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# *Bryoerythrophyllum duellii* Blockeel (Bryophyta: Pottiaceae), a new moss species from Greece and Cyprus, and its molecular affinities

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A moss first collected on Crete by Prof. Ruprecht Düll in 1976 but never satisfactorily identified is described as a new species, *Bryoerythrophyllum duellii*. It is known from five localities in Greece and Cyprus. It belongs to the *B. recurvirostrum* group, and its status as a distinct taxon is supported by molecular data. The molecular relationships of the genus *Bryoerythrophyllum* are discussed, and they suggest that the genus is monophyletic only if *Erythrophyllopsis*, *Mironia* and *Saitobryum* are included. The *B. recurvirostrum* and *B. wallichii* groups apparently form a young complex of taxa that are not very diverse molecularly, but sometimes have a distinctive morphology. *Bryoerythrophyllum duellii* is one of several lineages within this complex that may have experienced a longer period of reproductive isolation leading to the fixation of distinctive morphological and molecular features.

**Keywords:** Eastern Mediterranean, Pottiaceae, *Bellibarbula*, *Bryoerythrophyllum rotundatum*, *Bryoerythrophyllum wallichii*, *Erythrophyllopsis*, *Mironia*, *Rhexophyllum*, *Saitobryum*, ITS, *rps4-trnS*, *trnM-trnV*

## Introduction

In 1976 the late Prof. Ruprecht Düll collected a species of *Bryoerythrophyllum* P.C.Chen growing on schist rocks in a valley south of Skines in western Crete. This was originally identified as *B. jamesonii* (Taylor) H.A.Crum by Richard Zander and this identification is the basis for the inclusion of *B. jamesonii* in Prof. Düll's distribution catalogue of European bryophytes (Duell, 1984). At the time of the original identification Zander's concept of *B. jamesonii* was broad, and the occurrence of the species in Europe was soon considered doubtful. In the update to his catalogue, Duell (1992) noted that the record from Crete 'does not belong to this [*B. jamesonii*] but to an undescribed taxon'. However his material was too sparse to be described formally. In his recent account of the bryophytes of the Aegean islands (Düll, 2014) he listed the Cretan plant as *Bryoerythrophyllum jamesonii* aff., noting that there was disagreement among bryologists about its status.

During a visit to Greece in 1988, the first author (TLB) collected a similar moss on Mt Hymettos near Athens but, like the Cretan specimen, it lacked

capsules. Nine years later, in 1997, he collected further plants of the same taxon on a rock ledge on the lower slopes of Mt Kionia in Cyprus. The absence of sporophytes in these collections made the status of the plant difficult to evaluate. Subsequently, however, TLB found fertile populations in the Paphos Forest on Cyprus in 2003 and more recently on the Aegean island of Ikaria in 2014. Study of the collections has shown that they agree closely with Prof. Düll's plant and that they do not match any of the seven *Bryoerythrophyllum* species currently known from Europe and the wider Mediterranean region (Hodgetts, 2015). In order to investigate the molecular affinities of the unidentified taxon, TLB consulted the second author (JK), who performed a molecular analysis and evaluated the data on a phylogenetic basis. The molecular analysis incorporated data obtained by the third author (VF). The analysis provided evidence that the taxon from Greece and Cyprus forms a well-supported lineage nested within the *B. recurvirostrum* group.

## Materials and Methods

**Molecular sampling of taxa:** To date, the molecular relationships of the genus *Bryoerythrophyllum* on a

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larger scale have only been investigated by Fedosov & Ignatova (2008). Their treatment covered all Russian taxa of the genus and their affinities were assessed using the hypervariable nuclear ITS region. The treatment of *Erythrophyllopsis* Broth. by Cano et al. (2010) included three South American taxa of the genus and revealed members of that genus nested in *Bryoerythrophyllum* based on the data from two chloroplast loci. Therefore we decided to add chloroplast data for a selection of taxa including accessions sampled in the dataset of Fedosov & Ignatova (2008), and complete it with a wider selection of taxa within *Bryoerythrophyllum* and genera morphologically similar to it (*Erythrophyllopsis*, *Bellibarbula* P.C.Chen, *Mironia* R.H.Zander, *Saitobryum* R.H.Zander, *Rhexophyllum* Herzog) that have not been sampled previously. Although Cano et al. (2010) sampled *trnL-trnF* and *trnG* regions, we decided to continue sampling of *rps4-trnS* and *trnM-trnV* regions, successfully applied in our earlier studies, as JK's library of molecular data from these loci is substantially more representative. The final dataset includes 16 species of *Bryoerythrophyllum*, two species of *Bellibarbula*, and one species each of *Erythrophyllopsis*, *Mironia*, *Saitobryum* and the monotypic *Rhexophyllum*. A full list of specimens is included in the Appendix to this paper.

