A taxonomic review on the nivicolous myxomycete species described by KOWALSKI. II. *Physarales* and *Trichiales*

G. MORENO
H. SINGER
C. ILLANA
Departamento Biología Vegetal
Universidad de Alcalá
E-28871 Alcalá de Henares, Madrid, Spain

Received 7. 6. 2004

Key words: Myxomycota, *Dianema*, *Diderma*, *Lepidoderma*. – Chorology, SEM, taxonomy, type study.

Abstract: The type material of five myxomycete species described as new by KOWALSKI is revised. *Dianema aggregatum* and *D. subretisporum* from the order *Trichiales* are recognized as valid species. *Diderma brooksii* and *Lepidoderma crustaceum* from the order *Physarales* are recognized as valid species, whereas *L. aggregatum* is considered a synonym of *L. chailletii*. Micrographs of the taxonomic characters are provided, including a SEM study of the spore ornamentation.

Zusammenfassung: Das Typusmaterial von fünf von KOWALSKI beschriebene Schleimpilzarten wird untersucht. *Dianema aggregatum* und *D. subretisporum* der Ordnung *Trichiales* werden als gültige Arten anerkannt. *Diderma brooksii* und *Lepidoderma crustaceum* der Ordnung *Physarales* werden als gültige Arten anerkannt, während *L. aggregatum* als Synonym von *L. chailletii* betrachtet wird. Mikrofotografien der taxonomischen Merkmale werden geboten, ergänzt mit einer REM-Studie der Sporenornamentation.

Myxomycetes can develop on different substrates and with different ecological demands. There are foliicolous (on leaves), corticolous (on bark), lignicolous (on woody residues), fimicolous (on dung), and succulenticolous (on succulent plants) myxomycetes. However, one ecological group stands out that cannot be characterized by a special substrate, but by very peculiar requirements necessary for their fructification – the nivicolous myxomycetes. The essential needs for their development are the presence of a snow-layer lasting at least three months on the substrates where they fructify, an alternation of stress factors, such as frost-temperatures, dryness/humidity, a high humidity during the plasmodial stage and relatively low temperatures during spore germination and/or development of the fructifications. SCHINNER (1982) proved in the laboratory that *Lamproderma carestiae* fructified only at the low temperature of 4 °C.

MEYLAN (1868-1941) was the first investigator to dedicate himself to the group of the nivicolous myxomycetes and he gathered abundant specimens in the Swiss Jura. His work is reflected in numerous publications in which he described 18 nivicolous species as new between the years 1908 and 1935 together with 14 nivicolous varieties and many nivicolous forms. However, many investigators did not accept a large number of his taxa and synonymized them with others that were already known, without even having studied MEYLAN's material (KOWALSKI 1975 a). This was probably due to the short and incomplete descriptions published by MEYLAN for his new taxa, and to

the absence of understanding and experience of this particular group of myxomycetes by other investigators.

We can consider KOWALSKI the continuator of MEYLAN's studies, who gathered nivicolous myxomycetes in the mountainous regions in the west of the United States, mainly in the states of California, Oregon and Washington. Between the years 1966 and 1975 he described 16 new nivicolous species. These are: *Comatricha anastomosans*, *Diacheopsis effusa*, *D. serpula*, *Dianema aggregatum*, *D. subretisporum*, *Diderma brooksii*, *D. nigrum*, *D. subcaeruleum*, *Lamproderma acanthosporum*, *L. disseminatum*, *L. fusiforme*, *L. maculatum*, *Lepidoderma aggregatum*, *L. crustaceum*, *L. didermoides* and *Trichia synspora* (KOWALSKI 1966, 1967, 1968 a, b, c, 1970, 1971, 1972, 1973, 1974, 1975 a, b). Among these, very common species can be found, such as *Lamproderma maculatum* and *Lepidoderma aggregatum*, but also rare ones that have not been collected again and are thus known only from his type collections, such as *Diderma brooksii* and *D. nigrum*, or even from one single collection, *Trichia synspora*. In recent studies we have been able to demonstrate that several of these species are synonyms of other, more common species. We have proposed the synonymy of *Diderma nigrum* KOWALSKI with *D. asteroides* (LISTER & G. LISTER) G. LISTER (MORENO & al. 2003 a), *Diacheopsis spinosifila* M. L. FARR & R. L. CRITCHF. with *Lepidoderma didermoides* KOWALSKI (MORENO & al. 2003 b), *D. subcaeruleum* KOWALSKI was synonymized with *D. niveum* (ROSTAF.) T. MACBR. (SINGER & al. 2004 a) and *Trichia synspora* KOWALSKI with *T. varia* (PERS. ex J. F. GMEL.) PERS. (SINGER & al. 2003).

Reviewing KOWALSKI's type material, we apply for the first time the critical point drying technique and SEM microscopy on this material in order to study the spore ornamentation. First results of several of his species belonging to the order *Stemonitales* have been submitted recently for publication (SINGER & al. 2004 b). The current work is the continuation of these studies and contributes the review of the species from the orders *Physarales* and *Trichiales*.

