

A SEM-study of some types of nivicolous *Physarales*

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Abstract: The types of *Badhamia panicea* var. *nivalis*, *Leocarpus fulvus*, *Physarum albescens*, *Physarum vernum* and a collection of *Physarum vernum* f. *badhamioides* are studied. The synonymy of *Leocarpus fulvus* and *Physarum albescens* is confirmed and a lectotype and isolectotype are proposed for both species. The form *Physarum vernum* f. *parvisporum* is described as new and an epitype is given for *Physarum vernum* f. *vernum*.

Zusammenfassung: Die Typen von *Badhamia panicea* var. *nivalis*, *Leocarpus fulvus*, *Physarum albescens*, *Physarum vernum* und eine Aufsammlung von *Physarum vernum* f. *badhamioides* werden untersucht. Die Synonymie von *Leocarpus fulvus* und *Physarum albescens* wird bestätigt und ein Lectotyp und Isolectotyp für beide Arten werden vorgeschlagen. Die Form *Physarum vernum* f. *parvisporum* wird neu beschrieben und ein Epityp für *Physarum vernum* f. *vernum* wird aufgestellt.

The nivicolous myxomycetes are a peculiar group of organisms that require particular ecological conditions in order to complete their life-cycle, such as the presence of a stable snow layer that has been present for at least three months covering the substrate, an alternation of stress factors such as fluctuations in temperature and humidity, a high grade of humidity in the substrate during the plasmodial phase and relatively low temperatures during germination of the spores and/or development of the fructifications.

Due to the extreme habitat, the specific variability is wider and the species concept is broader than in low altitude species. This leads to considerable variation in the form, size and colour of fructifications, as well as in the morphology of the capillitium, consistency and colour of the peridium and the spore diameters. As these considerations have sometimes not been taken into account in the nivicolous myxomycetes, species have been separated by minimal differences. As examples, we can mention *Diacheopsis spinosifila*, *Diderma globosum* var. *europaeum*, *Diderma nigrum*, *Diderma subcaeruleum* and *Trichia varia*. We have been able to synonymize these taxa with other described species after having studied type material. In the present work we are comparing taxa that have already been synonymized by other authors.

Materials and methods

The material studied is cited separately under each species treated. The methods follow MORENO & al. (2004).

Physarum albescens ELLIS ex T. MACBR., N. Amer. Slime-Moulds, ed. 2: 86. 1922. (Figs. 1-4, 7-9)

= *Leocarpus fulvus* T. MACBR., N. Amer. Slime-Moulds: 82. 1899. Non *P. fulvum* FR. Syst. Mycol. 3: 143. 1829.

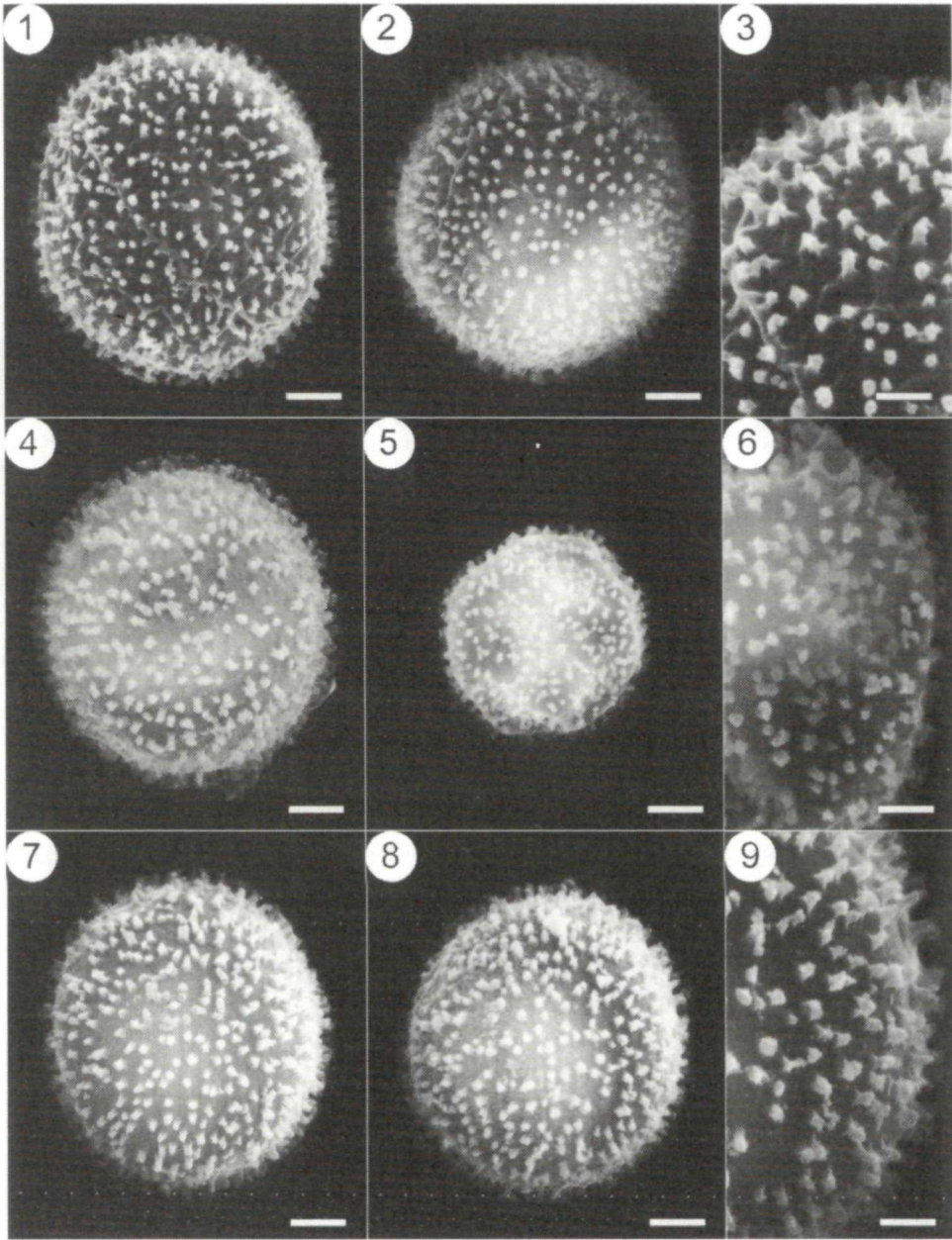
Original diagnosis: Sporangia gregarious, scattered, ovoid or globose, pale yellowish or fulvous, opening irregularly above, stipitate; the peridium double, the outer layer more or less calcareous, the inner delicate, almost indistinguishable, persistent below as a shallow cup; the stipe long, weak, striate, fulvous or yellow; hypothallus distinct, venulose, or more or less continuous; capillitium pallid or white, dense, with here and there below large continuous yellow calcareous nodules; columella none; spore-mass black; spores by transmitted light, dark brown, rough, 13-15 μm . Forms occur with a single (inner) peridium and simple physaroid capillitium.

