

## *Climacium dendroides* from Cofre de Perote, A High-Elevation Tropical Montane Site in Veracruz, Mexico

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**Abstract.** *Climacium dendroides* (Hedw.) F. Weber & D. Mohr is reported new to Mexico and in the first known locality in the tropics, at the elevation of 3,000 m, on the ancient shield volcano of Cofre de Perote. Variation in branching of the costa is assessed in this plant and in material of *C. dendroides* worldwide. Additional taxa of interest from this locality on Cofre de Perote include *Aulacomnium palustre* and *Polytrichum commune* (both new to the state of Veracruz).

**Keywords.** ‘Boreal’ mosses, *Climacium*, distribution, Mexico, montane tropics.

The ancient shield volcano of Cofre de Perote is located in the Neovolcanic Axis of Mexico, at 19°32' N, 97°30' W, and reaches an elevation of 4,200 m. The upper regions of the mountain have extensive *Pinus-Abies* forests with a rich flora of mosses, ferns, and cycads, that has been the focus of much botanical study in the past, including the visit by Baron Alexander von Humboldt in 1803. The moss flora has been studied by De Luna (1988) and Delgadillo (1984). At least 173 species of mosses are listed from the coniferous forest and alpine zones. Dominant species on soil include *Hypnum revolutum*, *Rhytidium rugosum*, and *Thuidium peruvianum*. The most frequent epiphytic mosses are *Entodon jamesonii*, *Fabronia ciliaris*, *Neckera chlorocaulis*, *Orthotrichum pycnophyllum*, *Platygyrium fuscoluteum*, *Pylaisiella falcata*, *Tortula amphidiacea*, *T. fragilis*, and *Zygodon ehrenbergii*. Open sites are colonized by *Symblepharis vaginata*, *Zygodon obtusifolius*, *Didymodon rigidulus*, and several species of *Bryoerythrophyllum*, *Leptodontium*, and *Ptychomitrium*. It is remarkable that several new taxa or new records for Mexico have been discovered on this volcano: *Philonotis corticata* (Crum & Griffin 1981), *Bryoerythrophyllum andersonianum* (Zander & Sharp 1981), *Leptodontiella apiculata*, *Pleurozium schreberi* (De Luna 1988), and *Leptopterigynandrum austro-alpinum* (De Luna 1986).

Plants of *Climacium* (Newton 4429, De Luna 2347, 2358) were collected in May and June 1998 on the northeastern side of Cofre de Perote at an elevation of 3,000 m (10,200 ft.) in a swampy habitat in an open shallow stream valley surrounded by *Pinus* spp. The area was fairly small, approximately

20 m across, and consisted of a series of small swamps connected by the small stream. *Climacium* was growing on low hummocks to one side of the stream, and the plants were deeply embedded in the surrounding mosses and other plants. Additional moss species in the immediate area included *Polytrichum commune* Hedw. (De Luna 2348, Newton 4427) and *Aulacomnium palustre* (Hedw.) Schwaegr. (De Luna 2349, Newton 4428), both new records for the state of Veracruz and very rarely recorded in Mexico (Sharp et al. 1994). Extensive areas of *Aulacomnium* were found in an adjacent, much larger swampy area surrounded by large stands of *Juncus* and various sedges, but a search for *Climacium* in this area was not successful. Following severe drought in the summer of 1998 large areas of forest on Cofre de Perote were damaged by fire. Fortunately the area in which the *Climacium* occurs was not affected by the fire and the continued presence of the plants in this locality was confirmed (De Luna) in November 2003.

The Climaciaceae consist of one genus, *Climacium*, with four or five species, and was discussed by Horton and Vitt in 1976. *Climacium dendroides* (Hedw.) Web. & Mohr is known from northern and central Europe and Asia, the South Island of New Zealand, and North America, where it is found across the north of the continent above ca 45° N, and in the western mountains as far south as New Mexico. *Climacium americanum* Brid. occurs in eastern North America from the Great Lakes and New York south to Florida and the Gulf Coast. *Climacium japonicum* Lindb. is known from Japan. *Climacium acuminatum* Warnst. was described from North America but was not mentioned by

Horton and Vitt (1976) and is little known. A fifth taxon is variously recognized as a species, *Climacium kindbergii* (Ren. & Card.) Grout, as a variety of *C. americanum*, or as a form not worthy of taxonomic rank (Horton & Vitt 1976). For the purposes of this paper, this latter taxon is regarded as part of *Climacium americanum*. No specimens of the genus have been reported previously from localities in tropical latitudes, with all previous records north of ca 27° N (North America, Europe, Asia, and Japan) or south of 40° S (New Zealand).

