IMI Descriptions of Fungi and Bacteria
No. 2214

DIDERMA NIVEUM

A. Sporocarps (bar = 1 mm). **B**. Capillitium and spores (bar = 20 µm). [Photographs: A. Michaud]

Diderma niveum (Rostaf.) E. Sheld., *Minnesota Botanical Studies* **1**: 477 (1895) [*IndexFungorum* identifier not issued; *Didymiaceae*, *Stemonitiida*]

Chondrioderma niveum Rostaf., *Śluzowce (Mycetozoa) Monografia*: 170 (1874) [publ. 1875]. [*IndexFungorum* 145361]

Chondrioderma physaroides Rostaf., *Śluzowce (Mycetozoa) Monografia*: 170 (1874). [*IndexFungorum* 235825]

Diderma albescens W. Phillips, *Grevillea* 5(no. 35): 114 (1877). [*IndexFungorum* 211630]

Chondrioderma albescens (W. Phillips) Massee, *A Monograph of the Myxogastres*: 209 (1892). [*IndexFungorum* 634761]

Diderma niveum f. *pulverulentum* Meyl., in H. Schinz, *Berichte der Schweizerischen Botanischen Gesellschaft* **30-31**: 3 (1922). [*IndexFungorum* 272393]

Diderma niveum f. *endoleucum* Meyl., *Bulletin de la Société Vaudoise de Sciences Naturelles* **55**: 240 (1924) [as '*endoleuca*']. [*IndexFungorum* 248781]

Diderma niveum var. *ferrugineum* Meyl., *Bulletin de la Société Vaudoise de Sciences Naturelles* **55**: 240 (1924) [as '*ferruginea*']. [*IndexFungorum* 487294]

Diderma subcaeruleum Kowalski, *Mycologia* **60**(3): 598 (1968). [*IndexFungorum* 329925]

Diderma cristatosporum A. Sánchez, G. Moreno & Illana, *Persoonia* **17**(4): 643 (2002). [*IndexFungorum* 374787]

Diderma niveum var. *cristatosporum* (A. Sánchez, G. Moreno & Illana) H. Singer, G. Moreno, Illana & A. Sánchez, in G. MORENO, H. SINGER, C. ILLANA & A. SÁNCHEZ, *Cryptogamie* Mycologie **24**(1): 52 (2003). [*IndexFungorum* 488977]

Diagnostic features. Sporangia pale and usually sessile, sometimes forming short plasmodiocarps; distinguished from other nivicolous *Diderma* species by the non-reticulate capillitium, the double-layered peridium with an inner layer powdered with lime, and spinulose spores.

On natural substratum. *Amoebal state* no information. *Plasmodium* white. *Hypothallus* white or ochraceous, rarely well developed. *Sporocarps* sessile sporangia, sometimes forming short plasmodiocarps. *Stalks* absent. *Sporothecae* densely crowded, white with coloured base, 0·7–2·0 mm diam., subglobose or short cylindrical when plasmodiocarps. *Peridium* double-layered, the outer calcareous, fragile, white, the inner delicate, powdered with small lime clusters, appearing greyish and dull. *Columella* large, subglobose or pulvinate, elongate in plasmodiocarps, ochraceous cream to bright rusty orange. *Capillitium* dark brown, rigid, rugose, threads 1–3 µm diam. *Spores* black *en masse*, individually violet-brown, (9–)11–13(–14) µm diam., minutely spinulose.

ASSOCIATED ORGANISMS & SUBSTRATA: **Animalia**. *Agathidium* sp. **Plantae**. *Bryophyta* indet.; *Deschampsia cespitosa* (L.) P. Beauv. (leaf); *Empetrum nigrum* subsp. *hermaphroditum* (Hagerup) Böcher (shoot); *Fagus sylvatica* L. (leaf, twig); *Gramineae* indet. (litter); *Juniperus communis* var. *saxatilis* Pall. [as *J. pygmaea* K. Koch] (leaf, twig), *J. sabina* L. (leaf, twig); *Magnoliophyta* indet.; *Nothofagus pumilio* (Poepp. & Endl.) Krasser (wood); *Picea schrenkiana* Fisch. & C.A. Mey.; *Pinus sylvestris* L. (bark); *Plantae* indet. (bark, litter, stem, wood); *Polytrichum juniperinum* Hedw. [as *P. alpestre* Hoppe]; *Vaccinium myrtillus* L. (stem, twig), *V. uliginosum* L. (stem). **Protista**. *Diderma meyerae* H. Singer, G. Moreno, Illana & A. Sánchez. **Associated organism of type specimen**. Not noted. **Comment**. This species occurs on dead dry leaves, twigs, fallen bark, dead wood, and decaying moss.