Description:

In continuation we describe the specimen of *Physarum albescens* that represents the first collection of this species studied by ELLIS (see observations below), bearing the number NY 5612 and being part of the ELLIS collection, as indicated on the box. The specimen is preserved in a box with the name "*Diderma albescens*?", written with Indian ink, that was crossed out and with pencil was written below: "*Physarum albescens* = *Physarum fulvum* (MACBR.) LISTER". Within the box there is a loose peace of paper with the note: "scarcely differs from *Diderma albescens* PHIL. except in its greenish color". On one side of the box there is a peace of paper stuck with the note: "WINGATE thinks this is not *D. albescens* or even *Diderma* but another genus." Stuck on the bottom of the box there are two further notes, one with the data of collection, "Pleasant Valley, Utah, S. J. HARKNESS", and another one with the name "*Diderma albescens*?" The material consist of several pieces of herbaceous stem stuck on the inside of the box-lid, with abundant sporocarps that are generally well conserved, except on one stem that only bears sclerotized sporocarps.

The specimen NY 5615 is kept in a box and on the inside of the box-lid a small peace of card is stuck that bears a fragment of a vegetal stem with a group of approximately 20 sporocarps. Another fragment of the stem is stuck on the inside of the lid itself, with approximately 15 sporocarps. Beside, the name *Diderma albescens* and data of collection are written. This specimen is a part of the specimen NY 5612.

Sporocarps aggregated, sessile to generally stalked, up to 3 mm of total height. Sporotheca obovoid to obpyriform, up to 1.5 mm in diam. and 2 mm high, yellowish white to ochraceous white. Hypothallus abundant, membranous, fulvous. Stalk membranous, as a continuation of the hypothallus and of the same colour, rugous and bent down towards the substrate. Peridium double; exoperidium calcareous, thick, smooth to rugous, of apical irregular dehiscence, united with the endoperidium; endoperidium membranous, greyish iridescent to yellowish. Columella absent. Capillitium elastic, greyish white, by LM hyaline to yellowish hyaline composed of threads of about 1 μm in diam., very branched, forming a very dense net with prominent yellowish to yellowish white lime nodes of very variable size and form. Spores in mass violaceous black, violaceous brown by LM, 12-13 μm in diam., globose, spiny. By SEM large, dense baculae of regular distribution can be observed.



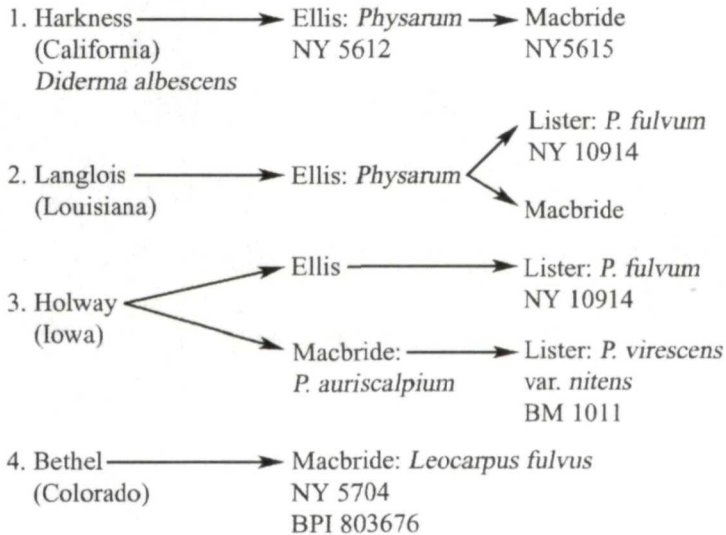
Figs. 1-9. 1-3. *Physarum albescens* (NY 5612). Spores and detail of spore ornamentation. 4. *Physarum albescens* (NY 5615). Spore. 5, 6. *Physarum nitens* (NY 10914). Spore and detail of spore ornamentation. 7-9. Lectotype of *Leocarpus fulvus* and *Physarum albescens* (NY 5704). Spores and detail of spore ornamentation. Spore: bar: 2 μm . Detail of spore ornamentation: bar: 1 μm .

Specimens examined: USA: California, Utah, Pleasant Valley, leg. S. J. HARKNESS, NY 5612 and NY 5615. Louisiana, 21. 1. 1901, leg. LANGLOIS, ex. herb. ELLIS, ex dono WINGATE, cf. WINGATE in litt. 28. 1. 1901, STURGIS Collection in NY 10915. Iowa, leg. HOLWAY, ex. herb. REX, ex dono WINGATE, cf. WINGATE in litt. 28. 1. 1901, STURGIS Collection in NY 10914. Juneau Co., Wis-

consin, Aug. 1937, leg. J.W. THOMSON, NY 8970. Eagle Co., Colorado, Mitchel Ranch, 6. 10. 1978, leg. MITCHEL, ex. personal collection MITCHEL & CHAPMAN, NY 8807. Lake Superior, leg. Prof. F.E. WOOD, "no. 27", NY 6465. Colorado, leg. COCKERELL, sec. WINGATE, "5079", NY 6466 and NY 6467. Colorado, Loveland Pass, 11000 ft., 15. 6. 1897, leg. E. BETHEL, new lectotype of *Leocarpus fulvus* and *Physarum albescens*, NY 5704 (as *Physarum fulvum*). "Colorado?", leg. E. BETHEL, BPI 803676, new isolectotype of *Leocarpus fulvus*.