Materials and methods

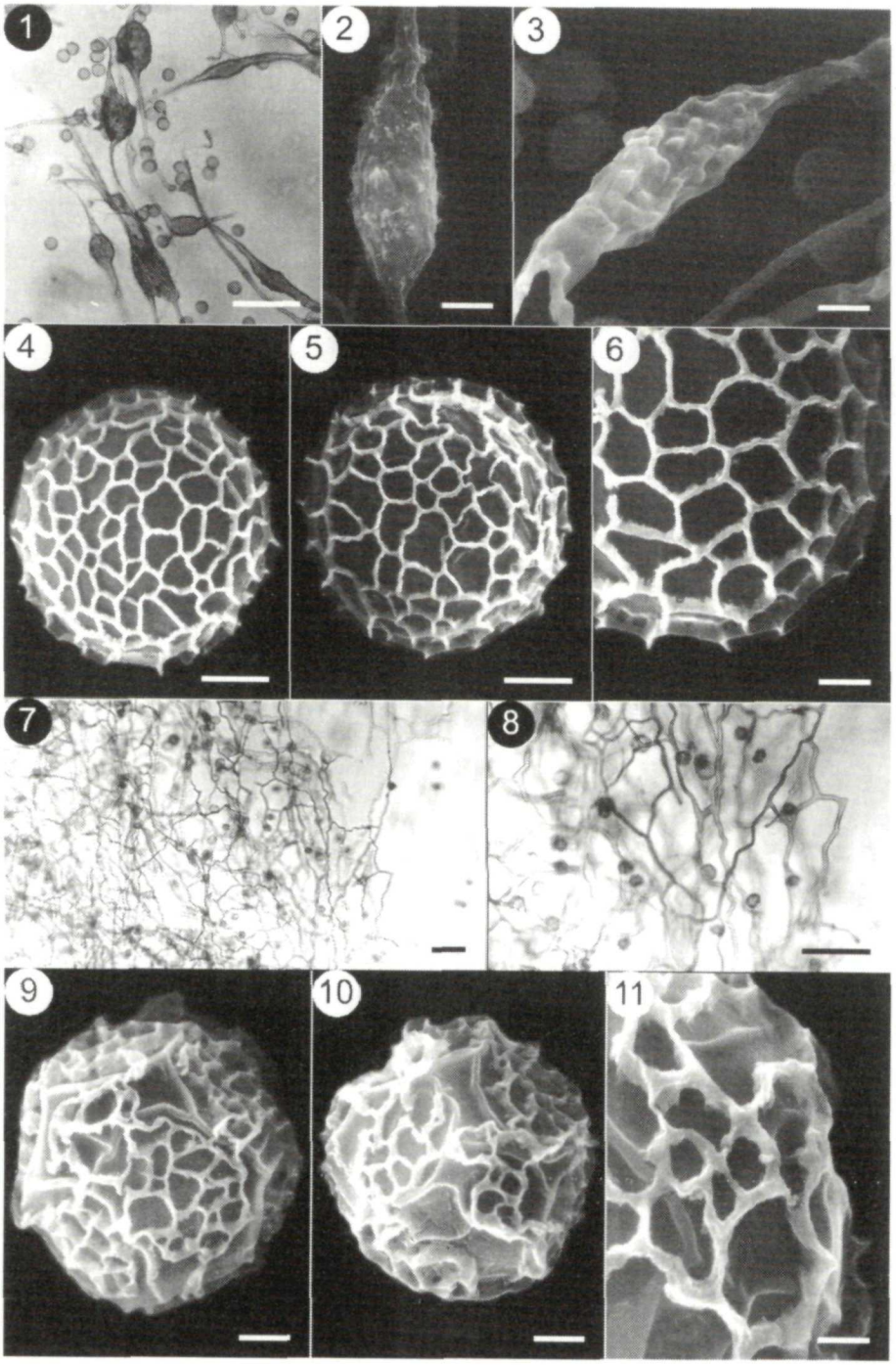
The collected material was studied with a binocular microscope and, after mounting in Hoyer's medium, with a Nikon (Optiphot) microscope. Scanning electron microscopy (SEM) micrographs were taken in the University of Alcalá de Henares using a Zeiss DSM-950. Spore measurements were made under the oil immersion objective and include surface structures such as spines or warts.

SEM-preparation: Sporocarps were rehydrated in concentrated ammonium hydroxide (28-30%) for 30 min, dehydrated in aqueous ethanol (70%) for 30 min, fixed for 2 h in pure ethylene glycol dimethyl ether (= 1,2-dimethoxymethane) and finally immersed in pure acetone for at least 2 h followed by critical point drying and sputtering with gold-palladium.

The terminology of the spore-producing stages follows DÖRFELT & MARX (1990) and LADO & PANDO (1997). The spore wall ornamentation as seen in the SEM is described according to the terminology proposed by RAMMELOO (1975 a, b). The abbreviations for author citations follows KIRK & ANSELL (1992).

***Dianema aggregatum* KOWALSKI**, Mycologia **59(6)**: 1081. 1968. ["1967"] (Figs. 1-6)

Original diagnosis: Sporangiis gregariis, sessilibus, hemisphaericis, subbrunneis, 0,5-2,0 mm diam. Peridio membranaceo, persistenti. Columella nulla. Capillitio copioso, filamentis solidatis, subbrunneis, 1-2 µm diam., cum fusiformibus nodulis, affixo peridio. Sporis globosis, subbrunneis, reticulatis, 8-10 µm diam. Plasmodio ignoto.



Figs. 1-6. *Dianema aggregatum* (holotype). 1. Capillitium (bar: 50 µm). 2, 3. Capillitium nodes (bar: 5 µm). 4, 5. Spores (bar: 2 µm). 6. Detail of the spore ornamentation (bar: 1 µm). Figs. 7-11. *Dianema subretisporum* (holotype). 7, 8. Capillitium (bar: 50 µm). 9, 10. Spores (bar: 2 µm). 11. Detail of the spore ornamentation (bar: 1 µm).

Description:

The type material is deposited in two boxes of the herbarium BPI, with the numbers BPI 746314 and BPI 826667. In the first one there is a microscope slide and a matchbox with a small portion of fructifications stuck in its base with hardly any substrate. The second box contains a piece of bark with many well-conserved sporocarps. As both specimens are indicated by the herbarium as type, we consider the more abundant one (BPI 826667) the holotype, and the other one an isotype. Another isotype with the number MICH 41826 consists of six woody pieces, mainly bark, with many, very well-conserved sporocarps.

