

***Bucklandiella lamprocarpa* (Musci, Grimmiaceae) in the central and northern Andes**

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Abstract – The current geographical distribution of the rheophytic moss *Bucklandiella lamprocarpa* (Müll.Hal.) Bednarek-Ochyra et Ochyra in the central and northern Andean countries in South America is reviewed and mapped. The specimens reported from Peru as *Racomitrium bartramii* (Roiv.) H.Rob. are taxonomically assessed and some details of their structure are illustrated. As a result of this study it was determined that its morphological features fall well within the range of variability of *Bucklandiella lamprocarpa*. The global geographical distribution of *B. lamprocarpa* is outlined and the species is confirmed to be an austral cool-adapted moss which deeply penetrates into the tropics, occurring at high elevations in central and northern South America and in East and Central Africa.

Andes / Bryophyta / *Bucklandiella* / hydrophytes / phytogeography / *Racomitrium* / rheophytes / South America / taxonomy

INTRODUCTION

The representatives of the subfamily Racomitrioidae are generally considered to be associated with dry and open saxicolous habitats. This is true for the vast majority of species, which were previously classified in a large and heterogeneous genus *Racomitrium* Brid., but the recent studies revealed this genus to be a heterogeneous assemblage which was split into some segregates (Ochyra et al., 2003; Sawicki et al., 2015). This subfamily consists of about 80 species, some of which are associated with rheophytic or otherwise hydrophytic habitats. Most of them belong to the genus *Codriophorus* P.Beauv., one of four segregates of the traditionally understood genus *Racomitrium* Brid. (Bednarek-Ochyra et al., 2001) which, after excluding from it *C. varius* (Mitt.) Bednarek-Ochyra et Ochyra into the separate genus *Frisvollia* Sawicki, Szczeciska, Bednarek-Ochyra et Ochyra (Sawicki et al., 2015), consists of 14 species (Bednarek-Ochyra, 2006). Half of them, including *C. acicularis* (Hedw.) P.Beauv., *C. aquaticus* (Schrad.) Bednarek-Ochyra et Ochyra, *C. norrisii* (Bednarek-Ochyra et Ochyra) Bednarek-Ochyra et Ochyra, *C. aduncooides* (Bednarek-Ochyra) Bednarek-Ochyra et Ochyra, *C. mollis* (Cardot) Bednarek-Ochyra et Ochyra, *C. depressus* (Lesq.) Bednarek-Ochyra et Ochyra and *C. dichelymoides* (Herzog) Bednarek-Ochyra et Ochyra, are typical rheophytes which usually grow in stream beds in swiftly running water or otherwise wet sites close to brooks and rivers that are periodically washed by wave action or submerged. In addition, *C. ryszardii*

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(Bednarek-Ochyra) *Bednarek-Ochyra et Ochyra* from western North America is also a hydrophytic moss, thriving in damp or wet situations, although so far it has not been found to grow submerged or in running water (Bednarek-Ochyra, 2006).

In contrast, any species of *Racomitrium* s. str. and *Niphotrichum* *Bednarek-Ochyra et Ochyra* shows predilections to aquatic habitats and only a few species of *Bucklandiella* Roiv., the largest segregate of *Racomitrium*, are hydrophytes and occasionally rheophytes growing in frigid, montane streams, brooks, creeks, waterfalls and cascades. In the Northern Hemisphere the most typical rheophytic members of this genus are *B. macounii* (Kindb.) *Bednarek-Ochyra et Ochyra*, a pan-Holarctic disjunct montane species (Bednarek-Ochyra, 1995), *B. lusitanica* (Ochyra et Sérgio) *Bednarek-Ochyra et Ochyra* from Europe (Ochyra & Sérgio, 1992) and *B. shevockii* *Bednarek-Ochyra et Ochyra* from China (Bednarek-Ochyra & Ochyra, 2010). Likewise, hydrophytes in this genus are represented by only a few species in the Southern Hemisphere. This group includes two narrow endemics from South America, namely *B. visnadiae* (W.R.Buck) *Bednarek-Ochyra et Ochyra* from SE Brazil (Bednarek-Ochyra *et al.*, 1999) and *B. bartramii* (Roiv.) Roiv. from Tierra del Fuego (Roivainen, 1955; Deguchi, 1984), as well as *B. orthotrichacea* (Müll.Hal.) *Bednarek-Ochyra et Ochyra* from the Subantarctic and southern South America (Bednarek-Ochyra & Ochyra, 2012a; Bednarek-Ochyra, 2014a), *B. ochracea* (Müll.Hal.) *Bednarek-Ochyra et Ochyra* from the Kerguelen Biogeographical Province in Subantarctica (Ellis *et al.*, 2013), and *B. chlorocarpa* (Paris) *Bednarek-Ochyra et Ochyra* from Australasia (Bednarek-Ochyra, 2014b). However, the most widespread and best known rheophytic species of this genus is *B. lamprocarpa* (Müll.Hal.) *Bednarek-Ochyra et Ochyra*.