Notes:

The taxonomic history of this species is quite complicated, but very interesting. Four different collections have been the base for its latest description. The first collection was gathered by Dr HARKNESS in California (NY 5612) and sent to Mr ELLIS which he determined as *Diderma albescens* PHILLIPS. ELLIS then sent one small part of it to MACBRIDE (Iowa herbarium) commenting that he thought it was a *Physarum*. This material corresponds to the specimen NY 5615, showing the same data as collection NY 5612. Thus, the two specimens originating from the collection by Dr HARKNESS are presently in the herbarium NY (NY 5612 and NY 5615).



The second collection was made by Father LANGLOIS in Louisiana, who sent it to ELLIS, who thought that it was identical to the specimen received previously from Dr HARKNESS. ELLIS once again thought that it was a *Physarum*. We have been able to locate the LANGLOIS specimen (NY 10915), consisting of sparse material in poor condition, as already noted by MACBRIDE (1922). The label of this specimen indicates that the material of ELLIS passed to the property of WINGATE, who donated it to the STURGIS collection, from where it reached LISTER. LISTER determined it as *Physarum fulvum* LISTER (LISTER 1911). However, this epithet used by LISTER is incorrect, as it was previously used by FRIES (1829). Independently, MACBRIDE also received this material from Father LANGLOIS, but did not comment on it.

The third collection was gathered by Mr HOLWAY in Iowa, determined as a *Physarum* and split it in two parts. One part was sent to MACBRIDE and the other to ELLIS. MACBRIDE determined it as *Physarum auriscalpium* and sent one piece to

ARTHUR LISTER, who determined it as *Physarum virescens* var. *nitens* LISTER. The specimen studied by LISTER bears the number BM 1011 (LISTER 1911), and we have not been able to study it. The material received by ELLIS, was later also studied by LISTER and determined as *Physarum fulvum* LISTER. It corresponds to the specimen NY 10914. Thus, LISTER, who did not know that he was dealing with two parts originating from the same specimen, assigned them to two different taxa.

The fourth collection was made by Prof. BETHEL in Colorado and sent to MACBRIDE, who considered it to be different from the other material he had studied and consequently described it as a new species, *Leocarpus fulvus*.

Later, Mr BILGRAM, a correspondent of MACBRIDE, while revising the collections from Louisiana (NY 10915), Colorado (NY 5704) and the part of the collection from Iowa (NY 10914) that was sent to ELLIS, indicated that these specimens were very similar. As the Iowa material sent to ELLIS (NY 10914) and MACBRIDE (BM 1011) originated from the same plasmodium, it obviously presented two phases: a physaroid and a leocarpoid one. The physaroid phases were determined as *Physarum auriscalpium* by MACBRIDE (MACBRIDE in LISTER 1911) and *P. virescens* var. *nitens* by LISTER (1911). The leocarpoid phase was determined as *Physarum fulvum* by LISTER (1911), realising the new combination of *Leocarpus fulvus* T. MACBR. to the genus *Physarum*. However, this combination is invalid, as we have already indicated.

MACBRIDE (1922) admitted that his *Leocarpus fulvus* in reality was a *Physarum*, and proposed a new name for this species, *Physarum albescens* ELLIS ex MACBRIDE, as *Physarum fulvum* FR. was already occupied by another, different species (see above).

We studied the material from California (NY 5612, NY 5615), Louisiana (NY 10915) and Colorado (NY 5704) and from Iowa the specimen that had been sent to ELLIS (NY 10914), but it has not been possible to us to examine the material from Iowa that had been sent to MACBRIDE (BM 1011). All these specimens were studied by scanning electron microscopy. We came to the conclusion that all specimens except the one from Iowa are conspecific and show very well the characters according to the present concept of *Physarum albescens*, as described in NEUBERT & al. (1995).

According to our examination, the specimen of Iowa (Figs. 5, 6) corresponds to *Physarum virescens* var. *nitens*, which nomenclaturally is at present considered as *Physarum nitens* (LISTER) ING. Therefore we disagree with LISTER who determined it as *Physarum fulvum*. As the other part of the Iowa gathering (BM 1011) was determined by LISTER as *Physarum nitens*, on this way, the complete sending of Mr HOLWAY seems to correspond to *Physarum nitens*. The Iowa specimen studied by us (NY 10914) presents sessile, yellow, fructifications, single peridium, capillitium with yellow lime nodes and small, light violaceous brown spores, 9-10 µm in diam. It is not possible to determine it as *Physarum auriscalpium*, as it was done by MACBRIDE, because the latter species is characterized by darker, larger, violaceous brown spores, 13-15 µm in diam.

Problems arise in the identification of *Physarum albescens* because it is so variable, mainly in the colour of its fructifications that varies from whitish, greyish to yellowish, and the morphology of the sporothecae, which can be sessile or prominently stalked, subglobose, claviforme, obovoid or obpyriform, and the capillitium, hyaline, yellowish to brownish, with yellow lime nodes that can be abundant to completely absent. The spore ornamentation is spiny, by SEM baculae can be observed.

Physarum albescens is a common nivicolous species frequently cited.

***Leocarpus fulvus* T. MACBR.**, N. Amer. Slime-Moulds: 82. 1899. (Figs. 7-9)

Original diagnosis: Sporangia gregarious, scattered, ovoid or globose, pale yellowish or fulvous, opening irregularly above, stipitate; the peridium double, the outer layer more or less calcareous, the inner delicate, almost indistinguishable, persistent below as a shallow cup; the stipe long, weak, striate, fulvous; hypothallus distinct, venulose, or more or less continuous; capillitium pallid or white, dense, with here and there rather large, yellow calcareous nodes; columella none; spore-mass black; spores by transmitted light, dark brown, rough, 13-15 μm .

