Dacryophyllum falcifolium, a New North American Genus and Species (Musci: Hypnaceae) from California

Robert R. Ireland

Botany, National Museum of Natural History, P.O. Box 37012, Smithsonian Institution, Washington, D.C. 20013-7012, U.S.A. Ireland.Robert@nmnh.si.edu

ABSTRACT. *Dacryophyllum falcifolium*, a new North American genus and species of moss, is described and illustrated. The taxon is described from sterile California collections, where it occurs on calcareous rock in redwood forests in Monterey and Santa Cruz Counties. The new moss genus *Dacryophyllum* is considered a member of the large pleurocarpous family Hypnaceae and is morphologically close to *Taxiphyllum*.

Key words: California, *Dacryophyllum*, Hypnaceae, Musci, North America, *Taxiphyllum*.

Four collections of an unknown moss growing on calcareous substrates from three different localities in the redwood forests of Monterey and Santa Cruz Counties, California, located in the central coastal part of the state, recently were made by Kenneth M. Kellman and sent to me for identification. An examination of the four collections revealed that the plants have several distinctive features that show a relationship to the genus *Taxiphyllum* Fleischer, a member of the family Hypnaceae. Similarities in the plants' color, growth habit, branching pattern, leaf arrangement, costa features, leaf shape, leaf margins, leaf cell prorations, and presence of foliose stem pseudoparaphyllia all indicate a close relationship with some members of the Hypnaceae, especially *Taxiphyllum*. However, several of its morphological characters are sufficiently different to justify describing a new genus and species. The species is easily recognized by its small size (plants to 1.5 cm), its complanate-foliate, prostrate stems, its broadly falcate leaf apices, its usual lack of a costa or a short, indistinct double one, its short, broad apical leaf cells (shorter and broader than in most North American *Taxiphyllum* species), its basal row of leaf cells at the stem insertion with large prorulae at their proximal ends, and its foliose, serrulate to toothed pseudoparaphyllia, sometimes with single-celled, large teeth, usually mixed with entire filamentous pseudoparaphyllia. The calcareous substrate upon which it grows is also a clue to its recognition. The publication of this new genus is essential for the forthcoming Bryophyte Volume 28 of the *Flora of North America*.

Dacryophyllum falcifolium Ireland, gen. et sp. nov. TYPE: U.S.A. California: Santa Cruz Co., cliff on opposite side of South Fork Fall Creek from Blue Cliff, above Lime Kilns, Fall Creek Division, Henry Cowell Redwoods State Park, near Felton, ca. 37°03′30″N, 122°05′45″W, 244 m, on vertical face of calcareous rock in woods, 12 June 1999, *K. M. Kellman 704* (holotype, CAS; isotypes, DUKE, MO, NY, UC, US). Figure 1.

In ramis complanate foliatis in pseudoparaphylliis anguste foliosis in nervis caulis centralis nullis et in foliis falcatis laevibus ecostatis in cellulis numerosis basilaribus juxta caulem retroprorulis et margine inferne saepe binate denticulatis distinctum.

Plants in thin mats, complanate-foliate, light- to yellow-green, glossy; stems to 1.5 cm, 0.8–1.0 mm wide, prostrate, simple or sparingly and irregularly branched, cortical cells moderately small, thick-walled, in 2 or 3 rows, central cells large, thin-walled, central strand lacking; rhizoids few, smooth, ventrally inserted, single or in clusters below leaf insertion; axillary hairs ca. 108 μm long, mainly in axils of uppermost leaves near apical bud, consisting of 1 short brown basal cell and 1 or 2 elongate hyaline distal cells; pseudoparaphyllia narrowly foliose, 2 to 4 cells wide, serrulate to toothed, sometimes with single-celled, large teeth, usually mixed with some entire filamentous pseudoparaphyllia, 3 to 6 cells long, branch primordium not evident among pseudoparaphyllia. Stem and branch leaves similar, stiff, appressed-imbricate, flat, smooth, asymmetric, 0.3–0.5 × 0.1–0.2 mm, oblong-lanceolate, acute to obtuse, falcate, margins plane, serrulate, becoming serrate at leaf base, serrations often formed by two basal cells abutting, broadly incurved on one side at base, nondecurrent; costa lacking or indistinctly double; cells thin to moderately thick-walled, linear-flexuose to rhomboidal, especially near leaf apex, smooth or often with mi-

