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Notes on taxonomy of some European species of *Ephemerum* (Bryopsida: Pottiaceae)

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SUMMARY

Taxonomy of some European species of *Ephemerum* is reviewed. As in several other recent studies, *E. minutissimum* Lindb. is regarded as a distinct species from *E. serratum* (Hedw.) Hampe; it is recorded from N. America (by the newly designated lectotype and other specimens) and Turkey, in addition to Europe. *E. serratum* var. *angustifolium* Bruch & Schimp. may be a synonym of *E. minutissimum*; the costate forms *E. serratum* var. *praecox* A.W.H.Walther & Molendo and *E. intermedium* Mitt. in Braithw. are treated as synonyms of *E. serratum s.str.* Type specimens of *E. stellatum* H.Philib. are described, a lectotype is designated and it is placed as a synonym of *E. serratum s.str. E. hibernicum* Holyoak & V.S.Bryan is regarded as a synonym of *E. rutheanum* Schimp. in Ruthe. The latter is shown to be a rare, European endemic taxon with modern records from Ireland, S. Wales, Germany and The Netherlands, and old records from France and W. Poland; a lectotype is designated. Forms intermediate between *E. sessile* (Bruch.) Müll.Hal. and the N. American *E. crassinervium* (Schwägr.) Hampe occur in several countries in W. Europe, some of them indistinguishable from some of the American plants; forms intermediate between *E. sessile* and *E. rutheanum* are recorded from S. Portugal and (rarely) Ireland. Differences between *E. crassinervium*, *E. sessile* and *E. rutheanum* in characters of leaves, tubers and capsules are shown to be slight, with considerable overlap. Hence all three taxa are treated as subspecies of *E. crassinervium*. A revised key to European *Ephemerum* and *Micromitrium* is presented.

KEYWORDS: North America, Turkey, lectotypes, identification, key, European Red List

INTRODUCTION

Molecular data have established that the diminutive mosses of the genus *Ephemerum* should be classified in the Pottiaceae (Goffinet & Cox, 2000; Goffinet & Buck, 2004; Sato *et al.*, 2004; Werner, Ros & Goffinet, 2007) rather than being maintained as the family Ephemeraceae within the Funariales. The list of 7–9 European *Ephemerum* species has undergone several changes in recent years, as a result of new finds and of taxonomic reassessments. Risse (1996, 1997) argued that *E. minutissimum* should be separated at species rank from *E. serratum* and this has been widely followed (e.g. in the latest British and European checklists: Hill *et al.*, 2006, 2008). *E. spinulosum* Bruch & Schimp. ex Schimp. has been discovered new to Europe, initially in Ireland (Holyoak, 2001a) and subsequently in N. Spain (Infante & Heras, 2005) and Germany (Meinunger & Schröder, 2007). Studies based mainly on herbarium specimens led to the suggestion that collections assigned to *E. stellatum* H.Philib. represent forms of *E. serratum* and *E. minutissimum* rather than a valid species (Holyoak, 2001b). An apparently undescribed taxon found in Ireland was named as *E. hibernicum* (Holyoak & Bryan, 2005) and later found in S. Wales.

Bryan & Anderson (1957) carried out extensive studies on N. American *Ephemerum* and found considerable variability in the leaf characters of most species, often almost bridging the gaps between recognized species. Most of the European taxa are similarly variable, but this receives little or no comment in floras, although a recent study has stressed the variability of *E. cohaerens* (Hedw.) Hampe (Hugonnot, Boudier & Chavoutier, 2007). A study revealing additional characters of protonemata and rhizoidal tubers that aid identification of certain species was published by Pressel, Matcham & Duckett (2005). Some of these characters were included in a new identification key covering Iberian species (Infante, Sérgio & Heras, 2007). A detailed treatment of N. American species including a key has also appeared recently

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(Bryan, 2007) but it pays little attention to tuber and protonemal characters and does not recognize *E. minutissimum* as a valid species; *E. crassinervium* is listed there as a new record for Europe (from Germany).

The present paper reviews the taxonomic treatment of some European species of the genus, concentrating on taxa that have been given differing treatments in recent literature. A revised identification key to the European species is also presented, to incorporate the taxonomic innovations proposed and attempt to take account of the variability within the species.

Material and Methods

Extensive field studies of *Ephemerum* growing in England and Ireland have been carried out by the author during 1999–2008, mainly as parts of programmes of research on rare bryophytes in England by Plantlife International, in Republic of Ireland by National Parks and Wildlife Service and in Northern Ireland by Northern Ireland Environment Agency (formerly Environment and Heritage Service). Taxa growing in the inundation zones beside lakes and reservoirs received particularly detailed attention, as did *E. stellatum* at localities in England. Numerous herbarium specimens were collected during this work and retained in the author's herbarium, with duplicates being sent to BBSUK, BEL or DBN. Study of this large amount of material has allowed the variability of certain identification and taxonomic characters to be reassessed. Material of several of the species was also shared with Pressel *et al.* (2005), who provided new information on characters of the protonemata and tubers, which has provoked renewed study of herbarium specimens. Further studies have involved scrutiny of many additional specimens in herbaria (BBSUK, BEL, BM, CGE, DBN, E, NMW and S; also private herbaria of R.J. Bijlsma, T.L. Blockeel, S.D.S. Bosanquet, N.G. Hodgetts, H.W. Matcham, Mrs J.A. Paton, R.D. Porley and R.C. Stern) to re-examine not only the leaf and capsule characters traditionally relied on for identification of the species, but also protonema and tubers of the same plants.

When studying *Ephemerum* from inundation zones of lake margins, two or occasionally three species of the genus were often found growing together, sometimes closely intermixed, and usually accompanied by much larger amounts of protonemata lacking gametophores that was not identified to species level. Care was therefore taken to ensure that descriptions of identification characters were not based on mixed material.

