

Contribution to the bryophyte flora of Morocco: the Jbel Toubkal

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SUMMARY

The bryophyte flora of the Jbel Toubkal, included in the Toukbal National Park (Morocco), is catalogued. Only 12 bryophytes had been reported previously from this mountain, the highest in northern Africa. As a result of this study, the catalogue consists of 101 taxa (95 mosses and six liverworts), of which nine species are new for Africa (*Amblyodon dealbatus*, *Brachythecium collinum*, *Grimmia mollis*, *Hycomium armoricum*, *Pseudoleskeella tectorum*, *Schistidium cinclidodonteum*, *Syntrichia bolanderi*, *Syntrichia calcicola*, *Tortula guelpinii*), three species are newly reported for northern Africa (*Bryum klinggraeffii*, *Bryum muehlenbeckii*, *Schistidium rivulare*) and another six are new for Morocco (*Bryum mildeanum*, *Cirriphyllum crassinervium*, *Fissidens rivularis*, *Plagiochila porelloides*, *Rhynchostegiella teneriffae* and *Weissia levieri*).

KEYWORDS: Bryophytes, Mediterranean Basin, northern Africa, Morocco, *Schistidium cinclidodonteum*.

INTRODUCTION

This paper is a continuation of the research initiated several years ago by some of the authors on North African bryophytes and vegetation (Ros, Jiménez & Guerra, 1990, Cano *et al.*, 1999).

Previous studies on the Moroccan bryophytes were mostly undertaken by French bryologists in the second half of the 19th century and the first half of the 20th century. These often consisted of incomplete floristic lists from small areas. Consequently, most of the territory remains under-explored, or totally unknown bryologically. In the second half of the 20th century only a few publications, all by European bryologists, dealt with this area. Unfortunately, there are no resident specialists in Morocco and, among the other countries of North Africa, there are specialist bryologists only in Egypt. The checklist of the mosses of North Africa (Ros, Cano & Guerra, 1999) summarized the published data from this region, although no opinion about the taxonomic validity of the taxa was presented.

The Jbel Toubkal belonging to the Toubkal National Park is poorly known bryologically as compared with nearby areas of the High Atlas system. This could be due to previous difficulties in reaching the area. After an exhaustive search, only five papers were found with data on the bryophytes from this area. Maire & Werner (1934)

reported one liverwort from the Toubkal within a very large list of Moroccan bryophytes. Killian (1943) mentioned the presence of two mosses in a publication dealing with the vascular plant flora. Rauh (1952) published a list of mosses from the High Atlas, only five of them from the Toubkal. Jelenc (1955), in his bryophyte check-list, reported one moss. Finally, Jovet-Ast (1955) mentioned two mosses collected in that area. Summarizing all previous publications, only 12 bryophytes (one liverwort and 11 mosses) had previously been recorded from the Jbel Toubkal.

The Jbel Toubkal, the highest peak of northern Africa (4167 m), rises some 70 km south of Marrakech in the central High Atlas mountains. Geologically, the uppermost areas are Precambrian crystalline and igneous rocks, mainly andesites and granites. The lower parts of the massif are mostly sedimentary in origin, with the youngest being of Cretaceous and Neogene age. The climate in the uppermost part of the Jbel Toubkal (above 3000 m) is characterized by a high-mountain mediterranean bioclimate (Emberger, 1939, 1945).

Climate records (Ouhammou, personal communication) at Neltner refuge (3207 m) show that the high Toubkal is characterized by low temperatures (average maximum temperature of the warmest month of the year: 16°; average minimum temperature of the coldest month of the year: -10.5°), high annual precipitation (896 mm, mostly as

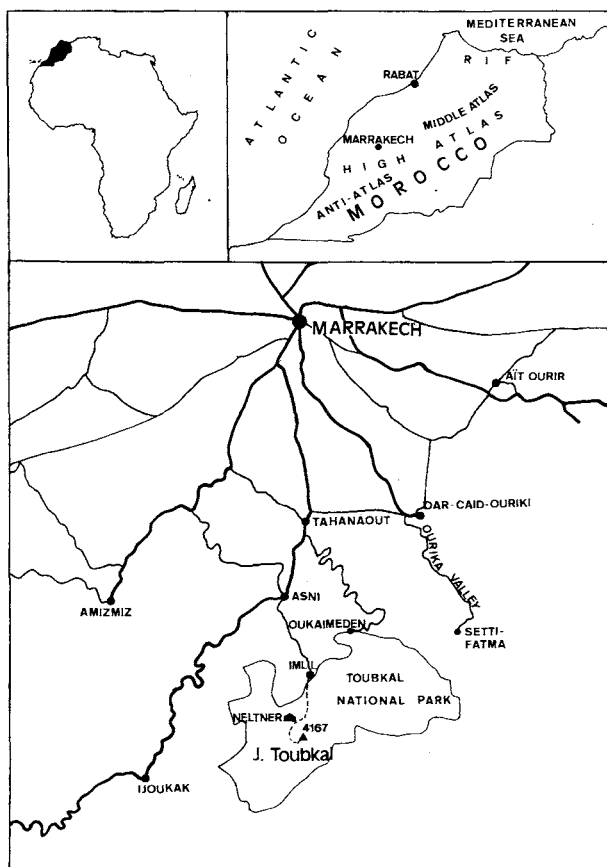


Figure 1. Geographical situation of the study area. Discontinuous line: altitudinal transect studied.

