

Physarum andinum, a new nivicolous species of myxomycete from the Patagonian Andes

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Abstract: A new nivicolous species of *Physarum* was discovered during the study of myxomycetes in the Patagonian Andes of South America. It is described herein under the name *Physarum andinum*. The species is characterized by stalked sporophores or more rarely sessile sporocarps or short plasmodiocarps. The sporocarps are strikingly large, reaching 2.6 mm tall and 3 mm diam when open, and have a peridium with three layers, the internal layer being clearly visible and opening separately. *Physarum andinum* was found at five localities in Argentina as well as in herbarium material collected about 100 y ago in Chile. The new species is reminiscent of the non-nivicolous species *Physarum brunneolum*, but the latter forms smaller sporophores, has darker spores and the three layers of the peridium are adhered and open together. The characters of the new species were examined under stereomicroscope, light microscope and scanning electron microscope and micrographs of relevant details are included.

Key words: Amoebozoa, Argentina, Chile, Mycetozoa, Myxogastria, Myxomycetes, SEM, species distribution, taxonomy

INTRODUCTION

The genus *Physarum* (Physaraceae, Physariales) is characterized by the presence of lime in the form of non-crystalline granules in the peridium, as well as in the nodes of the capillitium. Species of *Physarum* form sessile or stalked sporocarps or short to long and branched plasmodiocarps. Like other representatives of the Physaraceae, the species of *Physarum* produce a dark brown to black spore mass and the spores are usually covered by warts or spines. *Physarum* is the largest genus of Myxomycetes, comprising about 140 species (Lado 2012) distributed worldwide. Some species are restricted to particular environments, like

the nivicolous species that complete their life cycle close to melting snow patches. Five species of *Physarum* have been reported as nivicolous: *P. albescens* Ellis ex T. Macbr., *P. alpestre* Mitchel, S.W. Chapm. & M.L. Farr, *P. alpinum* (Lister & G. Lister) G. Lister, *P. nivale* (Meyl.) Mar. Mey. & Poulain and *P. vernum* Sommerf., all of which occur in the mountains of Europe, Asia and North America (e.g. Mitchel et al. 1980, Yajima et al. 2006, Lado and Ronikier 2008, Poulain et al. 2011). Only two species, *P. alpinum* and *P. vernum*, have been found in South America; *Physarum alpinum* was reported from the Venezuelan Andes (Farr 1974) and *P. vernum* from countries including Argentina and Chile (Farr 1976, Lado and Wrigley de Basanta 2008, Wrigley de Basanta et al. 2010).

During the first study of nivicolous myxomycetes carried out in South America under the framework of the Myxotropic Project (www.myxotropic.org) numerous collections of an unusual species of *Physarum* that formed strikingly large sporocarps were found in the Patagonian Andes. After a detailed examination of all samples and comparison with all the described species from the genus, we concluded that the South American material represents a distinct undescribed species, which we designate here as *Physarum andinum*.

MATERIALS AND METHODS

A total of 65 collections were obtained directly in the field at five localities in the Patagonian Andes of Argentina (FIG. 1) by investigators of the Myxotropic Project (A. Estrada-Torres, E. García, C. Lado, A. Ronikier, D. Wrigley de Basanta). All the localities were geo-referenced (Garmin, eTrex Vista HCx, Datum WGS84). In addition, one collection from Chile, found by R. Thaxter in March 1906 and preserved in Farlow Herbarium (FH) under the name *Physarum brunneolum* (W. Phillips) Massee, was examined. As comparative material, a further 10 collections of *Physarum brunneolum* from the herbaria FH and MA-Fungi and four collections of *P. albescens* from MA-Fungi and KRAM were studied. Observations and measurements of the morphological characters were undertaken with Nikon SMZ 1000 and SMZ 1500 stereoscopic microscopes. The total height of the sporocarps and/or length of plasmodiocarps as well as the height and the width of the sporothecae of 129 sporophores of the undescribed species and 70 of *Physarum brunneolum* were measured. Observations and measurements of microscopic characters were made on material mounted in Hoyer's medium, with the aid of a light microscope (Nikon Eclipse E-600) with DIC optics. Pictures of microscopic characters were taken from material

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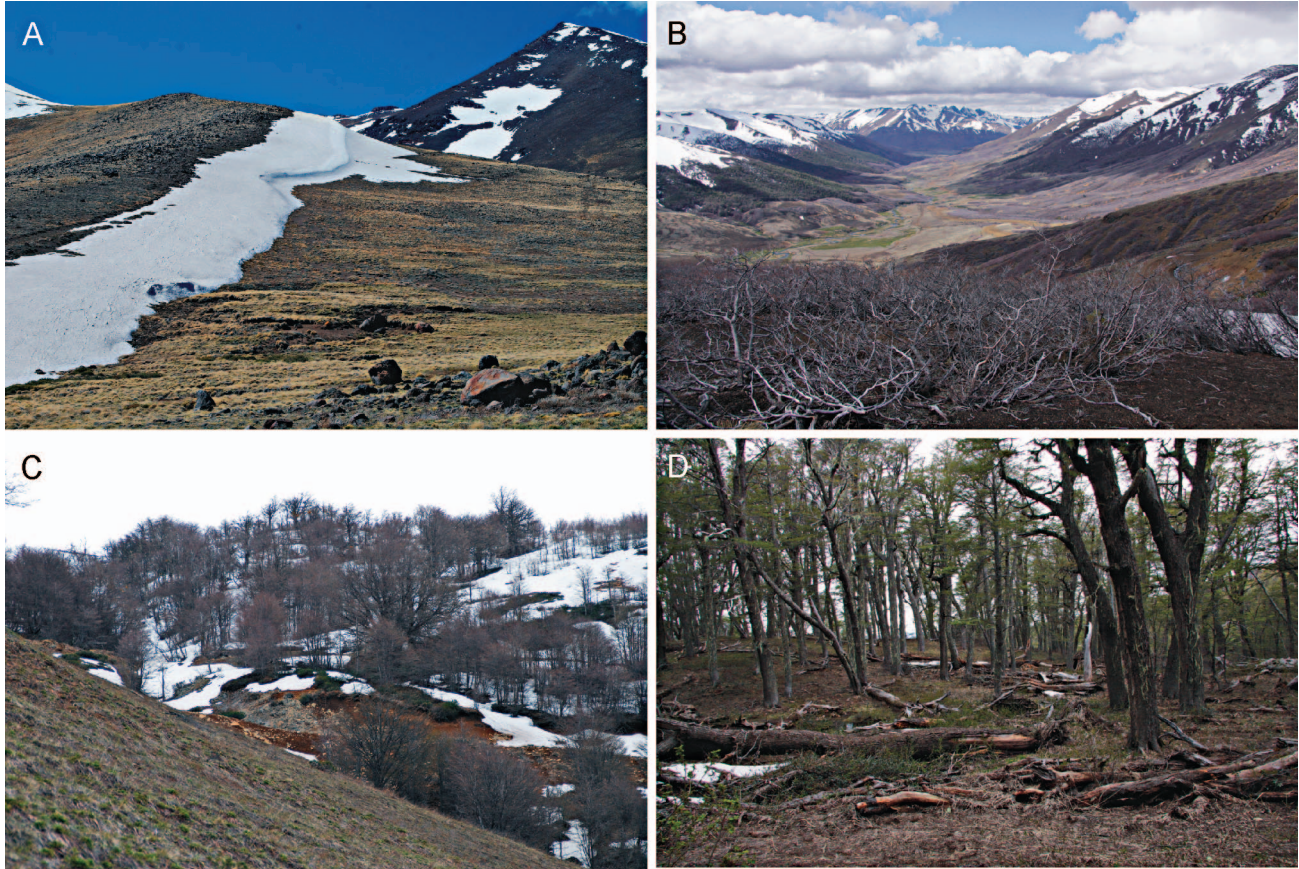