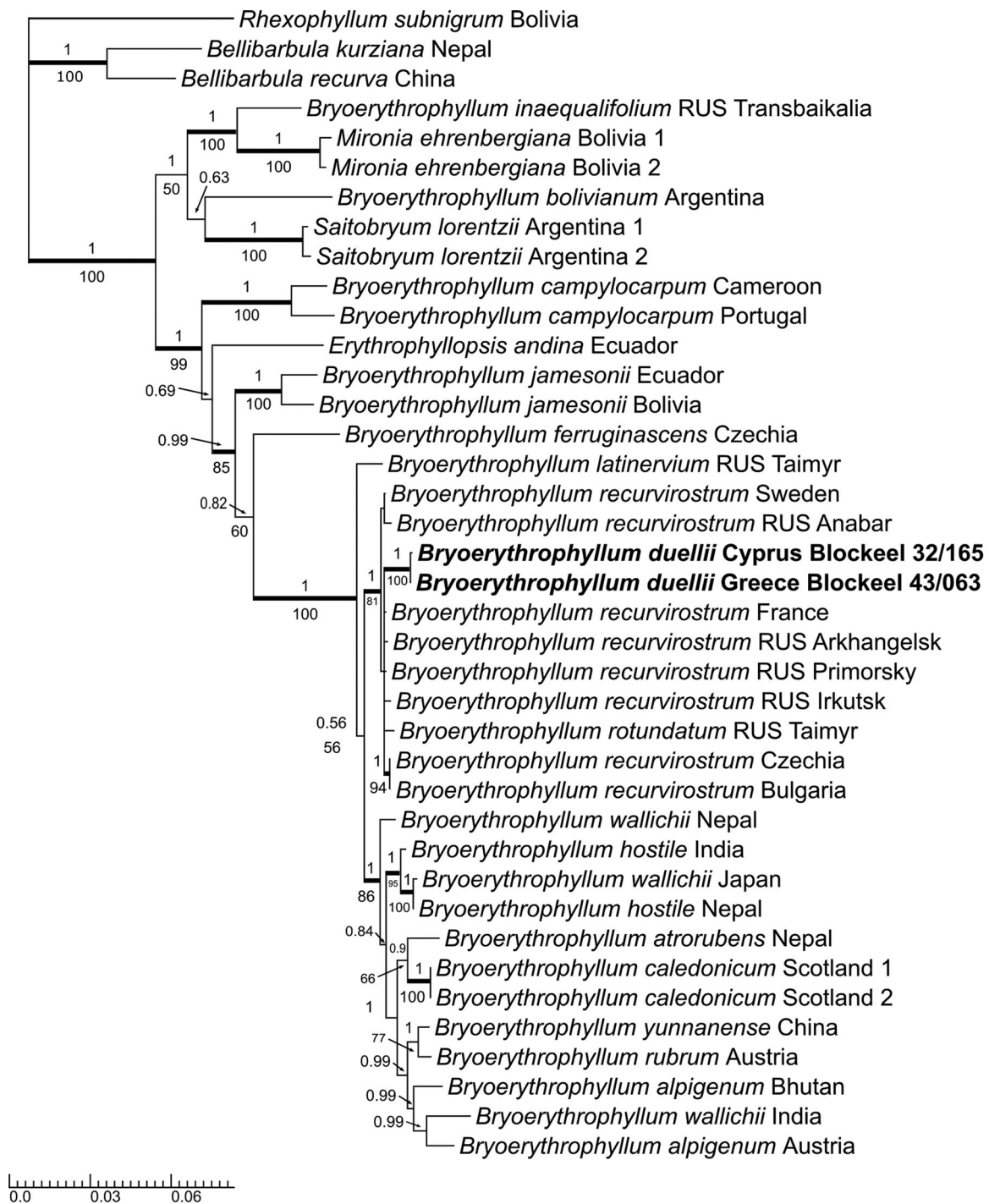
**Molecular protocols:** DNA extraction, amplification and sequencing of the target regions (ITS, *rps4-trnS*, *trnM-trnV*) performed by JK followed the protocols described in Köckinger & Kučera (2011) and Kučera et al. (2013), respectively. VF followed the protocols described by Gardiner et al. (2005). When the direct reading of ITS sequences was not possible due to the existence of mixed templates suggesting the presence of paralogs, we performed molecular cloning to obtain individual sequence variants (marked with an asterisk in the Appendix). The cloning procedures are described in detail in Košnar et al. (2012). For the subsequent analysis, the most common ITS variant was used; when the variants were equally represented, our choice was arbitrary.

**Sequence editing, alignment and data analysis:** The raw sequences obtained were edited and aligned using the procedures and software described in Kučera & Ignatov (2015). As the published affinities of *Bryoerythrophyllum* are rather ambiguous, the procedure for selection of outgroups at first included the alignment of all representatives of Pottioideae from public sources (GenBank) and the sequence library of JK. However, the alignment of ITS proved hardly possible due to large non-homologous sequence parts occurring e.g. in representatives of *Leptodontium* (Müll.Hal.) Hampe ex Lindb., *Barbula* Hedw., *Pseudocrossidium* R.S.Williams, *Didymodon* Hedw., *Tortula* Hedw., *Syntrichia* Brid., *Cinclidotus*