Observations

E. minutissimum *Lindb. and* E. serratum *(Hedw.) Hampe*

For several decades, British bryologists recognized two principal varieties within *E. serratum*, var. *serratum* and var. *minutissimum* (Lindb.) Grout (e.g. Blockeel & Long, 1998). These are only reliably distinguished by study of mature spores, which have a finely papillose exosporium and are surrounded by a hyaline veil in var. *minutissimum* and are coarsely papillose without a veil in var. *serratum*. They also differ in spore size and leaf shape, but there is some overlap in these characters (Risse, 1996, 1997; Smith, 2004). Opinions on the taxonomic status of *minutissimum* have varied widely, with Bryan (2007, and *in litt.*) regarding it as based merely on immature plants of *E. serratum*, whereas Risse (1996, 1997) argued that it should be raised to species rank, the latter being adopted by Smith (2004) and Hill *et al.* (2006, 2008). The former treatment of *minutissimum* as a variety of *E. serratum* by British authors probably owed much to the statement in Smith (1978) that 'occasional intermediates occur and Bryan & Anderson (1957) are correct in considering them to be varieties of one species'. However, this misrepresented Bryan & Anderson's (1957) conclusion that *minutissimum* does not merit taxonomic recognition at any level. Although Crundwell (in Hill, Preston & Smith, 1994) also mentioned that the forms are not always separable even with ripe spores, this may have been based on Smith's (1978) account.

Crundwell (*loc. cit.*) and Smith (2004) noted that *minutissimum* commonly occurs in arable fields in the British Isles, 'but it does not occur beside lakes or reservoirs' (Smith, 2004), whereas var. *serratum* is common in their inundation zones. My own collections from Britain and Ireland show only *minutissimum* in arable fields (17), mainly *serratum* in inundation-zones besides reservoirs, lakes and a pool (25; but with two records of *minutissimum* from beside Roadford Reservoir in N. Devon), both vars. in grasslands (two *serratum* and four *minutissimum*) and both in other habitats such as churchyards and path edges (two *serratum* and nine *minutissimum*).

The suggestion that *minutissimum* is merely immature *serratum* was discounted by observations made by the author on plants from several Cornish arable fields in 1999–2001; these retained the spore characters of *minutissimum* unchanged even after the gametophytes nearly rotted away and the capsule walls began to break down, without loss of the 'veil' from the spores or development of more coarsely papillose sporoderm ornamentation. The detailed study by Risse (1996, 1997) failed to locate any intermediates between *serratum* and *minutissimum*, and found two herbarium specimens containing both of them, concluding that 'In Europe the two taxa … are clearly different and deserve the rank of species'. My own observations have failed to reveal any intermediates, provided that only the characters of mature spores are considered (based on scrutiny of 29 British or Irish gatherings of *serratum* and 32 of *minutissimum*).

The lack of recognition afforded to *minutissimum* in N. America (Bryan & Anderson, 1957; Bryan, 2007) cannot be because it does not occur there, since the type specimens came from 'Philadelphia (James), Carlton House, Saskatchewan (Drummond), etc.' (Lindberg, 1874).

Details of type specimens examined at S are given below. The wide range of spore size reported for N. American *E. serratum* by Bryan (2007) (55–106 × 27–75 μm) implies that both *E. minutissimum* and *E. serratum s.str.* were involved; papillosity of the sporoderm and the presence or absence of a 'veil' are not mentioned in the description. Further study will be needed to elucidate the separate ranges of these taxa in N. America and elsewhere. Specimens at S confirm that *E. minutissimum* also occurs in Turkey (see below).

Taxonomic notes and details of specimens examined. Two syntypes at S were examined, both of them annotated as *E. minutissimum* by Risse in 1991. A lectotype is designated here to stabilize application of the name.

Ephemerum minutissimum Lindb., Not. Sällsk. Fauna Fl. Fenn. Förh. 13: 411. 1874. Type: 'seen Mr Lindb (21 Jan 1874) … Cambridge, Mass. James coll. Ex Herb. Hj. Möller' (S, reg. no. B79796; lectotype, selected here) [almost illegible handwriting is underlined].

This specimen has spores light brown, finely papillose, some with remains of veil, 53–67.5 × 46–56 μm. Another syntype ('674 Macoun 1890. … Canada. Drummond n. 10. Ex Herb. N.C. Kindberg', S; reg. no. B79795 [the 1890 is apparently not the date of collection]) has spores yellowish-brown, finely papillose, some with veil or fragments of it, 39.5–48 × 34.5–39.5 μm (probably not fully mature).

Two specimens with mature spores confirm that *E. minutissimum* occurs in Turkey: Prov. Mugla, on path 5 km east of Güllük, 15 m alt., 4 April 1971, leg. N. Ayedem, A.C. Crundwell & E. Nyholm (S; reg. no. B64460), with weakly denticulate leaves and labelled as *E. stellatum*; and Prov. Mugla: about 5 km east of Güllük, flat soil, leg. E. Nyholm 687a/71 (S; reg. no. B64468), with leaves varying from denticulate to possessing strong teeth, labelled as *E. stellatum*.

E. serratum *var.* angustifolium *Bruch & Schimp.*

The original description is cited incorrectly in *Index Muscorum* (van der Wijk, Margadant & Florschütz, 1962, 1967), the generic name being given as *Phascum* instead of *Ephemerum*. This resulted in an unnecessary new combination in *Ephemerum* also being listed, with the further consequence that the authorship of the name given as *E. serratum* var. *angustifolium* (B.S.G.) B.S.G. is incorrect. The correct citation is:

Ephemerum serratum var. *angustifolium* Bruch & Schimp., Bryol. Eur. (fasc. 1. Mon.): 3. 1836.

The Protologue characterizes the variety as being small in size and having linear-lanceolate leaves with weak teeth ('obsolete dentatis'). It was based on specimens from 'Sardinia (Müller) et in Britannia una cum *Astomum Mittenii* prope Hurstpierpoint (Mitten)'. Limpricht (1890) mentions that the type was collected in Sardinia by Fr. Müller in 1827. The leaf characters of the variety are suggestive of *E. minutissimum* rather than *E. serratum s.str.*, but a change to the formal synonymy should be based on study of original material with mature spores, if it exists.

E. serratum *var.* praecox *A.W.H.Walther & Molendo*

This uncommon variety of *E. serratum* has the upper part of the larger leaves with a faint costa and narrow leaf cells (10–16 μm wide, compared to 16–24 μm in var. *serratum*) (Smith, 2004). Although Smith (*loc. cit.*) recognized the variety, he commented that it is 'very questionable' whether it is worth maintaining.