The global distribution range of *Bucklandiella lamprocarpa* was reviewed for the first time by Ochyra *et al.* (1988), but since then many additions to its range were made in the Subantarctic (Bednarek-Ochyra & Ochyra, 1998; Blockeel *et al.*, 2007a; Ellis *et al.*, 2010, 2011) and in South America (Blockeel *et al.*, 2002, 2008). Until now, the geographical distribution of this species was studied in detail for southern South America (Ochyra, 1993; Bednarek-Ochyra & Ochyra, 1994, 2012a; Bednarek-Ochyra *et al.*, 1996) and in South Africa (Bednarek-Ochyra & Ochyra, 2012b; Ochyra & van Rooy, 2013). In the present account the current distribution of *B. lamprocarpa* in the central and northern Andean countries in South America is presented.

AN OVERVIEW OF THE GEOGRAPHICAL DISTRIBUTION OF *BUCKLANDIELLA LAMPROCARPA*

Bucklandiella lamprocarpa is an austral cool-adapted species, having a wide pan-Holantarctic geographical range, although the main centre of its occurrence is in southern South America (Bednarek-Ochyra & Ochyra, 1994, 2012a; Bednarek-Ochyra *et al.*, 1996) and in South Africa (Bednarek-Ochyra & Ochyra, 2012b; Ochyra & van Rooy, 2013). As is the case with many south-cool-temperate species of moss, for example *Hymenoloma antarcticum* (Müll.Hal.) Ochyra (Ochyra & Bednarek-Ochyra, 2015), *Dicranella hookeri* (Müll.Hal.) Cardot (Blockeel *et al.*, 2007b; Ochyra & Bednarek-Ochyra, 2014), *D. campylophylla* (Taylor) A.Jaeger (Ochyra & Newton, 1985), *Chrysoblastella chilensis* (Mont.) Reimers (Ellis *et al.*, 2012a), *Andreaea nitida* Hook.f. et Wilson (Ellis *et al.*, 2012b), *Notoligotrichum trichodon* (Hook. & Wilson) G.L.S. (Ellis *et al.*, 2012d), *Blindia*

magellanica Müll.Hal. (Bartlett & Vitt, 1986; Blockeel *et al.*, 2010), *B. pachydictyon* (Cardot) Bednarek-Ochyra & Ochyra (Churchill *et al.*, 2000; Blockeel *et al.*, 2009), and *B. angustissima* Bednarek-Ochyra *et Ochyra* (Bednarek-Ochyra & Ochyra, 2011), *B. lamprocarpa* extends into more northerly latitudes in tropical mountains. The penetration of the south-cool-temperate species into the tropics passes off along one or more of the three main trans-tropical tracks, namely (a) the Andean pathway from Patagonia to the altimontane elevations in the Neotropics; (b) the African pathway from subantarctic islands in the Kerguelen Biogeographical Province across South Africa to East and Central African mountains; and (c) the Indomalayan-Melanesian pathway from southeastern Australia, Tasmania and New Zealand with offshore islands to the chain of Malesian islands with high mountains.

Interestingly, until recently *Bucklandiella lamprocarpa* has been recorded in the tropics only from sub-Saharan Africa, where it is bicentric in distribution. It is relatively frequent in the Cape Floristic Region in South Africa (Ochyra & van Rooy, 2013) and then, after a remarkable disjunction, it recurs in the high mountains in East and Central Africa. It occurs at elevations of 2800-4800 m in the Kilimanjaro Mountains of Tanzania, Ruwenzori Mountains of the Democratic Republic of Congo and Uganda, on Mount Kenya in Kenya and in the Virunga Massif in the Democratic Republic of Congo, Rwanda and Uganda (Ochyra *et al.*, 1988).

