
New Combinations and Synonyms in the Moss Family Diphysciaceae

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ABSTRACT. Phylogenetic analyses of sequence data of the chloroplast protein coding genes *rbcL* and *rps4*, and the chloroplast encoded *trnL* (UAA) intron suggest that morphological characters traditionally used in delimiting the genera *Diphyscium* Mohr, *Muscoflorschuetzia* Crosby, and *Theriotia* Cardot in the moss family Diphysciaceae are homoplastic; *Diphyscium* is paraphyletic, and *Theriotia* and *Muscoflorschuetzia* are nested in *Diphyscium*. Therefore, only *Diphyscium* Mohr should be recognized in Diphysciaceae, and *Muscoflorschuetzia* Crosby and *Theriotia* Cardot should be made synonyms of *Diphyscium*. Consequently, three combinations are newly made: *Diphyscium kashmirensis* (H. Robinson) Magombo, *Diphyscium lorifolium* (Cardot) Magombo, and *Diphyscium pilmaiquen* (Crosby) Magombo.

Key words: Diphysciaceae, *Diphyscium*, moss, *Muscoflorschuetzia*, *Theriotia*.

The Diphysciaceae are a small family of mosses distinguished by the unique combination of short setae, immersed capsules, collared axillary hairs, distinctly differentiated perichaetial leaves that have crenulate, dissected, lacinate or ciliate margins at apex, and arthrodontous peristomes that have pleated endostomes and exostomes that are rudimentary or lacking. The Diphysciaceae grow on rocks (limestone or sandstone) or in rock crevices, on soil, sometimes on rotten wood, and rarely on tree trunks. They are found in forests, along trails or footpaths, along streams and riverbanks, and sometimes close to waterfalls, on wet or frequently watered substrates, in fully or partially shaded places. Occasionally, the Diphysciaceae occur fully submerged in water. The Diphysciaceae grow at an altitudinal range from close to sea level to as high as 3400 m.

Most species in the Diphysciaceae are restricted in their distributions, although a few are widespread and exhibit disjunct distribution patterns (Robinson, 1965; Allen, 1996; Crosby, 1977; Deguchi, 1975, 1984a, 1984b; Norris, 1981; Noguchi & Iwatsuki, 1987; Deguchi et al., 1997; Tan, 1998). Twelve species occur in the Old World, and seven

of these are restricted to Asia (*Diphyscium fasciculatum* Mitten, *D. satoi* Tuzibe, *D. perminutum* Takaki, *D. suzukii* Z. Iwatsuki, *D. fulvifolium* Mitten, *Theriotia lorifolia* Cardot, and *T. kashmirensis* H. Robinson). The Old and the New World share five species (*D. foliosum* (Hedwig) Mohr, *D. mucronifolium* Mitten, *D. longifolium* Griffith, *D. pocsii* (Bizot) R. H. Zander, and *D. chiapense* D. H. Norris). Three species, *D. fendleri* Müller Halle, *D. domingense* (Bridel) W. R. Buck & Steere, and *Muscoflorschuetzia pilmaiquen* (Crosby) Crosby, are restricted to the New World. *Diphyscium foliosum* is the most widely distributed species of all Diphysciaceae. It is known from Central and North America, throughout Europe (including the Arctic regions), and Asia.

The Diphysciaceae traditionally consist of three genera: *Diphyscium* Mohr (12–15 species), *Theriotia* Cardot (2 species), and *Muscoflorschuetzia* Crosby (1 species). The first taxon now placed in *Diphyscium* was originally described as *Buxbaumia foliosa* Hedwig. Hedwig (1801) used the genus *Buxbaumia* to accommodate two species, *Buxbaumia aphylla* Hedwig and *Buxbaumia foliosa* Hedwig, which he characterized as dioicous species with terminal inflorescences and double peristomes that have truncate exostomes and plicate endostomes. Based on differences in gametophyte morphology, Mohr (1803) established the genus *Diphyscium*, with a single species *Diphyscium foliosum* (Hedwig) Mohr. Schwaegrichen (1830) returned *D. foliosum* to *Buxbaumia*, choosing not to recognize *Diphyscium* Mohr because of its similar peristome structure. However, Fleischer (1919) agreed with Mohr and established the family Diphysciaceae for *D. foliosum*.

The genus *Theriotia* was erected by Cardot (1904) based on a sterile collection (*Faurie 136*) from Ouen-San (Wonsan) in North Korea, which he named *Theriotia lorifolia* Cardot. Lamina thickness has traditionally been the main feature for distinguishing *Theriotia* (3 to 14 cells thick) from *Diphyscium* (1 to 2 cells thick). Cardot (1904) originally placed *Theriotia* in the Syrrhopodontaceae,

because its leaf form resembles that of *Syrrhopodon* Schwaegrichen subg. *Calymperidium* Dozy & Molk- enboer. The multistratose leaf structure of *Theriotia* was also compared to that of *Exodictyon* Cardot (Leucobryaceae), a genus that Cardot (1904) considered intermediate between Syrrhopodontaceae and Leucobryaceae. Brotherus (1925) was the first to place *T. lorifolia* in the Diphysciaceae, because its peristome is similar to that of *Diphyscium*. A second species was added to *Theriotia* when Robinson (1965) described *T. kashmirensis* H. Robinson with a leaf structure similar to that of *T. lorifolia*.