Description:

The collection that we consider to be the lectotype of *Leocarpus fulvus*, NY 5704 (see below), is conserved in a box bearing the stamp of the ELLIS collection and "*Diderma*" written on the lid, which was crossed out and "*Physarum fulvum*" written below. The material consists of six fairly large twigs stuck on the inside of the box-lid, bearing abundant and well preserved sporocarps. The sporocarps have a greyish capillitium with a dark violaceous spore mass inside. On one side of the box a piece of paper is stuck with the note: "Loveland Pass, June 15, 1897, altitude 11000 ft., abundant on an alpine salix. This has a white coating but these specimens have been badly injured by the breaking down of my wheel." On the bottom of the box there is a further note stuck: "*Diderma* very near *D. laciniatum* PHILL. in GREV. V/113 (sec. MCBRIDE), Colorado (Bethel), no. 283".

The isolectotype consists of a microscope slide that shows residues of an ochraceous yellowish peridium, spiny, globose, non-collapsed spores 12-14 μm in diam., and a hyaline anastomosed capillitium, approximately 1 μm broad, with scant lime nodes; in some of them globular nodules of calcium carbonate can be found.

The macro- and microscopic description of *Leocarpus fulvus* coincides completely with the description of *Physarum albescens* indicated above and with the present concept of the species (NEUBERT & al. 1995).

Specimens examined: USA: Colorado, Loveland Pass, 11000 ft., 15. 6. 1897, new lectotype of *Leocarpus fulvus* and *Physarum albescens*, leg. E. BETHEL, NY 5704 (as *Physarum fulvum*). "Colorado?", leg. E. BETHEL, BPI 803676, new isolectotype of *Leocarpus fulvus*. "Colorado?", indicated on the box: "probably type of *Leocarpus fulvus*", BPI 803677. "Colorado?", Lake Eldora, 1911, indicated on the box: "appears to be part of BETHEL's collection", BPI 803680. "Colorado?", indicated on the box: "may be part of type of *Leocarpus fulvus*", BPI 803689. Colorado, Lake Eldora, 20. 5. 1911, leg. E. BETHEL, indicated on the box: "probably type of *Physarum albescens*", BPI 803690. Colorado, Lake Eldora, on coniferous wood, 12. 8. 1915, NY 10913 (as *Physarum fulvum*). Larimer Co., Colorado, 8000 ft., 16. 5. 1928, leg. E. C. SMITH, NY 7380 (as *Physarum fulvum*). Switzerland: Les Auges, Sainte Croix, 1350 m, May 1927, ex. Herb. MEYLAN, NY 7385 (as *Physarum fulvum*).

Notes:

When MACBRIDE (1899) described this species he did not allocate a type specimen and only indicated material gathered by BETHEL of Denver. Later, LISTER (1911) gives us evidence of a type specimen, providing the following information: "The type of this species was gathered by Mr E. BETHEL on living willow, growing in snow, 11000 feet

altitude, Loveland Pass, Colorado, in June, 1896." From the herbarium BPI we have received a specimen that is indicated as type of *Leocarpus fulvus*, gathered by BETHEL (BPI 803676), consisting of a microscope slide. Furthermore we have received several doubtful specimens referred to as probable types (BPI 803677, BPI 803690), probable part of type (BPI 803689) and probable part of BETHEL's collection (BPI 803680); the specimen BPI 803690 was collected by Mr BETHEL, we can read "leg. E. BETHEL" on the box. The herbarium BPI itself indicates that they are not sure whether it is type material. However, we consider the microscope slide indicated as type (BPI 803676) as isolectotype, being a part of the lectotype of *Leocarpus fulvus*, that we indicate below.

We have also been able to study several specimens from the herbarium NY, that were not considered type material. Surprisingly, we have found among this material what we consider to be the type of this species (NY 5704), as the data of collection indicated on the note within the box, coincides with that which LISTER (1911) indicates, in all aspects except in the year of collection, 1897. The year of collection of the type material that LISTER indicates is 1898. We think that this difference is due to a mistake in the transcription of the information committed by LISTER, as the rest of the information coincides, even the substrate willow, month and altitude where this specimen was gathered. As the type material obviously is not be found in the herbarium BM, we propose the specimen NY 5704 as lectotype and the specimen BPI 803676 as isolectotype.

The lectotype of *Leocarpus fulvus* has to be considered as the lectotype of *Physarum albescens*, in accordance with MARTIN & ALEXOPOULOS (1969).

***Physarum vernum* SOMMERF. in FRIES, Syst. Mycol. 3: 146. 1829.**

Original diagnosis: Fusco-atrum, peridiis tenuissimis subrotundo-depressis confluentibus laevibus, floccis raris albis, sporidiis fusco-nigris - SOMMERF.! in litt.

Gregarium, depressum, versiforme, confluens, at non sinuosum. Peridium tenuissimum, fragillimum lacero-dehiscens, demum evanescens, proprie albidum uti prius, sed sporidiis translucens fusco-atrum. Simplex 1-2 lin. (1,1-2,2 mm) latum, confluens in latas plagas abit. Flocci adnati, vagi, albi, quibus a P. albo eximie dignoscitur. Nobilis species.

Ad ramos, stipulas, folia decidua, etc. Norvegiae circa Christianiam detexit verno tempore SOMMERFELT. (v.s.)

Description of the holotype of *Physarum vernum*:

The holotype of this species is divided in two parts, designated α and β , each conserved in an envelope, in the inside of which it is protected by cotton wool. On each envelope the name *Physarum cinereum* was written with pencil and crossed out. The specimen O 300010 α consists of several pieces of leaves and herbaceous stems with abundant sporocarps. Most of them are crushed due to inappropriate conservation. The sporocarps and small plasmodiocarps that are present are irregularly aggregated. Generally, no measurements can be given due to their poor condition, but in some areas we can measure plasmodiocarps 4 x 1 mm. Hypothallus sparse, greyish, rarely whitish. Stalk absent. Exoperidium absent, endoperidium membranous, greyish to grey irides-

cent, fragmenting irregularly. Columella absent. Capillitium formed by prominent white calcareous nodes of variable morphology, angular to fusiform, united by slender hyaline threads of approximately 1 µm diam., sometimes giving a badhamoid appearance, branched and forming a very dense net. Spores in mass dark violaceous brown, light violaceous by LM, with an ornamentation formed by more or less irregularly distributed spines forming on its surface distinct dark patches by LM, 11-12 µm in diam., globose. By SEM, baculae with broad apices that merge into groups of two or three observable.