P.Beauv. and others. We therefore restricted the selection of outgroups to two of the lineages within Pottioideae which were of obvious interest to this study on morphological grounds and could be aligned reasonably well with the ingroup taxa. These lineages included the genera *Rhexophyllum* and *Bellibarbula*. Both of them seem to represent parallel lineages to the ingroup taxa based on the preliminary results from the chloroplast dataset. Chloroplast and nrITS data were first evaluated separately, but given the nearly identical topology from the separate analyses (available on request from the authors) we present results only from the analysis of a concatenated matrix, with partitions corresponding to ITS data, chloroplast data as a whole and indel data scored using the simple indel coding method (Simmons & Ochoterena, 2000). Phylogenetic analyses were performed using the Bayesian inference (BI) in MrBayes v. 3.2.6 (Ronquist et al., 2012) and maximum likelihood (ML), computed using the RAxML v. 8.2.4 (Stamatakis, 2014). For the analysis settings, see Kučera & Ignatov (2015).

## Results and Molecular Affinities

The genera *Bryoerythrophyllum*, *Erythrophyllopsis*, *Mironia* and *Saitobryum* form a strongly supported clade of related taxa, although its coherence must definitely be tested, as there are still many taxa, both in *Bryoerythrophyllum* and other Pottioideae, which were not available to our study. According to the results of the phylogenetic analysis of the concatenated dataset (Figure 1), the genus *Bryoerythrophyllum* in its current circumscription is monophyletic only after *Erythrophyllopsis*, *Mironia* and *Saitobryum* are included. The position of *Saitobryum* appears least certain, with results from some analyses (such as the ITS data alone with some versions of the alignment) suggesting a slightly supported sister position of *Saitobryum* to the rest of the taxa (*Bryoerythrophyllum*, *Erythrophyllopsis* and *Mironia*). Basal taxa of *Bryoerythrophyllum* are mostly South American ones extending occasionally to other regions, such as *B. campylocarpum* (Müll.Hal.) H.A.Crum, *B. jamesonii*, *B. bolivianum* (Müll.Hal.) R.H.Zander or *B. inaequalifolium* (Taylor) R.H.Zander, and they appear interspersed on the phylogenetic tree among species of *Erythrophyllopsis*, *Mironia* and *Saitobryum*. Most Eurasian *Bryoerythrophyllum* species, including the genotype, *B. recurvirostrum* (Hedw.) P.C.Chen, form a well-supported clade with remarkably small molecular divergences. Indeed, the chloroplast sequences of *B. wallichii* (Mitt.) P.C.Chen, *B. hostile* (Herzog) P.C.Chen, *B. rubrum* (Jur. ex Geh.) P.C.Chen, *B. yunnanense* (Herzog) P.C.Chen, *B. atrorubens* (Besch.) P.C.Chen and *B. caledonicum* D.G.Long differ from each other only in rare and unique one-base substitutions and the



**Figure 1** Phylogenetic tree, rooted with *Rhexophyllum subnigrum*, based on the BI on the concatenated dataset, partitioned among nrITS, chloroplast (*rps4-trnS* + *trnM-trnV*) and indel data. Posterior probability from BI is displayed above the branches, bootstrap support (500 replications) from ML analysis is displayed below the branches. Solid branch lines displayed in bold denote high support from both BI (>0.95) and ML (>85).

branching pattern in the presented cladogram is driven solely by the divergence in ITS sequences. Within the *B. recurvirostrum* clade, *B. latinervium* (Holmen) Fedosov & Ignatova seems to occupy the basal position. The rest of the taxa cluster into two clades. The first one contains monoicous taxa of the *B. recurvirostrum* group consisting of *B. recurvirostrum*, *B. rotundatum* (Lindb. & Arnell) P.C.Chen and the newly described species *B. duellii*. The second clade contains dioicous taxa of the

*B. wallichii* group, morphologically similar to *B. wallichii* or even regarded as synonymous with it (*B. caledonicum*, *B. atrorubens*, *B. hostile*), and taxa which are morphologically more similar to *B. recurvirostrum* on the basis of narrow leaf apices and hardly differentiated marginal leaf cells (the monoicous *B. alpigenum* (Venturi) P.C.Chen, and dioicous *B. rubrum* and *B. yunnanense*).

The taxon here described as *Bryoerythrophyllum duellii*, represented by two accessions in the dataset,

seems to form a well-supported lineage nested within the *B. recurvirostrum* group. Particularly the ITS sequences contain multiple synapomorphic substitutions and indels within the group, resulting in the relatively long branch of the *B. duellii* clade. A parallel situation might apply to *B. rotundatum*, another morphologically well-defined taxon which seems to be molecularly nested within the *B. recurvirostrum* group.

## Taxonomy

### *Bryoerythrophyllum duellii* Blockeel, sp. nov.

(Figures 2–3)

**Diagnosis:** Related to *B. recurvirostrum*, but differing in (1) its lingulate leaves, 2.4–5 times longer than wide, with rounded or broadly obtuse, occasionally apiculate, apices, (2) leaf margins less strongly recurved, to 1/2–4/5 the leaf length, (3) the peristome rudimentary, with fragile teeth up to 100 µm long.

