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Barbula amplexifolia (Mitt.) A.Jaeger in Europe

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Summary

Barbula amplexifolia (Mitt.) A.Jaeger, formerly known only from Asia and North America, is reported from the Alps as new to Europe, being rather widespread in calcareous regions of Austria. It resembles a small *B. crocea* but differs in entire leaves and small, mostly ovoid, reddish-brown to purple axillary gemmae with slightly protuberant to smooth outer cells. Although the European population differs from the typical Indian material, we refrained from taxonomic segregation because of the enormous variability of the species in Asia and the existence of numerous intermediate morphs. *Barbula amplexifolia* probably reached the Alps vegetatively by means of gemmae across the cold Pleistocene steppes from Central Asia. This hypothesis is supported by the absence of male plants and sporophytes in the Alps and the relatively low level of morphological and anatomical variability, which seems to correspond well with the ecological conditions at the sites. It is an early pioneer on bare calcareous soil, nowadays probably much more frequent than earlier as a consequence of the extensive forest road construction of the last decades.

KEYWORDS: Alps, Asia, *Barbula*, Bryopsida, distribution, ecology, North America, Pottiaceae, Sino-Himalayan region, taxonomy.

Introduction

The genus *Barbula* in its current delimitation (Saito, 1975; Zander, 1993) is known to be represented by five species in the European Alps. In addition to the 'weedy', cosmopolitan species *B. unguiculata* Hedw. and *B. convoluta* Hedw., we find the regionally common *B. crocea* (Brid.) F.Weber & D.Mohr and two rare species – the subendemic *B. enderesii* Garov. and the endemic, high-alpine *B. bicolor* (Bruch & Schimp.) Lindb. – all typically calciphilous mosses.

In 1998, both authors first collected at different localities a small *Barbula* with axillary gemmae, which later proved to be a rather widespread (though not frequent) moss in calcareous regions of the Austrian Alps. The plants did not fit any of the known European species of the genus. Later we came across the article of Mogensen & Zander (1999), where they reported on the discovery of *B. amplexifolia* in Greenland. It was quite obvious from the figure and description that our plant was in many aspects similar and hence loans of specimens were requested to confirm the eventual identity. At first we hesitated to name the European plants *B. amplexifolia*, as the typical morph from the Indian Himalayas is in many aspects different but subsequent study of specimens from other regions, partly filed under *B. haringae* H.A.Crum and *B. coreensis* (Cardot) K.Saito, proved that the morphological (and probably also genetical) variability in *B. amplexifoli* is indeed too complex with respect to the relatively low number of available specimens from Asia to allow for safe taxonomic recognition of additional morphologically delimited taxa.

The nomenclature of bryophytes occurring in Europe follows Hill *et al.* (2006) and Grolle & Long (2000).

Description of the European *Barbula amplexifolia* (Figs 1, 2)

Plants in low, dense (rarely loose) turfs or patches or scattered among other bryophytes, yellowish green above, brown below. *Stems* brown, erect, normally unbranched, to 10(−25) mm high; in transverse section circular to indistinctly rounded-pentagonal, consisting of an outer cortex of 1–3 layers of small, stereid cells, a medulla of 3–5 layers of large, moderately thick-walled cells and a strong central strand; hyalodermis mostly intermittently present. *Leaves* ± crowded, broadly lanceolate, distal half moderately bent inwards and often slightly twisted to nearly straight and appressed when dry, with incurved apex, spreading when moist, (0.50)0.70–1.65 × 0.35–0.60 mm, 2.0–3.5 : 1,