FIG. 1. Collecting sites of the new *Physarum* species. A. Locality 1. high mountain meadow above timberline. B. Locality 3. high mountain shrubland of *Nothofagus* sp. C. Locality 4. edge of a forest. D. Locality 5. *Nothofagus pumilio* forest. For description of localities, see *Specimens examined*.

mounted in water with a Nikon DS-Fi1 camera. Permanent slides of examined collections are deposited in KRAM with duplicates in MA-Fungi. Spore measurements of all mature specimens of the new species (50 per collection, 2900 in total) were made at 1000 \times magnification and include ornamentation. Values present in less than 1% of the measurements are given in parentheses in the description provided below. Statistical tests were calculated with Statistica 6 software. The critical-point drying technique was used for scanning electron microscopy (SEM) preparations, and specimens were examined with a Hitachi S-3000N scanning electron microscope, at 15 kV. Color notations in parentheses are from the ISCC-NBS color name charts illustrated with centroid colors (Anonymous 1976).

RESULTS

All collections, 65 in total, of the *Physarum* species sampled at five different localities in the Argentinian Andes had constant features: (i) strikingly large, usually stalked sporocarps, up to 3 mm diam when open; (ii) yellow to whitish sporotheca and (iii) a

three-layered peridium with the internal layer clearly visible and separate from the other two layers. This combination of characters has never been seen in other representatives of the genus. In the literature, Sturgis (1916) mentioned an “extraordinarily robust form” of *P. brunneolum* collected in Chile. According to the description, the collection was paler than the typical *P. brunneolum*, dirty white or pale tawny and larger, 1.3–1.8 mm diam, which agrees with the characteristics of the new morphotype we found in Argentina. This specimen and others of *P. brunneolum* were requested on loan. On the herbarium label of one, the material mentioned by Sturgis (1916), FH 00270270, the collection was identified preliminarily as *Chondrioderma trevelyanii*, probably by the collector, and then revised by W.C. Sturgis as *Physarum brunneolum*. Inside the herbarium envelope we found a revision note “tested” by G. Lister without any date. After examination of this collection we concluded that it is the same as the specimens from Argentina and also represents the new species that we describe below.