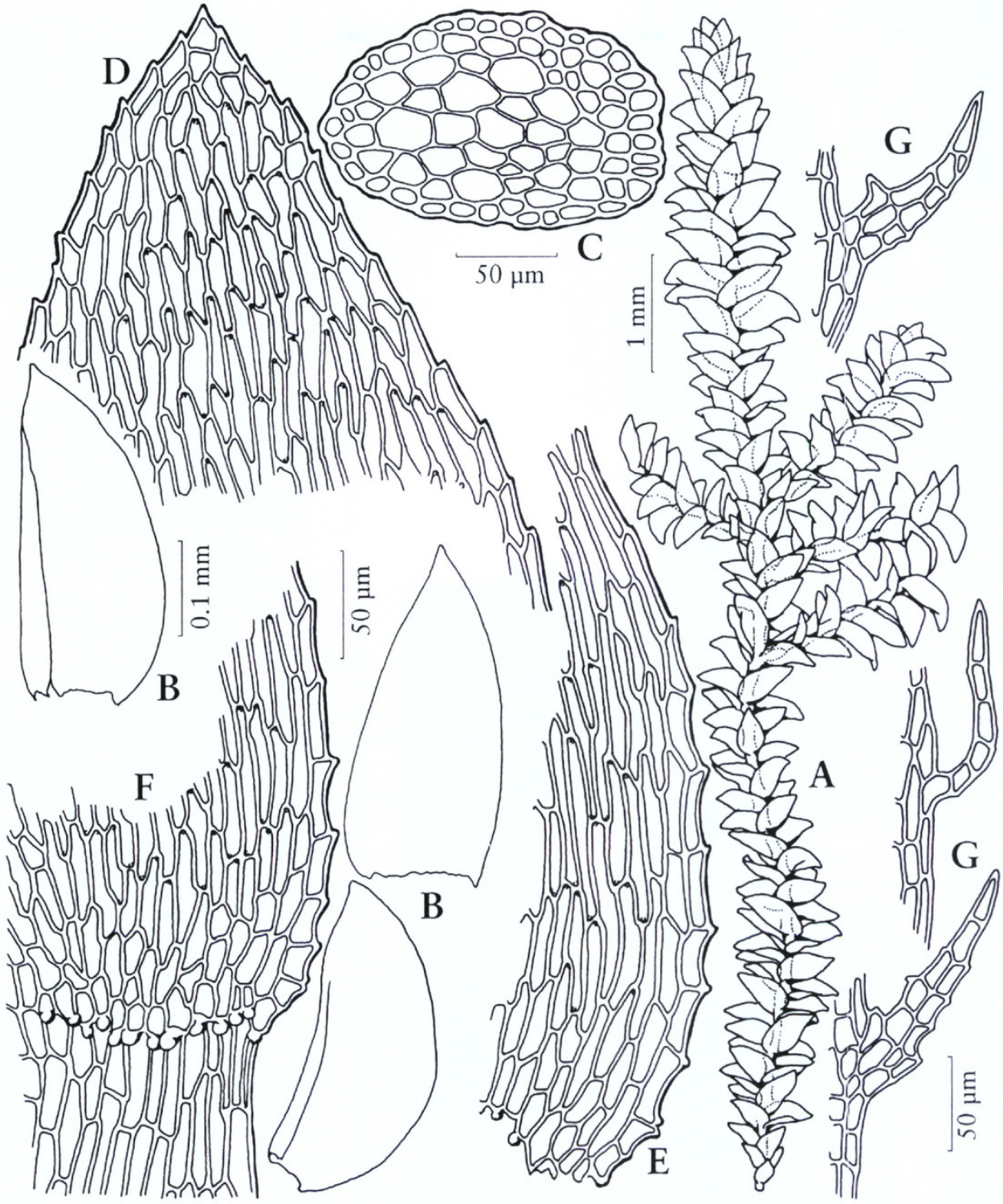

Figure 1. *Dacryophyllum falcifolium* Ireland. —A. Habit. —B. Leaf outlines. —C. Stem cross section. —D. Apical leaf cells on abaxial surface. —E. Basal-marginal leaf cells on abaxial surface showing serrations (note serration formed by abutting cells just above E). —F. Basal leaf cells on abaxial surface showing large prorulae on proximal ends of cells at stem insertion. —G. Pseudoparaphyllia (note large tooth on uppermost pseudoparaphyllium). Drawn by P. M. Eckel from isotype (US).