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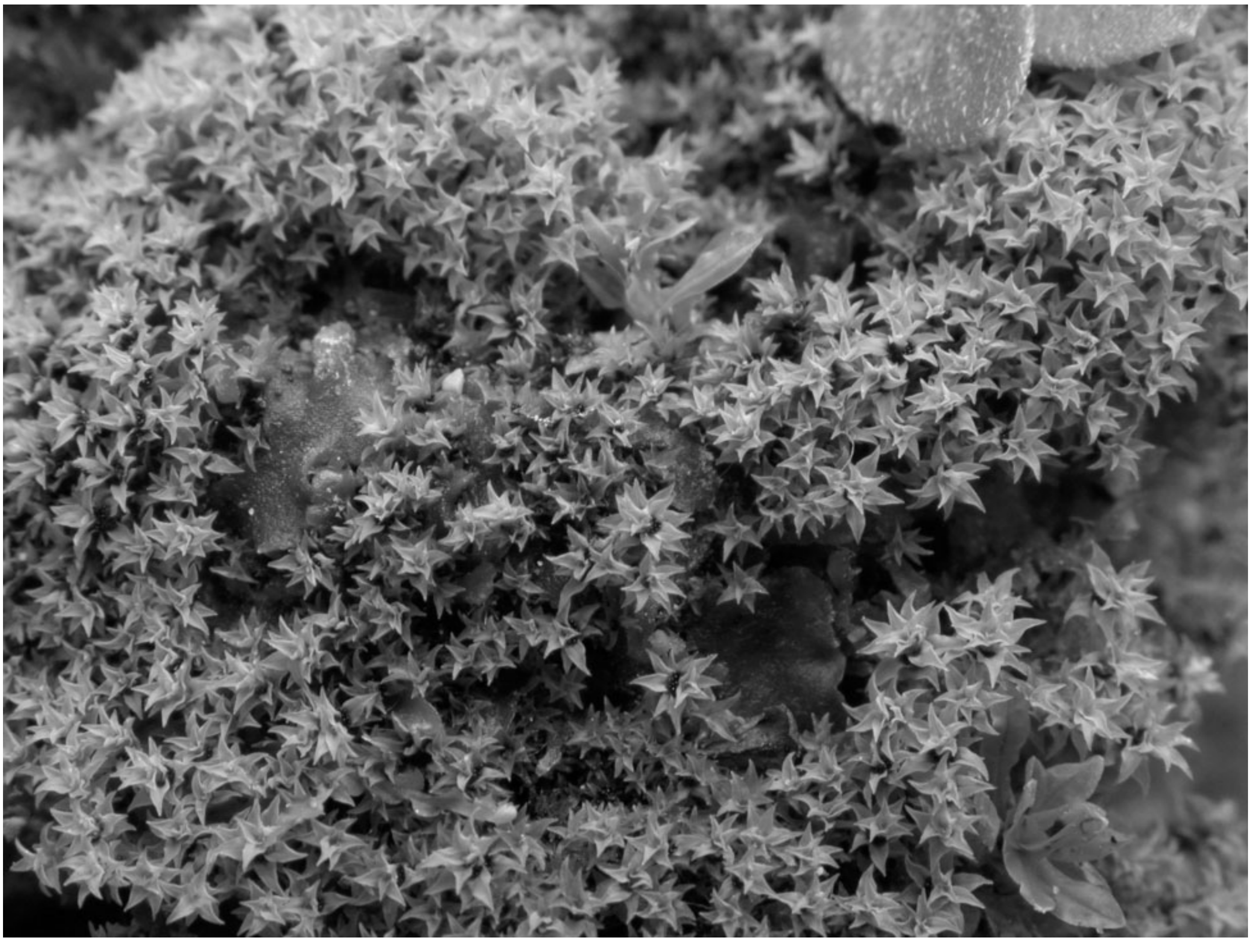

Figure 1. European *Barbula amplexifolia*, growing in typical habit on moist, calcareous soil on the north-facing slope of a mountain road. Austria, Carinthia, Gailtaler Alpen, Egger Alm S. of Greifenburg, 1350 m, 9.9.2004 (*Köckinger 11361*, KL). Photo: Tomas Hallingbäck.

leaf base half-sheathing, yellowish or hyaline, rectangular to trapezoidal extending typically to 1/3–2/5 of leaf length; limb gradually narrowed towards a triangular, rarely somewhat lingulate upper part, apex acute, rarely obtuse; *costa* brownish, 45–85(−100) μm wide in basal part, slightly tapering to apex; percurrent to excurrent in a short, sharp, cuspidate, flat point, often slightly denticulate; both abaxially and adaxially with scattered and low to rather dense and high, bluntly conic papillae over mostly shortly elongated cells; transverse section in upper part circular to semicircular, in lower part becoming elliptical, with one row (medially sometimes two rows) of (2−)4–6 guide cells, weak hydroid band, strong abaxial and weak adaxial stereid band and a moderately distinct epidermis at both sides; *lamina* unistratose, flat or slightly flexuose transversally, sharply keeled and deeply grooved below the apex; *margins* flat, entire but often with a small denticle at one or both sides of the apiculus when costa not excurrent; *cells* in the upper part rounded-quadrate, moderately thickened, bulging on both sides, (5−)7–10 μm wide, densely papillose with blunt, simple or multifid papillae, which make the areolation partly obscure, towards margin sometimes wider than long, paracostal cells sometimes elongate, basal cells thick- to moderately thin-walled, 35–80 × 5–8(−10) μm, with walls up to 4 μm, (2−)4–10(14) : 1, towards margin mostly shorter and sometimes even quadrate to base. *Asexual propagation* by clusters of multicellular gemmae, mainly ovoid but not rarely pyriform, (irregularly) clavate or less commonly short-ovoid to nearly spherical, with outer walls usually slightly protuberant to smooth, reddish-brown to purple, looking glossy and blackish in the field, usually abundantly produced on short, brownish, branched stalks arising from leaf axils, 60–110 × 90–160(210) μm. *Dioicous*. *Perichaetia* rare, perichaetial leaves slightly differentiated, only slightly longer than normal leaves with a narrower apex and an enlarged sheathing part. *Perigonia* and *sporophytes* not found.