Sporocarps tightly aggregated, sessile. Sporotheca globose, subglobose or pulvinate, sometimes laterally compressed, 0.5-2 mm in diam., amber to light brown, mottled with abundant and tight, small, dark reddish wart-like dots. Hypothallus thick, colourless, continuous. Stalk absent. Peridium single, persistent, membranous, yellowish-straw to light brown by LM; dehiscence irregular. Columella absent. Capillitium brownish by magnifying glass, reddish brown by LM; threads 1-3 µm in diam., somewhat flexuous, branched, forming a more or less lax net, with abundant fusiform to subglobose nodes of very variable size and morphology (Fig. 1); nodes bearing an irregularly warted surface (Figs. 2, 3), concolorous with the rest of the capillitium to somewhat darker. Spores light brown in mass, pale yellowish to yellowish brown by LM, 8-10 µm in diam., globose to subglobose, reticulate. By SEM, a complete reticulum consisting of narrow and irregular meshes observable (Figs. 4-6). The wall of the reticulum homogenous, except its base sometimes having a few perforations resembling an aqueduct.

Specimens examined: USA: California, Tehama Co., 5 miles west of Child's Meadows, 5100 ft., on decaying bark, 30. 4. 1966, leg. D. T. KOWALSKI, DTK 2852 (type) distributed in BPI 746314 (isotype), BPI 826667 (holotype), MICH 4827 (isotype).

Notes:

Dianema aggregatum can be recognized easily by plentiful and aggregated, amber to light brown fructifications, capillitium with abundant enlarged nodes and reticulate spores with narrow meshes. The capillitium nodes of *D. aggregatum* resembles the nodes of *Lepidoderma granuliferum* (W. PHILLIPS) R. E. FR., but the latter species clearly differs in its peridium with characteristic calcareous scales and non-reticulate spores.

Two other species of the genus with reticulate spores are known: *Dianema depressum* (LISTER) LISTER and *D. subretisporum*. *Dianema depressum* is a not nivicolous species which differs by flattened sporocarps with a tendency to form plasmodiocarps, growth of the sporocarps isolated or in a small group, dark brown peridium which lacks dots and penicillate capillitium without nodes. *Dianema subretisporum* is also a nivicolous species, but it differs by larger spores, with a very irregular reticulum, and by densely reticulate capillitium lacking nodes.

At present *Dianema aggregatum* is a Californian endemic (KOWALSKI 1967) as there are no further citations from other countries or continents. One additional collection made by KOWALSKI bearing the number DTK 6457 was studied by SEM by RAMMELOO (1983).

***Dianema subretisporum* KOWALSKI**, Mycologia **59(6)**: 1080. 1968. (Figs. 7-11)

Original diagnosis: Sporangiis dissipatis, sessilibus, globosis vel hemisphaericis, brunneis, 1-2 mm diam. Peridio membranaceo, evanescentio. Columella nulla. Capillitio summe copioso, filamentis ramosis et anastomosantibus formandis reticulum, laevigatis, solidatis, subbrunneis. Sporis globosis, subbrunneis, reticulatis, sed reticuliis interrumpere ad laevigatae aereae, 12-13 µm diam. Plasmodio ignoto.

Description:

The type material kept in a box with the number BPI 826738 consists of one microscope slide and a small decorticated twig with a few sporocarps, only about 19 of which have retained parts of their peridium and capillitium, and others consist of hardly more than a basal peridium cup.

Sporocarps scattered to gregarious, sessile. Sporotheca globose, subglobose or pulvinate, 0.5-2 mm in diam., reddish brown to greyish brown. Hypothallus membranous, colourless, confluent. Stalk absent. Peridium single, evanescent, persistent at the base, membranous, yellowish-straw by LM; dehiscence irregular. Columella absent. Capillitium ochraceous brown by magnifying glass, reddish brown by LM; threads 1-3 µm diam., flexuous, branched and anastomosed, forming a dense net (Figs. 7, 8). Spores greyish brown in mass, pale yellowish to yellowish brown by LM, 12-13 µm in diam., globose to subglobose, reticulate. By SEM a complete reticulum composed by meshes of very variable diameters observable, the largest meshes reaching up to 3 µm in diam. (Figs. 9-11).

Specimens examined: USA: California, Tehama Co., Well's Cabin Campground, 6300 ft., on decaying fir twigs, 18. 6. 1966, leg. D. T. KOWALSKI, DTK 3607 (type) in BPI 826738 (holotype).

Notes:

Dianema subretisporum is characterized by scattered to gregarious sporocarps, flexuous and branched capillitium forming a dense net without nodes, and spores with meshes of very different dimensions. *Dianema aggregatum* differs clearly by copious and aggregated fructifications, capillitium with abundant nodes and smaller spores being reticulate with narrow meshes.

This species is also cited from Colorado (MITCHEL & al. 1980), and in Europe from France (POULAIN & al. 2000). The collection of KOWALSKI with the number DTK 6138 was studied by SEM by RAMMELOO (1983).

***Diderma brooksii* KOWALSKI**, Mycologia **60(3)**: 595. 1968. (Figs. 12-16)

Original diagnosis: Sporangiis dissipatis vel gregariis, sessilibus vel breve stipitatis, globosis, albis vel cremeis, 1,0-1,5 mm diam.; hypothallo generaliter conspicuo, albo, calcareo; peridio duplici, pariete extremo calcareo, crustaceo, laevigato, denso, pariete interno ab extremo discreto, membranaceo, tenui; stipite, quandocumque presenti, extensione hypothalli; columella prominenti, conica, alba; capillitio copioso, persistenti, retiformo; sporis globosis, brunneis, verrucosis, 10-12 µm diam.; plasmodio ignoto.

Description:

The type material is conserved in three boxes of the herbarium BPI with the numbers BPI 813547, BPI 813551 and BPI 813552. The box BPI 813547 contains a peace of twig without bark with abundant well conserved sporocarps. The box 813552 contains another, smaller box with a peace of twig without bark with abundant well preserved sporocarps. The box BPI 81351 only contains a microscope slide. All these boxes are indicated as types by the herbarium, but we consider the specimen BPI 813547 the holotype as it is abundant and has very well preserved the characters of this species, and the rest of the specimens isotypes.