Four specimens from three localities have been examined (see below). The inconsistent development of the costa in some but not all large leaves (specimen 4) or in some but not all adjacent plants (specimen 1) implies this character is not of much significance. Cell size in the upper leaf lamina varied widely and showed no correlation with the presence or absence of a costa. Hence, there seems little value in recognizing var. *praecox* or its illegitimate synonym var. *intermedium*. The spore characters show that both are referable to *E. serratum s.str.* rather than *E. minutissimum*.

Some costate leaves in *E. serratum* have a 'shouldered' outline (broad leaf base contracting abruptly to acumen) suggesting the leaf shape of many *E. cohaerens*, although they lack the cell rows radiating from the costa which characterize that species. The possibility that a costa appears occasionally in *E. serratum* as a result of hybridization with *E. cohaerens* or other costate *Ephemerum* species may nevertheless be worth investigating using molecular techniques.

Ephemerum serratum (Hedw.) Hampe, Flora 20: 285. 1837. Basionym: *Phascum serratum* Schreb. *ex* Hedw., Spec. Musc. Frond. 23. 1801.

syn. nov.: *Ephemerum serratum* var. *praecox* A.W.H.Walther & Molendo, Laubm. Oberfrank. 89. 1868.

syn. nov.: *Ephemerum intermedium* Mitt. in Braithw., Brit. Moss Fl. 1: 184. *27C.* 1884.

Four specimens from three localities have been examined, as follows. (1) Type specimen of *E. intermedium* Mitt., from exposed mud of pond at Pond Leigh, Sussex, England; *leg.* Mitten; 1847 (S; reg. no. B147844); this has a well-developed costa in the upper part of the leaf of one plant, whereas several neighbouring plants are otherwise similar but lack a costa; a capsule of an ecostate plant had large, coarsely papillose spores characteristic of *E. serratum s.str.* (2) A later collection from the same locality, mud at the N.E. extremity of Pond Leigh near Cuckfield, West Sussex; *leg.* W.E. Nicholson; 18th Oct. 1902 (E; reg. no. 00201430); this has a weak costa in the upper part of the larger leaves and coarsely papillose spores. (3) France: Seine-et-Oise, auf Schlamm um den Petit Étang Neuf im Forste von Rambouillet, 20 Okt. 1912, *leg.* J. Douin (E. Bauer, *Musci europaei exsiccati* no. 951, as *E. intermedium* Mitt.; S; reg. no. B147843); with a well-developed costa in upper part of leaf of two plants checked; spores of one of them were large and coarsely papillose. (4) [Germany]

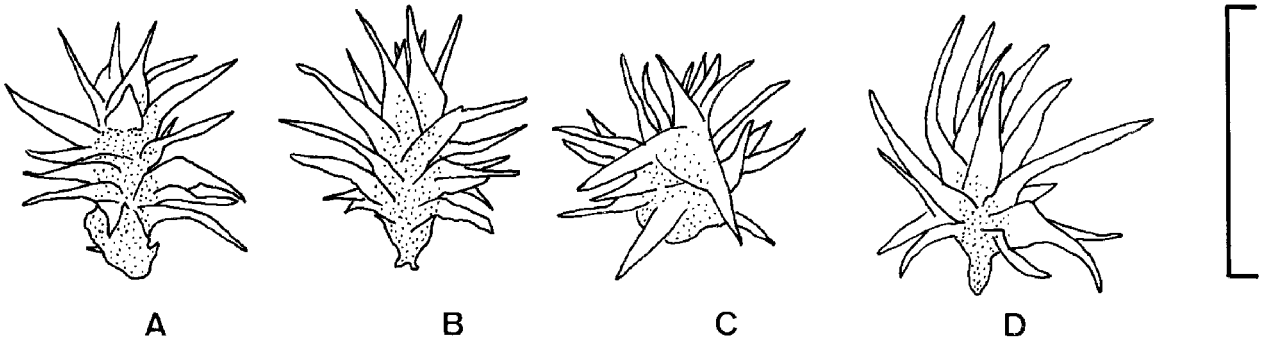

Figure 1. Drawings of four plants from the lectotype of *Ephemerum stellatum* H.Philib. (S; reg. no. B147248). Scale bar=1.0 mm.

Baireuth-Adjoiroinat prope Krogshof 1100′ in limo, 1868, *leg*. Molendo & Walther (S; reg. no. B147845) [nearly illegible handwriting underlined]; two plants studied have costa in upper part of some larger leaves; spores coarsely papillose.

E. stellatum *H.Philib.*

English and Irish specimens showing characters of *E. stellatum* occur intermixed with *E. serratum* or *E. minutissimum* at several different localities and also appear to be linked to them by intermediates, leading to them being reidentified as forms of these species with edentate or weakly dentate leaves (Holyoak, 2001a). However, the French type material of *E. stellatum* proved elusive and the protologue (Philibert, 1879) and other old descriptions (Husnot, 1884–1890; Nicholson, 1902; Douin, 1907) differ in some respects from the more modern specimens that have been identified as this taxon. Hence, formal synonymization of the name seemed inadvisable, especially since it was uncertain whether the synonymy should be with *E. serratum* or *E. minutissimum*. Subsequently, Infante *et al.* (2007) have argued that *E. stellatum* is a valid species, occurring in Portugal, despite spore size and some other characters that differ markedly from those described in the protologue of *E. stellatum*.

Type specimens from France have recently been discovered at S (see below). Because these are too fragile to withstand repeated handling they are illustrated here with both drawings (Fig. 1) and photographs (Fig. 2). Study of them allows confirmation of some features described in the protologue and reassessment of others. The large number of leaves for an *Ephemerum* (20 or more) and their spreading stance ('une vingtaine de feuilles serrées, qui divergent en forme d'étoile, et qui donnent un aspect particulier à cette espèce') are confirmed. Several details of leaf structure are also confirmed, including the lack of a costa, presence of only weak marginal denticulation, thickened leaf base and nature of the areolation. The stem is described only as 'la tige extrêment courte' (extremely short) which is correct in absolute terms (<0.6 mm) but fails to draw attention to the fact that the stem is much more developed than is normal in any other European *Ephemerum*, being remarkably stout for such a tiny moss and forming two-thirds or more of the total height of some plants (Fig. 1A, B; *cf.* Douin, 1907: Fig. 70) but less than half the height of others (Fig. 1C, D). In the protologue no mention was made of the lack of gametangia at the apices of the taller stems, whereas *all* well grown (i.e. mature) stems in other European *Ephemerum* end in either female or male inflorescences. Douin (1907, pp. 244, 308–309: Figs 26–38) notes that in *E. stellatum*, mature sterile plants differ conspicuously in appearance from mature fertile plants, but his comments appear to be based mainly on his own specimens rather than types. Douin (*op. cit.*) suggests that the continued stem development of non-fertile plants is due to lack of fertilization resulting from stems becoming buried in the surface of soft wet soil, but this interpretation would appear to be contradicted by the lack of unused archegonia at the stem tips. Instead, the peculiarities of stem development and lack of gametangia may imply that development was abnormal, for unknown reasons that might include galls (due e.g. to fungi, nematodes, or mites) or some physiological deficiency. The small amount of material available (*ca* 30 stems in the lectotype, <10 stems in the isolectotypes) precludes destructive analyses in search of possible causes.