Differentiation

Well-developed European *Barbula amplexifolia* can be recognized in the field (Fig. 1) by its yellowish-green turfs or patches with triangularly tapering, spreading leaves and the often copiously present and conspicuous clusters of gemmae in the leaf axils, looking strongly glossy and nearly blackish in fresh material. Microscopically, the reddish-brown to purple, spherical to ovoid or clavate, rather small gemmae with usually slightly protuberant or smooth outer walls allow a secure identification.

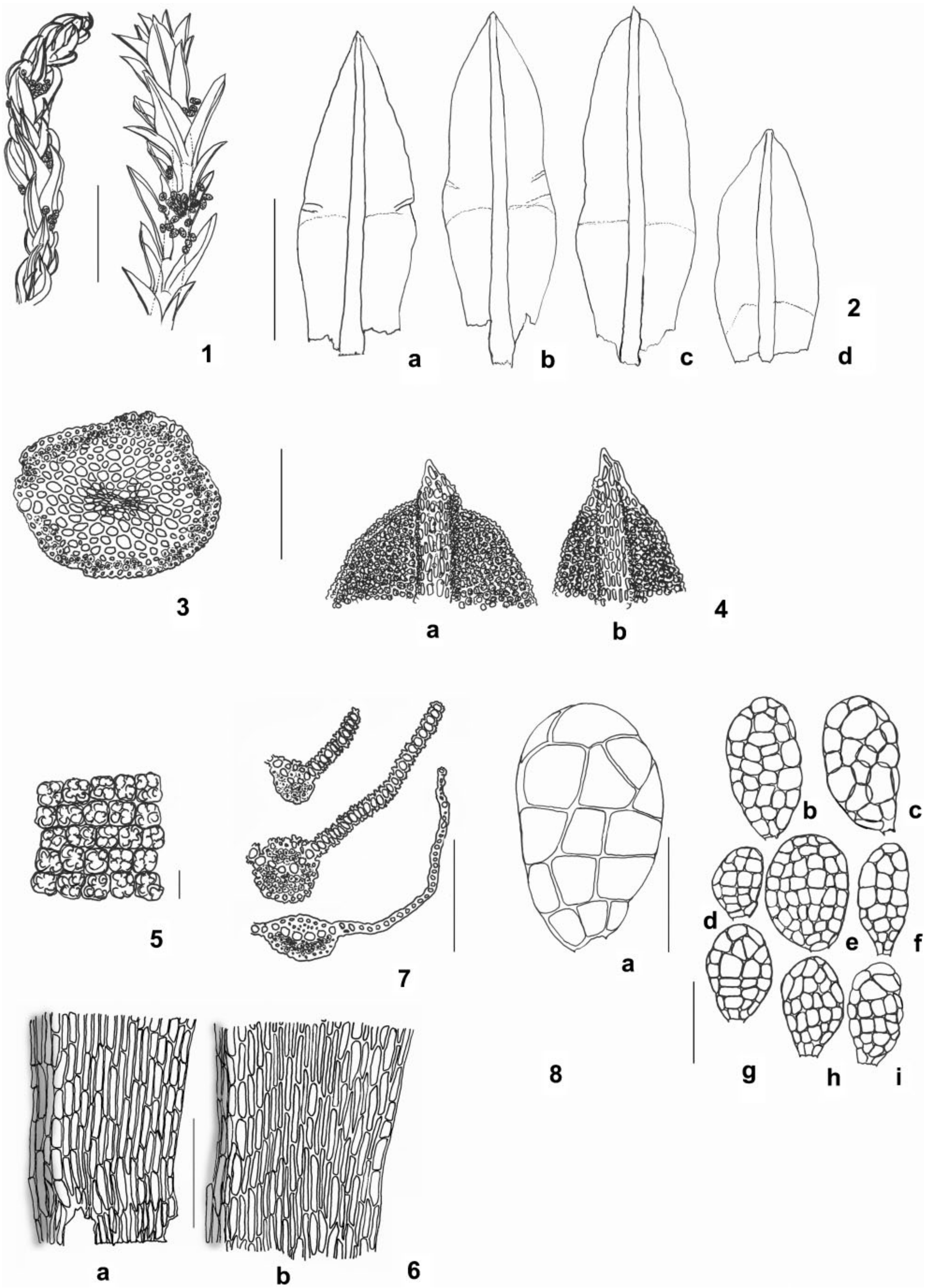

Figure 2. *Barbula amplexifolia*: (1) habit when dry (left) and moist (right); (2a–d) leaves; (3) stem cross-section; (4) leaf apices; (5) detail of upper lamina; (6) basal leaf cells; (7) stem leaf cross-sections from the upper, middle and basal part; (8a–i) axillary gemmae. Scale bars: 1=1 mm; 2=500 μm; 3, 4, 6, 7, 8b–i=100 μm; 5=10 μm; 8a=50 μm. All drawn by J. Kučera from European material: 1 from *Köckinger 99-1125*; 2a from *Köckinger 11361*; 2b, c, 4a from *Köckinger 03-576*; 2d, 8e from *Köckinger 11365*; 3, 4b, 6b, 7, 8a, b, d, f-h from *Köckinger 11368*; 5, 8f, i from *Kučera 12472*; 6a from *Köckinger 11235*; 8c from *Köckinger 11344*.

