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Two new species of nivicolous *Lamproderma* (Myxomycetes) from the mountains of Europe and America

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Abstract: As a result of the revision of European and American collections of genus *Lamproderma* two new nivicolous myxomycete species, *Lamproderma argenteobrunneum* and *L. kowalskii*, are described. The new species are characterized by the silvery-brown sporothecae, the areolate peridium and the ferruginous-brown spores in mass. They differ from one another mainly in spore size and ornamentation, the form of the capillitium and the stalk length and ratio of the stalk length to the total height of the sporocarp. The morphology of the new species was examined with light microscopy and scanning electron microscopy (SEM), and micrographs of relevant details are included. *Lamproderma argenteobrunneum* also was obtained in moist chamber culture, and the mature sporocarps displayed all features typical of field-collected samples. The known geographical distribution of *L. argenteobrunneum* includes the main ranges of the European alpine system (Alps, Carpathians, Pyrenees) as well as those of North America, while *L. kowalskii* has been recorded so far from several sites in California in the United States.

Key words: *Lamproderma fuscatum*, moist chamber culture, Mycetozoa, Myxogastria, Protozoa, SEM, species distribution, taxonomy

INTRODUCTION

The myxomycete genus *Lamproderma* Rostaf. was described by Rostafiński (1873), who recognized nine species (Rostafiński 1874). The genus is characterized by globose, usually stipitate sporocarps, a persistent and iridescent peridium, the presence of a columella, the capillitium usually originating from the apex of the columella and the dark brown to blackish spores in mass. More than 135 y later the number of known *Lamproderma* species has increased considerably and currently 44 species are recognized in the genus (Lado 2008), about one-third of them described in the past 20 y. More than half the known *Lamproderma* species belong to the well recognized ecological group of nivicolous myxomycetes. Among them eight were described or raised to species in the past decade, and many have their type localities in the European Alps (Bozonnet et al. 1991, 1995, 1997; Meyer et al. 1994; Poulain et al. 2002, 2003, 2005). In addition studies of the type material of the older taxa (Moreno et al. 2002, 2005; Poulain et al. 2003; Singer et al. 2003) have clarified the taxonomic situation of several species. In the recent phylogenetic analysis of the dark-spored myxomycetes it has been demonstrated that *Lamproderma* is a paraphyletic genus and suggested that the species with evanescent peridium might represent a distinct group that should be treated as a separate genus (Fiore-Donno et al. 2008).

During the study of the diversity of nivicolous myxomycetes from the Pyrenees (Lado and Ronikier 2008, 2009) a collection belonging to genus *Lamproderma* was found, with a silvery-brown sporotheca, a persistent and areolate peridium and ferruginous-brown spores in mass, which were pale brown under transmitted light. The same morphotype was found independently in material from the Austrian and French Alps, French Jura and the Polish Carpathians. All these collections agreed in part with the description provided by Kowalski (1970) for species *L. fuscatum* Meyl.

Lamproderma fuscatum, according to the original description (Meylan 1932), has a nonpersistent peridium disappearing in small patches. This character together with the funnel-shaped ends of the capillitial threads was confirmed by an analysis and new description of the lectotype (LAU) by Moreno et al. (2002) and by observations made by M. Poulain and M. Meyer (unpubl data). When these two descriptions were compared with those provided by Kowalski (1968, 1970, 1975) based on American specimens, differences in the type of peridium dehiscence and spore ornamentation were found. Kowalski (1968, 1970) described the peridium of the American collections as ''thick, firm, persistent,

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splitting irregularly, but persisting as a cup at the base of the sporangium'' and the capillitium as ''forming a net with abundant sharp, pointed, free ends''. In addition Kowalski (1970) mentioned that he also studied four of Meylan's collections from Switzerland and noted that in the European collections the spores were spinulose while in USA material the spores were minutely warted with the warts often slightly elongated. ''This difference is constant; there is no overlapping,'' Kowalski said. ''Although this discrepancy probably shows some genetic divergence between the two populations, I do not believe it is large enough to warrant the separation of these populations into different taxa,'' he said. Kowalski (1975) also cited the differences in peridium characteristics among the American collections with a persistent peridium and the European collections with a fugacious peridium that remains in small fragments. The great differences in the descriptions of *L. fuscatum* from Europe and America suggested that different species were involved. The objective of this paper was to provide a comprehensive revision of both the European and the American specimens of ''*L. fuscatum*'' and establish their taxonomic position.

MATERIALS AND METHODS

We studied specimens collected from different localities in the European mountains, deposited in the herbaria MA-Fungi, KRAM, the private collection of Marianne Meyer (coll. MM) or the private collection of Wolfgang Nowotny (coll. Now). In addition we examined all collections identified by Donald T. Kowalski (DTK) as ''*Lamproderma fuscatum*'' deposited at UC (herbarium of the University of California).

Observations and measurements of the morphological characters were done under a stereoscopic microscope Nikon SMZ 1500. The total height of the sporocarps as well as the height and the width of the sporothecae were measured. Whenever possible 10 sporocarps of each collection were measured (212 sporocarps in total). Observations and measurements of microscopic characters were made on material mounted in Hoyer's medium, under a light microscope, Nikon Eclipse E-600. Permanent slides of all examined collections are deposited in KRAM. Spore measurements (50 per collection, 1600 in total) were made under an oil immersion objective and include ornamentation. Values of spore size present in fewer than 1% of the measurements are given in parentheses in the descriptions provided below. The statistics were calculated with Statistica 6 software.

Critical point drying was used for scanning electron microscopy (SEM) preparations, and specimens were examined with a Hitachi S-3000N or Hitachi S-4700 scanning electron microscopes at 10–15 kV. SEM studies of the collections were made at the Royal Botanic Garden of Madrid and in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis, at the Institute of Geological Sciences of the Jagiellonian University, Kraków.