In North America, the distributions of *C. dendroides* and *C. americanum* overlap in the northeastern part of the continent, and the two species intergrade to some extent in the characters used to differentiate them, including shape of stipe and branch leaves, size of auricles, and length:width ratio of the upper lamina cells (Horton & Vitt 1976). Although *C. americanum* extends farther south than *C. dendroides*, it is primarily a species of lower elevations, whereas *C. dendroides* is primarily a boreal-montane species.

The plants found on Cofre de Perote conform closely to the description of *C. dendroides* as given by Horton and Vitt (1976), and match specimens from North America and Europe. Since the nearest known locality for *C. dendroides* is in New Mexico, at 35°50' N, 105°40' W (*Crosby 16529 MO* <http://mobot.mobot.org/W3T/Search/most.html>) our report represents a significant range extension.

The plants are glossy golden-green, with filamentous paraphyllia forming a dense stem tomentum and erect, rather strongly plicate and concave branch leaves. The stipe leaves are up to 2.6 mm long by 1.8 mm wide, with obtuse apices abruptly narrowed to a slightly curved or reflexed apiculus to 0.18 mm long (Fig. 1), and with a single or variously spurred or forked costa to the middle or upper lamina. The branch leaves are up to 2.3 mm long by 1.25 mm wide, deeply plicate when wet and fairly abruptly narrowed to a short acute and distinctly serrate apex, with a long, stout, single costa reaching into the upper lamina. Auricles in both types of leaves are present but weakly developed, and with distinct patches of inflated thin-walled alar cells. Upper lamina cells range from short to long rhomboid, up to 50 µm long, with an average length:width ratio of 8:1 and a range of 4:1 to 10:1. According to Horton and Vitt (1976) upper leaf cells of *C. dendroides* vary from (6)7:1 to 13:1, whereas in *C. americanum* the range is from 3–7(8):1. Although the average length:width ratio in the Mexican plant falls in the overlap between these two species, it is evident that the range more closely matches that of *C. dendroides*.

Only one character differs from those previously described for the family, the presence of distinct

basal spurs or forking of the costa (Fig. 2). Although only present in ca 1/5 of the stipe leaves, this feature occurs in leaves along the length of the stipe, so is not due to heteroblastic changes along the stipe. Material from North America and Europe in the herbarium of the Natural History Museum (BM) was examined to determine whether this feature occurs elsewhere. Considerable variation in the length and stoutness of the costa was seen, often between stems in a single collection. In several collections short axillary costae were seen, originating adjacent to but separate from the principle costa. In a small number of specimens very occasional forks or spurs were found to be present. It therefore seems that some variation in the form of the costa is widespread in *Climacium dendroides*, but has not been reported in the standard floras.

The possible relationship of the Climaciaceae to the Hylocomiaceae was suggested by Crum and Anderson (1981), but the difference in costa morphology (long and single versus short and double, respectively) was raised as a possible objection by these authors. The presence of forked or spurred costae in some specimens of *Climacium dendroides* might be construed as morphological support for this taxonomic placement.

Given the high elevation and extensive coniferous forests on this and other mountains in the neovolcanic axis, it may be hardly surprising that this moss assemblage, more typical of boreal habitats, should be found on Cofre de Perote. A significant number of such "boreal" species have previously been recorded from this area by Delgadillo (1984): *Didymodon rigidulus* Hedw. var *gracilis* (Hook. & Grev.) Zand.; *D. rigidulus* var *icmadophila* (C.M.) Zand.; *Grimmia affinis* Hornsch.; *G. fuliginosa* C. M.; *G. fusco-lutea* Hook.; *G. incurva* Schwaegr.; *Paraleucobryum enerve* (Thed.) Loeske; *Rhytidium rugosum* (Hedw.) Kind.; *Tayloria splachnoides* Hook.; *Zygodon viridissimus* (Dicks.) Brid. and by De Luna (1986 and 1988): *Timmia megapolitana* Hedw. subsp. *bavarica* (Hessl.) Brassard and *Pleurozium schreberi* (Brid.) Mitt. Further exploration of the area and examination of existing collections can be expected to reveal additional range extensions.