snow), a short dry period in summer, long permanence of snow-cover, and strong and almost permanent winds. The influence of the summer dry period is small, due to the high percentage of days with storms during that period.

The characteristic tree of high elevation areas of the High Atlas is *Juniperus thurifera* L. In this supra-Mediterranean belt it can be found up to 2700 m on the sunny slopes and up to 2600 m on northern exposures. It usually predominates in mixed stands with *J. phoenicea* L. and *J. oxycedrus* L.

At higher altitudes, the trees disappear and are substituted by a xerophytic formation composed of thorny shrubs. Dominant in it are *Arenaria pungens* Clemente ex Lag., *Bupleurum spinosum* Gouan and *Hormatophylla spinosa* (L.) P. K pfer, although many other species can be also found. These are the typical formations of the 'oro-Mediterranean' belt. The siliceous soil and the snow, which lasts a long time on the slopes, facilitate the formation of peaty soils, which make possible the presence of arctic and holarctic species in an area otherwise with Mediterranean vegetation. Above 3800 m altitude the vegetation is reduced to a low dense alpine meadow restricted to streamlet borders, where few herbaceous species can grow. In this belt, the 'cryoro-Mediterranean', is found the highest concentration of endemic cormophyte species.

Table 1. Notable range extensions represented by recent discoveries in the Jbel Toubkal.

Taxon	Range extension	Previous distribution in Africa
<i>Amblyodon dealbatus</i>	Africa	–
<i>Bryum klinggraeffii</i>	Northern Africa	Sub-Saharan Africa
<i>Bryum mildeanum</i>	Morocco	Algeria
<i>Bryum muehlenbeckii</i>	Northern Africa	Sub-Saharan Africa
<i>Cirriphyllum crassinervium</i>	Morocco	Algeria, Tunisia
<i>Fissidens rivularis</i>	Morocco	Algeria
<i>Grimmia mollis</i>	Africa	–
<i>Hyocomium armoricum</i>	Africa	–
<i>Pseudoleskeella tectorum</i>	Africa	–
<i>Rhynchostegiella teneriffae</i>	Morocco	Algeria, Tunisia
<i>Schistidium cinclidodonteum</i>	Africa	–
<i>Schistidium rivulare</i>	Northern Africa	Sub-Saharan Africa
<i>Syntrichia bolanderi</i>	Africa	–
<i>Syntrichia calcicola</i>	Africa	–
<i>Tortula guerpinii</i>	Africa	–
<i>Weissia levieri</i>	Morocco	No country cited
<i>Plagiochila porelloides</i>	Morocco	Algeria

SITES STUDIED

The area has been studied by an altitudinal transect (Fig. 1), which begins at 2000 m above sea-level in Aremd (31° 07' N, 7° 55' W), proceeds to the Neltner refuge (31° 03' N, 7° 56' W, 3207 m) and finishes at the geodesic summit of the Jbel Toubkal (31° 04' N, 7° 55' W, 4167 m). Specimens were collected by the three first authors during a bryological expedition to the High and Middle Atlas in June 1998 and are deposited at MUB and MA.

BRYOPHYTE CATALOGUE

The catalogue includes 95 mosses and six liverworts. According to Wigginton & Grolle (1996), O'Shea (1999) and Ros *et al.* (1999), nine are new for Africa, three for northern Africa and six for Morocco. For the nomenclature of most taxa the list of Ros *et al.* (1999) has been followed. For each taxon, habitat, altitudinal range and previous reports, if any, are indicated.

Mosses

Amblyodon dealbatus (Hedw.) Bruch & Schimp. Pseudoturfaceous soils, 3200 m. A circumboreal species scattered over the boreal zone and mountains, rare in the Arctic and above the tree-limit, extending south in Europe to the Sierra Nevada, Pyrennees and Alps, in Asia to Caucasus, Iran and Altai Mts and in N. America to Colorado and S.E. Canada (Hill, Preston & Smith, 1994). New to the African continent and its distribution is extended southwards.

Barbula bolleana (M ll.Hal.) Broth. Submerged on quartzitic rocks, 3800 m.

Barbula unguiculata Hedw. Ledges of granitic rocks and soil on quartzite near a stream, 2850 m.