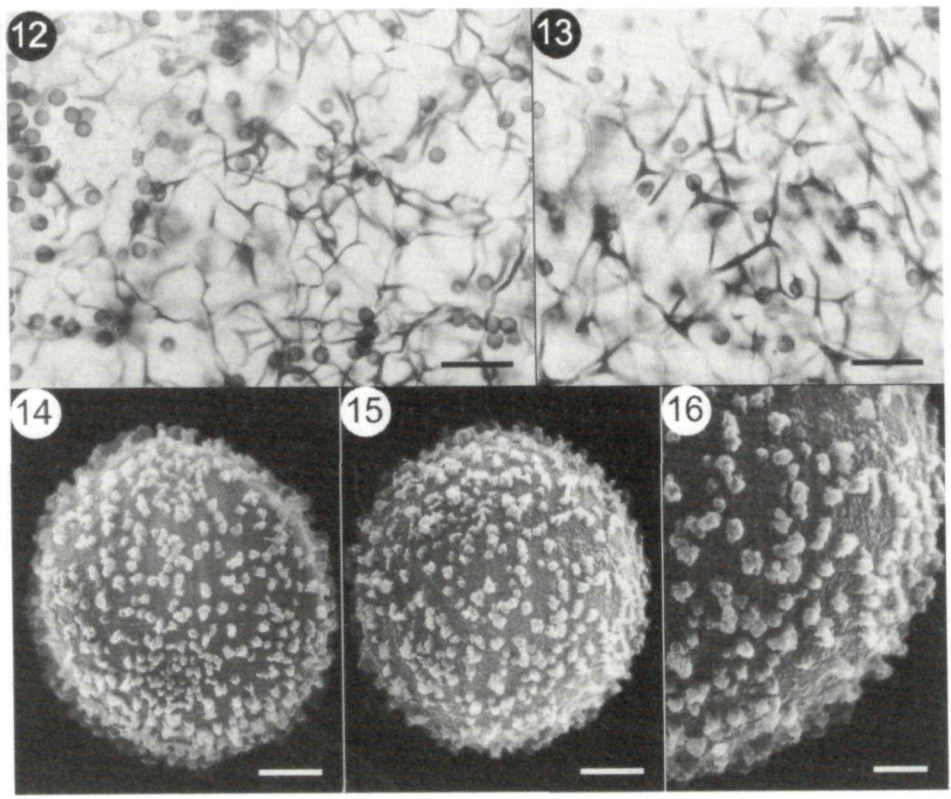
Sporocarps rarely scattered to crowded, sessile. Sporotheca globose to obovoid, 1-2 x 1-1.5 mm in diam., snow white to creamy white. Hypothallus abundant, membranous, rugose, whitish, confluent. Stalk absent. Peridium double; exoperidium calcareous, cartilaginous, thick, smooth, rarely rugose, dehiscence irregularly egg-shell-like, clearly separated from the endoperidium; endoperidium thin, membranous, whitish grey by magnifying glass, light yellow by LM; dehiscence irregular. Columella very prominent, cylindrical, whitish, occupying up to two thirds of the height of the sporotheca. Capillitium greyish by magnifying glass, by LM dark brown in its ramifications, lighter in the rest of the capillitium, colourless in the extremities; threads 1-3 µm in diam., flexuous, branched, anastomosed, forming a dense net with small meshes, axils triangular up to 10 µm wide; free ends narrower, more or less abundant. Spores in mass and by LM violaceous brown, 10-12 µm in diam., globose, verrucose. By SEM dense and irregularly distributed baculae of different sizes observable.

Specimens examined: USA: California, Butte Co., 4 miles above Sterling City, 4000 ft., on dead twigs, 27. 5. 1967, leg. D. T. KOWALSKI, DTK 6259 (type) in BPI 813547 (holotype), BPI 813551 (isotype) and BPI 813552 (isotype).

Notes:

Diderma brooksii is a species that can be characterized by globose to obovoid, snow white to creamy white sporocarps, cartilaginous peridium, a prominent, cylindrical columella, a densely anastomosed capillitium that resembles a *Physarum*, and verrucose spores, 10-12 µm in diam. This species is very different from other *Diderma* spp. due to its physaroid capillitium. Macroscopically it resembles *Diderma alpinum* (MEYL.) MEYL., *D. meyerae* H. SINGER, G. MORENO, ILLANA & A. SÁNCHEZ and *D. niveum*, that also possess a calcareous, cartilaginous white to whitish peridium. But these species differ clearly by having smaller, subglobose to globose columellae, by capillitia not forming a net, and different spore ornamentation (MORENO & al. 2003 c). With *Diderma lyallii* (MASSEE) T. MACBR. it shares the form and colour of the sporocarps and a prominent columella, but *D. lyallii* can be distinguished clearly by rough, more or less distinctly maculate peridium, the absence of a capillitium net and larger spores with a more prominent ornamentation.

Diderma brooksii was described from a single abundant collection from California made by KOWALSKI (1968 b) and subsequently has been gathered also from Colorado (MITCHEL & al. 1980).



Figs. 12-16. *Diderma brooksii* (holotype). 12, 13. Capillitium (bar: 50 µm). 14, 15. Spores (bar: 2 µm). 16. Detail of the spore ornamentation (bar: 1 µm).

Lepidoderma aggregatum **KOWALSKI**, Mycologia **63(3)**: 511. 1971. (Figs. 17-21)

Original diagnosis: Sporangiis gregariis, sessilibus, hemisphaericus, subglobosis vel depressis, 1,5-3 mm diam.; peridio membranaceo, tenuo, atro-brunneis, squamulis minutissimis pallido-brunneis numerosis praesentis; hypothallo generaliter conspicuo, tenuo, perluciduo vel opacuo; columella prominenti, pulvinata, hemisphaerica vel subglobosa, cremea vel pallido-brunneis; capillitio abundanti, brunneis ad apicem incoloratis, filamentis angustis, rarisis ramosis; sporis globosis, violaceo-brunneis, spinulosis, 11-15 µm diam.; plasmodio probabiliter albo.

Description:

The type material is conserved in a box with the number UC 1408496 and consists of six woody stems stuck to its base, all of which have abundant, well-formed and well-conserved material.