A trial moist chamber culture was set up with pieces of the substrate of a field collection of *Lamproderma* from the Pyrenees (MA-Fungi 75785) without any sporocarps. Small fragments of the substrate (plant stems) were placed on a Whatman filter paper disk in a sterile, 9 cm diam plastic Petri dish. The substrate was scattered with spores from a mature sporocarp of the same collection. The material was loosely covered with a second filter paper disk to simulate conditions under melting snow. Distilled water was added to thoroughly moisten both layers of filter paper and the substrate, and excess water was poured off after 24 h. The Petri dish was placed inside a plastic box in the center of a laboratory refrigerator in the dark at 5 C. The culture was maintained 3 mo (15-II-2007–21-V-2007). The culture was examined at approximately weekly intervals during which time it was exposed to light and an increase of temperature for a maximum of 20 min.

RESULTS

More than 30 collections of ''*Lamproderma fuscatum*'' from Europe and America were studied, and it was confirmed that the material described by Kowalski (1970) in his monograph was not conspecific with the *L. fuscatum* described by Meylan (1932). The detailed description provided by Kowalski (1968, 1970) fits the characters of one morphotype found by us in many European mountains. In addition in the American material identified by Kowalski as ''*L. fuscatum*'' a second morphotype was found with distinguishing characters in spores, capillitium and columella. No species from genus *Lamproderma* has been described with a similar set of characters, and therefore we conclude that the two morphotypes represent two different new species.

Lamproderma argenteobrunneum A. Ronikier, Lado & Mar. Mey., sp. nov. FIGS. 1A–C, 2
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Sporocarpia in gregibus dispersis, cum stipitibus brevibus, vel paene sessilia, 0.78–2.24 mm alta. Sporotheca 0.62–1.6 mm diam, globosa vel ovata. Peridium permanens, argenteo-griseum, chalybaeo-brunneo-griseum, cum aureis nitoribus (imprimis in parte inferiore sporothecae), relative crassum. Stipes brevis, 0.04–0.64 mm, atro-griseus, lucens. Hypothallus membranaceus, discoides, translucidus, aurantiaco-brunneus vel brunneo-ruber. Columella fere dimidiam partem sporothecae attingens, anguste conica ad conica, circa apicem se coartans (vel raro se dividens). Capillitium constanter ferrugineo-brunneum, mediocriter densum vel densum, in superiore parte columellae oriens, rigidum. Sporae ferrugineo-brunneae in massa, subbrunneae luce transmissa, globosae (8–)9–11(–12) μm diam, in superficie non dense ornatae brevibus cristis quae spinis junctis intermixtis cum solitariis spinis formantur. Plasmodium ignotum. Species prope nivem liquefactam fructificans.

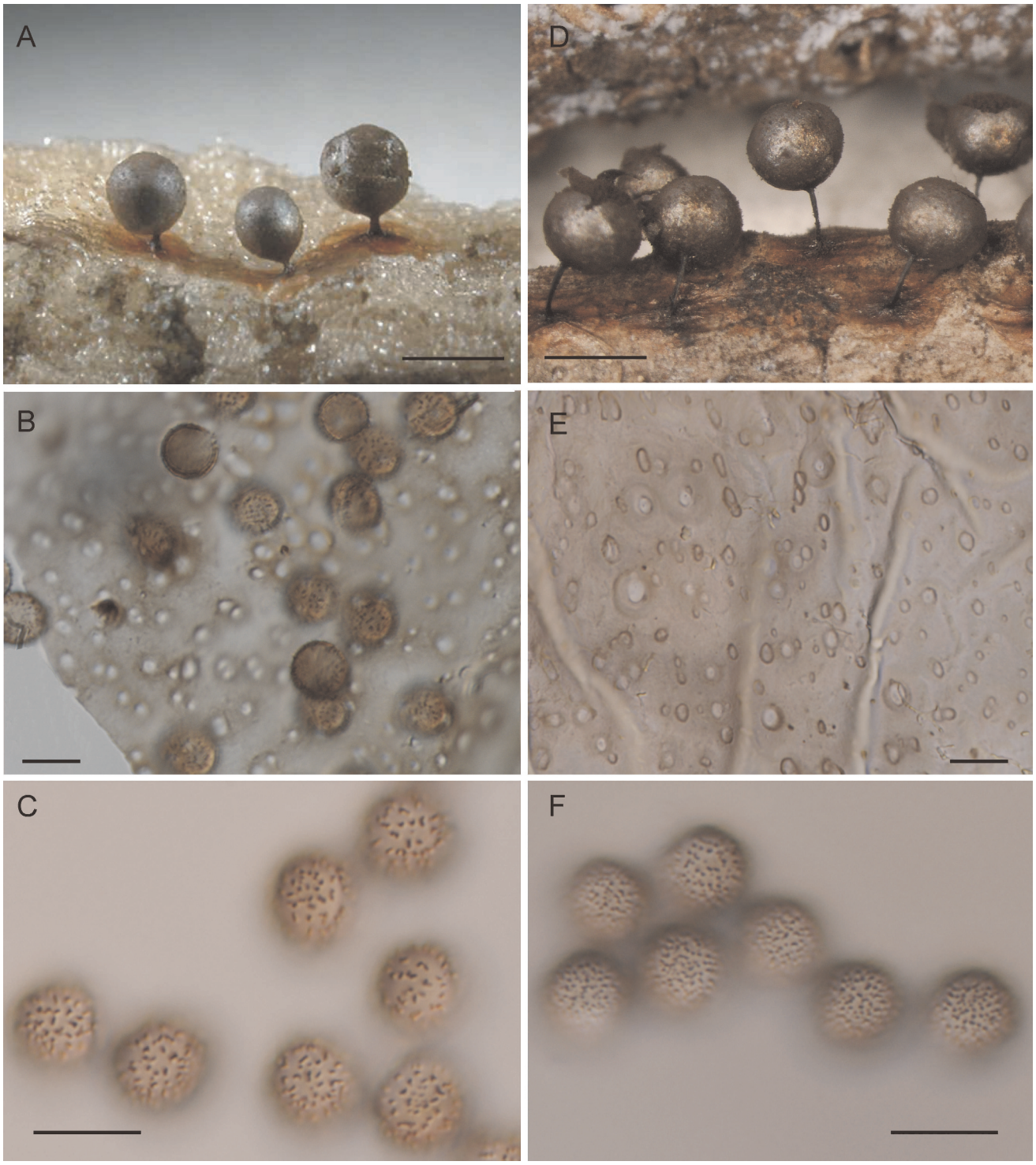

FIG. 1. Characteristic features of the two new *Lamproderma* species. A–C. *Lamproderma argenteobrunneum*—HOLOTYPE (Lado 6792). A. Sporocarps. B. Peridium (inner side) in light microscope. C. Spores in light microscope. D–F. *Lamproderma kowalskii*—HOLOTYPE (DTK 6408). D. Sporocarps. E. Peridium (inner side) in light microscope. F. Spores in light microscope. Bars: A, D = 1 mm, B–C, E–F = 10 μm.