Bucklandiella lamprocarpa has its maximum occurrence in the temperate zone in southern South America. It is widespread in the *Nothofagus* zone at the western fringes of the continent, ranging from lat. ca 39°S in the Valdivian Biogeographical Province to Tierra del Fuego and the Falkland Islands, with an isolated site in Sierra de la Ventana in the eastern part of southern South America (Ochyra *et al.*, 1988; Bednarek-Ochyra *et al.*, 1996) and extending northwards to the Juan Fernández Islands (Robinson, 1975). The species was also reported from the Santiago Metropolitan Region in central Chile at lat. ca 33°25'S (Bednarek-Ochyra *et al.*, 1996) and it was then the northernmost extension of the species on mainland South America. However, this record was based upon the erroneous taxonomic conclusion on the conspecificity of *Racomitrium looseri* Thér. with *R. lamprocarpum* (Müll.Hal.) A.Jaeger. In fact, this species is identical to *Bucklandiella orthotrichacea* (Bednarek-Ochyra & Ochyra, 2012a).

The occurrence of *Bucklandiella lamprocarpa* in the southern regions of South America and Africa makes it a typical south-temperate species. The species occasionally extends to some subantarctic islands in the Kerguelen Biogeographical Province, where it may be considered as a post-glacial immigrant (Van der Putten *et al.*, 2010) and additionally it is known from the Iberian Peninsula in Europe (Ochyra *et al.*, 1988).

CENTRAL AND NORTHERN ANDEAN REPRESENTATION OF *BUCKLANDIELLA LAMPROCARPA*

Although the occurrence of *Bucklandiella lamprocarpa* in the neotropical mountains was expected, since there are no phytogeographical or other reasons which could prevent its northward migration along the Andean chain, the species has long been unknown from central and northern Andean countries. In 1975-1985 there have been several specimens of a rheophytic *Racomitrium* collected in Venezuela, which closely resembled *B. lamprocarpa*, and they were described by

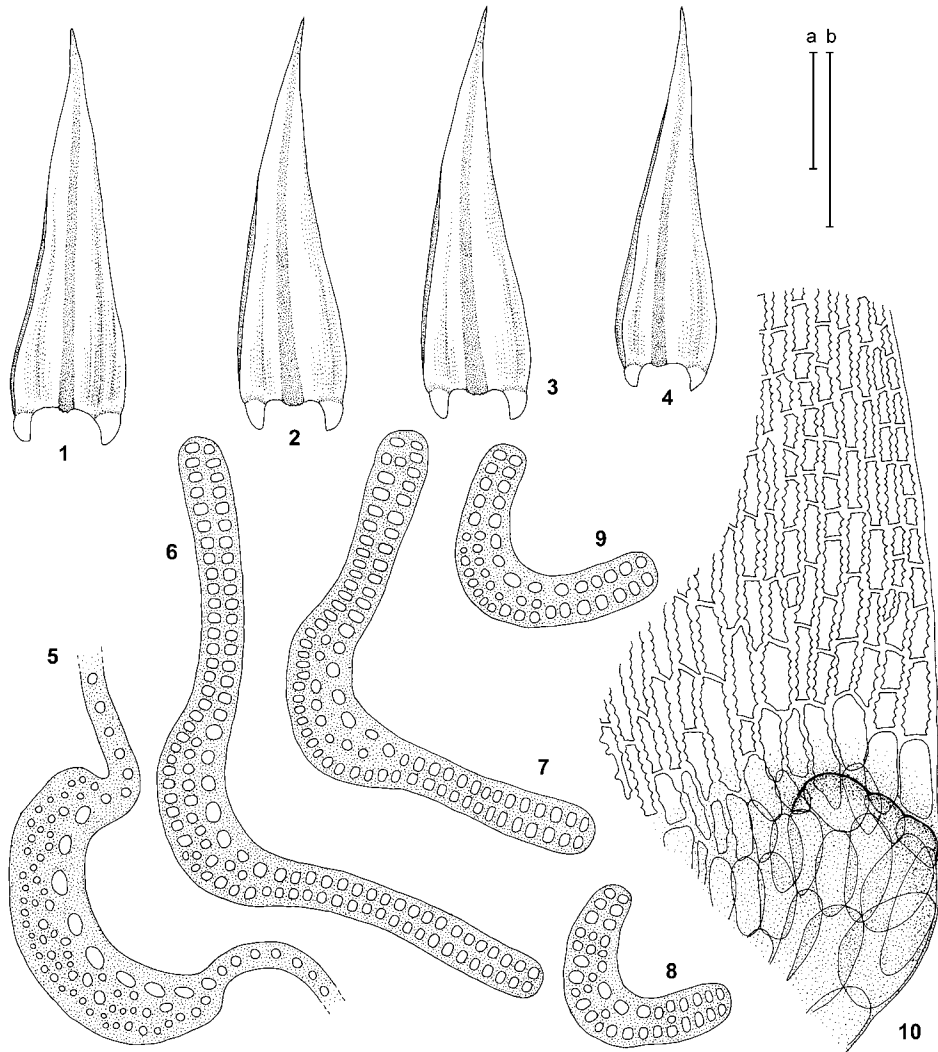
Griffin (1987) as *Racomitrium steerei* D.G. Griffin. This species was only recently assessed taxonomically (Bednarek-Ochyra, 2014c) and it was found to be conspecific with *B. lamprocarpa*.

