Join *Dermatocarpon* sampling campaign!

Project FunDive

In FunDive we work towards putting fungal diversity on the map to enhance European conservation efforts. Fungi are essential for our ecosystems but have often been neglected in monitoring efforts and conservation practices, leaving them vulnerable to threats and habitat loss. We would like to engage you to change this.

For more information, please visit https://fun-dive.eu/

FunDive is a pan-European initiative funded by Biodiversa+ that brings together 33 partners in 22 countries to improve fungal monitoring across the continent. The goal of FunDive is to close the knowledge gap dealing with fungal distributions to improve fungal conservation using the help from you and other citizen scientists.

Why is fungal monitoring important?

Fungi are generally under-studied. Their global distribution patterns are poorly resolved. Also in Europe, despite centuries of fungal research, there is a lack of the distribution patterns of many fungal species. However, this knowledge is very important for effective conservation practices. For example, assessments of species for the IUCN Red List require an understanding of the distribution of said species.

What can you do?

FunDive is structured in different projects, each focusing on a specific target group of fungi. You can engage in each project by documenting and collecting fungal specimens. The process is simple:

- **Select** the project you would like to join
- **Join** the 'Citizens for FunDive' project in PlutofGO app, following FunDive step-by-step joining guide:
  https://fun-dive.eu/wp-content/uploads/2024/08/FunDive_Joining-guide.pdf

  In some countries you can use dedicated country-level recording apps instead of PlutofGo. Check it with your country-level coordinator.
- **Find** target species – in this case **Leather lichens, *Dermatocarpon* spp.**
- Make an informative **photo** of your finding, following FunDive step-by-step Photo guide:
  https://fun-dive.eu/wp-content/uploads/2024/08/How-to-photograph.pdf
- **Register** your specimen in PlutofGO app, completing as mach metadata as possible and following the FunDive step-by-step Specimen registration guide:
  https://fun-dive.eu/wp-content/uploads/2024/08/How-to-register-specimen.pdf

  Remember, that the better metadata provided for collected specimens, the bigger is the chance they will be included in the DNA barcoding.
- **Collect** a specimen and prepare it for transfer, following theFunDive step-by-step Collection guide:
  https://fun-dive.eu/wp-content/uploads/2024/08/prepare-for-transfer.pdf
- **Send** your **Leather lichens, *Dermatocarpon* spp** for barcoding. S**end your dried sample (or a part of it - at least app. 5 mm in diam., max. 3 years old - better: freshly collected, but dried sample) directly to:**

  Holger Thüs
  the State Museum of Natural History, Botany Department,
  Rosenstein 1,
  70191 Stuttgart, Germany
- When received your specimen will be processed and identified based on molecular information. You can follow your fungus on FunDive records: https://fun-dive.eu/dataportal/.
- In case of any questions feel free to contact your country representatives.

Remember, to have all permits needed before sampling!

For more information on how to document your records, please visit https://fun-dive.eu/get-involved/how-to-engage/	

FunDive Lichens

Lichenised Fungi (or short: “lichens”) are a heterogeneous group of fungi which are united by their nutritional mode - they live in a symbiotic relationship with either algae or cyanobacteria and additional co-inhabitants in a composite body (the thallus) which looks like an individual organisms but in fact represents an entire miniature ecosystem.

While the focus of our citizen science projects is on typical “mushroom” producing species, we also include selected lichen forming fungi in this endeavour. Many lichens are equally or even more threatened compared to other fungi and they also play important ecological roles, e.g. as food source and shelter for other organisms or in retaining moisture in otherwise rapidly drying micro-environments.

Leather lichens (*Dermatocarpon*) - FunDive focal lichen genus for 2024

For the 2024 sampling campaign of FunDive we have selected the **Leather lichens (*Dermatocarpon*)** as target genus, because they are large lichens which are easily spotted in the field, collecting can be carried out without the need of specific tools and it is not damaging the substratum, preliminary data indicate the presence of still unrecognized, possibly cryptic species, there is a need to clarify species boundaries before robust assessments of the threat to the different species can be carried out, and some of the taxa may become important for monitoring the effects of climate change at a continental scale.