Sporocarps in loose groups, shortly stipitate or almost sessile (FIGS 1A, 2A), total height 0.78–2.24 mm. Sporotheca subglobose to slightly ovoid, 0.62–1.6 mm diam, silvery-brown, sometimes with golden reflections mainly at the bottom. Peridium single, membranous, persistent, thick, splitting irregularly and often persisting as a cup at the base of the sporotheca, brownish and usually with an areolate

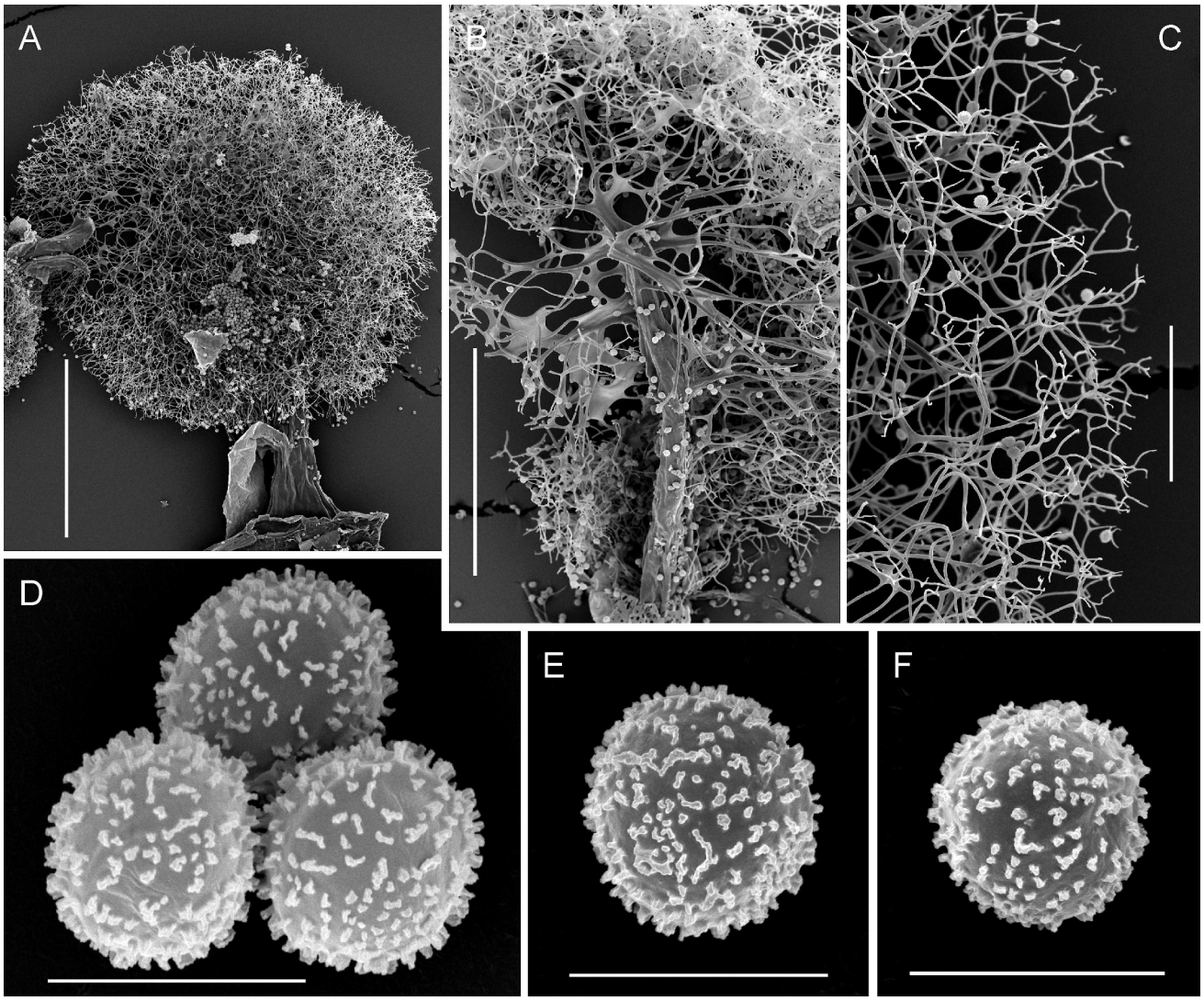

FIG. 2. Microphotographs of *Lamproderma argenteobrunneum* from scanning electron microscope—HOLOTYPE (Lado 6792). A. Sporocarp. B. Columella and primary branches of the capillitium with membranous expansions. C. Peripheral part of capillitium. D–F. Spores. Bars: A = 500 μm, B = 300 μm, C = 100 μm, D–F = 10 μm.

pattern at lower part under transmitted light (FIG. 1B). Stalk short, erect, 0.04–0.64 mm long, dark brown, shining, occasionally absent. Hypothallus membranous, discoid, translucent, orange-brown or red-brown. Columella reaching about half the sporotheca height, conical to narrowly conical (FIG 2B). Capillitium uniformly ferruginous-brown, dense, originating from the upper part of the columella, rigid, primary branches with membranous expansions, capillitial threads at peripheries with many pointed free ends (FIG. 2C). Spores in mass ferruginous-brown, pale brown by transmitted light, globose, (8–) 9–11(–12) μm diam, ornamented with loosely arranged, short, curved ridges and some isolated spines between the ridges (FIGS 1C, 2D–F). Plasmodium unknown.