In 1982, the German BRYOTROP Expedition collected in Peru two specimens of a similar aquatic moss. They were studied by Deguchi (1987) who named them *Racomitrium bartramii* (Roiv.) H. Rob., although the plants were not a good match for the type material from Tierra del Fuego. This species is known only from a single type specimen from Mt. Buckland in western Isla Grande de Tierra del Fuego and it was actually described as *Bucklandia bartramii* Roiv. (Roivainen, 1955). Because this generic name is a later illegitimate homonym, Roivainen (1972) proposed *Bucklandiella* Roiv. as its replacement and *Bucklandiella bartramii* (Roiv.) Roiv. is its generitype. This species is closely related to *B. lamprocarpa* and the two species share the strong costa, bistratose upper laminal cells and large spores, which are more than 25 µm in diameter (Deguchi, 1984). However, *B. bartramii* has narrowly lanceolate leaves, a wider costa that occupies about a quarter of the leaf base and is distinctly excurrent as a stout terete awn and an obloid capsule abruptly contracted into the seta.

The Peruvian plants of named *Bucklandiella bartramii* (collections by *Philippi P-244* and *Schultze-Motel P-160* in B) are medium-sized, coarse and rigid mosses, greenish-brown to dark green above, blackish below, and grow in loose tufts. The leaves (Figs 1-4) are ovate-lanceolate, epilose, straight to slightly falcate, 3.1-3.6 mm long, 0.7-0.8 mm wide, gradually acuminate, with enlarged, thick-walled alar cells forming pronounced, convex and orange-brown decurrencies (Fig. 10). The costa is stout, 120-150 µm wide at the base, percurrent, strongly convex on the dorsal side in the proximal part, reniform or flattened dorsally below and situated on the bottom of a deep furrow and consisting of 7-8 enlarged guide cells on the ventral side, with 2-3 layers of stereid cells on the dorsal surface (Fig. 5). The costa becomes less prominent and weakly demarcated from the laminal cells and broadly canaliculate in the median and upper parts of the leaves (Figs 6-8). The laminal cells are entirely smooth throughout, moderately thick and sinuose-walled, quadrate to short-rectangular distally, becoming rectangular in mid-leaf and long-rectangular in the base, with strongly nodose lateral walls. The basal marginal border is not differentiated, composed of short-rectangular cells with thick and sinuose walls. The leaf lamina is perfectly bistratose in the distal portion and imperceptibly merges with the costa, becoming unistratose with many bistratose strands and bistratose leaf margins towards the base. The leaf margins are entire, plane in the distal part, broadly recurved on one side in the proximal part, and bistratose throughout. The moss is in fine fruiting condition, with the obloid capsules 1.9-2.2 mm long, 0.7-0.9 mm wide, and gradually narrowed into the seta, which is 4-6 mm long and dextrorse when dry.

The morphological and anatomical features of Peruvian plants clearly indicate that they fall well within the range of variation of *Bucklandiella lamprocarpa*. As is the case with many aquatic and especially rheophytic mosses, this species is exceedingly variable, especially with regard to the stoutness of the costa, the stratosity of the laminal cells and the presence of the thickened leaf margins. All of these are rheophytic adaptations which are known in many unrelated moss taxa growing in rheophytic habitats (Ochyra, 1985a, b, 1987; Ochyra & Shevock, 2012).

Besides Peru and Venezuela. *Bucklandiella lamprocarpa* was also collected in 1987 in Bolivia in the central Andes (Blockeel *et al.*, 2009), in 1995 in Colombia (Ramírez & Churchill, 2002) and in 2000 in Ecuador (Blockeel *et al.*, 2002).