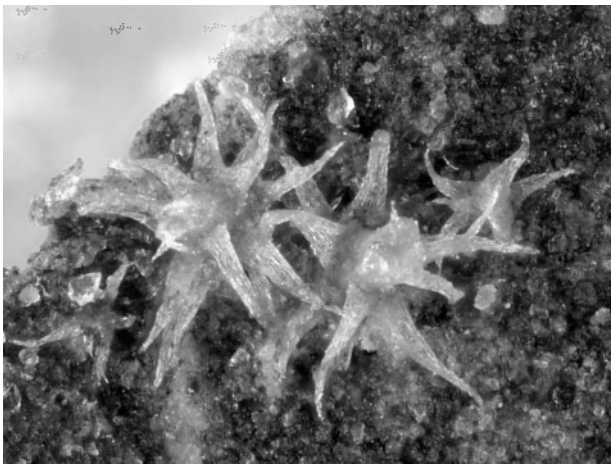

Figure 2. Photograph of specimens from the lectotype of *Ephemerum stellatum* H.Philib. (S; reg. no. B147248). The published photograph is based on combination of multiple images. The plants are about 1 mm high.

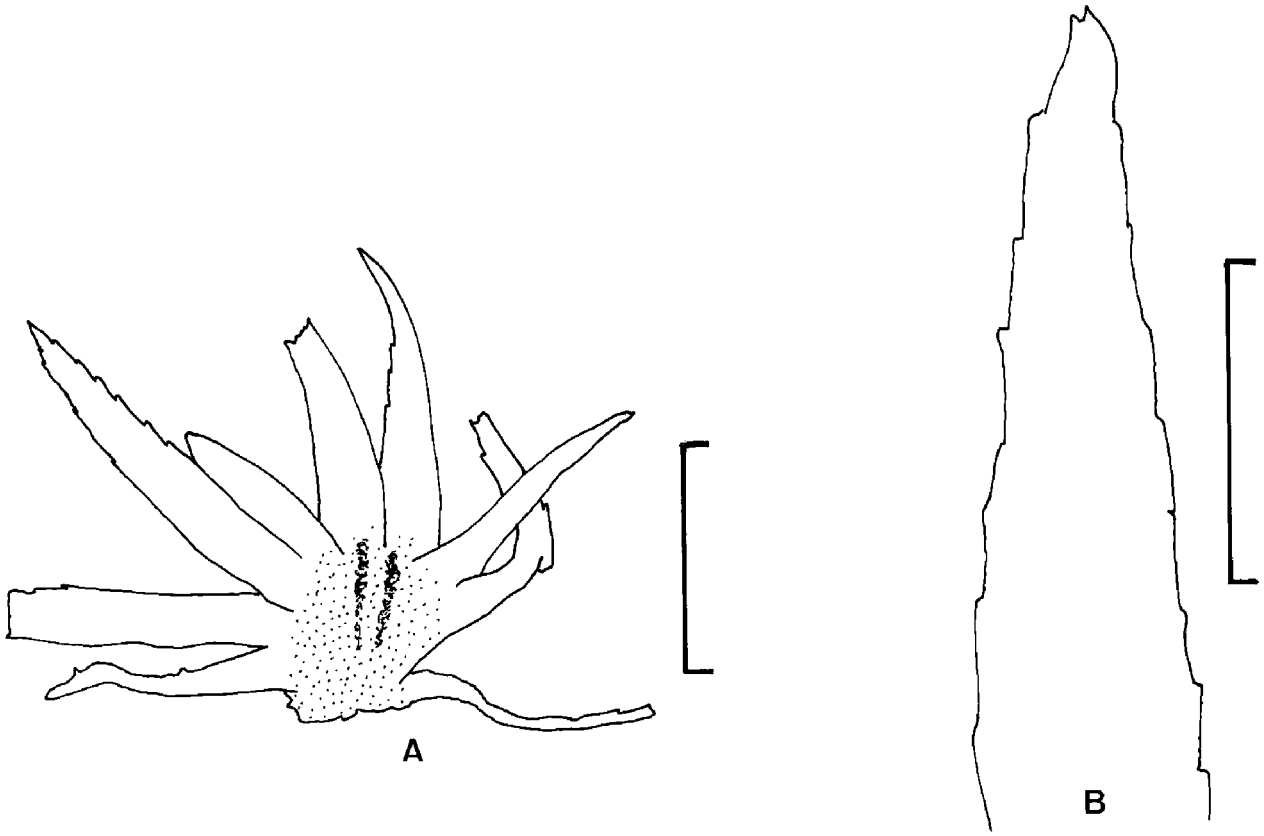

Figure 3. Plant apparently intermediate between *Ephemerum serratum* and *E. stellatum* H.Philib. growing with isolectotype of latter taxon (S; reg. no. B147376). (A) Whole plant; (B) apical part of largest intact leaf. Scale bar for A: 500 μm, for B: 200 μm.

Oesau (2007) has reported the development of abnormal leaf arrangements in atypical sterile populations of another tiny moss from the Pottiaceae, *Acaulon triquetrum* (Spruce) Müll.Hal. The sterile populations persisted year after year and consisted of plants with spreading leaf apices rather than the erect leaves of typical fertile plants. These differences in leaf stance correspond to those present in the sterile *Ephemerum stellatum* compared to the fertile *E. serratum*.