**Description:** *Stems* to 1 cm tall, in section with a wide central strand, hyalodermis absent. *Rhizoids* pale to dark brown, smooth. *Leaves* opaque, mid-green when young, becoming brown or orange-brown with age. Lowermost leaves ovate-lanceolate to ovate-lingulate, obtuse. Upper leaves to 2.5 mm long, lingulate, almost parallel-sided or slightly tapered, weakly to distinctly expanded at the base, mostly 2.4–5 times longer than wide, apex rounded to broadly pointed, sometimes with a small apiculus and often slightly cucullate; leaf margins recurved to 1/2 to 4/5 the length of the leaf, with a few teeth, notches or irregularities near the leaf apex, the teeth when well-developed consisting of projecting, sharp-pointed, thick-walled, smooth cells, sometimes forming a group at the tip of the leaf; margins more rarely ± entire. *Leaf lamina* unistratose; median leaf cells quadrate, 7–12 µm wide, densely and obscurely multi-papillose; marginal cells not differentiated; basal cells strongly differentiated, the inner and paracostal cells hyaline or pale yellow, short to long rectangular, mostly 30–80 µm long, smooth, with colourless or yellowish walls; marginal basal cells narrower, usually long rectangular but occasionally shortly so, often chlorophyllose, with the walls not thicker than those of the inner cells. *Nerve* single, ceasing shortly below the leaf apex or percurrent, stout, to 120 µm wide, typically 1/6 to 1/4 width of leaf at base, in section with a hydroid strand, and 1–3 layers of ventral and 3–5 layers of dorsal stereids; cells on ventral nerve surface similar to adjacent laminal cells; dorsal epidermis of nerve weakly differentiated, the cells elongate to linear in surface view with scattered simple papillae. *Rhizoidal tubers* and vegetative propagules not seen, apparently absent.

*Synicous.* Perichaetial leaves similar to vegetative leaves, but more broadly expanded at the base. *Capsules* narrowly ellipsoid, ca 1.75 mm long

(excluding the lid). Lid conical with inclined beak, 0.5–0.7 mm long. Annulus of large inflated cells. *Peristome* rudimentary, basal membrane low, slightly projecting above capsule mouth; teeth paired, fragile and often partly broken, to 100 µm long, papillose. *Spores* 18–25 µm.

**Etymology:** The new species is named after the late Prof. Ruprecht Düll, its original finder, in recognition of his extensive bryological field work in Greece.

**Holotype: Cyprus:** western Troodos: along the road from Kannaviou to Stavros, from the Panagia road junction north to Agia, in extended low patches on earthy bank by forest road, ca 500–600 m alt., 21 April 2003, *T. L. Blockeel* 32/164 (E).

**Paratypes:** All specimens in Priv. Herb. *T. L. Blockeel*, except where stated otherwise. **Cyprus:** western Troodos: along the road from Kannaviou to Stavros, from the Panagia road junction north to Agia, with sporophytes, 21 April 2003, *T. L. Blockeel* 32/165 (dupl. in CBFS), and 32/166; eastern Troodos: lower slopes on NE side of Mt Kionia, SW of Kapedes, on soil on rock ledge in deep valley, 28 March 1997, *T. L. Blockeel* 26/149. **Greece:** Ikaria: stream valley west of Steli, 37°35.62'N, 26°09.06'E, in earthy rock crevices on steep bank in ravine, ca 290 m alt., with sporophytes, 7 March 2014, *T. L. Blockeel* 43/063 (dupl. in CBFS); Attiki: Mt Hymettos (Imitos), near Kesaraini Monastery, among dry rocks in scrub, April 1988, *T. L. Blockeel* 17/307; Crete: creek valley below Hosti in the direction of Skines, *Erica arborea* L. vegetation in side valley on light and wet siliceous rocks (Tonschiefer), ca 300 m s.m., 14 April 1976, *R. Düll*, dupl. ex Herb. R. Düll.

**Differentiation:** When well-developed, *Bryoerythrophyllum duellii* is readily recognised as distinct from the widespread *B. recurvirostrum*, even in the field. It differs from the latter in several morphological characters: (1) the lingulate shape of the leaves with rounded or broadly pointed apices (typically linear-lanceolate and acute or obtusely pointed in *B. recurvirostrum*), (2) the leaf margins less strongly recurved, often only to 2/3 the leaf length, occasionally to 4/5 (recurved almost to the leaf apex in *B. recurvirostrum*) and (3) the peristome teeth rudimentary and fragile, to 100 µm long (well-developed, to 300 µm in *B. recurvirostrum*).