Brachythecium collinum (Schleich. ex Müll.Hal.) Schimp. Wet grassland, 3300 m. According to Düll (1985) it is an arctic-alpine species, previously known from Europe, Asia (except the S.E. part) and N. and C. America. New to the African continent.

Brachythecium dieckei Roell. Fissures of quartzitic rocks, 3250–3280 m.

Brachythecium rivulare Schimp. Wet quartzitic rocks and peaty soil, 2850–3200 m. Also reported by Jovet-Ast (1955) at 3300 m.

Brachythecium rutabulum (Hedw.) Schimp. Fissure of granitic rocks, 2225 m.

Brachythecium velutinum (Hedw.) Schimp. Ledges of granitic rocks, 3200 m.

Bryoerythrophyllum recurvirostrum (Hedw.) P.C.Chen. Peaty soils, 3200 m.

Bryum alpinum With. Wet granitic rocks and taluses, 2000–3000 m.

Bryum argenteum Hedw. Moist granitic rocks, sometimes in fissures of rocks and on humid or dry soils, 2000–3280 m.

Bryum caespiticium Hedw. Fissures of granitic rocks and moist grasslands, 3200–3280 m. Also reported by Killian (1943) at approximately 3200 m on peaty soils.

Bryum canariense Brid. Ledge of quartzitic rocks, 2900 m.

Bryum capillare Hedw. Ledges and fissures of granitic and quartzitic rocks and peaty soils, 2100–3300 m.

Bryum capillare Hedw. var. *rufifolium* (Dixon) Podp. Peaty soils, 3200 m.

Bryum dichotomum Hedw. (= *Bryum bicolor* Dicks.). In the last synopsis of Asiatic Bryoideae by Ochi (1985), he considered *B. dichotomum* and *B. bicolor* inseparable and this view is followed here. Dry soils and on quartzitic rocks where water flows temporarily, 2100–3200 m.

Bryum donianum Grev. Ledge of granitic rocks, 2850 m.

Bryum elegans Brid. Fissure of granitic rocks, 2175 m.

Bryum klinggraeffii Schimp. Soil on granitic rocks, 2175 m. It is a suboceanic species (Düll, 1985) widespread in Europe and present in China, Japan, Canada, U.S.A. and Argentina (Hill *et al.*, 1994). New for northern Africa.

Bryum mildeanum Jur. Submerged on quartzitic rocks, 3850 m. It is widespread in Europe in montane areas, also present in S.W. and S.E. Asia and N. Africa (Hill *et al.*, 1994). New to Morocco.

Bryum muehlenbeckii Bruch & Schimp. Fissure of granitic rock in a stream, 2300 m. This is a subarctic-subalpine

species (Düll, 1985). It is present in Europe from N. Scandinavia south to C. Europe and the mountains of Spain and Corsica; Caucasus, N. America, S. Africa, Australia and Chile (Hill *et al.*, 1994). New to northern Africa.

Bryum pallescens Schwägr. Ledges of granitic rocks, grasslands at the edges of streams, and moist taluses with running water on quartzitic rocks, 2225–3300 m.

Bryum pseudotriquetrum (Hedw.) P.Gaertn., B.Mey. & Scherb. Peaty soils, wet grasslands, quartzitic rocks periodically inundated, and ledges of granitic rocks in a stream, 2100–3350 m. Reported by Jovet-Ast (1955) at 3350 m as *B. ventricosum* Dicks. ex Relhan.

Bryum radiculosum Brid. Ledges of granitic rocks, 2210–2400 m.

Bryum schleicheri Lam. & DC. var. *latifolium* (Schwägr.) Schimp. Reported by Rauh (1952) at 3200 m.

Bryum subelegans Kindb. Ledges and fissures of granitic rocks, 2225–3280 m.

Bryum torquescens Bruch & Schimp. Soil at the base of moist rocks and ledges of quartzitic rocks, 2100–2400 m.

Bryum turbinatum (Hedw.) Turner. Wet grassland, 3200 m.

Bryum weigelii Spreng. Reported by Rauh (1952) as *B. duvalii* Voit at 3200 m.

Cirriphyllum crassinervium (Wilson) Loeske & M.Fleisch. Quartzitic rock near a stream, 3850 m. Known in Europe north to Scandinavia, Macaronesia, Algeria, Turkey, Caucasus and Iran (Hill *et al.*, 1994). New to Morocco.

Cratoneuron filicinum (Hedw.) Spruce. Wet soils, moist quartzitic rocks, fissures of granitic rocks and peaty soils, 2850–3200 m.

Dichelyma falcatum (Hedw.) Myrinin. Cited by Rauh (1952) at 3200 m.

Didymodon australasiae (Hook. & Grev.) R.H.Zander. Fissure of granitic rock, 2175 m.

Didymodon rigidulus Hedw. Dry soil, 3570 m.

Didymodon vinealis (Brid.) R.H.Zander var. *flaccidus* (Bruch, Schimp. & W.Gümbel) R.H.Zander. Moist granitic rocks and ledge of granitic rocks, 2000–2900 m.