INTERACTIONS & HABITATS: For a thorough introduction to myxomycete ecology, see MADELIN (1984). The dead plant material with which myxomycetes are very widely associated, while undoubtedly a platform for their sporocarps, is not necessarily a source of nutrition. Sporocarps are the only stage in myxomycete life cycles where species can be identified by morphology. The other states, as amoebae and plasmodia, have received little attention. SHCHEPIN *et al.* (2019) suggested that populations of myxomycete amoebae may inhabit much wider ecological niches than indicated by records of their sporocarps. With the advent of molecular techniques (KAMONO *et al.*, 2013), specific information about the ecology and nutrition of the amoebal state of *D. niveum* is now starting to emerge (BORG DAHL, 2018). In their amoebal state, myxomycetes are known to feed on small organic particles and micro-organisms (including some fungi), but the identity of those micro-organisms is rarely, if ever, recorded. *Diderma niveum* is nivicolous, being found in spring at the edge of melting snow patches in mountainous regions; there are several observations of this species specifically in alpine, montane, moorland and tundra ecosystems, even at lower elevations, where it may also occur in lowland coniferous forests. Other myxomycetes have been observed growing on the same substratum, and there is one record of an association with a beetle (STEPHENSON *et al.*, 1994). Although associations with fungi are known or suspected, no observations were found where the associated organism was identified to genus or species level.

GEOGRAPHICAL DISTRIBUTION: AFRICA: Algeria, Morocco, Rwanda. NORTH AMERICA: Canada (Alberta, British Columbia, Ontario), Mexico, USA (Alaska, California, Colorado, Indiana, Maryland, Michigan, Montana, Nevada, North Carolina, Oregon, Texas, Utah, Washington, Wyoming). CENTRAL AMERICA: Costa Rica. SOUTH AMERICA: Argentina, Chile, Colombia, Venezuela. ANTARCTICA:

Antarctic Peninsula, South Georgia and the South Sandwich Islands. ASIA: India (Himachal Pradesh, Uttarakhand), Japan, Kazakhstan (Almaty Oblast, West Kazakhstan), Nepal, Pakistan, Russia (Chukotka Autonomous Okrug, Kamchatka Krai), Turkey. AUSTRALASIA: Australia (New South Wales, Tasmania), New Zealand. EUROPE: Austria, Belgium, Bulgaria, Czech Republic, Estonia, Finland, France, Germany, Greece, Iceland, Italy, Norway, Poland, Portugal, Russia (Kaliningrad Oblast, Karachay-Cherkess Republic, Leningrad Oblast, Moscow Oblast, Murmansk Oblast), Spain, Sweden, Switzerland, Ukraine, UK. PACIFIC OCEAN: USA (Hawaii).

Elevation (m above sea level). Records up to 4050 (Venezuela); 3350 (USA: Colorado); 2700 (Chile); 2700 (Rwanda); 2600 (Russia: Karachay-Cherkess Republic); 1780 (Australia: New South Wales).

Comment. Recorded from every continent including Antarctica, but not in general from oceanic islands. As the species is thought to be nivicolous, some tropical and subtropical records from localities where snow is either unlikely or impossible, for example from Algeria, Costa Rica and Hawaii, may need re-examination: they may represent different but lookalike species. Native to cool temperate hills and to mountains worldwide. Almost 40% of all records are from France, with most of the others from the Pacific northwest and Rocky Mountains of the USA.

ECONOMIC IMPACTS: There is experimental evidence that this species can accumulate heavy metals (KRYVOMAZ, 2015*a*; KRYVOMAZ & ANDRUSISHINA, 2016; KRYVOMAZ *et al.*, 2016, 2017). KRYVOMAZ (2017*a*) measured metal levels in sporocarps of *D. niveum*. The levels of different elements were, in descending order, as follows [µg of metal per g of myxomycete tissue]: Ca (100320), Mn (3400), Fe (1240), Al (746·7), Ni (706·7), Mg (653·33), Si (293·33), Zn (93·33), Pb (52), Cd (1·07), Cu (0·12), Cr (0·008). Analysis of those results showed that Ca, Mn, the highly toxic heavy metals Cd and Pb, and the moderately toxic heavy metal Ni were accumulated much more strongly by this species than by the others included in the study. Heavy metal accumulating properties are likely to have significant positive economic potential (STEPHENSON & MCQUATTIE, 2000). Although nothing has yet been developed for the present species, there is considerable interest in use of fungi with similar abilities for bioremediation and other applications (GADD, 2007). No evaluations have been made of any other possible positive economic impact of this organism (e.g. as a recycler, as a source of useful products, as a provider of checks and balances within its ecosystem, etc.). No reports of negative economic impacts have been found.