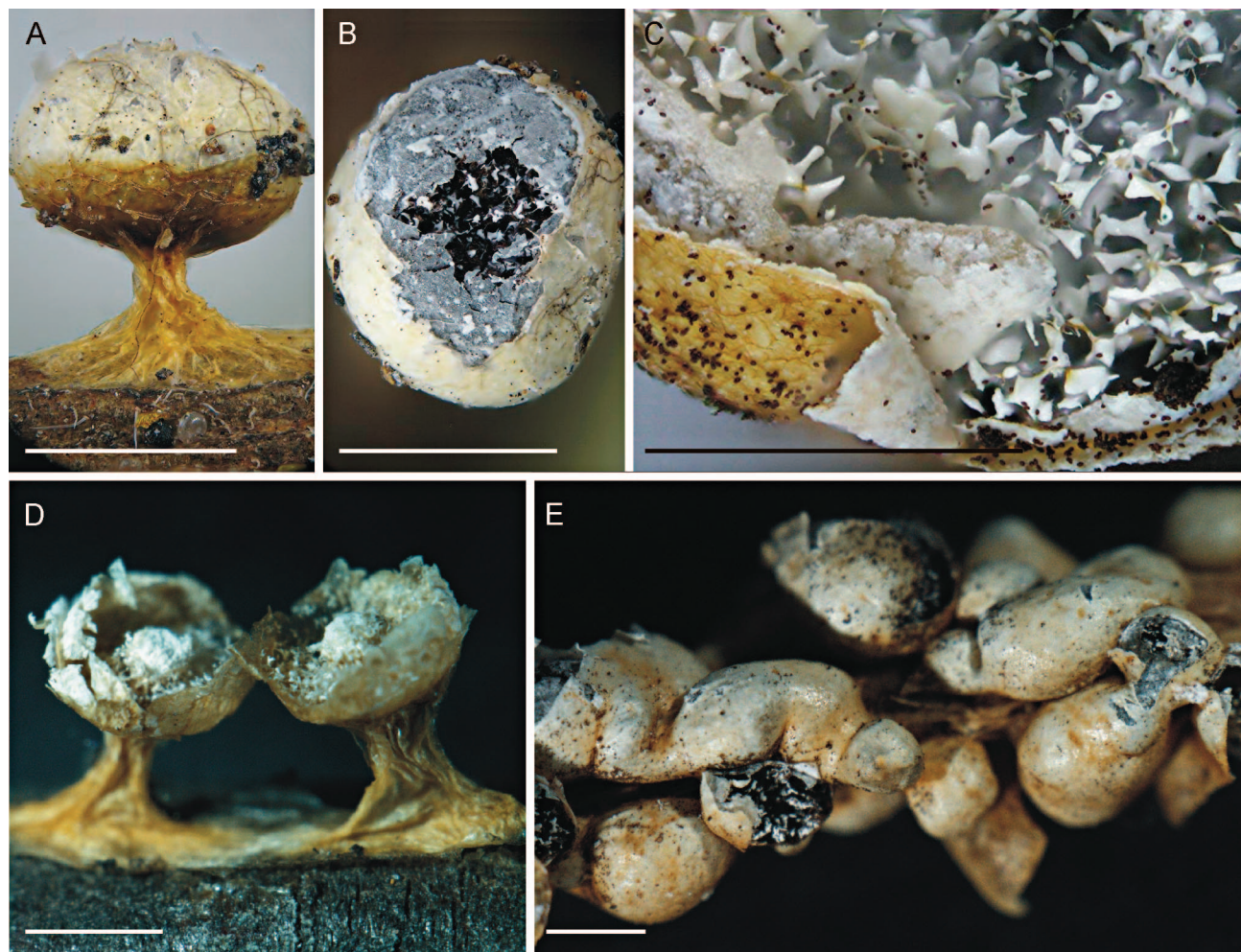


FIG. 2. *Physarum andinum*. A. Sporocarpic, stalked fructification (side view). B. Sporocarpic, stalked fructification (top view). C. Capillitium and peridium details. (A–C: Lado 20903–HOLOTYPE). D. Sporocarps with prominent pseudocolumella (Lado 20327). E. Plasmodiocarpic form (Lado 20364). Bars: A, B, D, E = 1 mm; C = 0.5 mm.

TAXONOMY

Physarum andinum A. Ronikier & Lado, sp. nov.

FIGS. 2–3, 6A–F

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Sporophores scattered to grouped, sporocarpic (FIGS. 2A–B, D, 6A–C), more rarely plasmodiocarpic (FIG. 2E). Sporocarps stipitate to sessile, sometimes two sporocarps fused (each remaining on its own stalk), total height (0.84)1.1–2.62(2.67) mm (mean 1.73 mm). Plasmodiocarps usually short, exceptionally slightly elongated, up to 5.67 mm long. Sporotheca subglobose to subhemispheric, slightly horizontally elongated, almost always wider than tall, (0.54–)0.84–1.75 mm tall (mean 1.22 mm), (0.60–)1.0–2.12(–2.67) mm wide (mean 1.53 mm), yellow to whitish (92. y White – 86. l. Y), usually darker at the base and paler at the top, 1–3 mm diameter open. Hypothallus membranous, readily visible as a disk at the base of the stalk, more rarely connecting several sporocarps, concolorous with the stalk. Stalk present or absent, thick and erect, more rarely weak and somewhat prostrate, up to 1.57 mm

long (mean length 0.50 mm), almost always shorter than the half of the total sporocarp height, limeless, yellow to olive-brown (87. m. Y – 95. m. Ol Br) in reflected light, yellow to yellowish-brown (84. s. Y – 74. s. y Br) by transmitted light. Peridium three-layered (FIGS. 2C, 3A, B), outer layer thin, membranous, smooth and shining or slightly rugulose-wrinkled, sometimes revolute after dehiscence (FIGS. 2C, 3A, 6B, C), transparent, pale yellow (89. p. Y) or whitish, olive-brown toward the base (94. l. Ol Br) in reflected light, dark yellow to olive-brown (88. d. Y – 95. m. Ol Br) by transmitted light, middle layer calcareous, white (263. White), tightly fused with the outer membrane forming one thick unit, fragile and breaking when the sporocarp is open, the inner layer distinctly separate from the two other layers, membranous, gray (264. l. Gray) to whitish (FIGS. 2C, 6C), powdery from lime deposits and rough, sometimes with thicker lime deposits from remnants of the middle layer in places, hyaline under transmitted light, covered with colorless lime globules 1–2 μ m diam; dehiscence irregular, opening first on the top of the sporotheca (FIG. 2B) or at one side (FIG. 6A), the inner