nute prorulae on abaxial surface at distal and proximal ends, prorulae sometimes more prominent on basal cells, with walls nonpitted; median cells 32–45 × 4–5 µm; apical cells 10–28 × 5–7 µm; basal row of cells at stem insertion each with a large prorula at proximal end on the abaxial surface; alar cells 8–19 × 6–7 µm, quadrate to rectangular, in 1 to 4 rows with 2 to 7 cells in marginal row. Asexual reproductive bodies lacking. Plants sterile, sex organs unknown.

Etymology. The genus name is derived from the Greek *dakryo*, meaning to shed tears or weep, and *phyllon*, meaning leaf, referring to the basal leaf cells at stem insertion with proximal prorulae on the abaxial surface (Fig. 1F) giving the appearance of tears, and the downward-pointing leaf apices adding to the weeping meaning (Fig. 1A). The species epithet is from the Latin *falcis*, meaning sickle, and *folium*, meaning leaf, referring to the sickle-shaped leaf apices of the plant (Fig. 1B, lowest leaf outline).

Distribution and habitat. Endemic to California. The collections were made in Coast Redwood forests on vertical surfaces of shaded, calcareous rock cliffs and rock outcrops at elevations of 50–244 m. According to the type collector the localities have a typical Mediterranean climate, with a dry, warm summer and a cool, rainy winter, which is generally from October to April. The common trees at the sites are *Sequoia sempervirens* (D. Don) Endlicher, *Acer macrophyllum* Pursh, and *Lithocarpus densiflorus* (Hooker & Arnott) Rehder. The mosses associated with *Dacryophyllum* are *Brachythecium* species, *Didymodon* species, *Fissidens crispus* Montagne, and *Isothecium myosuroides* Bridel.

Morphology and relationship. Dacryophyllum falcifolium is primarily distinct because of its prostrate small-sized plants, stems to only 1.5 cm long and 0.8–1.0 mm wide (Fig. 1A), its small, complanate-foliate leaves, 0.3–0.5 mm long, with acute to obtuse leaf apices, usually strongly falcate (Fig. 1B), and its serrulate to serrate leaf margins (Fig. 1D–F). The basal cells on the margins in the alar region often have two abutting cells forming a serration similar to the basal serrations in the pleurocarpous moss *Conardia compacta* (J. K. A. Müller) H. Robinson (Crum & Anderson, 1981) and those on the leaf margins of several species of the acrocarpous moss *Philonotis* (Fig. 1E, just above letter). The apical leaf cells are noticeably short and broad, 10–28 × 5–7 μm (Fig. 1D). The leaf cells have minute prorulae on the abaxial surface on the distal ends of the cells or sometimes at both ends (Fig. 1E). The costa is usually lacking or indistinct and short and double. The basal row of leaf cells at stem insertion is unique because of the large prorulae at the proximal ends on the abaxial surface (Fig. 1F). One other unique feature is the narrowly foliose, 2 to 4 cells wide, serrulate to toothed pseudoparaphyllia, sometimes with a single-celled, large tooth (Fig. 1G, uppermost pseudoparaphyllium), usually intermixed with filamentous entire pseudoparaphyllia, 4 to 6 cells long (Fig. 1G, middle pseudoparaphyllium).