Sporocarps densely crowded to gregarious, sessile. Sporotheca hemispherical to pulvinate, laterally compressed, 1.5-3 mm in diam., whitish to creamy white. Hypothallus more or less developed, thin, whitish, confluent. Stalk absent. Peridium double; exoperidium formed by a layer of small, densely aggregated calcareous scales; scales polyhedral to rounded, very variable, 13-30 x 10-45 µm, whitish to creamy white with

ferruginous zones; irregular dehiscence into large pieces, clearly separated from the endoperidium; endoperidium thin, membranous, hyaline to iridescent by magnifying glass, yellowish by LM; dehiscence irregular. Columella hemispherical, thick, whitish to creamy white, up to 1 mm broad and up to two thirds of the height of the sporotheca. Capillitium by magnifying glass and by LM dark brown, extremities hyaline; threads 1-1.5 µm in diam., slender, originating from the columella in a more or less parallel manner and united with the endoperidium, little branched, smooth, rarely with nodes; free ends usually more or less dichotomously branched. Spores dark brown in mass, violaceous brown by LM, 11-14 µm in diam., globose, spiny, with a clearer area. By SEM large baculae up to 1 µm with more or less coralloid apices observable, of lax and irregular distribution.

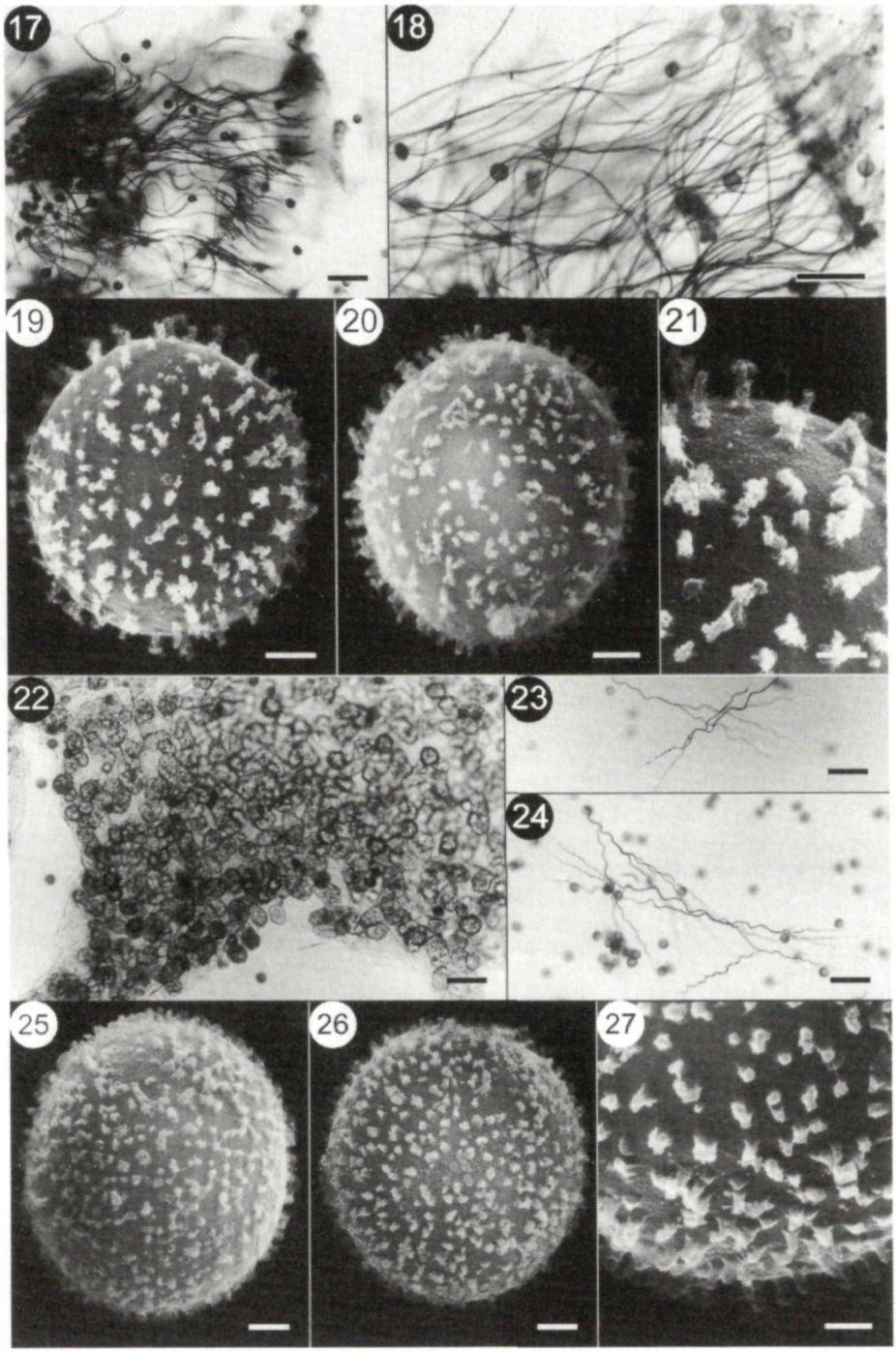
Specimens examined: USA: Washington, Whatcom Co., Sixteen miles east of Glacier, 4000 ft., on branches of shrubs, 16. 6. 1968, leg. D. T. KOWALSKI, DTK 8870 (type) in UC 1408496 (holotype).

Notes:

Lepidoderma aggregatum is characterized, according to KOWALSKI (1971) by "large, usually densely clustered sporangia, 1.5-3 mm in diam., which are always sessile and usually seated on a broad base, the dark brown, single peridium, and the spores with widely scattered spinules."