Figs 1-10. *Bucklandiella lamprocarpa* (Müll.Hal.) Bednarek-Ochyra et Ochyra: **1-4**. Leaves. **5-9**. Leaf cross-sections, sequentially from base to apex. **10**. Alar cells. (All from *Philippi P-244*, B). Scale bars: a - 1 mm (1-4); b - 100 µm (5-10).

DISTRIBUTION OF *BUCKLANDIELLA LAMPROCARPA* CENTRAL AND NORTHERN SOUTH AMERICA

In the latest catalogue of tropical Andean mosses (Churchill *et al.*, 2000), *Bucklandiella lamprocarpa* was recorded only from three countries, namely Venezuela, Colombia and Peru, while the occurrence in Bolivia was indicated with a question mark. Having revised the herbarium holdings from several world

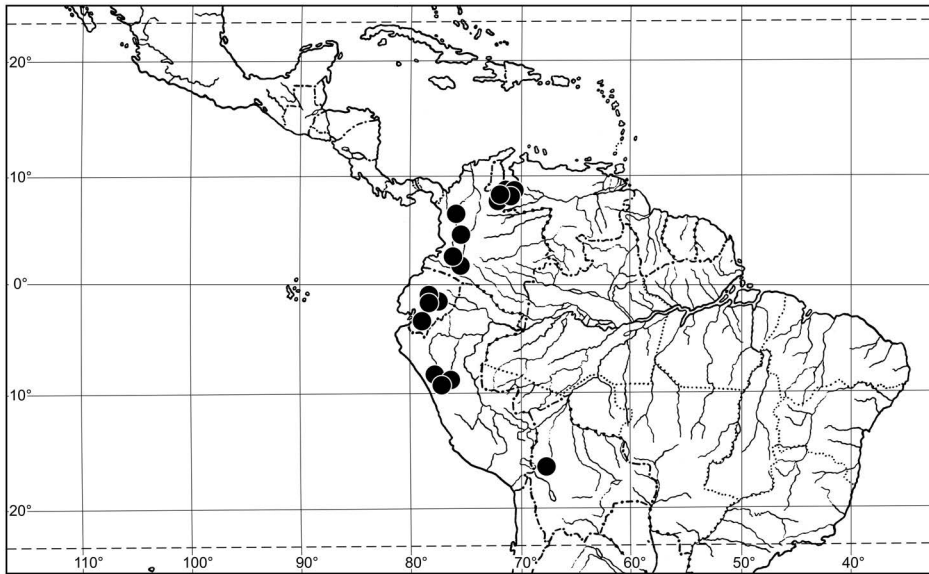


Fig. 11. Distribution map for *Bucklandiella lamprocarpa* (Müll.Hal.) Bednarek-Ochyra *et* Ochyra in central and northern Andean countries.

herbaria, additional records of this species were detected and at present it is known from all central and northern Andean countries (Fig. 11).

Bucklandiella lamprocarpa is very rare in the central Andes where it is known only from a single site in Bolivia and three sites from Peru. On the other hand, it is known from four localities in Ecuador, four in Colombia and five in Venezuela. Generally, the species occurs at alti-montane elevations, ranging from 2650 m in Colombia to 4900 m in Peru. In Bolivia it occurs at 4000-4020 m and in Peru at 4100-4900 m. Likewise, in Ecuador all records come from 3300-4500 m, whereas in Colombia and Venezuela the species occurs at lower elevations, from 2650 to 3400 m and 3400 to 3750 m, respectively.

The discovery of *Bucklandiella lamprocarpa* in tropical South America established it as an Afro-American species. This distribution pattern is shown by no less than 74 species of liverwort (Gradstein, 2013) and over 80 species of moss (e.g. Buck & Griffin, 1984; Allen & Crosby, 1986; Ochyra *et al.*, 1992; Delgadillo, 1993; Wilbraham & Matcham, 2010; Ellis *et al.*, 2012c). This number constantly increases with progress in taxonomic studies on tropical mosses and exploration of understudied regions in the Neotropics and sub-Saharan Africa and the case of *B. lamprocarpa* represents the best confirmation of this phytogeographical fact.