INFRASPECIFIC VARIATION: No subspecific taxa have been described other than those listed in the synonymy above. SINGER *et al.* (2005) synonymized *D. niveum* f. *pulverulentum* with *D. meyerae* H. Singer, G. Moreno, Illana & A. Sánchez [*Descriptions* sheet **2213**], but this has not been accepted by *Nomen.mycetozoa.com* [accessed 17 November 2019].

DISPERSAL & TRANSMISSION: For a general discussion about myxomycete dispersal, see KRYVOMAZ & STEPHENSON (2017). Myxomycete spores are dispersed considerable distances by wind. Field experiments and mathematical modeling have shown that, with winds of 0·1 m/s, spores can travel up to *c.* 1·8 km, and when wind speed reaches 28 m/s, this rises to over 500 km (TESMER & SCHNITTLER, 2007). Spores and myxamoebae may be dispersed by rainwater, meltwater and water in soil. Some local dispersal may also occur by movement of myxamoebae and plasmodia. Insects and other invertebrates feed on sporophores, as probably do terrestrial vertebrates including birds, and myxomycete spores have been found in insect faeces, suggesting that animals may play a part in their dispersal. For some species (but probably very rarely or never nivicolous myxomycetes), plant debris floating in seawater may also contribute to dispersal between land masses.

CONSERVATION STATUS: The IUCN's Red Listing Criteria were originally designed for evaluation of vertebrate animals and flowering plants, and present challenges to those trying to apply them to organisms like myxomycetes which are unicellular for a significant part of their life cycle. A discussion of those challenges, particularly in respect of myxomycetes and climate change, is provided by KRYVOMAZ & STEPHENSON (2017). **Previous evaluations**. Red listed for Thuringia, Germany (MÜLLER & RIEMAY, 2011). **Information base**. About 2000 records (specimens, databases and bibliographic sources combined, excluding duplicates) from at least March 1875 to June 2018, with observations in every month of the year, with a peak in the northern hemisphere from March to August. **Estimated extent of occurrence** [calculated using *http://geocat.kew.org*]. Over 59·2 million km^2 (Africa [sub-Saharan only]: insufficient data; Antarctica: insufficient data; Asia [excluding Turkey]: 25·5 million km^2; Australasia: 1·4 million km^2; Europe [including north Africa and Turkey]: 10·9 million km^2); North America [including Central America]: 15·0 million km^2; Pacific Ocean: insufficient data; South America: 6·4 million km^2. **Estimated area of occupancy** [calculated using *http://geocat.kew.org*]. Well over 1022 km^2. The method for estimating area of occupancy has produced an artificially low figure. The species is likely to be under-recorded because of the small number of people with the skills to search for and identify it. Some of the plants with which it is associated are common and widespread species. **Threats**. *Diderma niveum* is nivicolous and, as such, is likely to be seriously threatened by climate change. Insufficient information to enable other threats to be identified. In particular, possible vulnerabilities of the amoebal and plasmodial states of this species are currently completely overlooked. **Population trend**. Not known. Of datable records, *c.* 5% are pre-1961, 65% post-1960 but pre-2001, and 30% post-2000. **Evaluation**. Using IUCN criteria (IUCN SPECIES SURVIVAL COMMISSION. *2006 IUCN Red List of Threatened Species* [*www.iucnredlist.org*]. Downloaded on 15 May 2006), the species is assessed globally as Data Deficient. ***In situ* conservation actions**. None noted. ***Ex situ* conservation actions**. 122 nucleotide sequences and 6 PopSet sequences were found in a search of the NCBI GenBank database [*www.ncbi.nlm.nih.gov*, accessed 11 November 2019]. No living strains of this species are listed by the ATCC, CABI and Westerdijk Institute [formerly CBS] culture collections.

NOTES: Molecular analysis has shown that rDNA from *D. niveum* is highly unusual in having at least 20 group I introns. The significance of this is discussed by HEDBERG & JOHANSEN (2013). Molecular techniques are now being developed to detect myxomycetes in soil, and this may make it possible to identify species in their amoebal state. *Diderma niveum* was included in one such pioneering study (HOPPE & SCHNITTLER, 2015). Radiation levels in this and several other nivicolous myxomycetes were monitored by KRYVOMAZ (2015*b*), and found not to exceed acceptable levels.

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