Lepidoderma aggregatum hardly differs from *L. chailletii* ROSTAF. and *L. didermoides* KOWALSKI. *Lepidoderma chailletii* can be distinguished from *L. aggregatum*, according to the literature, only by calcareous scales that are separated and do not form a closed layer, and by smaller fructifications, 0.5-1 mm in diam. Unfortunately, after an extensive search and consultation in various herbaria, we have been unable to locate the type indicated by ROSTAFINSKI (1874). We thus follow the interpretation of LISTER (1925) for this species, who studied the type material and, apart from a complete description from the species, gives us a small description of the type, which shows: "clustered sessile sporangia, hemispherical on broad brown bases, with columella ridge-like or hardly developed." Based on LISTER's description (LISTER 1925) and due to the minimal differences between *L. aggregatum* and *L. chailletii*, we consider them synonyms. This hypothesis can only be resolved definitely either by examination of ROSTAFINSKI's type or the creation of a possible neotype.

Lepidoderma didermoides differs from *L. aggregatum* by more dispersed growth habit, the very separated calcareous scales on the peridium, capillitium bearing nodes and larger spores 14-17 µm in diam. However, these characters are not stable, as the growth habit is a very variable character, as is the character of calcareous peridial scales which may be due to irregular development. On the other hand, the presence of larger spores is not unusual among nivicolous myxomycetes, that frequently present macrosporic forms, and the capillitium nodes may be more or less developed. We also bear in mind that *Lepidoderma didermoides* is known only from the original collections made by KOWALSKI in California. Subsequently, there are scarce and very doubtful records from Germany and Japan (MORENO & al. 2003 b). Thus, we consider *Lepidoderma didermoides* an aberrant or incomplete fructification and a synonym of *L. chailletii*.



Figs. 17-21. *Lepidoderma aggregatum* (holotype). 17, 18. Capillitium (bar: 50 µm). 19, 20. Spores (bar: 2 µm). 21. Detail of the spore ornamentation (bar: 1 µm). Figs. 22-27. *Lepidoderma crustaceum* (holotype). 22. Peridium with calcareous scales (bar: 50 µm). 23, 24. Capillitium (bar: 50 µm). 25, 26. Spores (bar: 2 µm). 27. Detail of the spore ornamentation (bar: 1 µm).

Aberrant fructification and malformation of the calcareous scales gave rise to the description of *Diacheopsis spinosifila* M. L. FARR & R. L. CRITCHF. as a new species. Recent morphological studies of the capillitium and spore ornamentation have demonstrated the conspecificity with *Lepidoderma didermoides* (MORENO & al. 2003 b) and therefore now with *L. chailletii*.

Lepidoderma aggregatum from the Kola Peninsula (Russia) has been studied recently by SEM by NOVOZHILOV & al. (1997). Surprisingly their description agrees with that given by KOWALSKI, where the photos show spores with prominent baculae up to 1 µm of length and a capillitium with nodes identical with the type of *L. didermoides*, also supporting the synonymy of *Lepidoderma aggregatum* and *L. chailletii*.

Another nivicolous species of *Lepidoderma* that forms sporocarps is *Lepidoderma crustaceum*. The differences between these two species are described below.

Lepidoderma aggregatum is a very common species that is known from USA from California (CRITCHFIELD & DEMAREE 1991) and Washington (KOWALSKI 1971), and in Europe from Austria (NEUBERT & al. 1995), Scotland (ING 1997, 1999), France (LADO 1994), England (ING 1999) and Russia (NOVOZHILOV & al. 1997).
We propose the following taxonomic treatment:

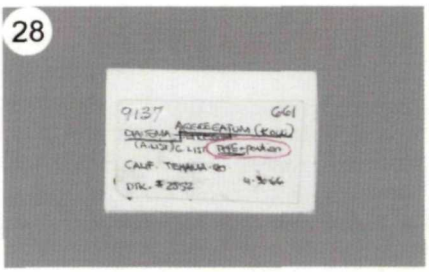
***Lepidoderma chailletii* ROSTAF.**, Sluzowce Monogr.: 189. 1874.
= *Lepidoderma didermoides* KOWALSKI, *Mycologia* **63(3)**: 503. 1971.
= *Lepidoderma aggregatum* KOWALSKI, *Mycologia* **63(3)**: 511. 1971.
= *Diacheopsis spinosifila* M. L. FARR & R. L. CRITCHF. in FARR, Int. J. Mycol. Lichenol. **3(2-3)**: 206. 1988.

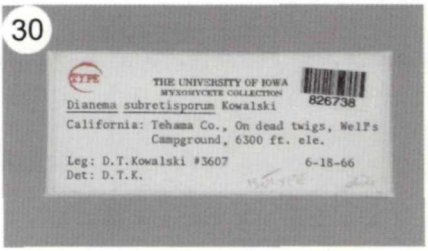
***Lepidoderma crustaceum* KOWALSKI**, Mycologia **59(1)**: 167. 1967. (Figs. 22-27)

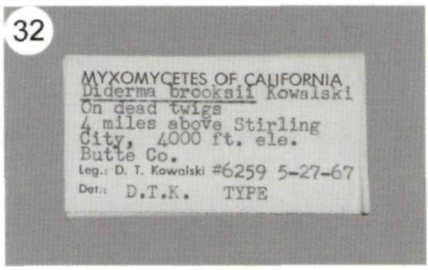
Original diagnosis: Sporangiis globosis, aggregatis, sessilibus vel stipitatis, pallidobrunneis, 1-1,5 mm diam.; peridio duplici, parietibus internis membranaceis, parietibus externis crustaceis, squamulis minutissimis numerosis compositis; columellis nullis; pseudocolumellis saepe praesentibus; capillitiis sparsis, filamentosis 2-3 µm diam., basibus atris ad peridiis pallidioribus; sporis globosis, atris, verrucosis, 11-13 µm diam.; plasmodio ignoto.