Plants of the holotype (*Kellman 704*) and one paratype (*Kellman & Shevock 2671*) were sent to A. J. Shaw (DUKE) who conducted a DNA test on a single chloroplast gene from plants of the two specimens in order to see how the unknown California moss was related to many other pleurocarpous moss species he had tested in the past. The sequencing was done on the *trn*L-*trn*F region (Taberlet et al., 1991). He admitted (pers. comm.) that "a single chloroplast gene doesn't give much useful resolution, especially in the Hypnales, where species, genera, and even some families are extremely closely related in a genetic sense." The two specimens he tested yielded identical sequences. The closest species that it came to in his DNA test was *Hypnum pallescens* (Hedwig) P. Beauvois, which as he stated "gives some support to the Hypnaceae idea" where I thought the species belonged. However, it is not very close morphologically to *Hypnum pallescens* or to any other species of *Hypnum*. *Hypnum* taxa often have stems that are regularly pinnate, leaves that are often falcate-secund, standing out from the stems, with acuminate to long-subulate apices, apical cells that are elongate, and the pseudoparaphyllia on the stems are usually broadly foliose, with or without teeth or with ciliate margins.

I originally intended to describe this unknown moss as a *Taxiphyllum*, a member of the Hypnaceae that I have worked on for several years. However, I had some reservations and wanted to confirm its generic position, so I sent some of the holotype and one of the paratype (*Kellman & Shevock 2671*) specimens to William R. Buck (NY), an authority on the pleurocarpous mosses. He thought (pers. comm.) the genus was close to the family Neckeraceae, which has many genera with a somewhat similar appearance and morphology. *Isodrepanium lentulum* (Wilson) Britton, e.g., has a superficial similarity with its smooth, falcate, cultriform leaves, but it differs in many important microscopic morphological features, especially the lack of large prorulae on the abaxial surface at the proximal ends of the basal cells at the stem insertion. Other taxa in the Neckeraceae have rhombic to rhomboidal leaf cells, usually without prorulae, and sometimes paraphyllia are present or the pseudoparaphyllia that are present in some species are narrowly foliose with entire margins. He excluded the plants from *Taxiphyllum* because (1) the plants, especially those from North America, were too small (*Taxiphyllum* in Asia, however, can be very small, e.g., *Taxiphyllum arcuatum* (Bosch & Sande Lacoste) Si He); (2) the pseudoparaphyllia had large teeth, composed of almost whole cells (rather than serrulate with only cell ends projecting); and (3) the most important reason was the cells at the leaf in-

sertion with the stem were strongly prorulose at their proximal ends on the abaxial surface and project down from the leaf base. He stated that he had not seen leaf insertion cells of that type before. It was the presence of prorulose cells at the leaf insertion that prompted me to seek the opinion of two other bryologists, namely Lewis E. Anderson (DUKE) and Harold E. Robinson (US). Both (pers. comm.) thought the plants should be described as a new genus because of major differences with *Taxiphyllum*, especially because of the unique prorulose cells at the leaf insertion first observed by Buck, who also was in favor of recognizing it as a new genus.

The plants of *Dacryophyllum falcifolium* are somewhat close in appearance to some species in the genus *Taxiphyllum*; both genera grow on calcareous substrates and share some common morphological characteristics. The similarities are the green or yellow-green, glossy, prostrate, mostly complanate-foliate, simple or sparingly branched plants, the leaves that are nondecurrent often with serrulate to serrate margins, sometimes with obtuse apices, the costa that is almost lacking in *Dacryophyllum* and sometimes so in *Taxiphyllum*, the abaxially prorate leaf cells with the prorulae very prominent at the distal cell ends in *Taxiphyllum*, present but usually minute in *Dacryophyllum*, and the presence of foliose pseudoparaphyllia. *Dacryophyllum* is distinguished by the falcate leaf apices, the lack of a central strand of cells in the stem, and the pseudoparaphyllia that are much narrower than in *Taxiphyllum* (Ireland, 1971, fig. 57). Sometimes the pseudoparaphyllia have single-celled, large teeth, and they are mixed with filamentous pseudoparaphyllia, neither of which *Taxiphyllum* possesses. In addition, the leaf cells often have prorulae on the abaxial surface at both ends, and, most importantly, the basal row of cells at the leaf insertion is strongly prorulose at the proximal ends. The branch primordia are not evident among the pseudoparaphyllia in *Dacryophyllum* as they are in most species of *Taxiphyllum* where the raised branch primordia on the stem are surrounded by the pseudoparaphyllia. At first the pseudoparaphyllia appeared to be paraphyllia but they always or nearly always occur in clusters in the leaf axils like pseudoparaphyllia, and they are not scattered along the stems like paraphyllia. They are, however, present on the stems around the young developing branches and on the bases of more mature branches like typical pseudoparaphyllia. The lack of obvious, raised branch primordia sometimes occurs on the stems in other genera that have pseudoparaphyllia, e.g., *Isopterygium*, which has filamentous pseudoparaphyllia. Often, in *Isopterygium* species, however, there is some evidence that a branch primordium may sometime develop because of a difference in coloration, often an orange area, among the pseudoparaphyllia, or else some differentiated stem cells may be evidence that a branch primordium is present at that particular site. This type of evidence of a branch primordium was difficult to observe on the stems among the pseudoparaphyllia of *Dacryophyllum* because the clustered pseudoparaphyllia often obscured the view of the stem cells, which made it difficult to note any evidence of differentiated cells among them. Another explanation could be that they are not yet fully developed in the specimens examined, perhaps due to the absence of the necessary environmental factors at the time when the plants were collected. Sometimes some of the pseudoparaphyllia looked like paraphyllia when only one was seen at a particular site on the stem. However, none were observed on the abaxial or adaxial surfaces of the stems like paraphyllia in species that possess them, e.g., *Cratoneuron* and *Thuidium* species, where they occur randomly all around the stems. I therefore believe all of them are pseudoparaphyllia.