The specimen O 300010β consists of several herbaceous stems and a piece of leaf with abundant sporocarps that in some cases have preserved a part of their complete peridium. Peridium white, single, very delicate. Generally only a very delicate iridescent membrane with irregular dehiscence present. Also forming sporocarps to small plasmodiocarps up to 3 x 1 mm. Differing from the specimen α by the somewhat darker spores with a lighter zone and larger spores, 13-14 µm in diam., with regularly and densely distributed spines, coinciding in the rest of the micro- and macroscopic characters. By SEM, slender solitary baculae without broad apices observable.

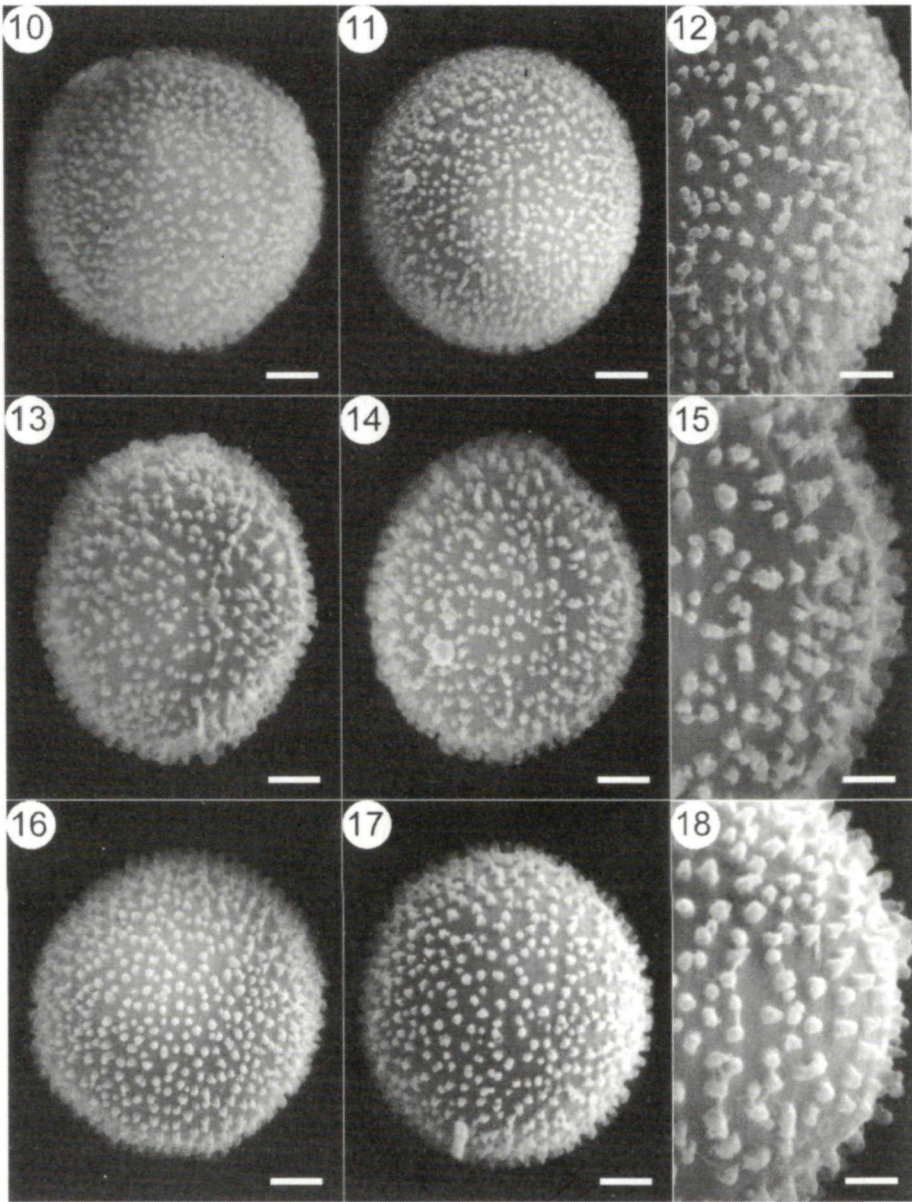
Specimens examined: *Physarum vernum* f. *parvisporum*. Spores (10-)11-12 µm: **Spain:** Sierra Nevada, Hoya de la Mora, 2575-2625 m s. m., on *Cytisus oromediterraneus*, 11. 5. 2001, AH 29055, AH 29108, AH 29115 and AH 29135. *Ibidem*, on grass, AH 29146. Segovia, Puerto de Navacerrada, on *Cytisus oromediterraneus*, 12. 3. 1997, AH 19516. Segovia, Puerto de Navafria, on twig of *Pinus sylvestris*, 15. 3. 1997, AH 19517. Madrid, Puerto de Navacerrada, on grass (*Poaceae*), 18. 4. 1996, AH 22215 (holotype). **Norway:** near Oslo, spring, leg. SOMMERFELT, on leaves and grass stems, O 300010α, part of the holotype of *P. vernum*. *Physarum vernum* f. *vernum*. Spores (12-)13-14(-15) µm: **Spain:** Sierra Nevada, Hoya de la Mora, 2575-2625 m s. m., on *Cytisus oromediterraneus*, 11. 5. 2001, AH 29032, AH 29049, AH 29066 (without lime), AH 29068 (without lime), AH 29071 (with *Physarum albescens*), AH 29104, AH 29116 (epitype), AH 29117, AH 29134, AH 29137 (with *Lamproderma ovoideum*) and AH 29140. *Ibidem*, on twig of *Pinus sylvestris*, AH 29127. **Norway:** near Oslo, spring, leg. SOMMERFELT, on leaves and grass stems, O 300010β, part of the holotype of *P. vernum*, new lectotype of *Physarum vernum* f. *vernum*.