HOLOTYPE. SPAIN. Lérida: Naut Arán, Salardú, Aiguamotx, La Muntanyeta, 42°37′47″N, 0°54′48″E, 2000 m, on pteridophyte, 29-VI-1994, *leg. C. Lado & S. Santamaría*, Lado 6792 (MA-Fungi 75785). *Isotypes* at KRAM (M-1292), and in the private collection of M. Meyer (MM 30500).

Specimens examined. AUSTRIA. Steiermark: Altaussee, Loser, 1300 m, on branch of living shrub, 17-V-2002, *leg. W. Nowotny*, Now 11693/2 (MM 28459); Now 11776. Altaussee, Loser, 1500 m, on branch of living shrub, 30-V-1997, *leg. W. Nowotny*, Now 8683/3. Altaussee, Loser, 1200–1300 m, on branch of living shrub, 10-V-1998, *leg. W. Nowotny*, Now 9456; Now 9459. Altaussee, Loser, 1100–1150 m, on branch of living shrub, 10-V-2008, *leg. W. Nowotny*, Now 14513. Oberösterreich: Ebensee, Feuerkogel, 1550 m, on dead plant stems, 29-V-1993, *leg. W. Nowotny*, Now 5406/1. Bad Ischl, Hoisnradalm, 850–950 m, on branch of living shrub,

23-IV-2005, *leg. W. Nowotny*, Now 13171/1. Tirol: Scharnitz, Karwendeltal, 1500–1600 m, on branch of living shrub, 14-V-2002, *leg. W. Nowotny*, Now 11599/1. FRANCE. Ain: Grand Colombier, 1400 m, on twig of deciduous tree, 2-V-1988, *leg. J. Bozonnet*, No. JB O05023 (MM 8789). Grand Colombier, on dry herbaceous plants, 5-V-1995, *leg. J. Bozonnet*, No. JB V05056 (MM 30171). Grand Colombier, on dead leaf, 18-V-1985, *leg. J. Bozonnet*, No. JB L05182 (MM 30173). Grand Colombier, 1300 m, on dead twig of *Fagus sylvatica*, 17-IV-1995, *leg. M. Meyer* (MM 8421; KRAM M1491). Innimond, Le Grand Pertuis, 1080 m, on dead twig of *Fagus sylvatica*, 5-IV-1995, *leg. J. Bozonnet*, No. JB V04054 (MM 30170). Teillat Corniche du Valromey, 1150 m, on dead twig of deciduous tree, 14-IV-1988, *leg. J. Bozonnet*, No. JB O04142 (MM 30172). Savoie: Celliers, 1850 m, on living twig of *Alnus viridis*, 1-VI-1993, *leg. M. Meyer* (MM 7421; KRAM M-1488). Méribel, vers l'altiport, 45.4078°N, 06.5780°E, 1700 m, on dead twig of *Picea excelsa*, 27-V-1995, *leg. M. Meyer* (MM 8500). Fontaine-le-Puits, Barrage de la Coche, 45°28′11″N, 06°30′02″E, 1450 m, on leaf and dead twig of *Fagus sylvatica*, 28-IV-1992, *leg. M. Meyer* (MM 15295; KRAM M-1490; MA-Fungi 35146). Les Arcs, 2000 m, on branch of *Rhododendron ferrugineum*, 9-V-2003, (MM 23268; KRAM M-1487). Col de la Madeleine, 1800 m, on twig of *Alnus viridis*, 3-VI-2000, *leg. B. Martin*, No. JLBM 2028 (MM 27142). Jura: Les Rousses, Bois d'Amont, on dead stem of herbaceous plant, 20-V-1991, *leg. J. Duc*, No. JLBM 462 (MM 6833). POLAND. The Carpathians: Tatry Mountains, a gully in Mała Koszysta mountain toward Waksmundzka Polana meadow, 49°15′03″N, 20°03′28″E, 1630 m, on living shoots of *Salix silesiaca*, *leg. A. Ronikier & M. Ronikier*, 1-VI-2008 (KRAM M-1482). USA. California: Butte County, 4 miles above Stirling City, 4000 ft. (1219 m), on bark, 9-V-1969, *leg. D.T. Kowalski*, DTK 10016 (UC 1408212, as *L. fuscatum*). Washington: Olympic National Park, Hurricane Ridge, 5200 ft. (1585 m), on twigs, 27-VI-1968, *leg. D.T. Kowalski*, DTK 9576 (UC 1408234, as *L. fuscatum*). Olympic National Park, Hurricane Ridge, 5200 ft. (1585 m), on twigs, 24-VI-1968, *leg. D.T. Kowalski*, DTK 9361 (UC 1408277, as *L. fuscatum*). Mount Rainier National Park, Bench Lake Trail, 4500 ft. (1372 m), on twig, 13-VI-1968, *leg. D.T. Kowalski*, DTK 8630 (1408271, as *L. fuscatum*).

Etymology. From Latin: *argentum* = silver, *brunneus* = brown. The epithet refers to the characteristic silvery-brown sporotheca.

Habitat. On plant remnants (ferns), decaying wood, branches of dead or living trees and bushes (*Alnus viridis*, *Fagus sylvatica*, *Picea abies*, *Salix silesiaca*, *Rhododendron ferrugineum*) near melting snow.

Distribution. Known from the mountains of Europe: the Alps, Carpathians, Jura and Pyrenees (Austria, France, Poland, Spain) and North America (USA) (FIG. 5).

Moist chamber culture. Six stipitate sporocarps with scanty peridium but with the typical areolate pattern on the peridial remnants at the base of the sporothecae were obtained from the moist chamber culture 21 May 2007, just over 3 mo after the culture was set up. They had brown capillitium with many free ends and well developed spores that were constant in shape, measurement and ornamentation. All characters agreed with those of the field specimen (MA-Fungi 75785) used to supply the spores and the substrate for the culture. The plasmodium was not observed.