Crosby (1977, 1978) added a third genus to the Diphysciaceae when he described *Muscoflorschuetzia*. He placed this genus in the Diphysciaceae, because of its short setae, collared axillary hairs, and inner perichaetial leaves that have ciliate margins at the apex. *Muscoflorschuetzia* differs from other members of the Diphysciaceae in its lack of a peristome, long and narrow capsule shape, and consistently unistratose lamina (Crosby, 1977, 1978).

Variation in morphological characters, particularly plant size, leaf morphology, lamina cell structure, capsule morphology, exothecial cell morphology, stomata, peristome, annulus, and sexuality has led to debate on character evolution and has affected ideas on how genera and species might be related in the Diphysciaceae (Crosby, 1977, 1978; Deguchi, 1975, 1984b; Allen, 1996; Deguchi et al., 1997; Norris, 1981; Robinson, 1965). On the basis of molecular data the Diphysciaceae are considered monophyletic (Goffinet et al., 2001; Magombo, 2002) and are sister to haplolepideous and diplolepideous mosses (Beckert et al., 1999, 2001; Newton et al., 2000; Goffinet et al., 2001; Magombo, 2002). However, phylogenetic analyses of sequence data of the chloroplast protein coding genes *rbcL* and *rps4*, and the chloroplast encoded *trnL* (UAA) intron (see Magombo, 2002) suggest that the morphological characters traditionally used in delimiting *Diphyscium*, *Muscoflorschuetzia*, and *Theriotia* are homoplastic; recognition of *Theriotia* and *Muscoflorschuetzia* makes *Diphyscium* paraphyletic since both genera are nested in *Diphyscium*. Therefore, only *Diphyscium* should be recognized in the Diphysciaceae; *Theriotia* and *Muscoflorschuetzia* are synonyms of *Diphyscium*. Consequently, three combinations are newly made in *Diphyscium*. A detailed taxonomic account of the Diphysciaceae is presented in the forthcoming revision of the family in the *Journal of the Hattori Botanical Laboratory*.

Diphyscium Mohr, *Observ. Bot.* 34. 1803. TYPE:

Buxbaumia foliosa Hedwig (= *Diphyscium foliosum* (Hedwig) Mohr).

Theriotia Cardot, *Beih. Bot. Centralbl.* 17: 8. 1904. Syn. nov. TYPE: *Theriotia lorifolia* Cardot.

Muscoflorschuetzia Crosby, *Bryologist* 81: 338. 1978. Syn. nov. Replacement name for *Florschuetzia* Crosby, hom. illeg., non *Florschuetzia* Hopping & Muller. TYPE: *Florschuetzia pilmaiquen* Crosby (= *Muscoflorschuetzia pilmaiquen* (Crosby) Crosby).

1. *Diphyscium kashmirensis* (H. Robinson) Magombo, comb. nov. Basionym: *Theriotia kashmirensis* H. Robinson, *Bryologist* 68: 314. 1965. TYPE: [Pakistan] Kashmir. Karakorum Range, upper Hushe Valley, Atosar Valley, 17 July 1955, G. L. Webster & E. Nasir 6173a (holotype, US).

Robinson (1965) used the name *Theriotia kashmirensis* when he first described this species because its leaf structure (3 to 14 cells thick) is similar to that of *Theriotia lorifolia*. The two taxa have indeed been considered closely related and have traditionally been separated from members of *Diphyscium*, which have lamina of one or two cells thick. However, *Theriotia kashmirensis* is similar to members of *Diphyscium* in peristome structure, collared axillary hairs, and inner perichaetial leaves with ciliate margins. Furthermore, phylogenetic analysis of molecular evidence (Magombo, 2002) shows *Theriotia kashmirensis* nested in *Diphyscium*. Therefore, a new combination is made.

2. *Diphyscium lorifolium* (Cardot) Magombo, comb. nov. Basionym: *Theriotia lorifolia* Cardot, *Beih. Bot. Centralbl.* 17: 8. 1904. TYPE: Corée [North Korea]. Ouen-San, October 1901, P. U. J. Faurie 136 (holotype, PC).

Like *D. kashmirensis*, *D. lorifolium* is different from other Diphysciaceae because of the lamina structure (3 to 14 cells thick). However, it is similar to other *Diphyscium* species in its peristome structure, collared axillary hairs, as well as inner perichaetial leaves with ciliate margins. Furthermore, placement of this species in a separate genus, *Theriotia*, is not supported by molecular evidence (Magombo, 2002). Consequently, a new combination is made. Both *D. kashmirensis* and *D. lorifolium* occur in the Old World (Asia).

3. *Diphyscium pilmai quen* (Crosby) Magombo, comb. nov. Basionym: *Florschuetzia pilmai quen* Crosby, Bryologist 80: 149. 1977. *Muscoflorschuetzia pilmai quen* (Crosby) Crosby, Bryologist 81: 338. 1978. TYPE: Chile. Province Valdivia/Prov. Osorno: Forest Reserve at Planta Hydroeléctrica Pilmai quen, along Río Pilmai quen, 29 Jan. 1976, M. R. Crosby 12235 (holotype, MO).

Diphyscium pilmai quen is the most distinctive species in Diphysciaceae because of its lack of peristome, lamina consistently unistratose, and a long and gradually narrow capsule. Its placement in *Diphyscium*, and therefore the need for a new combination, is supported by collared axillary hairs, immersed capsule, perichaetial leaves with ciliate margins, and molecular evidence (see Crosby, 1977, 1978; Magombo, 2002). *Diphyscium pilmai quen* is rare, known only from the type locality in southern Chile.

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