Notes:

Physarum vernum presents a capillitium with calcareous nodules interconnected by hyaline threads. As these threads sometimes are very short, giving a badhamoid appearance, this species was considered as *Badhamia verna* by ROSTAFINSKI (1874), *Badhamia panicea* by LISTER (1894) and *Badhamia panicea* var. *nivalis* by MEYLAN (1925). However, MEYLAN (1914) previously described *Physarum vernum* f. *badhamoides*, separating it from *B. panicea* var. *nivalis* "par le peridium, le capillitium et l'absence toujours complète de fausse columelle".

LISTER (1894) considered *Badhamia verna* to be a form of *B. panicea* that differed from the type of the latter one only "in the more scanty deposits of lime, and in the narrow bands of the capillitium contracting here and there into hyaline threads", characters that he frequently observed in British material of *B. panicea*.

Some years later, LISTER (1911) recognized *Physarum vernum*, and considered it to be close to *P. cinereum*. However, he indicated that he observed intermediate collections between the two species and concluded that *Physarum vernum* possibly only represented a very robust variety of *P. cinereum* with a peridium covered with abundant calcareous deposits and possessing larger, darker spores.



Figs. 10-18. 10-12. Lectotype of *Physarum vernum* f. *vernum* (O 300010 β). Spores and detail of spore ornamentation. 13-15. Lectotype of *Badhamia panicea* var. *nivalis* (herbarium MEYLAN in LAU). Spores and detail of spore ornamentation. 16-18. Epitype of *Physarum vernum* f. *vernum* (AH 29116). Spores and detail of spore ornamentation. Spore: bar: 2 μ m. Detail of spore ornamentation: bar: 1 μ m.

SCHINZ (1920) hardly appreciated differences between *Physarum cinereum* and *P. vernum*. But *Physarum vernum* has darker, larger spores than *P. cinereum* and he therefore considered them to represent different species. As SCHINZ (1920) indicated, MEYLAN considered the alpine occurrences of *Physarum vernum*, corresponding with the type, to be distinct from collections made at low altitudes and representing *P. cine-*

reum.

HAGELSTEIN (1944) also considered *Physarum cinereum* to be related to *P. vernum* and separated the latter by its "robust sporangia and large, long, plasmodiocarps, with thick walls densely charged with lime" and its darker spores. According to this author, there are phases of *Physarum cinereum* with larger and darker spores in North America, which never have the massive fructifications that are typical of *P. vernum*.

MACBRIDE & MARTIN (1934) considered that many of the American collections of *Physarum vernum*, should be placed in *P. cinereum*, regardless of their larger spores. They observed a difference between European and American material of *P. vernum*, the European being more definitely plasmodiocarpic and having a much firmer peridium.

MARTIN & ALEXOPOULOS (1969), considered *Physarum vernum* to be close to *P. cinereum* and separated *P. vernum* by "its more limey and crustose peridium, greater tendency to fruit as plasmodiocarps, and somewhat larger and darker spores". They also indicated that their American collections are different from those from Europe and that some of their specimens of *P. vernum* seem to be very limy specimens of *P. cinereum*.

FARR (1976) also considered *Physarum vernum* as being closely related to *P. cinereum* but separated the first on account of its pure white colour and its fructifications being generally larger and less crowded. According to this author, gatherings from Europe show robust, strongly calcareous fructifications, seated on a conspicuous white hypothallus, a double peridium and spores medium brown or slightly darker, densely verruculose, larger than in collections made in other parts of the world. These are less robust, present a scanty, inconspicuous hypothallus, and dark brown, echinulate or coarsely verrucose spores of smaller dimensions. She also cites intermediate forms with the habit and size of *Physarum vernum* and spore characters of *P. cinereum*, and vice-versa, or forms being intermediate in all characters. FARR (1976) suspects that the concept of *Physarum vernum* includes more than one valid species.

NANNENGA-BREMEKAMP (1991) separated *Physarum vernum* from *P. cinereum* by its more calcareous peridium, dark spores with coarser warts and its predominantly plasmodiocarpous habit.

ING (1999) also recognizes the close proximity of *Physarum vernum* and *P. cinereum*, and separates *P. vernum* by its more frequent long plasmodiocarps, with more abundant lime and larger and darker spores.

In short, all the cited authors consider *Physarum vernum* and *P. cinereum* to be two very closely related species, and accept that they can be separated by spore characters. Furthermore, the majority of the authors distinguish *P. vernum* by its more robust and more plasmodiocarpic fructifications. MACBRIDE & MARTIN (1934), MARTIN & ALEXOPOULOS (1969) and FARR (1976), observed differences between European and American material. ING (1999) does not recognize differences between alpine and lowland forms, while MEYLAN (in SCHINZ 1920), assigns them to two different species, *P. vernum*, alpine and *P. cinereum*, non-alpine.

As we have been unable to locate the type material of *Physarum cinereum*, we unfortunately cannot resolve the problem of a precise separation of *Physarum vernum* and *P. cinereum*. But we are convinced that the two taxa have been confused by previous authors, especially as their separation was based on the characters of spore colour and size. Such variation is found within the species *Physarum vernum* itself.

We have been able to observe differences in the spore characters between the parts named α and β of the holotype of *Physarum vernum*: The specimen α has spores 11-12 μm in diam., with an ornamentation formed by more or less irregularly distributed spines seen as distinct dark spots by LM. The part β has spores 13-14 μm in diam., with a dense ornamentation formed by regularly distributed spines, with a somewhat lighter zone. We have been able to isolate from the specimen β a leaf and a piece of herbaceous stalk with fructifications presenting the spore characters of the part α . Obviously, someone separated the type in two parts basing himself on spore characters. We have been able to see this variability also in material collected and studied in Spain.