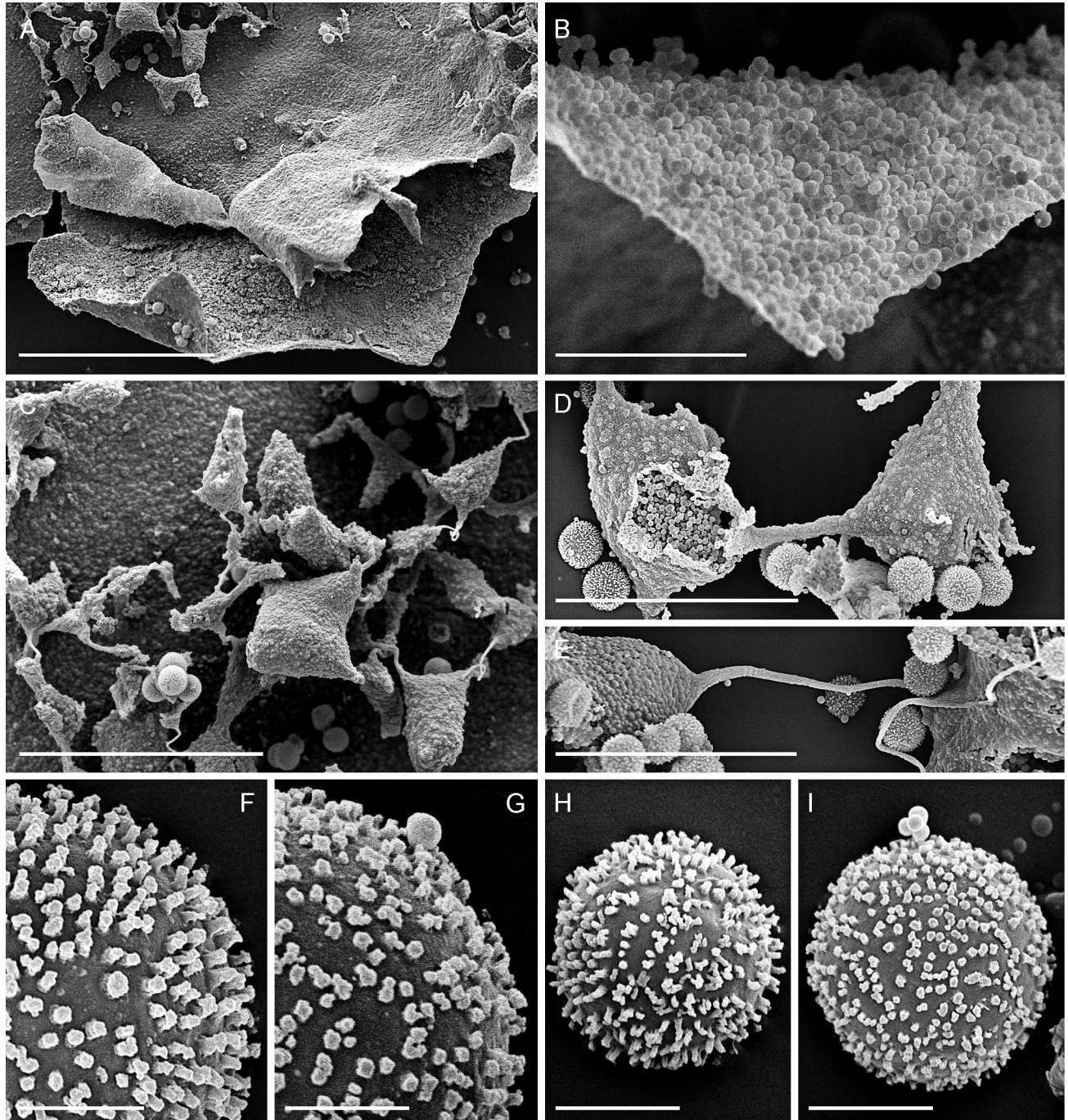


FIG. 3. *Physarum andinum* by SEM. A, B. Three-layered peridium: outer and inner layers membranous, middle layer calcareous (A: Lado 20683, B: Lado 20683). C–E. Capillitium (C: Lado 20683, D: Lado 20712, E: Lado 20364). F, G. Details of spore ornamentation (F: Lado 20712, G: Lado 20903–HOLOTYPE). H, I. Spores (H: Lado 20364, I: Lado 20903–HOLOTYPE). Bars: A = 200 µm; B = 20 µm; C = 100 µm; D, E = 50 µm; F, G = 2.5 µm; H, I = 5 µm.

layer remaining separate from the other two layers. Columella absent, pseudocolumella sometimes present (FIG. 2D), formed by the agglomeration of lime deposits at the base of sporotheca, 0.4–0.8 mm high and 0.5–1.2 mm wide. Capillitium dense (FIGS. 2C, 3C–E), usually strongly calcified and resembling the badhamioid type, with

abundant, calcareous, polygonal nodes, $55\text{--}130 \times 32\text{--}90$ µm, white (263. White) in reflected light, yellowish (92. y White – 89. p. Y) by transmitted light, connected with short threads, limeless, hyaline or more rarely slightly yellowish (92. y White) when observed by transmitted light. Spores blackish to dark brown in mass, grayish brown (80.

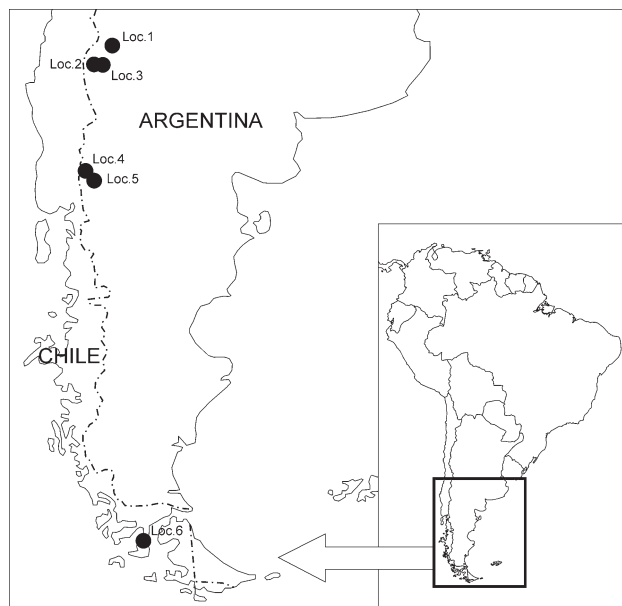


FIG. 4. Distribution of *Physarum andinum*. For explanation of localities, see *Specimens examined*.

gy. y Br – 61. gy. Br – 58. m. Br) by transmitted light, globose, (7–)9–12.5(–14.5) μm diam, ornamented with densely and irregularly arranged, short, delicate, darker warts or spinules, baculate to pilate by SEM (FIGS. 3F–I, 6D–F). Plasmodium unknown.

Holotype. ARGENTINA. RÍO NEGRO: Bariloche Department, San Carlos de Bariloche, Nahuel Huapi National Park, Challhuaco valley, Neumeyer refuge, 41°15'33.1"S, 71°17'31.6"W, 1438 m, near patches of melting snow in a *Nothofagus pumilio* forest, on twigs of *Nothofagus pumilio*, 22 Nov 2009, leg. A. Estrada, E. García, C. Lado, A. Ronikier & D. Wrigley de Basanta, Lado 20903 (MA-Fungi 80910). *Isotypes* at KRAM (M-1553) and TLXM.

Specimens examined: ARGENTINA. NEUQUÉN: Chos Malal department, Chos Malal, Tromen Provincial Reserve, Cerro Waile refuge, 37°04'44.9"S, 70°07'09.3"W, 2243 m, open grassy vegetation with low shrubs, near patches of melting snow, 7 Nov 2009, (FIGS. 1A, 4 – Loc. 1): on plant shoots, Lado 20315 (MA-Fungi 80911); on grass culms, Lado 20320 (MA-Fungi 80912), Lado 20321 (MA-Fungi 80974), Lado 20323 (MA-Fungi 80913), Lado 20324 (MA-Fungi 80914). NEUQUÉN: Ñorquin Department, Andacollo, Moncol, Puerto Pichachén, Road 57, 17 km SW police station, 37°26'51.3"S, 71°05'57.4"W, 1930 m, shrubs of *Nothofagus* sp., near patches of melting snow, 8 Nov 2009, (FIG. 4 – Loc. 2): on living twigs of *Nothofagus* sp., Lado 20327 (MA-Fungi 80915), Lado 20333 (MA-Fungi 80916), Lado 20343 (MA-Fungi 80918); on twigs, Lado 20335 (MA-Fungi 80917). NEUQUÉN: Ñorquin Department, Andacollo, Moncol, Puerto Pichachén, Road 57, 16 km southwest of police station, 37°26'49.9"S, 71°06'18.5"W, 1880 m, shrubs of

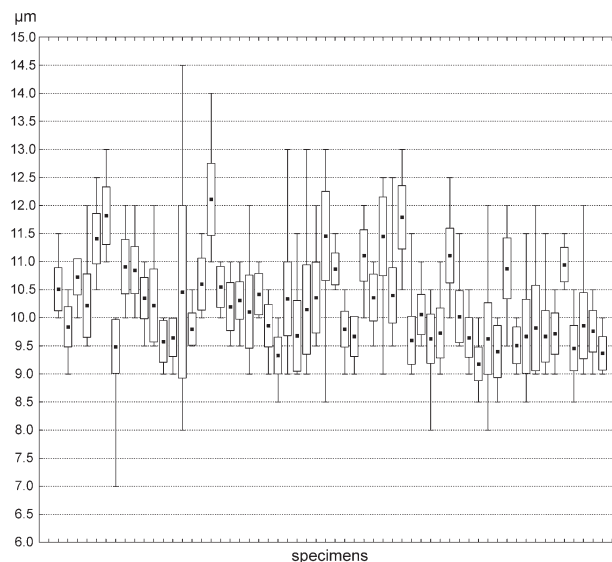


FIG. 5. Box plots for spore size of 58 measured collections of *Physarum andinum*, ■ – average, box – standard deviation, vertical line – extreme values.