Distichium inclinatum (Hedw.) Bruch, Schimp. & W.Gümbel. Peaty soils, 3200 m.

Encalypta raptocarpa Schwägr. Ledges and fissures of quartzitic rocks, 3300–3400 m.

Encalypta vulgaris Hedw. Ledge of granitic rocks, 2100–2400 m.

Eurhynchium hians (Hedw.) Sande Lac. Fissure of granitic rock, 2225 m.

Fissidens crispus Mont. (= *F. limbatus* Sull.) Ledge of granitic rocks, 2225–2700 m.

Fissidens rivularis (Spruce) Bruch & Schimp. Quartzitic rock where water flows temporarily, 2300 m. It is known from Europe, Macaronesia, Africa, Turkey and Caucasus (Hill, Preston & Smith, 1992). New to Morocco.

Fissidens viridulus (Sw.) Wahlenb. Ledge of granitic rocks and moist granites, 2210 m.

Funaria convexa Spruce. Ledge of granitic rocks, 2850 m.

Funaria hygrometrica Hedw. Soil on granitic rocks, 2345 m.

Funaria muhlenbergii Turner. Ledge of granitic rocks, 2225 m.

Funaria pulchella H.Philib. Fissure of granitic rocks, 2100 m.

Grimmia alpestris (F.Weber & D.Mohr) Schleich. Quartzitic rocks, 3200–3500 m.

Grimmia anodon Bruch & Schimp. Granitic rocks and ledges and crevices of quartzitic rocks, 2700–4000 m.

Grimmia ovalis (Hedw.) Lindb. Wet granitic rocks and dry quartzitic rocks, 2000–3200 m.

Grimmia mollis Bruch & Schimp. Submerged on quartzitic rocks, 4000 m. It grows on wet, inundated or periodically inundated acid rocks in streams, usually at high elevations. It is known from Europe, Siberia, Russian Far East and northern N. America. According to Düll (1984) it is a subarctic-subalpine species. New to the African continent.

Grimmia tergestina Tomm. Moist granitic rocks, 2000–3200 m.

Homalothecium sericeum (Hedw.) Bruch, Schimp. & W.Gümbel. Moist granitic rocks, ledges of rocks and soils, 2000–2700 m.

Hycomium armoricum (Brid.) Wijk & Margad. Soil near a stream, 3800 m. According to Schumacker *et al.* (1981), it has been considered endemic to W. Europe, with a subatlantic distribution. It is known from S.W. Norway to N. Portugal, through the Faeroes Islands, Great Britain, Normandy, Brittany, Western Pyrennees, Galicia and Algeciras. In C. Europe it is known from the Ardennes to the Schwarzwald and Eifel, with isolated localities in Macaronesia (Azores), W. Mediterranean (Corsica) and the Harz. It has been reported recently from Madeira (Sérgio & Nóbrega, 1985) and Turkey (Cetin, 1988). It is a new record for the African continent.

Hypnum vaucheri Lesq. Granitic rocks, sometimes in fissures of rocks, 2000–2400 m.

Mielichhoferia mielichhoferiana (Funck) Loeske. Reported by Rauh (1952) as *Mielichhoferia nitida* Nees & Hornsch at 3000 m.

Mnium stellare Hedw. Wet quartzitic rocks and ledges of granitic rocks, 2100–3200 m.

Oncophorus virens (Hedw.) Brid. Peaty soils, sometimes at stream edges, 3200–3300 m. It was also cited by Jelenc (1955) at 3000–4000 m.

Orthotrichum cupulatum Brid. Soil on granitic and quartzitic rocks, 2345–3570 m.

Orthotrichum rupestre Schwägr. Fissure of granitic rock, 2400 m.

Palustriella falcata (Brid.) Hedenäs. Peaty soils and moist quartzitic rocks, 2085–3300 m.

Phascum cuspidatum Hedw. Ledge of granitic rocks, 2100–2850 m.

Phascum cuspidatum Hedw. var. *piliferum* (Hedw.) Hook. & Taylor. Ledges of granitic rock, 2200 m.

Philonotis calcarea (Bruch & Schimp.) Schimp. Reported by Jovet-Ast (1955) at approximately 3200 m.

Philonotis fontana (Hedw.) Brid. Soil at the borders of streams and peaty soils, 2300–3300 m. Reported by Killian (1943) at approximately 3200 m on peaty soils.

Plagiomnium medium (Bruch & Schimp.) T.J.Kop. Wet quartzitic rocks, 2100–3200 m.

Plagiomnium rostratum (Schrad.) T.J.Kop. Quartzitic rocks temporarily inundated, 2085–2100 m.

Pohlia cruda (Hedw.) Lindb. On inundated quartzitic rocks, 3350 m.