Barbula crocea is the closest relative of *B. amplexifolia* in Europe and has a similar colouration, leaf shape and areolation, but the commonly present, distinctly larger ($\pm$200–500 μm long), multicellular, greenish to brown and mostly beaked gemmae, with conspicuously protuberant, thick-walled outer walls are strikingly different. The extraordinarily small gemma size given in Garilleti (2006) is erroneous (R. Garilleti, pers. comm.). The leaves of *B. crocea* are mostly distinctly toothed distally and normally much larger when growing in mixed stands. In xeromorphous, small-leaved modifications marginal teeth are sometimes absent. Such a morph, potentially synonymous with *B. amplexifolia*, was described as *B. funckiana* Schultz from the Austrian Alps and we therefore tried to get the type material of this taxon, but it was not available in ROST or B, where Schultz's herbarium should have been located. However, since Limpricht (1890) mentioned the presence of sporophytes and a rocky habitat, while the European *B. amplexifolia* is not known with sporophytes and avoids growing directly on rock, we are convinced that it was correctly synonymized with the variable *B. crocea*. The Japanese *B. hiroshii* K.Saito, questionably specifically distinct from *B. crocea*, differs by the same combination of characters but has more strongly toothed leaf margins and a slightly different leaf shape.

Barbula amplexifolia was often confused with the non-European, mainly Asian *B. gregaria* (Mitt.) A.Jaeger, which we, along with the view of Zander (1979), consider to be synonymous with the Japanese *B. horrinervis* K.Saito, due to numerous transitional morphs. *Barbula gregaria* is, according to our observations, most easily differentiated by its hardly sheathing leaf base, sometimes slightly recurved basal leaf margins, nearly lingulate apical leaf part, stout, dorsally markedly protuberant (cross section circular) and always strongly papillose costa, which is excurrent in a stout mucro (rarely percurrent to ending shortly below the apex), mostly larger lamina cells with distinctly c-shaped papillae, and the axillary gemmae greenish to brown, multicellular and beaked like those in *B. crocea* and *B. hiroshii* but rather smooth and nearly always bigger (100–180 $\times$ 150–280 μm) than in *B. amplexifolia*. Sollman (2000) considered *B. gregaria* to be 'identical with or very near *B. amplexifolia*', although he did not propose the formal synonymy of the two taxa. We were, however, unable to find any transitional plants that could not be assigned either to *B. amplexifolia* or *B. gregaria*, in both cases according to our broad circumscriptions, apart from a yet unnamed taxon, known to us from two remote localities in the high mountains of New Guinea and northern Canada, which shares some characteristics of both (see Discussion). Because of the absence of transitional morphs between that plant (probably a good species) and the other two, its existence cannot be used as an argument for uniting *B. amplexifolia* and *B. gregaria*.

The widespread *B. convoluta* var. *convoluta* is similar to *B. amplexifolia* in its yellowish coloration, but differs mainly in the slightly recurved leaf margins, the existence of only subterranean, brown gemmae on long rhizoids and the frequent production of sporophytes with long yellow setae. Another closely similar taxon is *B. convoluta* var. *gallinula* R.H.Zander, known only from northwestern North America, which is characterized by ovate leaves and extremely large, oval gemmae produced singly in leaf axils. Additionally, purplish and clavate (though mostly uniseriate) gemmae may mislead also to *Bryoerythrophyllum ferruginascens*, which, however, has distally much narrower, mostly somewhat reddish leaves with medially recurved margins.

Taxonomic discussion

Barbula amplexifolia was described as *Tortula amplexifolia* by Mitten (1859) from the Kumaon region of Uttaranchal in the Indian Himalayas. Later, Cardot (1904) described a new variety of *B. crocea* (as *B. paludosa* var. *coreensis*) from Korea but Saito (1975) was the first to provide a detailed description, based on both the type and numerous Japanese collections and raised it to the specific level as *B. coreensis* (Cardot) K.Saito. He also compared it with *B. amplexifolia* and *B. haringae* H.A.Crum, which was described only 20 years earlier from Arizona (Crum, 1956). Saito acknowledged that all three taxa form 'a distinct but coheren group within *Barbula*'. The putative differential characters among the three taxa were obviously based on a limited number of studied specimens; they can be found in various combinations in all of them and hence we must fully concur with Zander's proposals for synonymy (Zander, 1979, 1999; Mogensen & Zander, 1999).