The lectotype and second isolectotype specimen (see below) are accompanied by smaller numbers of larger *Ephemerum* plants that show coarsely toothed ecostate leaves similar to those of *E. serratum* along with a few immature capsules. Some of these are in direct contact with plants of *E. stellatum*, whereas no other bryophytes were obvious other than rare non-fertile stems of a *Cephaloziella* and a minute stem of a *Bryum*. A single mature capsule in the packet with the isolectotype proved to be of *E. serratum s. s.* (spores lacking 'veil', deep yellow-brown, with coarsely papillose sporoderm, measuring 76–86 × 58–69.5 μm). The same packet included one plant showing characters apparently intermediate between those of *E. stellatum* and *E. serratum* (Fig. 3): 14 leaves (more than the *ca* 10 that is the usual maximum in *E. serratum*, but fewer than the 20 or more of *E. stellatum*), the longest leaf with small regular teeth from mid-leaf upwards (much larger teeth than in the accompanying *E. stellatum*, but much smaller than in the accompanying *E. serratum*). This 'intermediate' plant has a short stem, with a female inflorescence at its apex (two archegonia). Douin (1907) found *E. serratum* growing with *E. stellatum* at five of his eight localities for the latter species and detected intermediate plants repeatedly, which he interpreted as hybrids.

The protologue described capsules and spores of *E. stellatum*, but none were present in the type material examined during the present study, all of the sporophytes being on larger plants with strongly toothed leaves that were identified as *E. serratum*. Several features described in the protologue may imply that immature capsules and spores were being examined by Philibert. Thus, the capsule was a little smaller than in *E. serratum*, the calyptra relatively larger (covering two-thirds of the capsule), spores yellowish, of diameter about one-half those of *E. serratum* and appearing smooth. Douin (1907) described his finds of *E. stellatum* as having a relatively small calyptra, and the spores as 35–50 μm with a finely papillose surface. Nicholson (1902) figured English plants (from Crowborough) with a capsule as *E. stellatum*. However, although these show several characters of *E. stellatum* (including numerous almost edentate leaves), they do not have an obviously elongate stem. However, much of his description was 'practically a translation of the original one given by Prof. Philibert'.

The close association of the *E. stellatum* type-specimen plants with normal *E. serratum*, the apparently abnormal growth of the type stems, along with the presence of an intermediate plant, strongly imply that *E. stellatum* is no more than an unusual if not aberrant form of *E. serratum* and should be treated as its synonym. It is evident that at least some of the characters of *E. stellatum* recur widely in European populations of both *E. serratum* and *E. minutissimum* (Holyoak, 2001a); N. American *E. serratum sensu lato* are also recorded with leaves varying to 'only subserrate to serrate, with short, sometimes even obscure teeth' (Bryan & Anderson, 1957) and 'varying to scarcely serrate' (Bryan, 2007); specimens of *E. minutissimum* from Turkey showing *E. stellatum* characters are also noted above. Further study may be needed of plants assigned to *E. stellatum* from Portugal by Infante *et al.* (2007), although the description and figures suggest that these may also be referable to forms of *E. minutissimum* with weakly toothed leaves and rather small or immature spores.

Taxonomic notes and details of specimens examined. The recent discovery of three syntypes of *Ephemerum stellatum* H.Philib. in S now allows designation of a lectotype:

Ephemerum serratum (Hedw.) Hampe, Flora 20: 285. 1837. Basionym: *Phascum serratum* Schreb. *ex* Hedw., Spec. Musc. Frond. 23. 1801.

syn. nov. *Ephemerum stellatum* H.Philib., Rev. Bryol., 6: 63. 1879. Type: *Ephemerum stellatum* Philib., Bruailles (Saône et Loire), France orientale, 16 octobre 1878, h. Philibert (S; reg. no. B147248; lectotype, selected here; S; reg. no. B147376, B147377, isolectotypes).

These data on the *E. stellatum* lectotype and the characters of the plants are in accordance with the protologue (Philibert, 1879) and the label appears to be in Philibert's handwriting; the specimen was formerly in the herbarium of Hj. Möller. The isolectotypes have very similar data, one in Philibert's handwriting (no. B147376) and the other not (no. B147377). The latter contains only a few stems of *E. stellatum* and was formerly in the herbarium of S.O. Lindberg. All three specimens consist of similar small flakes of fine sand with a clayey surface, on which plants of *E. stellatum* are scattered singly or in small groups. Since all the specimens appear to consist of subdivisions from a single gathering, the second and third specimens are regarded as isolectotypes rather than syntypes.

Two other names have been proposed for *E. stellatum* by Douin, as follows. It is uncertain whether they should be regarded as synonyms of *E. serratum* or *E. minutissimum*, a problem that is only likely to be resolved if type specimens Ex Herb. Douin can be located and they have mature spores.

Ephemerum serratum var. *subintegrum* [-*a*] Douin, Mém. Soc. Sci. Nat. Cherbourg 35: 285. 1900. Douin (1907, p. 243) stated that this name was based on a form of *E. stellatum*.

Ephemerum stellatum var. *denticulatum* Douin, Bull. Soc. Bot. France 59: 735. 1912. This name was overlooked by the compilers of *Index Muscorum* (van der Wijk *et al.*, 1962, 1967). The protologue states only 'j'ai récolté dernierment dans le bois di Dionval près Saint-Piat (E.-et-L.) une forme à feuilles nettement denticulées dans la moitié supérieure au moins (var. *denticulatum* in herb. Douin)'.

Introduction to E. crassinervium *(Schwägr.) Hampe,* E. sessile *(Bruch.) Müll.Hal. and* E. rutheanum *Schimp. in Ruthe*

In the following sections of this paper, it is demonstrated (a) that plants occur in Europe intermediate between the N. American *E. crassinervium* and the European *E. sessile*; (b) that *E. rutheanum* Schimp. in Ruthe (1867) is a taxon endemic to Europe that has mainly been overlooked in recent floras; *E. hibernicum* Holyoak & V.S.Bryan (2005) should be treated as its synonym; (c) that plants occur in Europe intermediate between *E. sessile* and *E. rutheanum*. Hence, under subheading (d), *E. crassinervium*, *E. rutheanum* and *E. sessile* are treated as subspecies of *E. crassinervium*.