Nothofagus sp., near patches of melting snow, 8 Nov 2009, (FIGS. 1B, 4 – Loc. 3): on bark of *Nothofagus* sp., Lado 20351 (MA-Fungi 80919), Lado 20369 (MA-Fungi 80925); on living twigs of *Nothofagus* sp., Lado 20361 (MA-Fungi 80920), Lado 20368 (MA-Fungi 80924), Lado 20370 (MA-Fungi 80926), Lado 20379 (MA-Fungi 80929), Lado 20385 (MA-Fungi 80931); on grass culms, Lado 20362 (MA-Fungi 80921); on twigs, Lado 20364 (MA-Fungi 80922, KRAM M-1541), Lado 20373 (MA-Fungi 80927), Lado 20383 (MA-Fungi 80930); on twigs of *Nothofagus* sp., Lado 20365 (MA-Fungi 80923); on plant shoots, Lado 20378 (MA-Fungi 80928). RÍO NEGRO: Bariloche department, San Carlos de Bariloche, Nahuel Huapi National Park, Villa Cerro Catedral sky center, 41°09'49.5"S, 71°27'34.7"W, 1364 m, shrubs of *Nothofagus pumilio*, near patches of melting snow, 21 Nov 2009, (FIGS. 1C, 4 – Loc. 4): on fallen leaves of *Nothofagus pumilio*, Lado 20660 (MA-Fungi 80932); on bark of *Nothofagus* sp., Lado 20667 (MA-Fungi 80933, KRAM M-1542); on fallen leaves of *Nothofagus pumilio* and grass culms, Lado 20672 (MA-Fungi 80934); on living twigs of *Nothofagus* sp., Lado 20677 (MA-Fungi 80935), Lado 20711 (MA-Fungi 80938), Lado 20717 (MA-Fungi 80940, KRAM M-1544); on twigs of *Nothofagus* sp. and grass culms, Lado 20683 (MA-Fungi 80936); on wood of *Nothofagus* sp., Lado 20706 (MA-Fungi 80937), Lado 20712 (MA-Fungi 80939, KRAM M-1543). RÍO NEGRO: Bariloche department, San Carlos de Bariloche, Nahuel Huapi National Park, Challhuaco valley, Neumeyer refuge, 41°15'33.1"S, 71°17'31.6"W, 1438 m, *Nothofagus pumilio* forest, near patches of melting snow, 22 Nov 2009, (FIGS. 1D, 4 – Loc. 5): on bark of *Nothofagus* sp., Lado 20743 (MA-Fungi 80941), Lado 20763a (MA-Fungi 80945), Lado 20786 (MA-Fungi 80949), Lado 20789 (MA-Fungi 80950, KRAM M-1548), Lado 20806 (MA-Fungi 80953, KRAM

M-1550), Lado 20821 (MA-Fungi 80954), Lado 20919 (MA-Fungi 80970), Lado 20931 (MA-Fungi 80971), Lado 20932a (MA-Fungi 80972); on twigs of *Nothofagus* sp., Lado 20752 (MA-Fungi 80942), Lado 20754 (MA-Fungi 80943), Lado 20759 (MA-Fungi 80944, KRAM M-1545), Lado 20769 (MA-Fungi 80946, KRAM M-1546), Lado 20798 (MA-Fungi 80952), Lado 20828 (MA-Fungi 80956), Lado 20837 (MA-Fungi 80957), Lado 20844 (MA-Fungi 80960), Lado 20859 (MA-Fungi 80962), Lado 20870 (MA-Fungi 80964), Lado 20902a (MA-Fungi 80967), Lado 20907 (MA-Fungi 80968, KRAM M-1554), Lado 20914 (MA-Fungi 80969, KRAM M-1555), Lado 20933 (MA-Fungi 80973); on twigs, Lado 20777 (MA-Fungi 80947), Lado 20883 (MA-Fungi 80966, KRAM M-1552); on living twigs of *Nothofagus* sp., Lado 20783 (MA-Fungi 80948, KRAM M-1547); on living twigs of *Berberis* sp., Lado 20795 (MA-Fungi 80951, KRAM M-1549); on twigs of *Ribes* sp., Lado 20840 (MA-Fungi 80958); on dead plant shoots (*Acaena* sp.), Lado 20822 (MA-Fungi 80955); on plant shoots and grass culms, Lado 20841 (MA-Fungi 80959), Lado 20850 (MA-Fungi 80961); on bark and wood of *Nothofagus* sp., Lado 20864 (MA-Fungi 80963, KRAM M-1551); on wood and mosses, Lado 20880 (MA-Fungi 80965). CHILE. Punta Arenas, 2 Mar 1906, *leg. R. Thaxter* (FIG. 4 – Loc. 6): on pieces of wood (FH 00270270, as *P. brunneolum*).

Etymology: From Latin: *andinum* = from the Andes. The epithet refers to the area of occurrence of the species.

Habitat: Near melting snow, on small living twigs, dead leaves, bark and wood of *Nothofagus* spp., other living or dead plant shoots (*Berberis*, *Ribes*, *Acaena*) and grass culms, exceptionally on mosses covering wood.

Distribution: Known in South America from the southern Andes: Argentina in Neuquén and Río Negro provinces and Chile in Magallanes and Antártica Chilena region (FIG. 4).