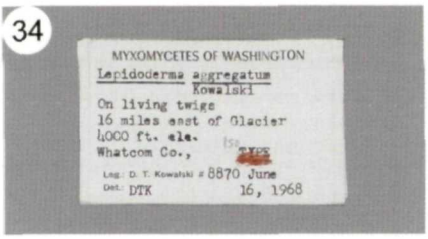
Description:

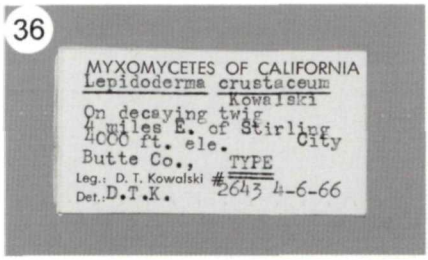
The material studied consists of two microscope slides (BPI 817971 and BPI 817974) and another specimen with abundant sporocarps (MICH 4823). KOWALSKI (1967) does not indicate in the original diagnosis the date of its collection. On the box bearing the number BPI 817974 the date 9th April 1966 is indicated. On box numbered BPI 817971 there is no collection date. The box from the herbarium of Michigan with the number MICH 4823 contains another smaller box, that inside bears the date 6th April 1966. According to KOWALSKI (1971) the correct date of recollection is 8th April 1966. We consider the material MICH 4823, which is an important collection with abundant sporocarps, the holotype, as it is indicated on the small box containing the sporocarps, and not an isotype, as indicated on the exterior box. Thus, we consider the two microscope slides conserved in BPI and indicated as types by the herbarium to be isotypes.











Figs. 28-37. Type material studied. 28, 29. *Dianema aggregatum*. Box of isotype BPI 746314 and isotype collection MICH 4827. 30, 31. *Dianema subretisporum*. Box of holotype BPI 826738 and holotype collection. 32, 33. *Diderma brooksii*. Box of isotype BPI 813552 and isotype collection BPI 813552. 34, 35. *Lepidoderma aggregatum*. Box of holotype UC 1408496 and holotype collection. 36, 37. *Lepidoderma crustaceum*. Box of holotype MICH 4823 and holotype collection.

Sporocarps gregarious to crowded, sessile or shortly stalked. Sporotheca obovoid to subglobose, 1-1.5 mm in diam., cream ivory to straw white. Hypothallus coriaceous, creamy white, confluent, forming a more or less distinct net. Stalk absent, or if present presenting a continuation of the hypothallus. Peridium double; exoperidium formed by a layer of small, thick, densely aggregated calcareous scales; scales subglobose to elongate, of variable size, 10-45 x 10-30 µm, whitish, clearly separated from the endoperidium; endoperidium thin, membranous, hyaline and iridescent by magnifying glass, yellowish by LM; dehiscence irregular. Columella absent. Capillitium scarce, by magnifying glass and LM dark brown, extremities hyaline; threads 1-3 µm diam., flexuous, little branched, generally smooth, covered with scattered warts and more rarely fusiform to vesicular expansions. Spores in mass dark brown, violaceous brown by LM, 12-14(-15) µm in diam., globose, verrucose, with a clearer zone. By SEM dense and irregularly distributed baculae less than 1 µm in height observable.

Specimens examined: USA: California, Butte Co., 4 miles east of Stirling City, on dead twigs, 6. 6. 1966, leg. D. T. KOWALSKI, DTK 2643 (type) in MICH 4823 (holotype), BPI 817971 (isotype) and BPI 817974 (isotype).

Notes:

Lepidoderma crustaceum is characterized by sporocarpous, cream ivory to straw white, didermoid fructifications, with distinct small and very aggregated calcareous scales, the absence of a columella, scarce, dark brown, sinuous capillitium and spores 12-14(15) µm diam., with baculae by SEM. *Lepidoderma chailletii* is a closely related species that differs from *L. crustaceum* by the presence of aggregated, hemispherical to pulvinate sporocarps, always sessile, the presence of a columella, slender capillitium and spiny spores that show large baculae with more or less coralloid apices by SEM.

Other species, such as *Lepidoderma carestianum* (RABENH.) ROSTAF. and *L. granuliferum* have clearly plasmodiocarpous fructifications. We have been able to prove this in the type material of *L. carestianum* from the herbaria B, BPI, BR and WRSL. According to KOWALSKI (1971) both *L. crustaceum* and *L. granuliferum* have a double peridium that is completely lacking of lime and is covered by a layer formed of calcareous scales. We have been able to observe a double peridium composed of a membranous endoperidium and an exoperidium formed by the calcareous scales. We agree with the results of SCHNITTLER & NOVOZHILOV (1999) who studied collections of this species from the Isle of Crete and proved by SEM that the peridium is double. However, POULAIN & al. (2002) consider *Lepidoderma crustaceum* a species with a triple peridium, as indicated by KOWALSKI (1971), and *L. granuliferum* with a double peridium. The character of the presence of three layers in the peridium is very subjective and its differentiation is not easy and may lead to confusion. As we have already mentioned, we can distinguish only two clearly differentiated layers. We prefer to use easier observable characters that are not so subjective, as for example the morphology of the capillitium and the spores, supported by the spore ornamentation by SEM.

We observed in *Lepidoderma crustaceum* larger spore diameters, 12-14(-15) µm, than indicated in the original diagnosis by KOWALSKI (11-13 µm). SCHNITTLER & NOVOZHILOV (1999) also observed larger spores, 13-14(-14.5) µm in the material from Crete.

In conclusion we think that *Lepidoderma crustaceum* can be considered to represent a different species.

There are records of *Lepidoderma crustaceum* in USA from California and Washington (KOWALSKI 1967, 1971) and in Europe from Greece (SCHNITTLER & NOVOZHILOV 1999), Italy (LADO 1994, BERSAN 1995) and Switzerland (KOWALSKI 1971).

This investigation has been partly financed by the research project of the Ministry of Science and Technology, National Plan of Scientific Investigation, Technological Development and Innovation, REN 2002-01965. We express our gratitude to Mr D. W. MITCHELL for the revision of the manuscript and wish to thank J. A. PÉREZ and A. PRIEGO of the Electron Microscopy Service of the University of Alcalá for their invaluable help with the SEM and the curators of the herbaria BPI, MICH and UC, especially Dr J. REJOS, curator of the herbarium AH.

H. SINGER thanks the National Program of the Professorship Formation, Ministry of Education and Culture of Spain, the conceded scholarship for the realisation of his doctoral thesis in the University of Alcalá.