Pottia davalliana (Sm.) C.E.O.Jensen. Fissure of granitic rock, 2175 m.

Pseudoleskea incurvata (Hedw.) Loeske. Ledges of quartzitic rocks, sometimes periodically moist, 3300–3400 m.

Pseudoleskeella tectorum (Brid.) Broth. Fissures and ledges of granitic rocks, 2400–3500 m. According to Wilson & Norris (1989) it grows at high latitudes or in the mountains and is known from Canada, Europe, U.S.A., and former U.S.S.R. It is new to the African continent.

Rhynchostegiella teneriffae (Mont.) Dirkse & Bouman. Quartzitic rocks where water flows temporarily, 2300 m. It is known from W., C., E. and S. Europe, Caucasus, Macaronesia and N. Africa (Dirkse & Bouman, 1995). New for Morocco.

Rhynchostegium riparioides (Hedw.) Cardot. Quartzitic rocks where water flows temporarily, 2100–3000 m.

Schistidium cinclidodonteum (Müll.Hal.) B.Bremer. Rocks with soil in a protected and dark cave, 2700 m. This species usually grows on acid rocks, periodically flooded, and in more permanent stream beds. It is characterized by its longly and narrowly acuminate leaves somewhat falcate, plane margins which are occasionally pluristratose, bistratose lamina, ventrally plane costa in cross-section, and ovoid to cylindrical capsules. Gametophytically similar

species growing in such habitats and consequently an expected source of confusion are *S. agassizii* Sull. & Lesq. and *S. occidentale* (E.Lawton) S.P.Churchill. The first is known from the Pyrenees and its presence in northern Africa is likely. It differs in having unistratose lamina and funnel-shaped capsules. *Schistidium occidentale* has been recently recognized from materials collected in Sierra Nevada, S. Spain (Casas, 2000), an area biogeographically strongly related to the Rif range of N. Morocco. It differs from *S. cinclidodonteum* in having the costa terete at the base and the lamina unistratose. An account of species related to *S. cinclidodonteum* is provided by Lawton (1979). It had previously been considered endemic to the Pacific Northwest (Lawton, 1971, p. 137). This new record in Northern Africa shows another *Schistidium* species in addition to *S. occidentale*, disjunct between the high mountains of N.W. North America and the S.W. Mediterranean mountains, and is a highly interesting addition to the African flora.

Schistidium confertum (Funck) Bruch & Schimp. Quartzitic and moist granitic rocks, 2000–3500 m.

Schistidium flaccidum (De Not.) Ochyra. Moist granitic rocks and fissures of rocks with soil, 2000–2400 m.

Schistidium rivulare (Brid.) Podp. Quartzitic rock submerged in a stream, 3200–3800 m. It is a boreal-montane taxon (Düll, 1984) present in N. and C. Europe, Azores, C. Africa, W. Asia, Siberia, Himalaya, Japan, N. America, Greenland and southern S. America (Hill *et al.*, 1992). According to Düll (1984) in N. Africa only the ssp. *latifolium* (J.E.Zetterst.) B.Bremer has been recorded, but no literature report was found (Ros *et al.*, 1999). Its presence in N. Africa is confirmed with the present record.

Schistidium singarense (Schiffn.) Laz. Moist granitic rocks and fissures of rocks with soil, 2000–2400 m.

Syntrichia bolanderi (Lesq. & James) R.H.Zander. Fissures of granitic rocks, 2225 m. It is an oceanic-Mediterranean species (Düll, 1984), previously known from N. America, the Canary Islands and France (Düll, 1992), also in Italy according to Blockeel (1995). New to the African continent.

Syntrichia calcicola J.J.Amann. Moist granitic rocks and fissures, 2000–2175 m. It is considered by Düll (1984) to be a submediterranean-montane taxon that has been recorded only in Europe, Crete, Madeira and Turkey. According to Kramer (1980), it is also known from the Near Orient, C. Asia and S.E. Ukraine, but these records have not been checked. New to the African continent.

Syntrichia inermis (Brid.) Bruch. Soil at the base of moist granitic rocks and fissures of rocks, 2000–2225 m.

Syntrichia intermedia Brid. Dry soil, 3570 m.

Syntrichia norvegica F.Weber. Fissures and ledges of quartzitic rocks, 3250–3500 m.

Syntrichia princeps (De Not.) Mitt. Dry soil, 2000–3200 m.

Syntrichia ruralis (Hedw.) F.Weber & D.Mohr. Ledges and fissures of granitic rocks, 2225–3400 m.

Syntrichia virescens (De Not.) Ochyra. Dry soil on granitic and quartzitic rocks, sometimes in fissures of rocks, 2850–3500 m.

Tortella tortuosa (Hedw.) Limpr. Fissures of moist granitic rocks, 2000–2400 m.

Tortula atrovirens (Sm.) Lindb. Ledge of granitic rock, 2100 m.