The above-mentioned taxa within this broadly defined *Barbula amplexifolia s. l.* and their available descriptions cover in fact only a part of the whole variation. Interestingly, the plants closely matching the type of *B. amplexifolia* from the Indian and Nepali Himalayas on the one hand and the European plants (including some nearly identical morphs from the Russian Altai and Yakutia) occupy the remotest positions within the worldwide morphological variability, whereas the plants which closely correspond to the type of *B. coreensis* and the hardly different type of *B. haringae* are morphologically intermediate. The main characters of these morphs are summarized in Table 1. The differences observed between the 'typical' *B. amplexifolia* and the European or North American plants can only partly be explained by different environmental conditions (a monsoon-influenced mountain climate with two seasons versus a mountain climate of the temperate or subarctic zone) and must to a certain degree be genetically based. For example, the discrepancy between large leaves with small gemmae in *B. amplexifolia s. str.* versus small leaves and large gemmae in the European morph cannot be simply attributed to different climates. The pattern of genetic variability will nevertheless probably be very complex in the mountains of south-eastern Asia, as evidenced by the existence of a nearly full range of various intermediate morphs (e.g. in plant height, leaf length, degree of leaf base sheathing, papillosity of the dorsal costa surface, gemma size) in the Sino-Himalayan region. We believe that *B. amplexifolia* has its origin in this area since (besides Japan, see below) sporophytes are only known from here alongside with the greatest, seemingly reticulate (in terms of, for example, correlation between size of gemmae, plant and leaf size) pattern of morphological variation. This cannot be explained in terms of phenotypic plasticity along local ecological gradients but rather we expect a high degree of genetic diversification and perhaps even a speciation process, which is, however, only partly reflected in morphology. We observed a similar pattern of variability, though on much fewer samples in Japan, where the species reproduces generatively as well. Other populations (Altai, Yakutia, North America, Papua New Guinea, Greenland) are only known sterile and show little variation among the individual colonies, pointing towards a vegetative, clonal propagation. Seemingly controversial to this statement is the note of Zander (1979), describing the remarkable, putatively phenotypical plasticity in the size of gemmae among individual sods in Steere's collection from Virginia Falls of the Canadian Northwest Territories. A duplicate deposited in MO contains, besides an admixture of *B. convoluta* var. *gallinula*, a mixed stand of rather normal American *B. amplexifolia* and another plant with distinctly larger gemmae (140–180 × 180–260 μm). We are convinced that the shoots with large gemmae belong to another, probably undescribed taxon, with the leaf and costa shape close to stunted forms of *B. gregaria*, but with gemmae matching in shape and colour those of *B. amplexifolia*. It is of great interest that identical plants were richly collected from high altitudes (3500–4500 m) of Carstensz Mts, West Irian, Indonesia (*Hope* M42, M53B, M99, M127, M132A; herb. L, MO), not very far away from a collecting site of a relatively typical *B. amplexifolia* (small morph) in the Star Mts of Papua New Guinea (10.4.1975 leg. *Touw*, herb. L). After the exclusion of that unnamed taxon, *B. amplexifolia* becomes relatively invariable in North America, being in accordance with the lack of sporophytes on this continent.

The rather uniform European population might be the descendant of a vegetatively spread population, which probably originated from a very small number of individuals, adapted to harsh environments like those of the continental mountain ranges of Central Asia. This hypothesis is supported by the existence of the morphologically closest populations among *B. amplexifolia s. l.* in the Altai and Yakutia. Plants from northern Central Asia may have reached the Alps vegetatively by means of their gemmae across the cold Pleistocene steppes. This migration of plants during the Ice Ages is well-known for many Alpine vascular

Table 1. *Comparison of important characters of the European, south-Himalayan and the remaining Asian and North American morphs of* Barbula amplexifolia. *Representative specimens are listed in the Appendix.*