(a) *E. crassinervium* and *E. sessile*

The N. American *E. crassinervium* var. *crassinervium* differs from the European *E. sessile* mainly in having the upper leaf lamina and costa more or less strongly papillose. Other characters that are compared in Tables 1 and 2, all show considerable overlap. However, at least some British and Irish material of *E. sessile* has some prorate cell ends on the upper lamina and very well developed papillae on the upper costa (see below).

Other European specimens of *E. sessile* also have some prorate cell ends in the upper part of the costa (including one specimen from France and two from Germany housed at S) and one from Turkey has strongly prorate (papillose) cell ends in the upper costa (S reg. no. B64324: see below). Hence there is nothing other than the locality data to distinguish weakly papillose *E. crassinervium* collected in N. America from the most strongly papillose *E. sessile* from Europe, although most populations differ. Bryan (2007) lists *E. crassinervium* var. *crassinervium* for 'Europe (Germany)' without giving any details, but it is unclear why that taxon was claimed rather than *E. sessile* with a strongly papillose upper leaf. The same author 'found no North American plants that are convincingly *E. sessile*, as distinct from *E. crassinervium*' despite old reports of the former species.

Details of specimens examined. Material of *E. sessile* with some prorate cell ends on the upper lamina and very well-developed papillae on the upper costa includes specimens from Britain (e.g. Holyoak 01-1009 from N. Devon, in Hb. D.T.Holyoak). Many other British and Irish gatherings have prorate (papillose) cell ends on the upper costa (e.g. NMW C.2001.019.15008 from W. Galway, NMW C.2006.003.512 from Co. Cavan, Holyoak 01-1035 from E. Sussex in Hb. D.T.Holyoak) as does a specimen from Turkey (Prov. Isparta, near Egridir Gölü, *ca* 900 m alt.,

cave in rocky hillside, 2 April 1972, *leg*. E. Nyholm, S reg. no. B64324).

(b) *E. rutheanum* and *E. hibernicum*

E. rutheanum was described from plants collected by Ruthe on 1 January 1866 at Selchow near Bärwalde in Neumark, now in W. Poland. Later Ruthe also found it at Schmarsendorf near Schönfliess in the same region. Thirteen of the specimens collected by Ruthe have been studied (see below).

Comparative studies have established that the same taxon was described by Holyoak & Bryan (2005) as *E. hibernicum*, a supposed new species from Ireland. There are no significant differences between them, so *E. hibernicum* is regarded as a synonym (see below).

Juratzka (1882) made the new combination *E. serratum* var. *rutheana* [*sic*] with the comment that 'ist wohl nur eine durch einen abnorme nassen Standort hervorgerufene Form'. This is clearly incorrect because *E. serratum* often grows alongside *E. rutheanum* in Ireland and when this occurs, the former species retains its much shorter and less attenuate leaf apex, without a costa. However, *E. rutheanum* was treated as a valid species by Boulay (1884), Husnot (1884–1890), Limpricht (1890, who pointed out that it is not closely allied to *E. serratum*) and by Roth (1904, who gives good figures). Nevertheless, Mönkemeyer (1927) placed it as *E. serratum* var. *longifolium* (Ruthe) Mönk., as did Podpěra (1954), although the name is illegitimate because it includes the type of the earlier name *E. serratum* var. *rutheanum* (Schimp.) Jur. *Index Muscorum* (Wijk *et al.*, 1962) again placed it as *E. serratum* var. *rutheanum* and the latest list of European mosses (Hill *et al.*, 2006) treated *E. serratum* var. *rutheanum* as a synonym of *E. serratum* without comment. Szafran (1957) placed the taxon as '*Ephemerum cohaerens* var. *longifolium* Mnkm.' with *E. rutheanum* as a synonym, but this apparently intentional new combination is illegitimate. Hence, in the recent literature, apparently only Meinunger & Schröder (2007) treat *E. rutheanum* as a valid species.

In addition to the two localities in Poland, *E. rutheanum* is recorded from Germany, The Netherlands, France, Ireland and S. Wales (see below). Thus, it appears to be a European endemic that is known by modern records from a total of only 19 localities; it should be assessed as a likely addition to the European Red List, and those for each of the countries from which it is known.

Taxonomic notes and details of specimens examined. Three specimens have been studied from the original Selchow gathering of *E. rutheanum* (one at BM ex Herb. Schimper and two at S), five from later gatherings at Selchow (S) and five from Schmarsendorf (S). A lectotype is designated here to fix application of the name to a specimen seen by Schimper:

Ephemerum rutheanum Schimp. in Ruthe, Verh. Bot. Vereins Brandenburg 9: 73. 1867 (replacing *E. longifolium* Schimp. in Ruthe, 1867, *op. cit.*, p. 49, *hom. illeg.*). Type: Ephemerum Rutheanum Schmpr … Selchow bei Bärwalde N/M. auf schlammigen Thonboden. … Ruthe (BM, reg. no. 000857997, Herbarium Schimperianum Proprium (ex Herb. Kew); lectotype, selected here).

syn. nov. *Ephemerum hibernicum* Holyoak & V.S.Bryan, J. Bryol., 27: 89, *f. 1–2.* 2005.

German records of *E. rutheanum* are from near Krughof in N. Bayern (published as *E. serratum* var. *praecox* by Walther & Molendo (1868), the specimen in REG having since been reidentified according to Meinunger & Schröder (2007); however, this may be incorrect: see the note on specimen 4 under *E. serratum* var. *praecox* above) and modern (1995–2002) reports from three other localities, two in Nordrhein-Westfalen and one in the southern part of Bremen Niedersachsen (Meinunger & Schröder, *loc. cit.*).

Specimens have been studied from two localities in The Netherlands which are among several discovered recently by Dr R.J. Bijlsma (*in litt.*): inundation zone of the Forelands of the Lower Rhine near Huissen, 18 September 2004 (Bijlsma 9454-1); scour hole in Forelands

Table 1. *Comparison of characters of leaves and tubers in taxa treated as subspecies of* Ephemerum crassinervium.