Tortula canescens Mont. Ledge of granitic rock, 2200 m.

Tortula euryphylla R.H.Zander. Wet grassland, 3300 m.

Tortula guepinii (Bruch & Schimp.) Broth. Ledge of quartzitic rock, 3300 m. It is an oceanic-submediterranean species (Düll, 1984) recorded from Europe, Israel, N. and C. America (Düll, 1992). New to the African continent.

Tortula subulata Hedw. var. *subinermis* (Bruch & Schimp.) Wilson. Ledges and fissures of granitic rocks, 2175–3280 m.

Trichostomum crispulum Bruch. Soil at the base of moist granitic rocks and fissures, 2000–2175 m.

Warnstorfia exannulata (Schimp.) Loeske. Cited by Rauh (1952) as *Drepanocladus exannulatus* (Schimp.) Warnst. at 3200 m.

Weissia controversa Hedw. Ledges and fissures of granitic and quartzitic rocks, 2225–2900 m.

Weissia levieri (Limpr.) Kindb. Ledge of granitic rock, 2225 m. It is only known from Europe and adjacent parts of the Mediterranean region (Hill *et al.*, 1992) as Turkey (Cetin, 1988). With this record its presence in North Africa is confirmed. Jelenc (1955) cited the taxon but without mention of any country. New to Morocco.

Liverworts

Marchantia polymorpha L. *sensu lato*. Pseudo-turfaceous soils, 3200 m. Also reported by Maire & Werner (1934) at 2500–3500 m.

Plagiochila porelloides (Torr. ex Nees) J.Lindb. Granitic rocks on river-banks, 2785 m. According to Hill, Preston & Smith (1991) it is a circumboreal species distributed throughout Europe, including the Arctic, becoming submontane in the south. New to Morocco.

Reboulia hemisphaerica (L.) Raddi. Ledges of granitic rocks, 2100–2700 m.

Riccia cavernosa Hoffm. Ledge of granitic rock, 2900 m.

Riccia crozalsii Levier. Ledge of granitic rock, 2700 m.

Targionia hypophylla L. Ledges of granitic rocks, 2100–2900 m.