Lamproderma kowalskii A. Ronikier, Lado & Mar. Mey., sp. nov. FIGS. 1D–F, 3
MycoBank 515371

Sporocarpia in gregibus dispersis, cum stipite, 1.32–2.02 mm alta. Sporotheca 0.82–1.28 mm diam, globosa. Peridium permanens, in fragmentis irregularibus fractum, praeter basim tanquam poculum permanentem, argenteo-griseum, chalibaeo-brunneo-griseum, plerumque cum aureis repercussis. Stipes circa tam altus quam sporotheca, 0.42–0.9 mm, atrobrunneus, lucens. Hypothallus membranaceus, discoides, translucidus, aurantiaco-brunneus vel brunneo-ruber. Columella circa dimidiam partem sporothecae attingens, cylindracea, plerumque ad apicem se dividens. Capillitium constanter ferrugineo-brunneum, densum, imprimis ad columellae apicem oriens, leviter flexuosum. Sporae ferrugineo-brunneae in massa, subbrunneae luce transmissa, globosae 8–9.5(–10) μm diam, brevibus spinis dense ornatae. Plasmodium ignotum. Species prope nivem liquefactam fructificans.

Sporocarps in loose groups, stipitate (FIGS 1D, 3A), total height 1.32–2.02 mm. Sporotheca globose, 0.82–1.28 mm diam, silvery-brown. Peridium single, membranous, persistent, splitting irregularly and persisting as a cup at the base of the sporotheca, brownish under transmitted light and with an areolate pattern at lower part (FIG. 1E). Stalk erect, 0.42–0.9 mm long, dark brown, shining. Hypothallus membranous, discoid, translucent, orange-brown or red-brown. Columella reaching about half the sporotheca height, cylindrical (FIG. 3B). Capillitium uniformly ferruginous-brown, dense, originating mainly from the apex of the columella, flexuose, capillitial threads at peripheries with many pointed free ends (FIG. 3C). Spores in mass ferruginous-brown, pale brown by transmitted light, globose, 8–9.5 (–10) μm diam, ornamented with densely arranged, short spines (FIGS. 1F, 3D–F). Plasmodium unknown.

HOLOTYPE. USA. California: Tehama County, Well's Cabin Camp ground, 6300 ft. (1920 m), on twigs, 24-VI-1967, *leg. D.T. Kowalski*, DTK 6408 (UC 1408233, as *L. fuscatum*).

Specimens examined. USA. California: Tehama County, 3 miles W of Child's Meadow, 5200 ft. (1585 m), on dead wood, 20-V-1967, *leg. D.T. Kowalski*, DTK 6169 (UC 1408279, as *L. fuscatum*). Tehama County, 3 miles E of Mineral, on decayed wood, *leg. D.T. Kowalski*, DTK 6161 (UC 1408235, as *L. fuscatum*). Tehama County, 1 mile S of Lassen National Park, on dead twigs, 28-V-1966, *leg. D.T. Kowalski*, DTK 3173 (UC 1408269, as *L. fuscatum*). Siskiyou County, Mount Shasta, 7600 ft. (2316 m), on dead twigs, *leg. D.T. Kowalski*, DTK 7453 (UC 1408275, as *L. fuscatum*). Tehama County, Morgan Summit, 5750 ft. (1753 m), dead