*Bryoerythrophyllum duelli* is perhaps more likely to be confused with *B. campylocarpum*, which is currently known only from Madeira and Portugal in Europe (Hodgetts, 2015). It has leaves that are typically linear-lingulate in shape, narrower than in *B. duellii*, and generally with an acute apex, occasionally broadly so. Microscopically it differs in having elongate ventral cells overlying the nerve in the lower and middle part of the leaf, though this character is

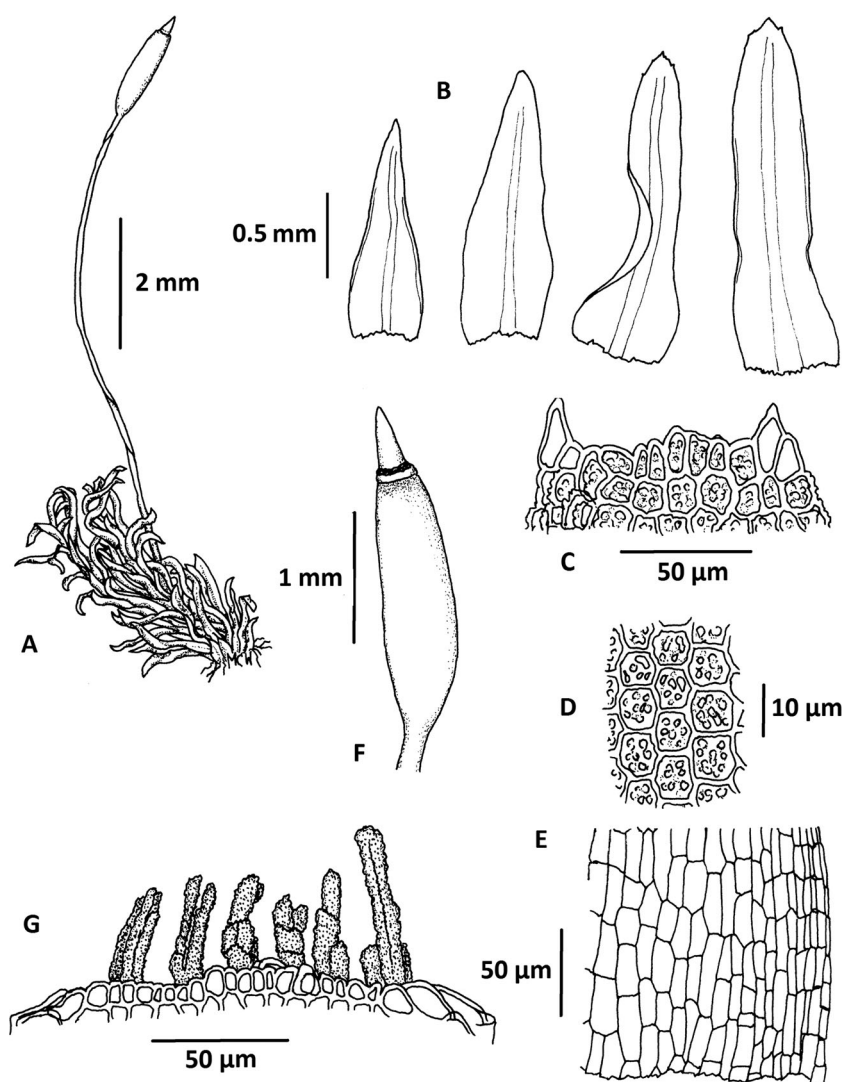


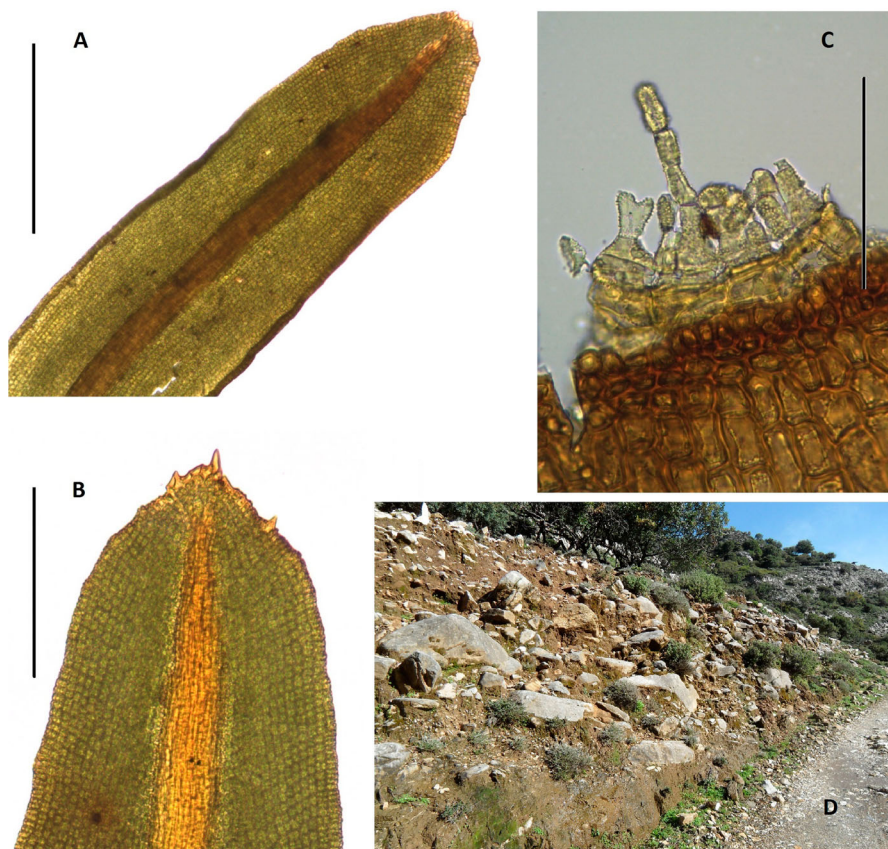
Figure 2 *Bryoerythrophyllum duellii* Blockeel. (A) Habit. (B) Lowermost and upper leaves. (C) Leaf apex, with two projecting teeth. (D) Median leaf cells. (E) Basal leaf cells. (F) Capsule. (G) Capsule mouth and peristome. Drawn by Malcolm Watling (A, B, F and G) from Blockeel 32/164 and (C, D and E) from Blockeel 43/063.