Other collections examined: *Physarum brunneolum*. CHILE. Región de Valparaíso: Quillota, Hijuelas, Parque Nacional La Campana, sector Palmar de Oca, sendero Quillay, 32°56'03"S, 71°04'35"W, 508 m, hojas de árbol esclerófilo, 2 Apr 2006, *leg. A. Estrada, C. Lado, D. Wrigley*, Lado 17877 (MA-Fungi 80698). PORTUGAL. Camposancos, en corteza de *Eucalyptus globulus*, 11 Feb 2001, *leg. C. Rey*, CR3M01, (MA-Fungi 50312). SPAIN. GUADALAJARA: Sayatón, presa de Bolarque, 30TVK1468, 600 m, en hoja y cúpula de *Quercus coccífera* y *Pinus* sp., 17 Jan 1990, *leg. C. Lado, M.T. Tellería*, Lado 4082 (MA-Fungi 25663). MÁLAGA: Jubrique, camino a Estercal, 30SUF0447, 700 m, en hoja de *Quercus* sp., 19 Jan 1989, *leg. C. Lado, F. Pando*, Lado 2723 (MA-Fungi 48234). VALENCIA: Bocairente, Sierra de Mariola, Casa Baba, 30SYH1090, 880 m, en hojas de *Quercus ilex*, 10 Jan 2004, *leg. A. Conca, M. Oltra*, 7028 Oltra (MA-Fungi 61178). VALENCIA: Bocairente, La Aguadannería, 30SYH1090, 880 m, en hojas de *Quercus ilex*, 10 Jan 2004, *leg. A. Conca, M. Oltra*, 6415 Oltra (MA-Fungi 60952).

ZARAGOZA: Zuera, en corteza de pino, 13 Mar 2004, *leg. C. Boza*, CB-JU 747 (MA-Fungi 59315). MADRID: Colmenar del Arroyo, 30TUK9875, 700 m, en hojas de *Quercus rotundifolia*, 21 Mar 1982, *leg. C. Lado*, Lado 816 (MA-Fungi 17294). USA. CALIFORNIA: Alameda County, Berkeley, Strawberry Canyon, on fallen leaves, 14 Feb 1971, *leg. V. Duran* 1195 (FH 00270269). CALIFORNIA: Santa Clara County, Stanford University campus, park-like U. Sonoran, on *Quercus agrifolia* leaves, 10 Oct 1935, *leg. A. L. Cohen* 159 (FH 270271). *Physarum albescens*. ARGENTINA. RÍO NEGRO: Bariloche department, San Carlos de Bariloche, Nahuel Huapi National Park, Villa Cerro Catedral sky center, 41°09'49.5"S, 71°27'34.7"W, 1364 m, shrubs of *Nothofagus pumilio*, near patches of melting snow, 21 Nov 2009, on twigs, Lado 20695 (MA-Fungi 82457). FRANCE. ALPES-DE-HAUTE-PROVENCE: Coll d'Allos, côte Ubaye, 44.31839°N 6.59400°E, 2240 m, branchettes mortes de *Larix* sp., *leg. M. Meyer* 33356 (MA-Fungi 81938). POLAND. The Carpathians: the ridge of Babia Góra Massif, Kępa Mountain, 1515 m, 3 May 2004, on stems of *Vaccinium myrtillus*, at a patch of melting snow, *leg. A. Ronikier, M. Ronikier* (KRAM M-1063). SPAIN. TERUEL: Valdelinares, Mirador El Monegro, 30TYK0174, 1860 m, 11 Apr 2006, en ramillas de *Juniperus communis* subsp. *hemisphaerica* viva, *leg. Miguel Oltra*, 9042.Oltra, (MA-Fungi 68880).

DISCUSSION

The most distinctive characters of the new nivicolous species are the large size of the sporocarps, that can reach 3 mm diam when open, the peridium with three layers, with a clearly visible inner layer that is distinctly separate from the two other layers (FIGS. 2B, C, 6B, C), and the strongly calcified capillitium with abundant, white calcareous, polygonal nodes connected by short limeless threads (FIG. 3C–E). The new species usually forms stalked sporocarps (FIGS. 2A, D, 6A, B), but occasionally short plasmodiocarpic fructifications are found (FIG. 2E). We observed that the habit depends on the substrate type. Specimens occurring on twigs, bark or wood (85% of the collections) were sporocarpic, while those from grass culms and plant shoots (15%) were predominantly plasmodiocarpic. In sporocarpic forms the fructifications usually were scattered or in small groups, while in plasmodiocarpic forms they were always grouped or aggregated. The plasmodiocarps were always short, up to 5.67 mm long.

Most spores (nearly 90% of measurements) of *P. andinum* were 9–11 µm diam, the smallest measured spore was only 7 µm diam, while the largest was 14.5 µm, however these extreme values were recorded for less than 1% of measurements (FIG. 5). The spores varied from very pale brown under transmitted light to moderately brown but never dark brown