Character	European plants (Alps)	South-Himalayan plants (closely matching the type)	Other Asian (including Himalayan) and North American plants (mostly matching the types of *B. coreensis* or *B. haringae* but partly closer to the foregoing morphs)
Stem length	To 10(25) mm	To 40(50) mm, rarely shorter than 20 mm	To 15 (30) mm
Leaf length	(0.5–)0.7–1.6 mm	1.4–2.5(3) mm	(0.8)1.1–1.8(2.6) mm
Leaf orientation when dry	Straight or incurved to moderately bent	Distinctly bent to flexuose or slightly curled	Incurved to bent or slightly curled
Leaf apex	Narrowly to broadly cuspidate, usually gradually narrowed, lamina sharply keeled below apiculus, deeply grooved	In the uppermost leaves $\pm$ narrowly cuspidate, in lower leaves more abruptly narrowed, lamina mostly nearly flatly inserted	Narrowly to broadly cuspidate, gradually narrowed, lamina sharply keeled below apiculus, deeply grooved
Leaf base	Slightly to strongly sheathing, broader but not suddenly enlarged through shoulders	Strongly sheathing, suddenly enlarged through shoulders	Slightly to strongly sheathing, broader but usually not very suddenly enlarged
Costa in the apex	Percurrent to excurrent in short, sharp, cuspidate flat point, slightly toothed from sides	Excurrent in stout, smooth mucro	Percurrent to excurrent in short, sharp, cuspidate flat point, slightly toothed from sides
Basal lamina cells	35–80 μm long, walls up to 4 μm thick	35–50 μm long, walls to 2 μm thick	25–55(–75) μm long, walls to 2.5 μm thick
Gemmae	60–110 × 90–160(–210) μm, reddish-brown to purple, mainly ovoid but not rarely pyriform, clavate or less commonly short-ovoid to nearly spherical, with mostly slightly protuberant outer cells	(38–)48–65 × 60–90(–110) μm, brown to reddish-brown, mainly spherical to short-ovoid with smooth outer cells	In some populations only 38–55 × 50–75 μm, typically about 60–85 × 70–100 μm, in some populations 70–90 × 100–150 μm, reddish-brown to purple, short-ovoid to spherical (rarely elongate), smooth or with slightly protuberant outer cells
Sporophyte production	Not known	Occasionally present	Occasionally present

plants and has been postulated also for some mosses, including *Voitia nivalis* and *Oreas martiana* (Gams, 1932). Immigration by means of propagula could also explain the apparent occurrence of only one sex (female) in the European population.

As we are confronted with various transitions between the typical *amplexifolia*- and the *coreensis*-morph in the Sino-Himalayan region, whereas especially in northern Asia (Altai, Siberia) no clear discontinuities between the latter and the European morph exist, we were unable to delimit any infraspecific taxa within the species and also refrain from describing the European plant as a distinct entity, at least until we know more about the genetic background of the entire complex.

Ecology

The European plant is an early pioneer on gritty, calcareous soil in mountainous areas with a bedrock of limestone, dolomite, marble or calcareous schist. It mainly colonizes newly built forest or mountain roads, where it occurs on the taluses, as well as on rarely used pavements. It was rarely found also in calcareous alluvia. Interestingly, whereas *Barbula amplexifolia* is said to grow also on calcareous rock outside Europe, Alpine populations (unlike *B. crocea*) do not grow directly on rock surfaces, though they were rarely found on soil- or detritus-covered rock ledges. It is somewhat cryophilous and is therefore confined to north-facing slopes and ravines at lower altitudes. Only in the subalpine and alpine belt can it be found also on south-facing slopes in strongly insolated habitats. In the montane belt, it grows most frequently associated with widespread basi- and hygrophilous pioneers like *Dicranella varia*, *Didymodon fallax*, *Leiocolea badensis*, *Preissia quadrata*, *Pellia endiviifolia* and *Bryum pallens*. *Barbula crocea* is a rather common associate in the dolomitic areas of the Alps. Also the neglected *Trichostomum crispulum* var. *viridulum* grows in this habitat, and often forms mixed stands with it. After some years, as with every true pioneer, *B. amplexifolia* is overgrown at such sites by vascular plants or pleurocarpous mosses, e.g. *Campylium stellatum*, *Ctenidium molluscum* or *Cratoneuron filicinum*. With increasing altitude it is found more frequently in natural habitats but mostly in smaller populations with dwarf plants, and it is much more difficult to detect. Above the treeline, it mainly grows at the edges of footpaths or in gaps in pastures or alpine meadows, rarely in base-rich snow-beds. The accompanying flora is much more diverse than at lower elevations. Among the associates we find, for example, *Palustriella commutata* var. *sulcata*, *Distichium capillaceum*, *Amblyodon dealbatus*, *Catoscopium nigritum*, *Scapania cuspiduligera* or truly alpine mosses like *Cyrtomnium hymenophylloides*, *Myurella tenerrima* and *Timmia norvegica*. Table 2 shows the frequency evaluation of bryophytes associated with 30 specimens from Austria.