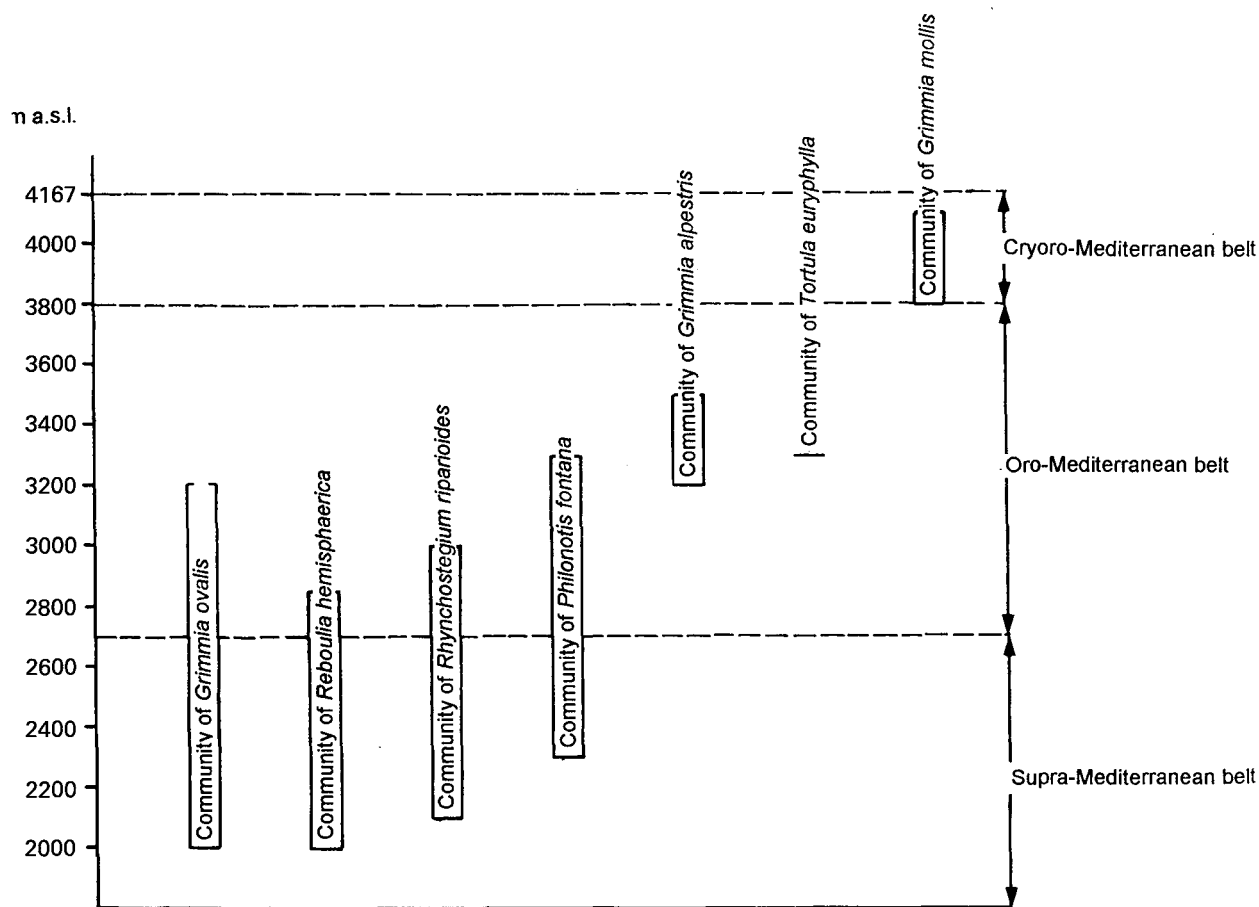


Figure 2 Altitudinal distribution of the bryophytic vegetation.

ALTITUDINAL DISTRIBUTION OF THE VEGETATION

The transect commenced at 2000 m altitude in the supra-Mediterranean belt, as shown in Fig. 2. At this altitude both a saxicolous and a terri-saxicolous community have been observed. The saxicolous community is dominated by *Grimmia ovalis* growing on granitic and quartzitic rocks to 3200 m approximately. It is mainly composed of species of the family Grimmiaceae, including *Grimmia anodon*, *G. tergestina*, *Schistidium confertum*, *S. flaccidum*, *S. singarense*, and some other species, e.g. *Homalothecium sericeum*, *Syntrichia calcicola*, *S. princeps*, *S. ruralis*, and *Tortella tortuosa*. The terri-saxicolous community is characterized by *Reboulia hemisphaerica*. It grows at the bases of rocks, or on rock ledges with accumulated soil, from 2000 to 2900 m. Other frequent species in this habitat are *Bryum torquescens*, *Didymodon vinealis* var. *flaccidus*, *Syntrichia inermis* and *Targionia hypophylla*. A *Rhynchostegium riparioides* community has been observed from 2100 m to 3000 m, growing submerged – sometimes with other aquatic species, such as *Bryum pseudotriquetrum*, *Fissidens rivularis*, *Plagiomnium medium*, *P. rostratum* and *Rhynchostegiella teneriffae*.

On peaty soils, from 2300 to 3300 m in the supra- and oro-Mediterranean belts, a hydrophilous community

develops, dominated by *Philonotis fontana*, *Bryum alpinum* and *Bryum pseudotriquetrum*. Other species found are *Amblyodon dealbatus*, *Brachythecium rivulare*, *Distichium inclinatum*, *Marchantia polymorpha*, *Mnium stellare*, *Oncophorus virens*, and *Palustriella falcata*.

From 3200 m to 3500 m, in the oro-Mediterranean belt, the most common community on acid rocks, although usually fragmentary, is composed of *Grimmia alpestris*, which is sometimes accompanied by *Grimmia anodon*, *Schistidium confertum*, *Syntrichia norvegica*, *S. virescens*, *Brachythecium dieckei*, *Pseudoleskea incurvata* and *Pseudoleskeella tectorum*.

On the wet grasslands at 3300 m altitude, also in the oro-Mediterranean belt, a terricolous community develops, dominated by *Tortula euryphylla* and very poor in species. Other species present are *Brachythecium collinum*, *Bryum capillare* and *B. pseudotriquetrum*.

In the so-called cryoro-Mediterranean belt, from 3800 to 4167 m, bryophytes are very scarce. It is only possible to find them in protected or submerged habitats, such as the community of *Grimmia mollis* growing in the streamlets, and formed also by *Barbula bolleana*, *Hyocomium armoricum* and *Schistidium rivulare*. The remaining species at this altitude grow isolated in very sheltered crevices and rock ledges.

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TAXONOMIC ADDITIONS AND CHANGES: Nil.

