, Japan and Mexico, reaching the tropics in Guatemala and Colombia (Hill et al., 1994). In N. Africa it was only known from Chad (Ros et al., 1999). New to Morocco.

**Scorpiurium** **circinatum** (Bridd.) M. Fleisch. & Loeske. 3, 4, 10. Vertical and overhanging limestones, sometimes in very shaded conditions.

**Scorpiurium** **deflexifolium** (Solms) M. Fleisch. & Loeske. 3. Sheltered limestone. Formerly it was known only from Europe, Macaronesia, E. and S.W. Asia (Düll, 1985). In N. Africa it has been reported from several countries: Algeria, Chad, Morocco and Tunisia (Ros et al., 1999). Nevertheless, it is a rare species in that continent.

**Scorpiurium** **sendtneri** (Schimp.) M. Fleisch. 9. Sheltered limestone under Quercus rotundifolia. It was previously known from Europe, Macaronesia and S.W. Asia (Düll, 1985). New to the African continent.

**Homalothecium** **aureum** (Spruce) H. Rob. 3, 4, 5, 6, 7, 8, 9, 10, 11. Rocks and scree with soil, more or less sheltered.

**Homalothecium** **philippeanum** (Spruce) Schimp. 9, 12. Deep and skeletal soils, sometimes also on sheltered rocks.

**Homalothecium** **sericeum** (Hedw.) Bruch, Schimp. & W. Gümbel 3, 4, 5, 7, 9, 10, 11, 12. Limestones and rock fissures, sometimes with a thin layer of soil.

**Brachythecium** **bellicum** W.R. Buck, J.A. Jiménez, Ros & M.J. Cano. 10, 11. Rock hollow with soil. Until now only known from Morocco (Buck et al., 2001).

**Brachythecium** **dieckei** Röll. 12. Exposed rocks and ledges with soil and also on scree between rocks.

**Brachythecium** **velutinum** (Hedw.) Bruch, Schimp. & W. Gümbel 4, 7, 9, 10, 11, 12. Sheltered rocks and scree, more
or less humicolous. Var. salicinum (Schimp.) Mönk. 9. Rock crevices with a thin layer of soil.

Scleropodium tourettii (Brid.) L.F. Koch. 1, 3, 7. On very sheltered screes.

Eurhynchium meridionale (Bruch, Schimp. & W.Gümbel) De Not. 3, 4, 5, 7. Bare rocks and fissures with skeletal soil.

Eurhynchium praelongum (Hedw.) Bruch, Schimp. & W.Gümbel 3. On very sheltered limestone rocks.

Eurhynchium schleicheri (R.Hedw.) Milde. 10. Rock fissure with skeletal soil. It is present in Europe, Macaronesia, Turkey and Iran (Hill et al., 1994). New to African mainland.

Eurhynchium striatum (Spruce) Bruch, Schimp. & W.Gümbel 3, 5. In very sheltered rocks fissures and on bare limestones.

Rhynchostegiella tenella (Dicks.) Limpr. 5. Rock hollow with skeletal soil.

Hypnum cupressiforme Hedw. 5, 10. Sheltered fissures and rocks.

Ctenidium molluscum (Hedw.) Mitt. 5. Partially sheltered limestone.

Liverworts

Targionia hypophylla L. 1, 3. Rock fissures with skeletal soil and sheltered screes.

Reboulia hemisphaerica (L.) Raddi. 3, 4, 5, 9, 10, 11, 12. Rock fissures and holllows with accumulated earth.

Athalamia hyalina (Sommerf.) S.Hatt. 9, 10, 11, 12. Rock fissures and bases with skeletal soil, in dark conditions.

Riccia ciliata Hoffm. 1. Scree under Quercus rotundifolia.

Riccia nigrella DC. 1. Dry and exposed soil.

Riccia sorocarpa Bisch. 1. Dry and exposed soil.

Fossombronia sp. 1. On the trunk base of Quercus rotundifolia.

Gongylanthus ericetorum (Raddi) Nees. 1. Humid and sheltered scree under Quercus rotundifolia.

Cephalozia divaricata (Sm.) Schiffn. 1. Very humid and shady scree.

Cephalozia turneri (Hook.) Müll.Frib. 1. Very humid and shady scree.

Radula lindenbergiana Gottscbe ex C.Hartm. 3, 7. Very sheltered and humid rocks.

Porella platyphylla (L.) Pfeiff. 5, 9, 10, 11, 12. In very sheltered fissures and on bare rocks.

Frullania dilatata (L.) Dumort. 2. On small scree under Quercus suber.

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