Character	Subsp. *sessile*	Subsp. *rutheanum*	Subsp. *crassinervium* s.str.	Subsp. *crassinervium* var. *texanum*
Costa in apical part of leaf	± excurrent	Percurrent to shortly excurrent	Percurrent or excurrent	Percurrent or excurrent
Costa near leaf base	Well defined	Well defined	Sometimes obsolete	Thin
Margin in apical half of leaf	Entire or denticulate (occasionally few teeth)	Serrulate or serrate (often with one or two spines)	Serrulate to strongly serrate	Serrate
Lamina in apical part of leaf	Smooth to somewhat papillose	Smooth to slightly papillose	± papillose	Densely papillose
Leaf outline 'shouldered'	No	Often	No	Often
Measurements of tuber cells from Pressel *et al.* (2005) (μm)	70–100 × 20–22	40–50 × 25–30	…	…
Measurements of tuber cells by author (μm)	66–168 × 18–31(39)	43–158.5 × 16.5–38	(50)53–218 × (15)23–48	73–188 × 20–35
Septa between rhizoidal tuber cells, from Pressel *et al.* (2005)	Oblique	Transverse	…	…
Septa between rhizoidal tuber cells (author's observations)	Mainly oblique, some transverse	Many transverse, and many oblique	Most transverse, few oblique	Transverse and oblique

Leaf characters are those of the largest leaves (perichaetial bracts) on female stems; extreme measurements are in parentheses.

of the Waal river 4 km NW of Nijmegen, 26 September 2009 (Bijlsma 12220.1).

It was also reported with a good description from two adjacent localities in France ('queue des étangs, Monjeu, Salzy' in Saône-et-Loire, leg. Carion, 1839–1841) by Boulay (1884) and Husnot (1884–1890). A rather small old specimen with poor data in partly illegible handwriting [underlined] at S (reg. no. B147885) may represent another locality in Saône-et-Loire ('Gallia, prope Bruailles ad (Saône et Loire) terram ad sylvis. J. [*sic*] Philibert', Ex Herb. N.C. Kindberg).

In Ireland, *E. rutheanum* (as '*E. hibernicum*') is now known from ten localities in seven vice-counties. The only other confirmed records from the British Isles are from S. Wales (with *E. sessile* on margin at N. end of Wentwood Reservoir, Monmouthshire, 22 November 2003, *leg*. S.D.S. Bosanquet, BBSUK; occasional on margin of Pant y Llyn seasonal lake, near Carmel, Carmarthenshire, 24 September 2004, *leg*. S.D.S. Bosanquet, BBSUK). Plants with characters approaching those of '*E. hibernicum*' have also been collected in S. Portugal (see the next section).

(c) Plants intermediate between *E. sessile* and *E. rutheanum*

Costate *Ephemerum* collected in S. Portugal (Algarve: Lagoa da Nave, see below) proved troublesome to identify as either '*E. hibernicum*' or *E. sessile* since they appeared intermediate between them, with the lamina continuous almost up to the leaf apex, a few large teeth on the denticulate leaf margins, a slightly papillose upper lamina and costa, and the costa rather ill-defined in the lower part of the leaf. Identification as *E. crassinervium* var. *crassinervium* also seemed rather unlikely as the upper lamina was only slightly papillose. Another specimen from the Algarve (Cerca dos Pomares, see below) shows similar characters, although it has stronger papillae formed by prorate cell ends in the upper lamina and costa.

Irish specimens of '*E. hibernicum*' are mainly distinct from those of *E. sessile*, but some individual plants are difficult to place on the basis of leaf characters. Indeed, there are few consistent differences between *E. rutheanum* and *E. sessile* other than the more strongly toothed leaves and better developed lamina in the leaf apex of the former taxon (Tables 1 and 2; Holyoak & Bryan, 2005). Differences between the tubers of *E. rutheanum* (as '*E. hibernicum*') and *E. sessile* reported by Pressel *et al.* (2005) were found to be inconsistent when material from numerous localities was surveyed systematically (Table 1), although *E. sessile* apparently never develops tubers as wide and short-celled as many of those in '*E. hibernicum*'. Study of tubers of N. American plants of *E. crassinervium* subsp. *crassinervium* and its var. *texanum* (Grout) V.S.Bryan & L.E.Andersen (at S) reveals that their characters also largely overlap those of the two European taxa. Apparent slight differences in their sporophytes and spores (Table 2) probably result partly from different authors using different terminology (e.g. when describing distribution of stomata on capsules, or spore ornamentation) and partly from scarcity of appropriate specimens (e.g. for measurement of spore size in *E. rutheanum*).

Details of specimens examined. Plants intermediate between *E. sessile* and *E. rutheanum* have been studied from two collections made in the Algarve, S. Portugal, as follows: Lagoa da Nave, near Nave do Barão, on moist sandy soil, March 1989, *leg*. T.L. Blockeel 18/086, in Hb. T.L. Blockeel; Cerca dos Pomares, near Aljezur, 37°19′3″N, 8°45′38″W, on soil in fallow arable field, pH 7.5, 7 January 2008, *leg*. R.D. Porley 2997, in Hb. R.D. Porley.

(d) Treatment of *E. crassinervium*, *E. rutheanum* and *E. sessile* as subspecies of a single species

The limited differences between *E. crassinervium*, *E. rutheanum* and *E. sessile* and the occurrence of occasional intermediate populations suggest that these taxa are no more differentiated from each other than are the varieties *crassinervium* and *texanum* within *E. crassinervium*. Nevertheless, each form mainly has a different range or habitat: *E. crassinervium* is essentially N. American, the others European in distribution; *E. rutheanum* tending to grow in sites that flood more deeply and for longer (e.g. lake margins) than the relatively dry habitats of *E. sessile* (which typically include only the upper fringe of lake inundation-zones, along with e.g. damp hollows in paths and tracks). Because of the geographical and ecological segregation involved, they appear better treated as subspecies than as varieties.

Three additional costate species of *Ephemerum* from other continents may prove to be closely related to *E. crassinervium sensu lato*, although all of them are reported to have smaller spores: *E. apiculatum* P.-C. Chen which is known only from China resembles *E. sessile* but has spores 25–32 μm (Li, Si & Zhang, 2003); *E. namaquense* Magill known only from S. Africa has spores 33 μm (Magill, 1987); *E. rehmannii* (Müll.Hal.) Broth. has spores 20–35 μm and is known in both S. Africa (Magill, 1987) and Australia (Stone, 2006).