variable and in some specimens elongate ventral cells are present only up to mid-leaf. The basal marginal cells of *B. campylocarpum* have the walls slightly to markedly thicker than the inner basal cells, and the inner basal cells are typically bulging and  $\pm$  calymeroid. The leaf margins are only slightly recurved in the lower 1/5 to 1/3 of the leaf. It also differs in its sexuality, being dioicous, and in its well-developed peristome teeth. Sporophytes are unknown in European material but according to Gallego (2006) the teeth are 200–225  $\mu\text{m}$  long in the type specimen.

Three other *Bryoerythrophyllum* species in Europe are relatively small in stature like *B. duellii* and have leaves that are typically less than 4 times longer than wide. In other characters they are clearly distinct from it. *Bryoerythrophyllum inaequalifolium* has ovate to ovate-lanceolate leaves with entire margins and it has abundant, unicellular, light brownish gemmae in the leaf axils. *Bryoerythrophyllum ferruginascens* (Stirt.) Giacom. also has ovate-lanceolate, entire leaves, but is

distinct in the production of reddish rhizoidal tubers, which are probably always present, though sometimes sparse. It is dioicous and sporophytes are unknown in Europe. *Bryoerythrophyllum caledonicum*, the only European representative of the *B. wallichii* group, which is apparently endemic to Scotland, is also dioicous, and is the only European *Bryoerythrophyllum* in which the leaves have a differentiated border of incrassate, smooth or nearly smooth cells. It further differs from *B. duellii* in its ecology, occurring on permanently wet, calcareous schist rocks. The other taxon of the group, the Asian *B. wallichii* (including the morphologically intergrading and doubtfully distinct *B. hostile* and *B. atrorubens*) is often larger, with shoots to 4 cm tall and leaves to 4 mm long (Long, 1982). Like *B. caledonicum* it often tends to develop incrassate marginal leaf cells forming a distinct border, although this character is variably developed in individual plants.

*Bryoerythrophyllum rotundatum* is a synoicous species which, like *B. duellii*, is nested within the *B.*



**Figure 3** *Bryoerythrophyllum duellii* Blockeel. (A) Upper half of leaf, showing lingulate shape, rounded apex and plane upper leaf margins. Scale bar = 0.4 mm. (B) Apical part of leaf, showing irregular teeth. Scale bar = 0.2 mm. (C) Portion of peristome, showing basal membrane, several broken teeth and one intact segment. Scale bar = 100  $\mu$ m. (D) Habitat of *B. duellii* on Ikaria. (A) and (B) from Blockeel 43/063, (C) from Blockeel 32/165.

*recurvirostrum* group and is morphologically well-defined (Fedosov & Ignatova, 2008). It differs from *B. duellii* in its ovate-lanceolate leaves with rounded apices, similar in shape to those of *B. inaequalifolium*, and additionally in the absence of a peristome. It is an Asian species known only from Eastern Siberia (Russia).

**Distribution:** The new species is currently known only from the eastern Mediterranean region, with single localities in mainland Greece (Attica), western Crete and the Aegean Islands (Ikaria), and two localities on the island of Cyprus. It is likely to be present in Turkey.

**Ecology and habitat:** *Bryoerythrophyllum duellii* is a pioneer species of open or lightly shaded habitats. It grows on thinly vegetated soil, often on steep banks, typically in rocky terrain. The known localities are at modest altitudes (ca 300–600 m alt.) in Mediterranean environments. At these sites soils range from mildly acidic to slightly basic. Prof. Düll's gathering from Crete was from 'light and wet siliceous rocks' in a valley in *Erica arborea* vegetation. Phyllite and quartzite schists occupy a large part of western Crete, and Prof. Düll's collection came from these schists (Düll, 2014). The collection from Mt Hymettos in Greece was made among rocks in low

shrubby vegetation (phrygana). The rocks on this mountain are metamorphic and include both marbles and schists.

At its sites in Cyprus and Ikaria, the soils are derived from igneous or metamorphic rocks. On Mt Kionia in Cyprus, *B. duellii* was collected on soil on an unshaded rock ledge in a deep valley. The locality in the Paphos Forest, Cyprus, was in partial shade on the steep bank of a forest road. On Ikaria, scattered patches of the moss grew on soil among small boulders near a road in a stream gully (Figure 3D). The steep banks and slopes on which it occurs at these sites offer some protection from constant insolation.