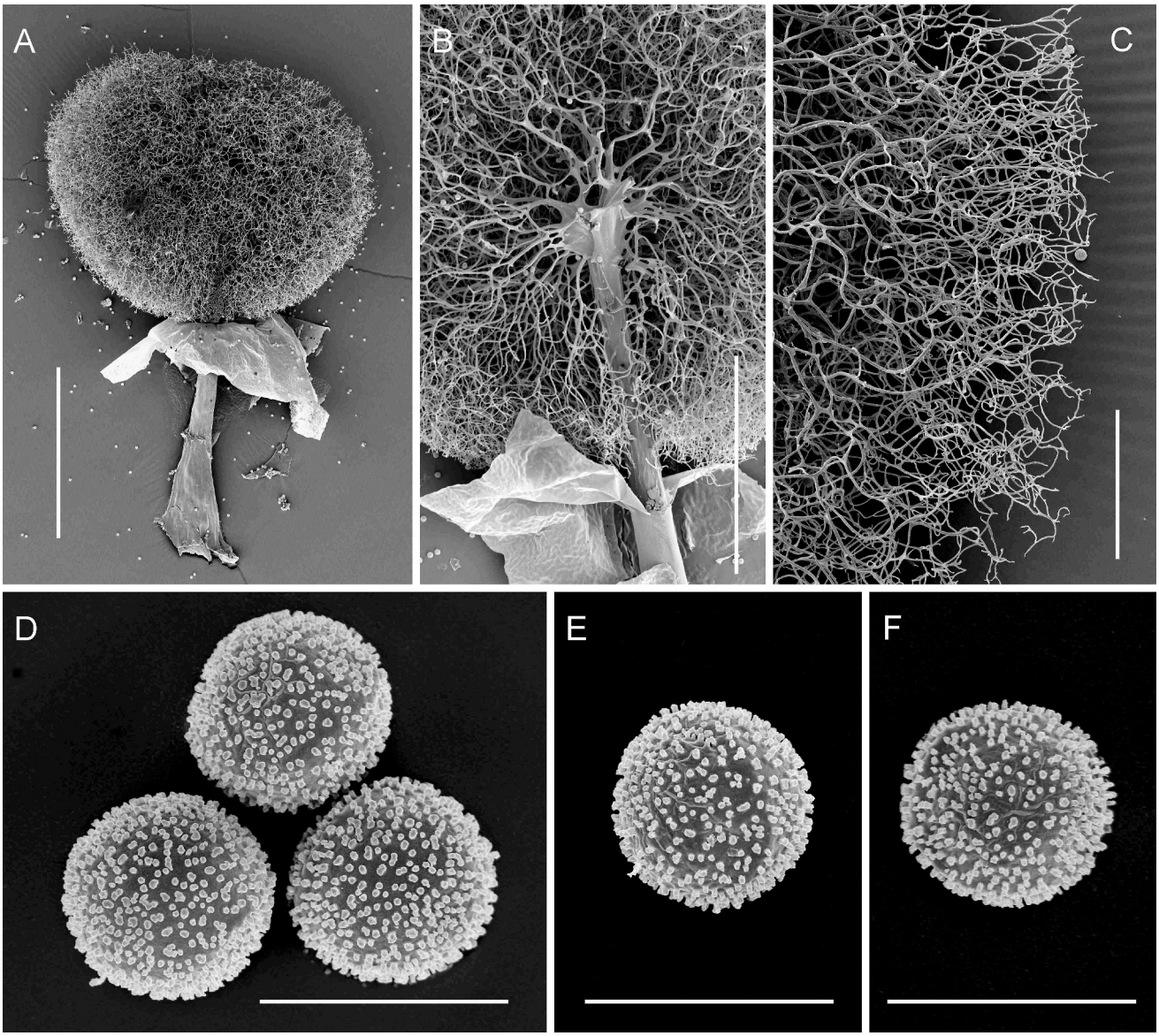

FIG. 3. *Lamproderma kowalskii* by scanning electron microscope—HOLOTYPE (DTK 6408). A. Sporocarp. B. Columella and primary branches of the capillitium without membranous expansions. C. Peripheral part of capillitium. D–F. Spores. Bars: A = 500 μm, B = 300 μm, C = 100 μm, D–F = 10 μm.

conifer twigs, 16-IV-1987, *leg. R.L. Critchfield Sr*, No. 2950 (MM 1685; NENB15269, as *L. fuscatum*).

Etymology. In honor of Donald T. Kowalski, the monographer of genus *Lamproderma* and collector of almost all specimens of the new species examined by us.

Habitat. On dead wood and twigs (coniferous) near melting snow.

Distribution. Known from the mountains of California (USA) (FIG. 5).

DISCUSSION

Morphology.—The two new species have silvery-brown sporothecae, with a hardly iridescent and areolate peridium (FIG. 1B, E), and ferruginous-brown spores in mass. These characters make them easy to recognize from other *Lamproderma* species. Although *L. argenteobrunneum* and *L. kowalskii* seem to be similar, numerous differentiating characters may be found after detailed examination of them. Macroscopically *Lamproderma argenteobrunneum* is more robust in general habit and it usually has subglobose to slightly ovoid sporothecae (slightly higher than wide) while *L. kowalskii* is more delicate and usually has globose sporothecae. Moreover *L. argenteobrunneum* can be recognized by having a shorter stalk no more than 0.64 mm (sometimes the stalk is absent) and especially a much lower ratio of stalk length to

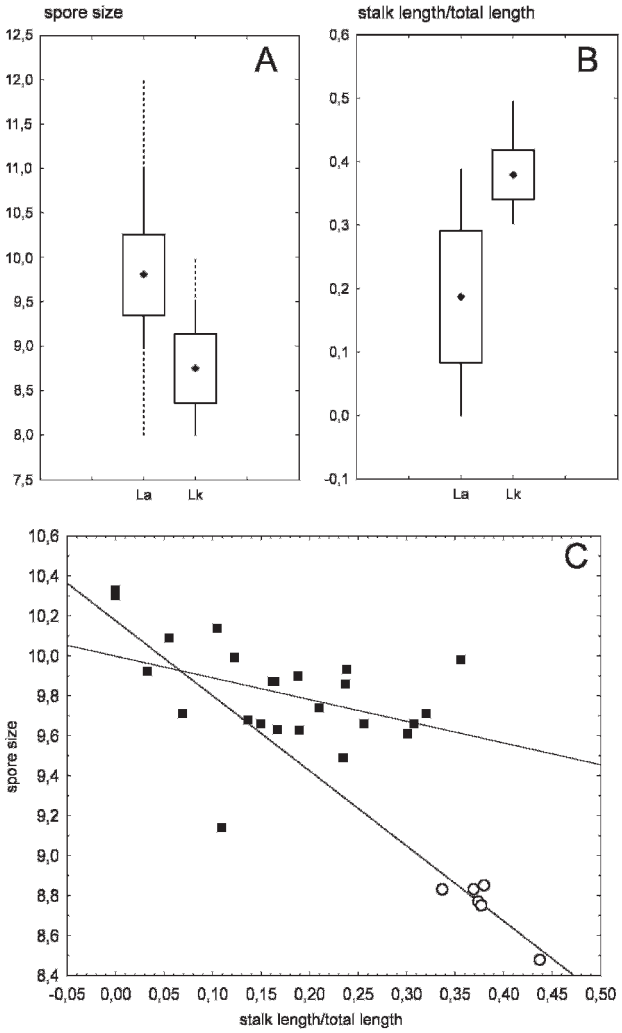

FIG. 4. Comparison of spore size and stalk length/total sporocarp height ratio of *Lamproderma argenteobrunneum* and *L. kowalskii*. A. Box plots for spore size. B. Box plots for stalk length/total sporocarp height ratio. La = *L. argenteobrunneum*, Lk = *L. kowalskii*, ♦ = average, box = standard deviation, vertical line = extreme values (dotted line reaches the values present in less than 1% of measurements). C. Scatter diagram of the relation of spore size and stalk length/total sporocarp height ratio for *L. argenteobrunneum* (■) and *L. kowalskii* (○).

the total height of the sporocarp (av. 0.19) than is the case of *L. kowalskii* (av. 0.38) (FIG. 4B, C). The two species can be readily distinguished microscopically by the spore size (FIG. 4A) and ornamentation, covered with short, curved and loosely arranged ridges in *L. argenteobrunneum* (FIGS. 1C, 2D–F) and densely covered with spines in *L. kowalskii* (FIGS. 1F, 3D–F). Further differentiating characters may be found in columella and capillitium (see TABLE I). *Lamproderma argenteobrunneum* is characterized by a conical to narrowly conical columella (FIG. 2B) while *L. kowalskii* has a cylindrical columella (FIG. 3B). The capillitium in *L. argenteobrunneum* is moderately dense, rigid, dark brown and with membranous expansions at the primary branches (FIG. 2B–C) vs. dense, flexuose and without membranous expansions at the primary branches in *L. kowalskii* (FIG. 3B–C).

All Kowalski's specimens identified by him as *L. fuscatum* (see list of collections under this species in Kowalski 1970) turned out to be one of the two new species described above, but one collection (USA: California: Tehama County, Well's Cabin Campground, 6300 ft. [1920 m], on twigs, 24-VI-1967, *leg. D.T. Kowalski*, DTK 6375 [UC 1408232]) is similar to *L. kowalskii* in all aspects (general habit, ratio of stalk length to the total height of the sporocarp, color of the sporotheca, shape of columella and capillitium and spore ornamentation) except for the larger spore size, (10.5–)11–12 µm diam. This material might be a large-spored form of the latter, but a taxonomic evaluation was impossible because only one collection is available.