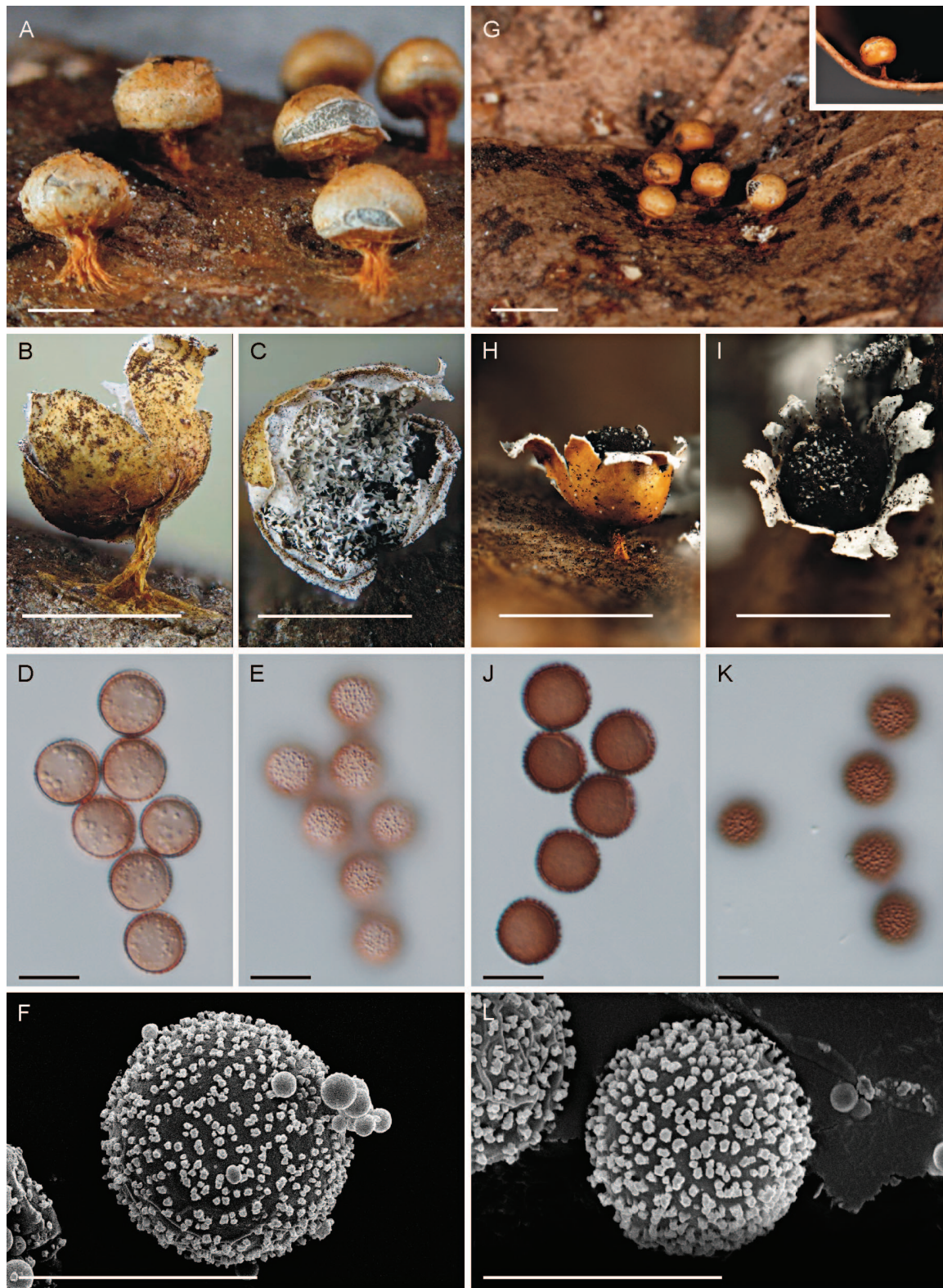


FIG. 6. Comparison of *Physarum andinum* and *P. brunneolum*. A–F. *Physarum andinum*. G–L. *Physarum brunneolum*. A. Stalked sporocarps of *P. andinum* (Lado 20712). B. Open sporocarp of *P. andinum* (side view). C. Open sporocarp of *P. andinum* (top view). D, E. Spores of *P. andinum* mounted in water, observed in light microscope. F. Spore of *P. andinum* by SEM (B–F: Lado 20903–HOLOTYPE). G. Stalked sporocarps of *P. brunneolum* (FH 270271). H. Open sporocarp of

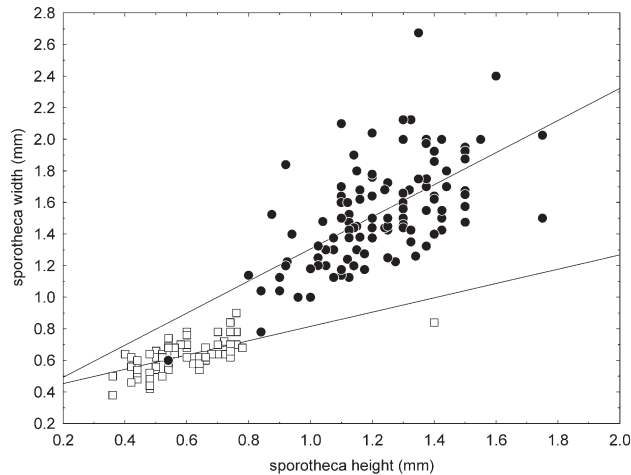


FIG. 7. Comparison of sporotheca size of sporocarpic forms of *P. andinum* (●) and *P. brunneolum* (□).

(FIG. 6D, E). The height of spore ornamentation also was slightly variable from short warts to baculate or pilate by SEM (FIGS. 3F–I, 6F), according to the terminology of Rammeloo (1974).

Physarum brunneolum seems to be most similar species to *P. andinum*. When the sporocarps are closed, both species usually form sporocarpic and stalked fructifications. However, *P. brunneolum* is considerably smaller (FIGS. 6G, 7), its sporotheca rarely exceeding 0.8 mm tall, while the sporotheca of *P. andinum* is larger (mean height 1.22) (FIGS. 6A, 7). The peridium of *P. brunneolum* is shiny and uniformly yellow-brown, and its three layers are closely attached (FIG. 6G–I), while the peridium of *P. andinum* is yellow to whitish, usually darker at the base and paler at the top (FIG. 2A), and with the inner layer distinctly separate from the two other layers (FIGS. 2C, 6C). The dehiscence of *P. brunneolum* is stellate (FIG. 6H–I) and the dehiscence of *P. andinum* is irregular, leaving peridial remains in the lower part of the sporotheca (FIGS. 2D, 6C). *Physarum brunneolum* also has dark brown spores with more prominent ornamentation (FIG. 6J–L).

Other species with a three-layered peridium (see Poulain et al. 2011) are *Physarum bogoriense* Racib. and *P. hongkongense* Chao H. Chung. These species resemble *P. andinum* in the color of the peridium (the outer layer of these two species is ochraceous yellow, the middle layer white and the inner layer grayish), the dehiscence of the peridium and the

close attachment of the outer and middle layers (considered one layer by the authors of these species, Raciborski 1898, Chung 1997) that opens separately from the inner layer. The two species, however, clearly differ from *P. andinum* in habit, forming exclusively sessile, elongated, sometimes branched plasmodiocarps, that are slightly laterally compressed in the case of *P. hongkongense*. Another species somewhat similar to *P. andinum* is *P. ovisporoides* Y. Yamam. & Shuanglin Chen., but, according to the original description (Yamamoto et al. 2002), it differs in the sporocarps or plasmodiocarps that are always sessile and in the ellipsoid spores. None of the above mentioned species are nivicolous; *Physarum bogoriense*, *P. hongkongense* and *P. ovisporoides* occur in tropical or subtropical areas, while *P. brunneolum* is found in the Mediterranean regions.

Among nivicolous species *Physarum albescens* is the most similar to *P. andinum* because it produces stalked sporophores. However, it clearly differs in having pear-shaped, vertically elongated sporocarps on a very weak and prostrate, membranous stalk (FIG. 8A) that is an extension of a well developed hypothallus (Poulain et al. 2011). Sporocarps of *P. andinum* are subglobose to subhemispheric on an erect and well defined stalk (FIGS. 2A, D, 6A). The two species also differ in the type and calcification of the capillitium. *Physarum albescens* has few, very small, yellow to orange lime nodes in a dense and non-calcareous capillitial net (FIG. 8B–D), while the nodes of *P. andinum* are numerous, larger and white and the capillitium does not form a network of limeless threads (FIGS. 2C, 3C–E). Peridium characters also differentiate the two species. The peridium is of three layers, the outer shining and smooth, fused to the middle layer making it appear thick in *P. andinum* (FIGS. 2A–C, 3A, B), while in *P. albescens* it is usually rough, much thinner and built up of two membranous layers with patches of lime deposits between them (FIG. 8B, C).