Patches of *B. duellii* are often almost pure, but species intermixed in the herbarium specimens include *Grimmia meridionalis* (Müll.Hal.) E.Maier, *Tortella squarrosa* (Brid.) Limpr. and *Trichostomum crispulum* Bruch.

## Discussion

The molecular data generated for this study significantly expand our insights into the phylogeny of *Bryoerythrophyllum* and related genera, which were previously limited to the assessment of Fedosov & Ignatova (2008) based on ITS data of the species occurring in Russia, although their molecular

sampling included non-Russian accessions of these taxa as well. The groups around *B. recurvirostrum* and *B. wallichii* seem to create a young, molecularly little differentiated complex of taxa. These taxa nevertheless sometimes exhibit a very distinctive morphology, for example the tiny *B. caledonicum* with relatively broadly acute, bordered leaves, in contrast to the mostly robust *B. rubrum* with narrowly lanceolate, curled and hardly bordered leaves to 6 mm long. Several lineages within this group have probably experienced a longer period of reproductive isolation which has led to the fixation of distinctive morphological and molecular features. One of these lineages seems to be the new species described here, *Bryoerythrophyllum duellii*, and another might be the East Asian *B. rotundatum*, although we were not able to obtain additional molecular data from any recently collected specimens. Our data also point towards the existence of cryptic taxa in the *B. wallichii* group. While the molecular data of some specimens, morphologically attributable to *B. wallichii*, *B. hostile* and *B. atrorubens*, confirm the views of Saito (1975) and Sollman (2005) in claiming the identity of these taxa, other accessions, although hardly differing morphologically, seem to represent distinct molecular lineages. A similar situation seems to occur among specimens morphologically identifiable as *B. alpigenum*. Parallel situations where morphologically distinct taxa show only slight molecular divergence and at the same time the molecular diversity is not matched by morphological divergence have been documented e.g. by Werner et al. (2005) in the genera *Weissia* Hedw. and *Trichostomum* Bruch, and by Kučera & Ignatov (2015) in *Didymodon* sect. *Rufiduli* (P.C.Chen) R.H.Zander.

The broader relationships of *Bryoerythrophyllum* are less clear. While *Bellibarbula* seems to be relatively distinct from the rest of the *Bryoerythrophyllum* species analysed, representatives of the South American genera *Saitobryum*, *Mironia* and *Erythrophyllopsis* form a paraphyletic grade together with species, also mostly South American, currently recognised in *Bryoerythrophyllum*, including *B. bolivianum*, *B. inaequalifolium*, *B. ferruginascens*, *B. campylocarpum* and *B. jamesonii*. It would be premature at this stage to judge whether it is more appropriate to retain a broad concept of *Bryoerythrophyllum* or to recognise the segregate genera *Saitobryum*, *Mironia* and *Erythrophyllopsis*, which would necessitate a generic transfer of the relevant *Bryoerythrophyllum* species. However we can anticipate future taxonomic changes among those taxa, pending a more detailed and focused study on this issue.

Our data again confirm that morphology alone does not provide sufficient information for the assessment of phylogenetical relationships, due to the high

degree of homoplasy among morphological characters. At a higher systematic level, this can be nicely illustrated by a comparison with the morphologically based cladistic treatment of the Pottiaceae by Zander (1993), which positioned the genera *Erythrophyllopsis* and *Erythrophyllastrum* R.H.Zander (the latter synonymised with *Erythrophyllopsis* in the previous treatment by Cano et al., 2010) as one of the basal-most groups of Pottiaceae, recognised as a distinct subfamily Erythrophyllopsioideae. In contrast, we propose the inclusion of *Erythrophyllopsis* in the genus *Bryoerythrophyllum* [recognised within the subfamily Merceoideae by Zander (1993), but clearly belonging to Pottioideae based on molecular data]. The same would apply to subfamilies Gertrudielloideae and Chionolomoideae in the sense of Zander (1993), which can be merged with the subfamilies Pottioideae and Trichostomoideae, respectively, on the basis of the studies by Cano et al. (2010) and Alonso et al. (2016).

The bryophyte flora of Europe has been intensively studied for over two centuries and it is now rather unusual for a morphologically distinct undescribed species to be detected. However south-eastern Europe and western Asia have been less well explored and the presence of *B. duellii* indicates that there is potential for further interesting discoveries in these territories. The distribution pattern of *B. duellii*, as currently known, is unusual among the bryophytes of the Mediterranean region. The nearest parallel is with another recently described species, *Oncophorus dendrophilus* Hedd. & Blokkeel, originally discovered in Crete and Cyprus (Hedderson & Blokkeel, 2006) and recently reported from western Turkey (Yayintas, 2013).

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Taxonomic Additions and Changes: *Bryoerythrophyllum duellii* Blockeel, sp. nov.