We agree with MEYLAN (in SCHINZ 1920) and consider *Physarum vernum* a strictly nivicolous species, very well described and recently photographed by NEUBERT & al. (1995), that we characterize by fructifications forming short sinuous plasmodiocarps, of a whitish colour due to calcium carbonate, capillitium with abundant fusiform lime nodes and spores with two possible diameters and ornamentation. Small spores (10-)11-12 μm in diam., with a more lax and irregular ornamentation, forming dark spots by LM. By SEM we observe baculae with broad apices that merge in groups of two or three and a second group with larger spores (12-)13-14(-15) μm in diam., with a dense and regular ornamentation, by SEM formed by slender solitary baculae without broad apices.

As we consider these differences not sufficient to separate two species, we suggest two forms of the same species for a practical purpose: We maintain as *Physarum vernum* f. *vernum* (β) the specimens with the large spores and *Physarum vernum* f. *parvisporum* (α) the specimens with the smaller spores. Possibly in the holotype of *P. vernum* two different collections have been mixed as, according to our experience, the differences we have here pointed out in the spore characters appear only in different populations and never occur together in the same colony.

In any case, the original diagnosis of *Physarum vernum* and the type material is difficult to categorize within the present concept of the species for the following reasons:

1. The type material was gathered near Oslo, a city at sea level. There are mountains in its surroundings but the exact locality of recollection it is not indicated. The possibility that it is a lowland collection is left open.

2. The type material hardly presents lime in the peridium and in the original diagnosis was described as "Peridium tenuissimum". The character of a robust peridium is pointed out by the majority of the authors. The type material does not seem to represent a typical specimen, we regard it as not very well matured, or maybe it has lost its lime due to external (environmental) conditions. Therefore it should not represent the type of a species and we propose an epitype for *Physarum vernum* (see below).

3. We can observe within the type collections two types of spore characters based on colours, size and ornamentation.

As the latter mentioned characters are fundamental in order to distinguish *Physarum vernum* from *P. cinereum*, and are used by the majority of the European and American authors, obviously *Physarum cinereum* is a very closely allied species. Only the localisation of the type of the latter species can resolve definitely this problem.

A close nivicolous species is *Physarum styriacum* GOTTSB. (GOTTSBERGER 1966),

that differs only by the presence of larger spores, 18-20 μm .

***Physarum vernum* f. *badhamioides* MEYL.**, Bull. Soc. Vaud. Sci. Nat. **50**: 5. 1914. (Figs. 22-24)

Original description: Quoique répandue, cette espèce (*Physarum vernum*, com. aut.) n'est jamais très abondante dans une même station. Outre les variations ordinaires de forme et de grosseur, ses sporanges varient au point de vue de la quantité de calcite utilisée. Lorsque cette calcite est très abondante, les sporanges sont parfaitement blancs et les nœuds du capillitium très nombreux, ramifiés, parfois anastomosés. Dans ce cas, les filaments hyalins qui unissent ces nœuds sont si courts qu'ils paraissent nuls: débarrassé de ses spores, l'intérieur des sporanges paraît être celui d'un *Badhamia* (f. *badhamioides* in herbar. mihi). Si la calcite manque, les sporanges, entourés de la seule membrane interne, paraissent d'un gris foncé, généralement irisé; les nœuds du capillitium sont rares et petits.

Description:

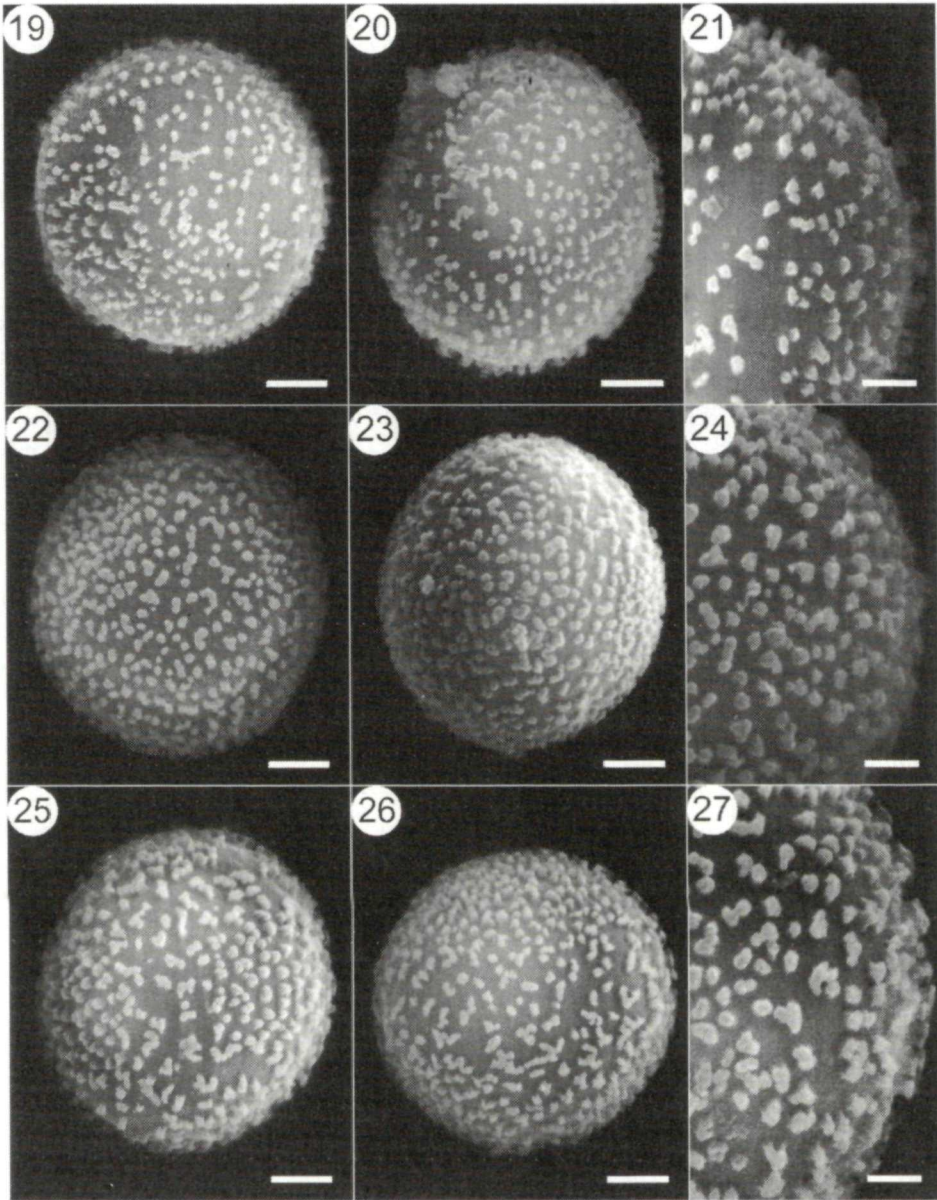
MEYLAN never designated type specimens. Therefore, KOWALSKI (1975) subsequently lectotypified the new species and varieties described by MEYLAN. However, he did not select nomenclatural types for forms. We have found in the herbarium LAU a specimen indicated as *Physarum vernum* var. *badhamioides*, although MEYLAN published it as a form. This material is conserved in a matchbox stuck on cardboard and consists of three dry stems about 4 cm long, with abundant and very aggregated, white sporocarps and plasmodiocarps.