Plasmodiocarpic forms of *P. andinum* may resemble *P. alpestre*, another nivicolous species that is always plasmodiocarpic, but in *P. alpestre* the plasmodiocarps are elongated and flattened, they have a longitudinally elongated columella that is usually yellow and the nodes of the capillitium are also yellow.

The degree of calcification of the capillitium of *P. andinum* is variable and specimens with a strongly calcified capillitium could resemble species from the

P. brunneolum (side view). I. Open sporocarp of *P. brunneolum* (top view) (H–I: MA-Fungi 60952). J–K. Spores of *P. brunneolum* mounted in water, observed in light microscope (FH 270271). L. Spore of *P. brunneolum* by SEM (MA-Fungi 17294). Bars: A–C, G–I = 1 mm; D–F, J–L = 10 μ m.

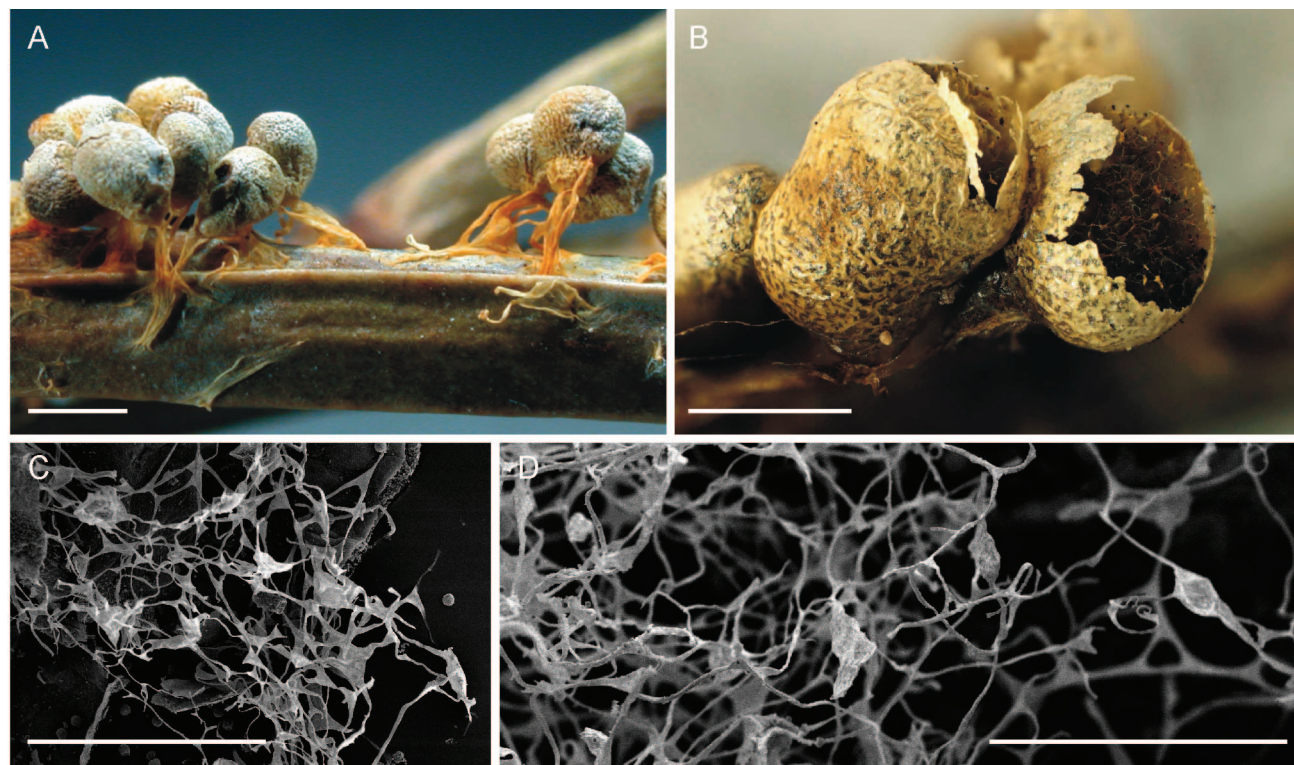


FIG. 8. *Physarum albescens*. A. Pear-shaped sporangia on a prostrate, membraneous stalks (KRAM M-1063). B. Rough peridium and capillitium with few colored nodes (Lado 20695). C. Capillitium and peridium of two membraneous layers with patches of lime deposits between them (MA-Fungi 68880). D. Capillitium in the form of a dense network of limeless threads with scanty lime nodes. Bars: A, B = 1 mm; C = 200 μ m; D = 100 μ m.

genus *Badhamia*. But the capillitium of *P. andinum* is composed of large to very large angular nodes connected with short limeless filaments (FIGS. 2C, 3C–E). Sometimes two or more nodes are fused so that the capillitium appears more badhamioid when observed under the stereomicroscope, but under the light microscope and SEM limeless connections could always be observed, supporting the assignment of the new species to *Physarum*. The only species of *Badhamia* similar in color to *P. andinum* and having a triple peridium is *Badhamia crassipella* K.D. Whitney & H.W. Keller. This species is easily distinguishable from the newly described *Physarum* because it forms elongated, terete and reticulate plasmodiocarps and its spores are clustered in groups of 4–40 (Whitney and Keller 1982).

The newly described *P. andinum* was always found during the austral spring close to melting snow. The collection FH 00270270 from Punta Arenas (Chile) was found in the first days of March (end of austral summer) but no information about habitat and locality is provided on the herbarium label. They seem to be slightly old, molded and tough, so they could have developed during spring and remained for some time in the field. Other cases of collecting

typically nivicolous species in South America during the austral summer without the presence of melting snow are known (Wrigley de Basanta et al. 2010).

The new species was found at 1364–2243 m and in several vegetation types (FIG. 1), in an open area above the timberline, in shrubby vegetation, as well as in *Nothofagus pumilio* forest. This shows that the species is not associated with any single vegetation type and it was found on various substrata. Its occurrence at relatively low elevation, inside the forest indicates that nivicolous myxomycetes are not exclusively alpine (associated with alpine belt) as demonstrated by Ronikier and Ronikier (2009). Based on the large number of collections of *P. andinum* we found in different localities it can be assumed that *P. andinum* is probably a common species in the Patagonian Andes.

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