The two new species could be confused with two other *Lamproderma* species, *L. cacographicum* Bozonnet, Mar. Mey. & Poulain and *L. fuscatum* (TABLE I), because they have macroscopically similar color. *Lamproderma fuscatum* has ferruginous-brown spores in mass, but it is distinguished from the two new species by an evanescent peridium, dehiscing in small patches, a capillitium with funnel-shaped capillitial ends and warted spores (Meylan 1932, Neubert et al. 2000, Moreno et al. 2002, M. Poulain and M. Meyer unpubl data). Although macroscopically similar *L. fuscatum* seems to be unrelated to the two new species. They are characterized by a persistent peridium, therefore it is most likely that they belong to the group of species forming a monophyletic clade of ''*L. ovoideum* group'' as defined by Fiore-Donno et al. (2008), while *L. fuscatum* belongs to the genetically distant clade of ''*L. atrosporum* group'' that could be treated as a separate genus.

Lamproderma cacographicum is the only previously described species of genus *Lamproderma* characterized by a silvery-brown sporotheca, but it is easily distinguishable from the two new species by its larger spores (12–15 µm diam) with a characteristic ornamentation of crests forming a subreticulate pattern (TABLE I; Bozonnet et al. 1997, Moreno et al. 2002).

The areoles of the peridium in the two new species usually are easily visible under the light microscope (oil immersion) at the base of the sporotheca. In most specimens they densely cover the peridial surface. However in some collections (MM 6833, 8421, 28409, 30173, Now 11693/2, DTK 10016, 8630, 9361) they are scattered and difficult to observe or even may be lacking. Such a characteristic peridium structure has not been noted in the literature for any other

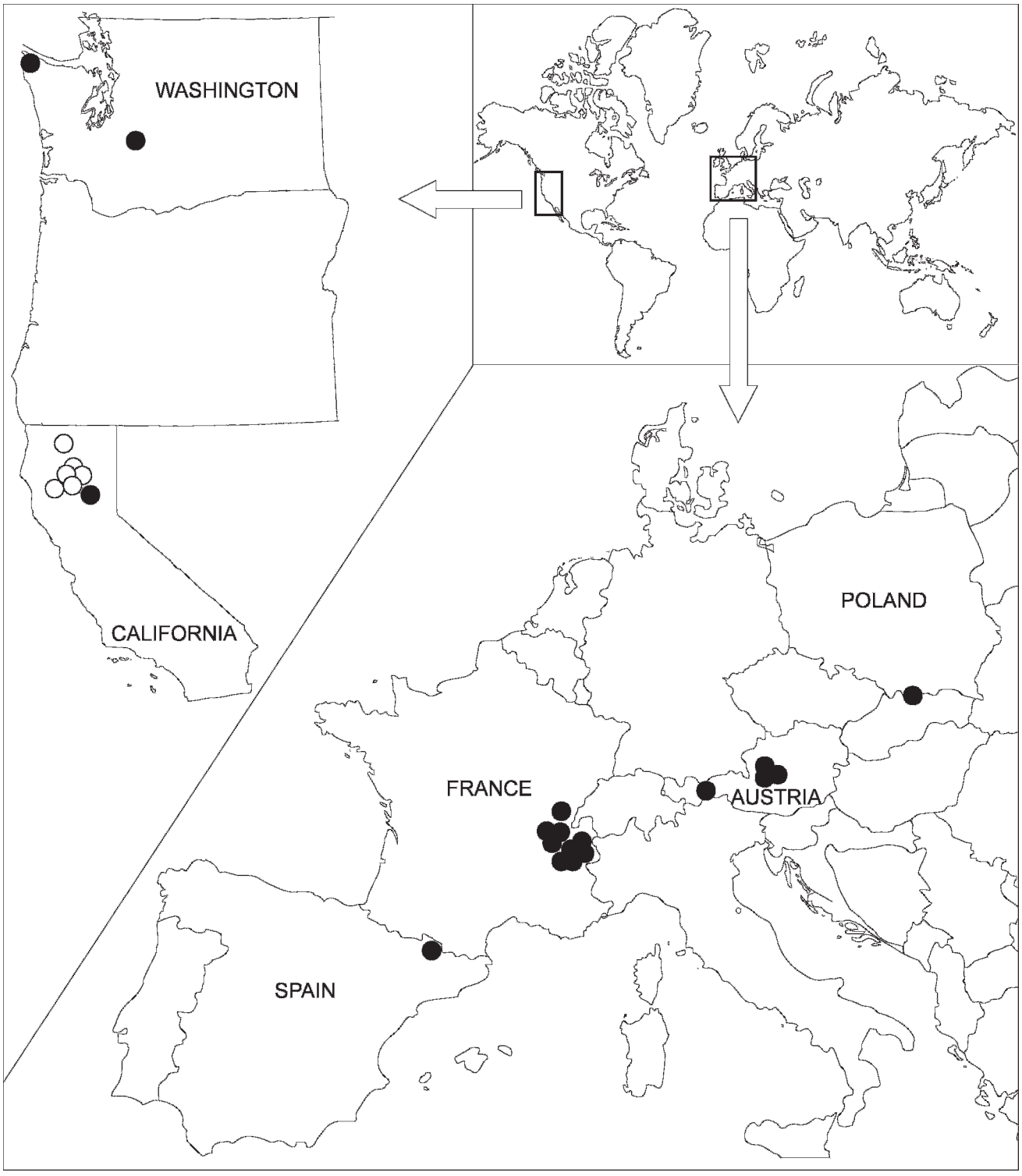

FIG. 5. World distribution of *Lamproderma argenteobrunneum* (●) and *L. kowalskii* (○).