Table 2. *Frequency of associated bryophytes in collections from 30 Austrian localities in percent.*

Species	Frequency of occurrence (%)
Didymodon fallax	50
Dicranella varia	47
Leiocolea badensis	40
Campylium stellatum	37
Preissia quadrata	37
Trichostomum crispulum var. viridulum	33
Encalypta streptocarpa	30
Bryum pallens	23
Pellia endiviifolia	23
Leiocolea collaris	20
Aneura pinguis	17
Barbula crocea	17
Dicranella grevilleana	17
Cratoneuron filicinum	13
Ctenidium molluscum	13
Jungermannia atrovirens	13
Moerckia hibernica	13
Amblyodon dealbatus	10
Distichium capillaceum	10
Fissidens dubius	10
Palustriella commutata var. sulcata	10
Scapania cuspiduligera	10
Catoscopium nigritum	7
Calliergonella cuspidata	7
Calliergonella lindbergii	7
Ditrichum flexicaule s. l.	7
Pohlia wahlenbergii var. wahlenbergii	7
Further 14 species	each 3

Distribution

Barbula amplexifolia is currently known in Europe only from the Alps but may be discovered in the phytogeographically related Carpathians as well. The altitudinal amplitude in the Alps covers about 2000 m, ranging from 400 to 2430 m a.s.l. In calcareous regions of the Austrian Alps it proved to be rather widespread but nowhere frequent. Already aware of its existence, it has been collected in the Austrian Alps at more than 50 localities since 1998, whereas only three earlier

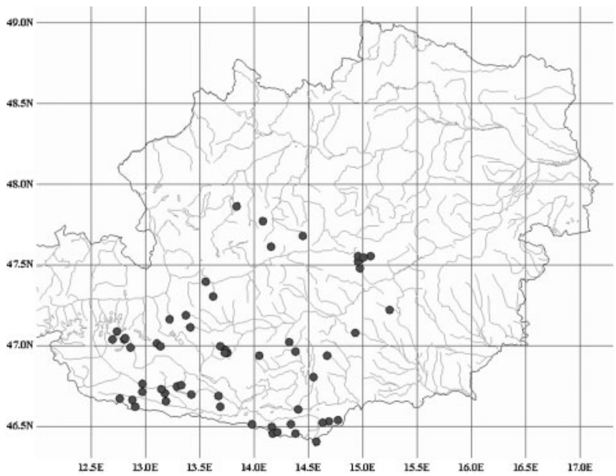

Figure 3. Known distribution of *Barbula amplexifolia* in Austria.

collected, misnamed herbarium specimens emerged (see Appendix). Figure 3 shows the known distribution in Austria which, however, gives a somewhat artificial impression of the regional frequency. The accumulation of dots in the southern part of Austria results from the Carinthian Bryophyte Mapping Project, carried out by H. Köckinger and co-workers in recent years. Based on detailed information by the first author it was recently also found in the Bavarian Alps close to the Austrian border (K. Offner, in prep.). The only known locality from the western Alps comes from a revision by P. Sollman, who in 2004 detected a specimen (under *B. crocea*) in L, collected by H. Greven in 1990 in Switzerland. Generally it has to be expected in all calcareous regions of the Alps.

Because of the numerous new gatherings, we made only limited efforts to search for old specimens (the oldest one we saw was collected by F. Koppe in 1962) but they may lie misnamed in public herbaria. An exemplary revision of *Barbula crocea*, *B. convoluta* and *Barbula* sp. (about 60 specimens) in herbarium LI, containing representative collections from the northern Alps, resulted in no old specimens and only one rather recent one being found. We are convinced that it was widely overlooked, as sterile Pottiaceae were infrequently collected by earlier bryologists.

The late discovery of this easily recognizable moss and its preference for man-made habitats may lead to the assumption of a recent introduction. This assumption can nevertheless be refuted by the existence of populations in natural alpine environments and the fact that a recent introduction from the remote area of Altai and Yakutia, where nearly identical morphs occur, seems very unlikely. The current abundance in Austria is a consequence of the extensive forest road construction in the last decades, where this earlier 'probably much rarer species' found perfect habitat conditions. *Bryoerythrophyllum ferruginascens*, a rather rare element in natural habitats of the Alps, could be a similar case. It was able to extend its distribution area enormously due to human alterations of the landscape during the last decades. In both cases, dispersal via propagula proved to be very successful. Spreading caused by changes in habitat availability is also known from Northern Europe, where, for example, *Pogonatum dentatum* has spread widely in the lowlands due to modern forest management (Hassel, 2000), though by means of spores.

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APPENDIX

List of representative specimens studied

The complete list will be sent on request by JK.