Dacryophyllum probably occurs elsewhere in California, and it should be searched for in calcareous habitats throughout the state. If sporophytes can be found they would undoubtedly reveal additional important information about the new genus and species. Also, it will be very interesting to see if the plants always occur in the Redwood forests of California.

Paratypes. U.S.A. **California:** Monterey Co., near S fork of Little Sur River below Old Coast Road, El Sur Ranch, 28 June 2003, *K. M. Kellman 3037* (CAS, DUKE, MO, NY, UC, US); Santa Cruz Co., Coast Redwood forest where Cave Gulch crosses under Empire Grade, on campus of U. of California, 8 Feb. 2003, *K. M. Kellman & J. Shevock 2671* (CAS, DUKE, US); cliff on opposite side of South Fork Fall Creek from Blue Cliff, above Lime Kilns, Fall Creek Division, Henry Cowell Redwoods State Park, near Felton, 15 June 2003, *K. M. Kellman 2995* (topotypes, CAS, DUKE, MO, NY, UC, US).

Acknowledgments. I am especially grateful to Kenneth M. Kellman of Ben Lomond, California, who first collected and sent me the new moss for identification, also providing me with important ecological data and a list of associated plants. I thank H. E. Robinson, Smithsonian Institution, for his support, comments on the morphology and relationship of the new taxon, as well as for his suggestion of the genus name and the preparation of the Latin description. I appreciate the interest and observations by W. R. Buck, New York Botanical Garden, on the morphology of several features of

the new species, especially his photographs of the prorulae on the basal cells that assisted the artist. I am indebted to A. J. Shaw, Duke University, for conducting the DNA test on the plants and for his comments. I am grateful to L. E. Anderson, Duke University, for rendering his opinion on the morphology and taxonomic status of the new species. D. H. Norris, University of California, brought my attention to important morphological information, which I gratefully acknowledge. P. M. Eckel, Missouri Botanical Garden, did the illustrations, and I owe her a debt of gratitude for the time taken to produce her excellent drawings. I thank S. He and V. C. Hollowell, Missouri Botanical Garden, for their helpful review of the paper, and I also have benefited from the discussion of the morphology of the new taxon by the former. Finally, the invaluable assistance of Scott Whittaker, who took pictures of the leaves of the plants with the SEM to better observe the location of the prorulae, is greatly appreciated.

Literature Cited

Crum, H. & L. E. Anderson. 1981. Mosses of Eastern North America, Vol. 2. Columbia Univ. Press, New York.

Ireland, R. R. 1971. Moss pseudoparaphyllia. Bryologist 74: 312–330.

Taberlet, P., L. Gielly, G. Pautou & J. Bouvet. 1991. Universal primers for amplification of three non-coding regions of chloroplast DNA. Pl. Molec. Biol. 17: 1105–1109.