The presence of these taxa may represent chance colonization by long-distance dispersal of spores into a suitable habitat, although given the rarity (at least currently) of sporophyte production in species such as *Rhytidium rugosum* this may be unlikely. Another possibility is that these distributions may reflect a relictual status of individual species or (as in this case) small communities that have maintained a presence in this cool temperate environment since the last glacial period when such species could be expected to have had a more southern dis-

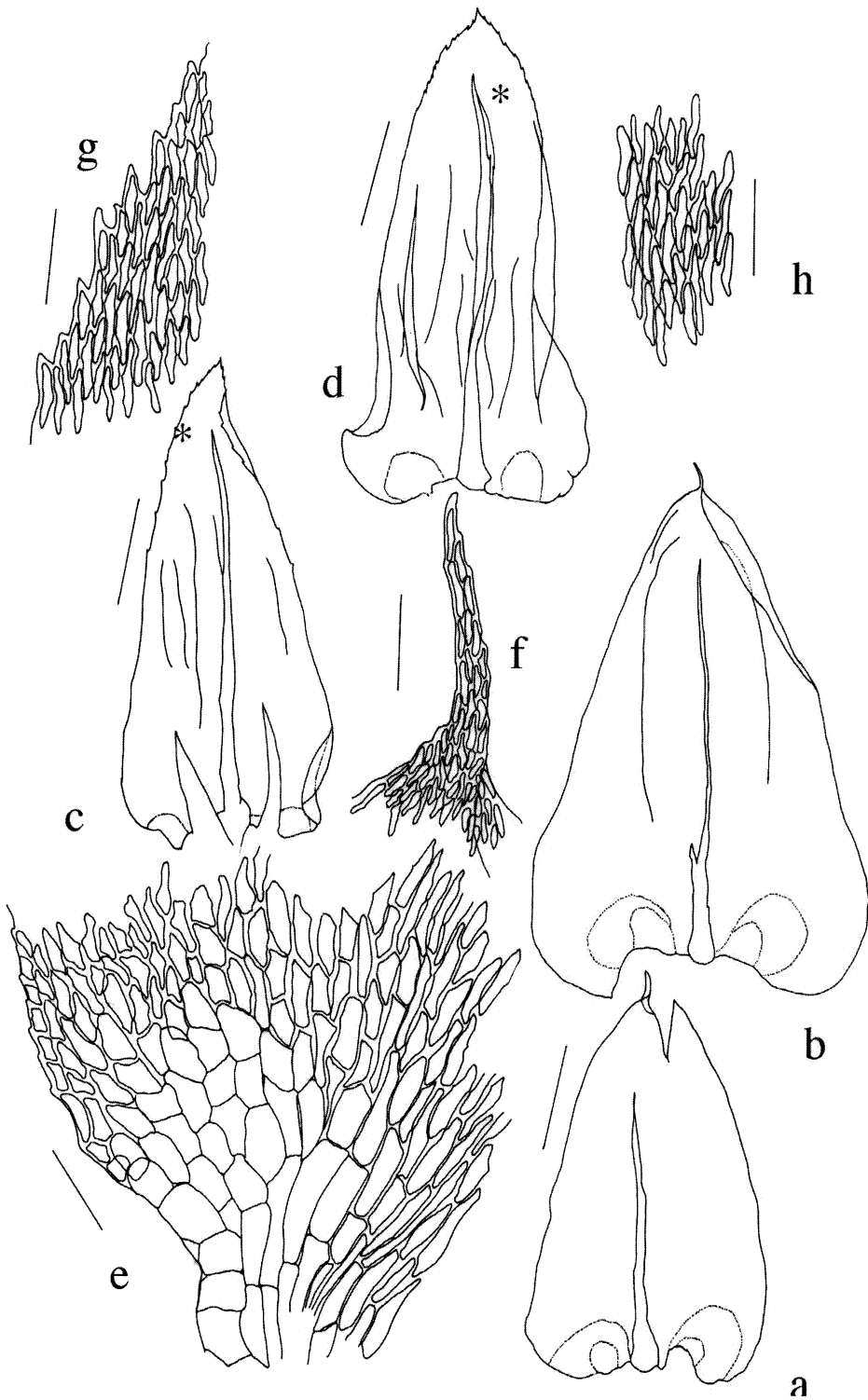


FIGURE 1. Stipe and branch leaves of *Climacium dendroides* from Cofre de Perote. — a–b. Stipe leaves. — c–d. Branch leaves. — e. Alar cells on stipe leaf. — f. Apiculus on stipe leaf. — g. cells at margin of branch leaf (location marked by \* on 1c). — h. lamina cells of upper branch leaf (\* on 1d). Scale bars: a–d = 0.5 mm. e–h = 50  $\mu$ m.