References

BERSAN, F., 1995: *Lepidoderma crustaceum*. I myxomiceti della zona alpina. – Rivista Micol. Boll. Ass. Micol. Bresadola **2**: 143-148.

CRITCHFIELD, R. L., DEMAREE, R. S., 1991: Annotated checklist of California Myxomycetes. – Madroño **38**: 45-56.

DÖRFELT, H., MARX, H., 1990: Zur Terminologie der sporenbildenden Stadien der Myxomyceten. – Beitr. Kenntnis Pilze Mitteleur. **6**: 5-14.

ING, B., 1997: Alpine myxomycetes in Scotland. – Bot. J. Scotland **50**: 47-53.

— 1999: The Myxomycetes of Britain and Ireland. An identification handbook. – Slough: The Richmond Publishing Co.

KIRK, P. M., ANSELL, A. E., 1992: Authors of fungal names. A list of authors of scientific names of fungi, with recommended standard forms of their names, including abbreviations index of fungi supplement. – England, Wallingford: C.A.B. International.

KOWALSKI, D. T., 1966: A new species of *Lamproderma* from California. – Mycologia **58**: 808-810.

— 1967: Two new members of the Physarales. – Mycologia **59**: 167-171.

— 1968 a: Observations on the Dianemaceae. – Mycologia **59**: 1075-1084.

— 1968 b: Three new species of *Diderma*. – Mycologia **60**: 595-603.

— 1968 c: Observations on the genus *Lamproderma*. – Mycologia **60**: 756-768.

— 1970: The species of *Lamproderma*. – Mycologia **62**: 621-672.

— 1971: The genus *Lepidoderma*. – Mycologia **63**: 490-516.

— 1972: Two new alpine Myxomycetes from Washington. – Mycologia **64**: 359-364.

— 1973: Notes on Western Myxomycetes. – Madroño **22**: 151-153.

— 1974: Notes on two species of *Trichia*. – Mycologia **66**: 369-374.

— 1975 a: The Myxomycete taxa described by Charles Meylan. – Mycologia **67**: 448-494.

— 1975 b: The genus *Diacheopsis*. – Mycologia **67**: 616-628.

LADO, C., 1994: A checklist of Myxomycetes of the Mediterranean countries. – Mycotaxon **52**:117-185.

— PANDO, F., 1997: Myxomycetes, I: Ceratiomyxales, Echinosteliales, Liceales, Trichiales. – In: Flora Mycologica Iberica **2**: pp. 1-323. – Madrid, Berlin, Stuttgart: Real Jardín Botánico, J. Cramer.

LISTER, A., 1925: A monograph of the Mycetozoa. Ed. 3. – London: British Museum.

MITCHEL, D. H., CHAPMAN, S. W., FARR, M. L., 1980: Notes on Colorado fungi IV: Myxomycetes. – Mycotaxon **10**: 299-349.

MORENO, G., SINGER, H., ILLANA, C., LIZÁRRAGA, M., 2003 a: *Diderma nigrum*, a synonym of *Diderma asteroides* (Myxomycetes). – Österr. Z. Pilzk. **12**: 23-29.

— — — 2003 b: *Diacheopsis spinosifila*, a synonym of *Lepidoderma didermoides*. – Mycotaxon **88**: 123-128.

— — — SÁNCHEZ, A., 2003 c: Studies on nivicolous Myxomycetes. The *Diderma niveum* complex in Europe. – Cryptog. Mycol. **24**: 39-58.

NEUBERT, H., NOWOTNY, W., BAUMANN, K., MARX, H., 1995: Die Myxomyceten Deutschlands und des angrenzenden Alpenraumes unter besonderer Berücksichtigung Österreichs. Band 2. *Physarales*. – Gomaringen: Karlheinz Baumann Verlag.

NOVOZHILOV, Y. K., SCHNITTLER, M., 1997: Nivicole myxomycetes of the Khibine Mountains (Kola Peninsula). – Nordic J. Bot. **16**: 549-561.

POULAIN, M., MEYER, M., BOZONNET, J., 2000: *Dianema inconspicuum* POULAIN, MEYER & BOZONNET, espèce nouvelle de myxomycota, et les espèces nivales du genre *Dianema*. – Stapfia **73**: 85-92.

— — — 2002: Deux espèces nouvelles de Myxomycètes: *Lepidoderma alpestroides* el *Lepidoderma perforatum*. – Bull. Féd. Mycol. Dauphiné-Savoie **165**: 5-18.

RAMMELOO, J., 1975 a: Structure of the epispore in the *Stemonitales* (*Myxomycetes*) as seen with the scanning electron microscope. – Bull. Jard. Bot. Belg. **45**: 301-306.

— 1975 b: Structure of the epispore in the *Trichiaceae* (*Trichiales, Myxomycetes*) . As seen with the scanning electron microscope. – Bull. Jard. Bot. Belg. **107**: 353-359.

— RAMMELOO, J., 1983: Icones Mycologicae 19-34. – Meise: Jardin Botanique National de Belgique.

ROSTAFINSKI, J. T., 1874: Sluzowce (Mycetozoa) Monografia. – Paris.

SCHINNER, F., 1982: Myxomyceten des Großglocknergebietes (Eine ökologische Studie). – Z. Mykol. **48**: 165-170.

SCHNITTLER, M., NOVOZHILOV, Y. K., 1999: *Lepidoderma crustaceum*, a nivicolous Myxomycete, found on the island of Crete. – Mycotaxon **71**: 387-392.

SINGER, H., MORENO, G., ILLANA, C., LIZÁRRAGA, M., 2003: *Trichia synspora*, a synonym of *Trichia varia*. – Mycotaxon **87**: 243-248.

— — — 2004 a: A revision of the types of *Diderma subcaeruleum* and *Diderma globosum* var. *europaeum*. – Mycotaxon **89**: 311-320.

— — —2004 b: A taxonomic review on the nivicolous species described by KOWALSKI. I.Order *Stemonitales*. – Mycol. Progress. (submitted).