Capillitium badhamioid, formed by abundant, white, prominent lime nodes of variable morphology united by hyaline very slender and short filaments clearly visible by LM, of about 1 μm in diam. Spores 11-12 μm in diam., light violaceous by LM, with dense spines of more or less regular distribution. By SEM the ornamentation consisting of baculae with broad apices that frequently merge forming short crests.

Specimens examined: Switzerland: Aiguille de Baulmes, 1400 m s. m., Apr. 1912, leg. C. MEYLAN, LAU.

Notes:

Physarum vernum is very variable and can have abundant or sparse lime in its fructifications. If calcium carbonate abounds, whitish calcareous sporocarps and a capillitium with abundant lime nodes can be observed. If it is missing, sporocarps with a delicate greyish more or less iridescent peridium and a capillitium with hardly or small lime nodes are present. This particularity was already observed by MEYLAN (1914) who consequently described the form *Physarum vernum* f. *badhamioides*, representing fructifications with abundant calcium carbonate. We have observed that the collection studied furthermore shows spores of smaller dimensions. Due to spore size and ornamentation by SEM we approximate it to *Physarum vernum* f. *parvisporum*.



Figs. 19-27. 19-21. *Physarum vernum* f. *parvisporum* (O 300010 α), spores and detail of spore ornamentation. 22-24. *Physarum vernum* f. *badhamioides* (herbarium MEYLAN in LAU). Spores and detail of spore ornamentation. 25-27. Holotype of *Physarum vernum* f. *parvisporum* (AH 22215), spores and detail of spore ornamentation. Spore: bar: 2 μ m. Detail of spore ornamentation: bar: 1 μ m.

Badhamia panicea var. *nivalis* MEYL., Bull. Soc. Vaud. Sci. Nat. **56**: 66. 1925 (Figs. 13-15)

Original diagnosis: Diffère du type par l'absence d'hypothalle rougeâtre; les spores plus nettement et fortement papilleuses; la station au bord des neiges fondantes au

printemps. Comme chez le type, le capillitium s'agglomère généralement, à la base du sporange, en une fausse columelle blanche.

Description:

The type is stuck on a cardboard that is conserved in a matchbox, on which "*Badhamia alpina*" can be read, that was crossed out and corrected subsequently to the present name. The specimen is composed of herbaceous stems with abundant whitish sporocarps.

Capillitium formed by white, prominent elongated to fusiform lime nodes, united by abundant and long hyaline threads clearly visible by LM and about 1 µm in diam. Spores 12-13 µm in diam., dark violaceous, with dense, regularly distributed spines. By SEM spore ornamentation formed by slender baculae.

Specimens examined: Switzerland: Alpes de Fully, Canton Valais, 2100 m s. m., on decayed herbaceous debris, Apr. 1916, leg. C. MEYLAN, lectotype, LAU.

Notes:

MEYLAN (1925) separates this variety from *Badhamia panicea* var. *panicea* by the absence of a reddish hypothallus, by its spores being more clearly and strongly papillose and its nivicolous habitat, sharing with it the white pseudocolumella in the base of the sporocarp formed by the capillitium.

According to MEYLAN (1925) the capillitium is intermediate between *Badhamia* and *Physarum*, with lime nodes interconnected by hyaline threads.

According to our experience, *Physarum vernum* may present a capillitium more or less badhamioid which, if the lime nodes are large, may fuse to a central pseudocolumella. As was the case with *Physarum vernum* f. *badhamioides*, it is a fructification with abundant calcium carbonate. Due to spore size and ornamentation by SEM we synonymize this variety with *Physarum vernum* f. *vernum*.

We propose the following taxonomic treatment:

Physarum albescens ELLIS ex T. MACBR., N. Amer. Slime-Moulds, ed. 2: 86. 1922.
= *Leocarpus fulvus* T. MACBR., N. Amer. Slime-Moulds: 82. 1899. Non *Physarum fulvum* FR., Syst. Mycol. 3: 143. 1829.

Physarum vernum f. *vernum* SOMMERF. in FRIES, Syst. Mycol. 3: 146. 1829. (Figs. 10-18)

= *Badhamia panicea* var. *nivalis* MEYL., Bull. Soc. Vaud. Sci. Nat. 56: 66. 1925.

Lectotype: Norway, near Oslo, spring, leg. SOMMERFELT, on leaves and grass stems, O 300010β.

Epitype: Spain, Sierra Nevada, Hoya de la Mora, 2575 m s. m., on *Cytisus oromediterraneus*, 11. 5. 2001, AH 29116.

Physarum vernum f. *parvisporum* f. *nova* (Figs. 19-27)

= *Physarum vernum* f. *badhamioides* MEYL., Bull. Soc. Vaud. Sci. Nat. 50: 5. 1914. nom. inval., new form not indicated, type not designated.

Diagnosis: A typo differt sporis minoribus (10-)11-12 μm diam., globosis, spinosis irregularibus.

Holotype: Spain, Madrid, Puerto de Navacerrada, on grass (*Poaceae*), 18. 4. 1996, AH 22215.

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