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## Appendix: specimens examined and specimens used for molecular study

### Additional Specimens Examined

*Bryoerythrophyllum campylocarpum*. PORTUGAL. Algarve: Peso, N. of Monchique, Serra de Monchique 29S 0538775 4131523, on compacted soil of path through mixed *Castanea sativa* — *Quercus suber* woodland, 620 m alt., 1 April 2016, R.D. Porley. MADEIRA. Passo di Poisso, between Monte and Poisso, on slopes and rocks of the path, 11 November 1968, A. v. Hübschmann, ex Herb R. Düll. MEXICO. Querétaro: Sierra Gorda, La Cañada, near El Tejamanil, 21°06'54"N, 99°39'57"W, on soil of road cutting, dry *Pinus/Quercus* forest, ca 2480 m alt., 20 March 2001, D.G. Long & C. Delgadillo 29707. All in Priv. Herb. T.L. Blockeel.

### Specimens Used for the Molecular Study

Genbank accession numbers refer to ITS, *rps4-trnS* and *trnM-trnV* loci, respectively. ITS accessions marked with asterisk (\*) denote sequence variants obtained from molecular cloning. All specimens or their duplicates filed in herb. CBFS.

*Bellibarhula kurziana* Hampe ex P.C.Chen. NEPAL, Long 30441, KY406806\*, KY406836, KY406872; *B. recurva* (Griff.) R.H.Zander. CHINA, Long 41710, KY406807\*, KY406837, KY406873; *Bryoerythrophyllum alpigenum* (Venturi) P.C.Chen. AUSTRIA, Köckinger 1.7.1994, KY406822, KY406855, KY406891; BHUTAN, Long 28718, KY406816, KY406849, KY406885; *B. atrorubens* (Besch.) P.C.Chen. NEPAL, Long 30404, KY406814\*, KY406847, KY406883; *B. bolivianum* (Müll.Hal.) R.H.Zander. ARGENTINA, Suárez 640, KY406829, KY406862, KY406898; *B. caledonicum* D.G.Long. UNITED KINGDOM, (1) Long 30178, KY406817, KY406850, KY406886; (2) Long 31310, KY406818, KY406851, KY406887; *B. campylocarpum* (Müll.Hal.) H.A.Crum. CAMEROON, Dančák 3203/7, KY406823, KY406856, KY406892; PORTUGAL, Porley s.n., KY406830, KY406863, KY406899; *B. duellii* Blockeel. CYPRUS, Blockeel 32-165, KY406808, KY406841, KY406877; GREECE, Blockeel 43-063, KY406824, KY406857, KY406893; *B. feruginascens* (Stirt.) Giacom. CZECH REPUBLIC, Kučera 15279, KY406825, KY406858, KY406894; *B. hostile* (Herzog) P.C.Chen. NEPAL, Long 30395, KY406812, KY406845, KY406881; INDIA, Long 26376, KY406813, KY406846, KY406882; *B. jamesonii* (Taylor) H.A.Crum. BOLIVIA, Lewis 88-425, KY406819, KY406852, KY406888; ECUADOR, Frahm 113, KY406820, KY406853, KY406889; *B. latinervium* (Holmen) Fedosov & Ignatova. RUSSIA, Fedosov 06-287a, FJ952617, KY406838, KY406874; *B. recurvirostrum* (Hedw.) P.C.Chen. CZECH REPUBLIC, Kučera 12925, JQ890527, JQ890468, JQ890407; BULGARIA, Kučera 13997, KY406826, KY406859, KY406895; FRANCE, Kučera 10728, KY406827, KY406860, KY406896; SWEDEN, Kučera 15847, KY406828, KY406861, KY406897; RUSSIA, Fedosov 06-287b, FJ952634, KY406839, KY406875; Churakova 933, FJ952630, KY406865, KY406901; Ignatov 06-2545, FJ952631, KY406840, KY406876; Ignatov 8.6.2005, FJ952635, KY406866, KY406902; *B. rotundatum* (Lindb. & Arnell) P.C.Chen. RUSSIA, Fedosov 06-510, FJ952628, KY406864, KY406900; *B. rubrum* (Jur. ex Geh.) P.C.Chen. AUSTRIA, Kučera 6337, KY406821, KY406854, KY406890; *B. wallichii* (Mitt.) P.C.Chen. INDIA, Long 22538, KY406811\*, KY406844, KY406880; JAPAN, Saito 16332, KY406810\*, KY406843, KY406879; NEPAL, Long 20898, KY406809, KY406842, KY406878; *B. yunnanense* (Herzog) P.C.Chen. CHINA, Long 24147, KY406815, KY406848, KY406884; *Erythrolylopsis andina* (Sull.) R.H.Zander. ECUADOR, Soldán s.n., JX679954, JX679978, JX679928; *Mironia ehrenbergiana* (Müll.Hal.) R.H.Zander. BOLIVIA, (1) Lewis 88-792, KY406831, KY406867, KY406903; (2) Lewis 88-1662, KY406832\*, KY406868, KY406904; *Rhexophyllum subnigrum* (Mitt.) Hilp. BOLIVIA, Lewis 88-480, KY406833, KY406869, KY406905; *Saitobryum lorentzii* (Müll.Hal.) Ochyra. ARGENTINA, (1) Buck 26099a, KY406834\*, KY406870, KY406906; (2) Suárez 610, KY406835\*, KY406871, KY406907.