SPECIMENS EXAMINED. VENEZUELA. MERIDA. Dist. Rangel, Sierra Nevada de Santo Domingo, páramo de Mucubaji, valley from Laguna Grande to Mucubaji mountains, on boulder in brook, *Espeletia*-páramo and mires, alt. 3500 m, 21 October 1981, *Fransén 1443* (FLAS, NY – type of *Racomitrium steerei*); Sierra de Santo Domingo, páramo de Macubaji, above the Laguna Grande, alt. 3500 m, on rock in páramo stream, July-August 1972, *Griffin III, López & Ruiz-Terán 905* (FLAS); páramo de Los Granates, around a sector of the páramo called El Chimborazo, with *Espeletia schultzii*, alt. 3400 m, 21 February 1985, *Griffin III & López PV-1058* (FLAS). **BÁRINAS.** Parque Nacional de la Sierra Nevada, páramo de Santa Cristo, cerca de la Laguna de Santo Cristo, with *Espeletia schultzii*, *Senecio*

formosana, *Hypericum* spp, alt. 3600-3750 m, on exposed and insolated rocks at stream bank, 20-22 June 1984, *Griffin III & Diaz PV-69, 71 & 82* (FLAS). **TÁCHIRA**. Distrito Jauregui: páramo El Ballatón, above the town of La Grita, between “el púlpero” peak and the marsh “el cienegón”, alt. 3700 m, on wet rocks in cascade, August 1975, *Griffin III, López & Ruiz-Terán 516* (FLAS).

COLOMBIA. ANTIOQUIA. Municipio De Urrao: Corregimiento de Encarnación, páramo de Frontino, alt. 3380 m, on rocks, 7 December 1986, *Curso de Fitogeografía 12* (MO). **CAUCA. Darien Municipio:** Valle del Cauca, “Páramo del Duende” – Cerro Calima, ca 60 km N of Cali, Páramo con bosque montano alto, al lado del río Copana, lat. 04°03'55"N, long. 76°30'50"W, alt. 3320 m, on rocks in riverbed, 26 July 1998, *Churchill 19531* (MO). **NARIÑO. Municipio de Pasto:** La Cocha Negra, Faldas del volcán Galeras, alt. 3400 m, 11 June 1995, *Ramírez 7694* (MO). **PUTUMAYO. Municipio de Colón:** Reserva Natural La Rejoja, orilla río Negro, lat. 01°18'N, long. 76°52'W, alt. 2650 m, in rock in riverbed, 28 December 1996, *Ramírez, G. Barrera, C. Barrera & Rojas 10362* (MO).

ECUADOR. PICHINCHA. Distrito Metropolitano de Quito, camino desde el teleferico de Quito (estación terminal) hast el Rucu-Pichincha, lat. 00°09'54"S, long. 78°33'36"W, alt. ca 4500 m, sobre roca en pequeña cascada, 15 September 2010, *Larraín 35852* (CONC). **NAPO.** Laguna Paracocha, lat. 00°16'S, long. 78°09'W, alt. 4000 m, amphiphytic – epilithic and submerged vegetation. 17 March 1979, *Løjtnant & Molau 11130* (MO, NY). **TUNGIRAHUA/NAPO.** Los Llanganates Mts (= Parque Nacional Llanagates), outflow from the lake Laguna Aucacocha (not far from tourist shelter), lat. 01°09'00.6"S, long. 78°19'22.1"W, alt. ca 3800 m, on boulders in a brooklet with rapidly flowing water, 5 October 2000, *Soldán s.n.* (KRAM). **LOJA.** surroundings of Laguna Chuquiragua east of Amaluza, lat. 04°37'S, long. 79°22'W, alt. 3300 m, 25 November 1998, *Laegaard, Terneus & Sanchez 19268* (MO).

PERU. ANCASH. Yungay Province: along a stream, ca 10 miles from Yungay, alt. 14000 ft (= 4900 m), 25 June 1984, *G. Allen 4331* (MO). **Huaraz Province:** Huaraz below Laguna Llanganuco near Huaraz, alt. 4100 m, on rocks, 29 September – 1 October 1982, *Philippi P-244* (B); by road between Huaraz and Chavin, on bare rocks in Tunnel Cahuishi, alt. 4400 m, associated with *Rhacocarpus purpurascens*, 2 October 1982, *Schultze-Motel P-160* (B).

BOLIVIA. LA PAZ. Inquisivi Province: small lake called locally Laguna Huichincani ca 1 km south of Río Glorieta along trail from Bicupaya and Mina Huichincani, ca 8.5 km north-west of Quime, lat. 16°57'S, long. 67°17'W, alt. 4000-4020 m, seeps over cliff by waterfall, 19 May 1987, *Marco Lewis 87479* (KRAM, MO).

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