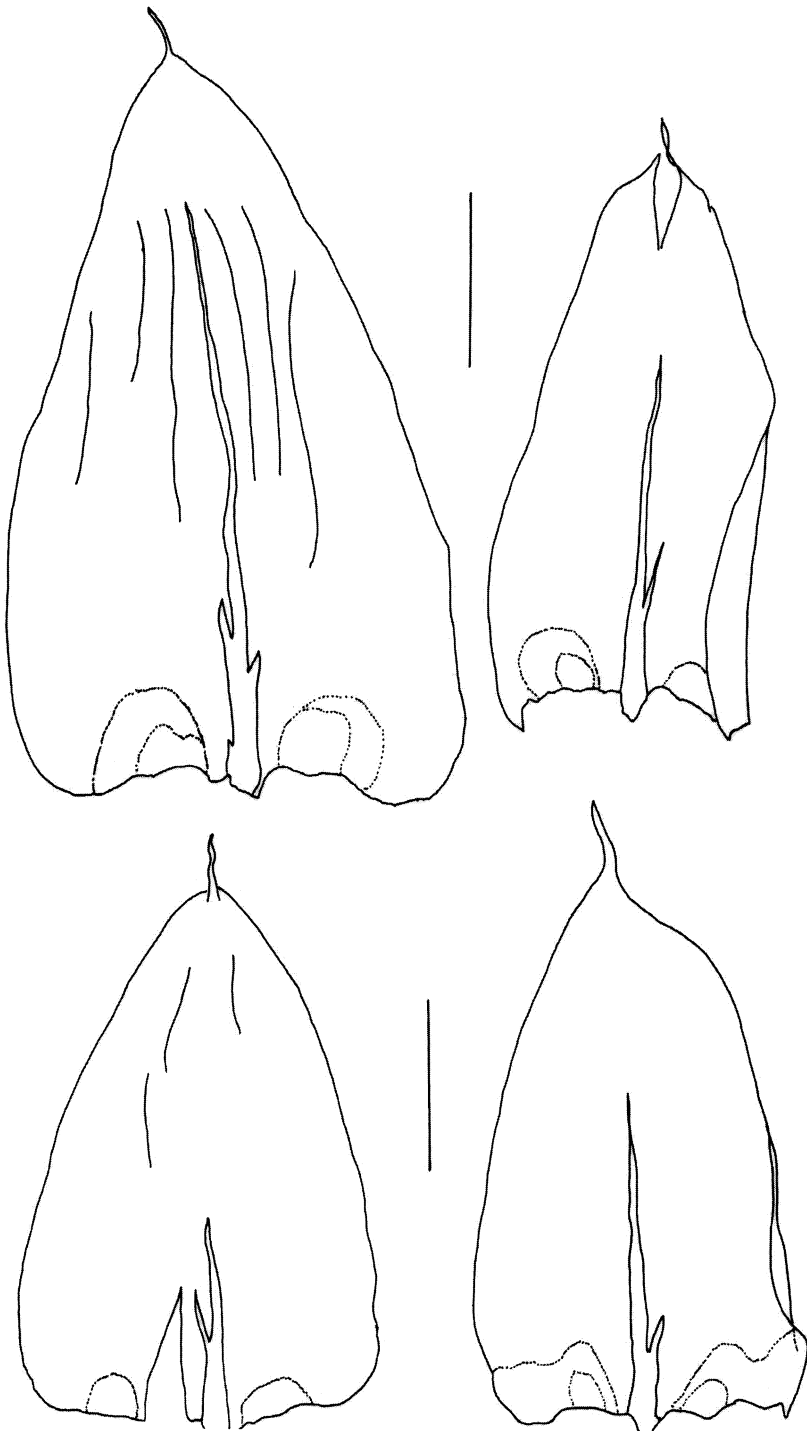


FIGURE 2. Variation in forking of stipe leaves on plant of *C. dendroides* from Cofre de Perote. Scale bar = 0.5 mm.

tribution. With gradual warming following the retreat of ice sheets, both globally and locally, such species would have migrated to higher levels and have now become isolated in these high-elevation

montane refugia. Many of the records of 'boreal' taxa from Cofre de Perote and adjacent high-elevation mountains such as Pico de Orizaba are from areas still significantly below the summits, but it

can be anticipated that with further warming the area of suitable habitat will be diminished and such species lost.

*Specimens examined.*—*Climacium dendroides*: MEXICO. VERACRUZ. Cofre de Perote, Valle Alegre, *Newton 4429* (BM), *De Luna 2347, 2358* (XAL). *Aulacomnium palustre*: MEXICO. VERACRUZ. Cofre de Perote, Valle Alegre, *Newton 4428* (BM, XAL), *De Luna 2349* (XAL). *Polytrichum commune*: MEXICO. VERACRUZ. Cofre de Perote, Valle Alegre, *Newton 4427* (BM, XAL), *De Luna 2348* (XAL).

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