1. European *Barbula amplexifolia*

AUSTRIA: **Carinthia**: Hohe Tauern Mts: E. of Mt Grossglockner, Pasterze, *Köckinger 11365* (KL); Nockberge Mts: Zunderwand W. of Erlacherhütte, *Köckinger 03–576* (KL); Drautal: Fellbach, *Köckinger 11235* (KL); Gailtaler Alpen: Kirchbachgraben, *Köckinger 11237* (KL); Bad Bleiberg N.W. of Villach, *Köckinger 11368* (KL); Karawanken Mts: Gratschenitzengraben S. of Rosenbach, *Köckinger 11344* (KL); Bärental S. Feistritz, *Köckinger 98–1122* (KL); S. of Globasnitz, Metnik, *Köckinger 02–252* (KL); Suchatal N.W. Oistra, *Suanjak 2119* (priv. herb., KL); **Salzburg**: Pongau: Mandling, untere Zaimwände, 8.7.1962, F. Koppe sub *B. convoluta var. propagulifera* (herb. Düll); Reitalpenbachtal above Hüttschlag, 1.8.1982, R. Düll (priv. herb.); Radstädter Tauern Mts: Rieding valley, *Köckinger 99–1125* (GZU); **Styria**: Totes Gebirge: Kirchfeld S.W. Hochmölbing, *Kučera 12472* (CBFS) & *Köckinger 11412* (GZU); Hochschwab: Lamingalm, *Köckinger 11513* (GZU); Stubalpe: Altes Almhaus, *Köckinger 11482* (GZU); Grazer Bergland: Guggenbach, 1.5.1989, M. Suanjak (LI); **Tirol**: Hohe Tauern: Ködnitztal S.W. of Mt Grossglockner, 1998, *Kučera 7112* (CBFS); **Upper Austria**: Mt Traunstein: Lake Laudach, 22.9.2001, G. Schlüsslmayr (priv. herb., GZU);

SWITZERLAND: **Valais**: Evolène, Ban de Lana, 23.7.1990, H. C. Greven sub *B. crocea* s. n., rev. P. Sollman 2004 (L);

Duplicates in the private herbaria of the authors.

2. 'Typical' *B. amplexifolia* from the southern Himalaya

INDIA: **Uttaranchal**: Kumaon region: Strachey & Winterbottom s.d. (NY) – Holotype; Nainital, 28.1.2002, Hallingbäck (priv. herb., dupl. CBFS); Tehri-Gahrwal, Lambatach, 3.5.1889, J. F. Duthie (NY); Mussoorie, IX.1899, J. F. Duthie (NY); Mussoorie, Kempti valley, 4.9.1889, J. F. Duthie (NY); Mussoorie, Arnigadh, 13.12.1895, W. Gollan (NY); Mussoorie, Charleville Hotel, 29.11.1903, W. Gollan (NY); N.W. Himalaya, Falconer s.d. (NY, L);

3. Other Asian and North American plants of *B. amplexifolia*

PAKISTAN: Sari-Kaghan valley, 1970, H. de Haas (L)

NEPAL: Ghorapani forest, *ca* 16 km N.W. of Pokhara, 9.11.1978, F. G. Davies (L); Phulchowki, S.E. of Kathmandu, 1.3.1992, C. C. Townsend (E); Rasuwa Distr.: above Thulo Syabru, 10.10.2001, D. G. Long (E); Nuwakot Distr.: Thare Danda ridge S. of Thare Pati, 1.5.1992, D. G. Long (E)

CHINA: **Yunnan:** Diqing Pref., Chung Jiang He valley, 17.6.1993, D. G. Long (E); Kunming Pref.: Xishan (Western Hills) Forest Park S.W. of Kunming, 21.5.1993, D. G. Long (E); **Sichuan**: Emei Xian: trail to Golden Summit, 22.8.1988, B. Allen (MO); Mt Omei Shan S.W. of Chengdu, 24.10.1980, A. Touw (L)

RUSSIA: **Altai Mts**: Chemal, 5.8.1991, M. S. Ignatov (MO); Kamga river basin, Bolshoy Shaltan Creek, 7.6.1989, M. S. Ignatov (MO); **Rep. Sakha/Yakutia**: Ust'-Maya District, Selyakh Creek W. of Allakh-Yun', 30.8.2000, M. S. Ignatov (MHA); Khlebnyi Creek 20 km E. of Yugorënok, 7.9.2000, M. S. Ignatov (MHA)

JAPAN: Saitama Pref., Ogamata River, 19.8.1970, K. Saito (L); Chichibu, Ochigawa River Nishigani, 26.4.1974, K. Saito (L); Chichibu Mts, near Okigo-daira, 6.10.1959, L. Nagano & Z. Iwatsuki (L)

PAPUA NEW GUINEA: West Sepik Distr., Star Mts, Tel Basin, 10.4.1975, A. Touw (L)

CANADA: **Northwest Territories**: Mackenzie District: Virginia falls, South Nahanni River, 13.7.1976, W. C. Steere (MO); Liard Range, 7th peak S. of 4924' mtn., 3.8.1977, D. H. Vitt (MO); **British Columbia**: Bridal Veil Falls Prov. Park, 20.7.1980, R. H. Zander (MO)

USA: **Arizona**: Cochise Co., W. of Huachuca Reserve, 31.10.1949, *L. N. Gooding 85*, (CANM – holotype of *B. haringae*, MO – paratype); South Huachuca Canyon, 24.2.1950, *L. N. Gooding 293* (MO, CANM, paratypes of *B. haringae*)

GREENLAND: Ella Ø. Solitærbugt, 23.8.1958, K. Holmen (C)

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