REFERENCES

- Bloeker TL. 1995.** Some bryophytes from southern Italy, including new records of *Tortula bolanderi* and *Aschisma carniolicum*. *Cryptogamie, Bryologie Lichénologie* **16**: 105–110.
- Cano MJ, Ros RM, Guerra J, García-Zamora P. 1999.** A new bryophytic community from the mountains of Southern Spain and Morocco: *Tortula subulatae-Syntrichietum ruralis*. *Cryptogamie, Bryologie* **20**: 197–202.
- Casas C. 2000.** El género *Schistidium* Bruch & Schimp. en España. *Boletín de la Sociedad Española de Briología* **16**: 1–9.
- Cetin B. 1988.** Checklist of the mosses of Turkey. *Lindbergia* **14**: 15–23.
- Dirkse GM, Bouman AC. 1995.** A revision of *Rhynchostegiella* (Musci, Brachytheciaceae) in the Canary Islands. *Lindbergia* **20**: 109–121.
- Düll R. 1984.** Distribution of the European and Macaronesian mosses (Bryophytina). Part I. *Bryologische Beiträge* **4**: 1–113.
- Düll R. 1985.** Distribution of the European and Macaronesian mosses (Bryophytina). Part II. *Bryologische Beiträge* **5**: 110–232.
- Düll R. 1992.** Distribution of the European and Macaronesian mosses (Bryophytina). Annotations and progress. *Bryologische Beiträge* **8/9**: 1–223.
- Emberger L. 1939.** Aperçu général sur la végétation du Maroc. *Veröffentlichungen des Geobotanischen Institutes Rübel in Zürich* **14**: 40–157.
- Emberger L. 1945.** Une classification biogéographique des climats. *Recueil des travaux des laboratoires de botanique, géologie et zoologie de la faculté des sciences de l'Université de Montpellier, Série Botanique* **7**: 3–43.
- Hill MO, Preston CD, Smith AJE. 1991.** *Atlas of the bryophytes of Britain and Ireland. Volume 1. Liverworts (Hepaticae and Anthocerotae)*. Colchester: Harley Books.
- Hill MO, Preston CD, Smith AJE. 1992.** *Atlas of the bryophytes of Britain and Ireland. Volume 2. Mosses (except Diplolepidae)*. Colchester: Harley Books.
- Hill MO, Preston CD, Smith AJE. 1994.** *Atlas of the bryophytes of Britain and Ireland. Volume 3. Mosses (Diplolepidae)*. Colchester: Harley Books.
- Jelenc F. 1955.** Muscinées de l'Afrique du Nord (Algérie, Tunisie, Maroc, Sahara). *Société de Géographie et d'Archéologie de la Province d'Oran* **72, 73, 74, 75, 76**: 1–152.
- Jovet-Ast S. 1955.** Muscinées du Grand-Atlas marocain (Récoltes de C. Guinet et F. Vaillant). *Compte Rendu des Sciences de la Société des Sciences Naturelles et Physiques du Maroc* **21**: 36–38.
- Killian C. 1943.** *Gentiana atlantica* de Litardiere et Maire endémique du Grand Atlas marocain. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord* **34**: 37–54.
- Kramer W. 1980.** *Tortula* Hedw. sect. *Rurales* De Not. (Pottiaceae, Musci) in der östlichen Holarktis. *Bryophytorum Bibliotheca* **21**: 1–165.
- Lawton E. 1971.** *Moss flora of the Pacific Northwest*. Nichinan: Hattori Botanical Laboratory.
- Lawton E. 1979.** *Grimmia pacifica*, a new species from western North America. *Bryologist* **82**: 276–280.
- Maire R, Werner RG. 1934.** Contribution à la flore cryptogamique du Maroc. Fascicule IV. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord* **25**: 40–60.
- Ochi H. 1985.** An annotated list of the mosses of the subfamily Bryoideae in South, Southeast and East Asia. *Journal of the Faculty of Education Tottori University* **34**: 41–96.
- O'Shea BJ. 1999.** Checklist of the mosses of sub-Saharan Africa, version 3. *Tropical Bryology Research Reports* **1**: 1–133.
- Rauh W. 1952.** Bemerkenswerte Neufunde von Moosen und Farnen im Hohen Atlas von Marokko. *Berichte der Deutschen Botanischen Gesellschaft* **65**: 79–83.
- Ros RM, Cano MJ, Guerra J. 1999.** Bryophyte checklist of Northern Africa. *Journal of Bryology* **21**: 207–244.
- Ros RM, Jiménez MN, Guerra J. 1990.** On the chorology, synecology and syntaxonomy of some terricolous bryophytic communities from Northern Africa. *Nova Hedwigia* **50**: 65–79.
- Schumacker R, Lecoq A, Touffet J, de Zuttere P, Leclercq L, Fabri R. 1981.** *Hycomium armoricum* (Brid.) Wijk & Marg. en Belgique et dans le Nord-Ouest de la France (Ardenne, Bretagne, Normandie). *Cryptogamie, Bryologie Lichénologie* **2**: 277–321.
- Sérgio C, Nóbrega M. 1985.** Novos elementos para a Flora Briológica da Madeira. In: Sérgio C. et al., eds. *Notulae Bryoflorae Macaronesicae I. Portugaliae Acta Biologica. Série B. Sistemática, Ecologia, Biogeografia e Paleontologia* **14**: 176–179.
- Wigginton MJ, Grolle R. 1996.** Catalogue of the Hepaticae and Anthocerotae of Sub-Saharan Africa. *Bryophytorum Bibliotheca* **50**: 1–267.
- Wilson P, Norris DH. 1989.** *Pseudoleskeella* in North America and Europe. *Bryologist* **92**: 387–396.

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