Taxonomic notes. Two new combinations are required, as follows:

Table 2. *Comparison of characters of capsules and spores in taxa treated as subspecies of* Ephemerum crassinervium.

Character	Subsp. *sessile*	Subsp. *rutheanum*	Subsp. *crassinervium* s.str.	Subsp. *crassinervium* var. *texanum*
Stomata on capsule	Few (2–4), anywhere on surface	Few, over whole surface	Very few, mostly near base	Few, scattered throughout
Spore size (μm)	75–85(100) × (50)63–75	61–69	43–107 × 35–75	68–120 × 50–80
Spore ornamentation	Verrucose	Coarsely papillose	Papillose	Papillose
Spore colour	Brown	Yellow-brown	Orange-brown	Dark-brown

Extreme measurements are in parentheses.

Ephemerum crassinervium subsp. sessile (Bruch) Holyoak **comb. nov.** Basionym: *Phascum sessile* Bruch, Jahresber. Pollichia 2(Verz.): 49. 1844.

Ephemerum crassinervium subsp. rutheanum (Schimp. in Ruthe) Holyoak **comb. nov.** Basionym: *Ephemerum rutheanum* Schimp. in Ruthe, Verh. Bot. Vereins Prov. Brandenburg 9: 73. 1867 (replacing *E. longifolium* Schimp. in Ruthe, 1867, *op. cit.*, p. 49, *hom. illeg.*).

Key to European Species of *Ephemerum* and *Micromitrium*

Leaf characters should be studied from the largest leaves of well-grown plants (with capsules developing). *Ephemerum crassinervium* subsp. *crassinervium* is included in the key because as discussed above, it has been reported from Germany (Bryan, 2007), although details desirable to confirm its first European record have not been published.

1 Capsule wall 1 cell thick, lacking stomata; calyptra minute, persistent; apical cells of protonemata all with rounded ends……
……..*Micromitrium tenerum* (Bruch & Schimp.) Crosby
- Capsule wall 2 cells thick, with scattered stomata at least near base of capsule; calyptra larger, not persisting; apical cells of protonemata with pointed or rounded ends……...(*Ephemerum* spp.) 2
2 Costa normally absent or weak; if present, restricted to upper part of larger leaves, where lamina is wide; tubers lacking……3
- Costa well developed in all large leaves, usually reaching to near leaf base; tubers often present……4
3 Spores coarsely papillose, without hyaline veil; (62)64–88(96) μm long……
…..*E. serratum* (includes var. *praecox*, *E. stellatum p.p.*)
- Spores finely papillose, usually with hyaline veil or remnants of it; (38)46–65(72) μm long……..
……*E. minutissimum* (includes *E. stellatum auct. p.p.*)
4 Mid-leaf cells usually in diagonal or oblique rows divergent from costa to leaf margin; upper leaves lanceolate to ovate-lanceolate with costa ending in apex; some upper leaves with prominent 'shoulders'; protonemata with fastigiate branches……..*E. cohaerens*
- Mid-leaf cells in rows $\pm$ parallel to costa and to leaf border; upper leaves ovate-lanceolate to linear with percurrent to $\pm$ excurrent costa; upper leaves only rarely 'shouldered'; protonemata with widely spreading or fastigiate branches……5
5 Upper leaves recurved; costa strong throughout leaf, but wide lamina continues almost to apex; capsule with strongly oblique apiculus; stomata only near base of capsule; calyptra cucullate; spores finely papillose, 35–50 μm long……*E. recurvifolium* (Dicks.) Boulay
- Upper leaves erect to erecto-patent, straight or secund; usually lacking combination of strong costa and lamina extending to near apex; capsule with erect to slightly oblique apiculus; stomata usually scattered over whole capsule (often few); calyptra mitrate; spores coarsely papillose, (43)60–80(120) μm long……6
6 Lamina cells in upper part of leaf with spinulose to spinose papillae; length : width of lamina cells at mid-leaf mainly 4 : 1–8 : 1; upper leaves often with some teeth strongly recurved; upper leaves narrowly lanceolate…
……*E. spinulosum*
- Lamina cells in upper part of leaf smooth or papillose but not with spinose papillae; length:width of lamina cells at mid-leaf mainly $<4:1$; upper leaves with strongly recurved teeth very few or 0; upper leaves narrowly lanceolate to ovate-lanceolate……..7
7 Upper half of leaves entire or denticulate (occasionally with few larger teeth); apical part of upper leaves consisting largely of excurrent costa; tuber cells mostly >65 μm long……*E. crassinervium* subsp. *sessile*
- Upper half of leaves usually serrulate or serrate; leaf usually with narrow lamina extending almost to apex; some cells of larger tubers <65 μm long……8
8 Upper ⅔ of lamina and costa usually markedly papillose (because of projecting cell ends); leaf outline lacking 'shouldered' appearance and long marginal spines; costa often obsolete near leaf base; apiculus on capsule often oblique……..
……*E. crassinervium* subsp. *crassinervium*
- Upper ⅔ of lamina and costa smooth to slightly papillose; some upper leaves with one or two sharp marginal spines, which may give 'shouldered' appearance to leaf outline; costa well developed near leaf base; apiculus on capsule erect……
……..*E. crassinervium* subsp. *rutheanum*

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TAXONOMIC ADDITIONS AND CHANGES: *Ephemerum minutissimum* Lindb., lectotype designated; *Ephemerum stellatum* H.Philib., lectotype designated; *Ephemerum serratum* (Hedw.) Hampe, syn. nov. *E. stellatum* H.Philib.; *Ephemerum serratum* (Hedw.) Hampe, syn. nov. *E. serratum* var. *praecox* A.W.H.Walther & Molendo; *Ephemerum serratum* (Hedw.) Hampe, syn. nov. *E. intermedium* Mitt. in Braithw.; *Ephemerum rutheanum* Schimp. in Ruthe, lectotype designated; *Ephemerum rutheanum* Schimp. in Ruthe, syn. nov. *E. hibernicum* Holyoak & V.S.Bryan; *Ephemerum crassinervium* (Schwägr.) Hampe subsp. *sessile* (Bruch) Holyoak comb. nov.; *Ephemerum crassinervium* (Schwägr.) Hampe subsp. *rutheanum* (Schimp. in Ruthe) Holyoak comb. nov.

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