Lamproderma species, but we did observe it in all studied collections (more than 30) of *L. cacographicum* and also in two collections of *L.* cf. *aeneum* Mar. Mey. & Poulain (MM 27521, MM 30849). *Lamproderma aeneum* can be easily recognized by the thin and strongly iridescent, bluish-violet peridium (Poulain et al. 2002) and the spores, which are dark brown in mass. It differs from *L. kowalskii* by its larger spores, 9.5–11(–11.5) µm, and from *L. argenteobrunneum* by the verrucose spore ornamentation.

TABLE I. Distinguishing characters of the two new species of *Lamproderma* and previously described macroscopically similar species

Character	*L. fuscatum* (from Moreno et al. 2002)	*L. argenteobrunneum*	*L. kowalskii*	*L. cacographicum* (from Bozonnet et al. 1997)
Sporotheca (form)	Globose to subglobose	Subglobose to slightly ovoid	Globose	Globose to ovoid
Sporotheca (color)	Rusty brown	Silvery-brown	Silvery-brown	Silvery-brown
Peridium	Evanescent in small patches, not areolate	Persistent, typically areolate	Persistent, typically areolate	Persistent, areolate
Stipe length	Up to 1 mm	0.04–0.64 mm	0.42–0.9 mm	0–1 mm
Columella (form)	Cylindrical	Conical to narrowly conical	Cylindrical	Obconical
Capillitium	Ferruginous, with membranous expansions at the primary branches, with funnel-shaped capillitial ends	Dark brown, rigid, with membranous expansions at the primary branches, with pointed free ends	Brown, flexuose, without membranous expansions at the primary branches, with pointed free ends	Dark brown, hyalines at the ends, with membranous expansions at the primary branches, with pointed free ends
Spores (color in mass)	Ferruginous-brown	Ferruginous-brown	Ferruginous-brown	Dark brown
Spore size	(9–)10–11 μm	(8.0–)9–11(–12) μm	8–9.5(–10) μm	(10.5–)12–15 μm
Spore ornamentation	Minutely warted	Loosely arranged short, curved ridges and spines	Densely spinulose	Crests forming a subreticulate pattern

Moist chamber culture.—Conditions of the culture of *L. argenteobrunneum* differed from those widely used for non-nivicolous myxomycetes. For the latter the incubation temperature is usually around 20 C (room temperature) and cultures are kept in diffuse light in an approximately 12 h light/dark regime (e.g. Härkönen 1977, McHugh 2005, Novozhilov and Schnittler 2008, Wrigley de Basanta et al. 2009). In an attempt to simulate conditions under melting snow the substrate material for *L. argenteobrunneum* was placed between moist filter paper disks and incubated in the dark at 5 C. It is not clear whether the initiates of the new sporocarps produced in the moist chamber culture were the spores added to the substrate or whether the plant remains already carried undetected dormant stages of the life cycle, such as sclerotia or microcysts that later gave rise to fruiting. Attempts to germinate spores from the same collection on agar were not successful. The moist chamber culture was established in 2007, but the collection (MA-Fungi 75785) that was used to supply the substrate and spores was made in 1994, 13 y earlier. The dormancy of the resistant stages of the life cycle of this myxomycete, whether as spores, cysts or sclerotia, was considerable. In the experiment by Erbisch (1964) on spores of a few non-nivicolous species it was demonstrated that they are able to germinate even after 75 y. Investigation is under way to determine spore viability, dormancy, germination and the moist chamber culture of nivicolous myxomycete species (D. Wrigley de Basanta unpubl data).

Few reports on the culture of nivicolous myxomycetes are available in the literature, and the method of culture has not been established. A report of the moist chamber culture of a nivicolous myxomycete was published by Marx (1998), who obtained sporocarps of *Trichia sordida* Johannesen after nearly 2 mo incubating a substrate at 12–16 C. A report in the literature of another typically nivicolous species, *Comatricha suksdorfii* Ellis & Everh., was isolated in moist chamber culture (Dulger et al. 2007), but the identification of the collection seems to be doubtful, and it might represent a non-snow bank species. The specimen was collected at 39 m, and although nivicolous myxomycetes may occur outside mountains (Novozhilov 1986) the locality of this report from a lowland area of the Mediterranean region is doubtful for a snow bank species. Dulger et al. (2007) used the standard method for moist chamber cultures and incubated the culture at 25 C. The collection reported by these authors unfortunately was not available for study, therefore we were not able to check the identity of the specimen. In addition there are two reports of agar culture of nivicolous myxomycetes either from spore to spore (Kowalski 1971) or from spores to myxamoebae (Wikmark et al. 2007).

Geographical distribution.—Nivicolous myxomycetes constitute a clearly distinguishable ecological group of

species requiring specific micro-environmental conditions for the development of fruit bodies (Lado 2004). These conditions can be found under long persisting snow, at the edges of snow banks and in places where the snow has just melted. As demonstrated by Ronikier and Ronikier (2009) nivicolous species are not alpine or arctic-alpine geographically but can be considered mountain species. Most data on the occurrence of nivicolous species are available from European mountains (e.g. Meylan 1914, 1932; Bozonnet 1984; Meyer 1986; Poulain et al. 2003, 2005; Moreno et al. 2003; Lado et al. 2005; Sánchez et al. 2007; Lado and Ronikier 2008, 2009; Ronikier et al. 2008), but many species also have been reported from North America (e.g. Kowalski 1971, 1975) and Asia (e.g. Tamayama 2000) in the northern hemisphere. Of the two species described here *L. argenteobrunneum* is characterized by wide geographical distribution (FIG. 5) but the other, *L. kowalskii*, seems to be restricted to a reduced region of North America (FIG. 5).

The species known so far from limited areas, such as *Diacheopsis pauxilla* Mar. Mey. & Poulain or *Dianema inconspicuum* Poulain, Mar. Mey. & Bozonnet (Meyer and Poulain 1998, Poulain et al. 2000) from the Alps, are recently described species, so their distribution is not yet fully known. The increasing number of reports of nivicolous species from the southern hemisphere (e.g. Stephenson and Johnston 2003; Stephenson et al. 2007a, 2007b; Stephenson and Shadwick 2009) and the similarity in their myxobiota suggest that most nivicolous myxomycetes are characterized by a worldwide but fragmented distribution, associated with the mountains of the world.

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