Fig. 1. *Dermatocarpon miniatum* var. *miniatum* on a cliff above a river in the Czech Republic.

What is *Dermatocarpon*?

The Leather lichens

Fungi in the genus *Dermatocarpon* (Leather lichens) are large and conspicuous lichens (fungi growing symbiontically with green algae). Typical for this genus is that their fruiting bodies are tiny and completely immersed in the lichen thallus. Only the black openings (ostioli) of the spherical spore producing structures (perithecia) are visible without cutting the thallus. These small black dots are evenly dispersed over the surface of the large and leathery thallus. The combination of these characters separate *Dermatocarpon* species from other lichens on rocks. In N-America the colloquial name “stippleback lichens” makes reference to black ostioli, while the name “leather lichens” (mostly used in Europe) refers to the tough texture of the (moist) thallus.

Some of the species, such as the freshwater species *Dermatocarpon luridum* (which turns from light brown or grey to bright green when wet) are easy to recognize in the field. Such species can often be verified based on a photo record. Most of the other species however have morphological look-alikes and DNA sequencing is required to assign an observation unambiguously to one of the several cryptic species within larger species aggregates such as the *Dermatocarpon miniatum* group.

Why is this genus interesting for FunDive?

The genus *Dermatocarpon* contains about 10 described species in Europe (25 worldwide) and several infraspecific taxa, but DNA-sequencing has shown, that some of these morphotaxa represent species aggregates with distinct phylogenetic patterns within and there is evidence that highly similar morphological types have evolved several times independently. This situation creates difficulties in the unambiguous identification and naming of specimens which belong to morphologically cryptic species or fall into one of several genetically separate groups of morphological look-alikes. All *Dermatocarpon* species are slow growing and sensitive to physical disturbance e.g. by natural disasters, but also anthropogenic influences such as the “cleaning” of walls, rock climbing or the installation of stream bank enforcements. The sub-alpine freshwater species *Dermatocarpon arnoldianum* and *D. rivulorum* have also been suggested as sensitive indicators of climate change effects.

Almost all the sequenced specimens of European *Dermatocarpon* are from Central and NW-Europe and very little is known on the genetic diversity of the genus in Southern and Southwestern Europe. Collections from Portugal, France, Italy and Greece are therefore particularly welcome for the FunDive-project and they will enhance our understanding of the distribution patterns and threats for these distinctive lichens.

Where can you find species of *Dermatocarpon*?

Dermatocarpon lichens are typically found on hard rocks, which do not move – they are excellent indicators of long habitat stability and sensitive to the effects of natural disasters or restoration activities on anthropogenic structures such as walls and castle ruins. Some species are restricted to the splash water zone of boulders in clean streams and cold mountain lakes, others occur in water seepages of cliffs, on old walls, castles and ruins, in cracks or on the top of boulders in rocky pastures and steppe-like open habitats.

By reporting your findings, you will add to the knowledge of these species and your records will be important contributions to nature conservation.

Collecting lichens for FunDive responsibly

For the collection of lichenised fungi there are some important aspects to take into account:

Mushroom- type fruiting bodies are usually short lived parts of a much more extensive fungal body, and removing some of these fruiting bodies for a scientific study usually represents a negligible impact.

Lichens generally grow much slower than most other fungi and if you collect a lichen thallus you remove not just an ephemeral fruiting body but an entire fungal organism (and its associated symbionts). Depending on where you are and which species is concerned, in a worst case scenario collecting of lichens ***can*** destroy an entire population. Therefore we want to re-emphasize that all collecting for FunDive should always be carried out either outside of protected areas or with the required permits.

For DNA-barcoding we only need a small fragment of a lichen thallus. If a local population consists of plenty of individuals we appreciate the collection of 2-3 thalli per site, but in cases where there are only a few individuals, please just take a photograph of the thallus and cut out the app. 0.5-1 cm of tissue from a single individual which you can subsequently post to us for microscopic analysis and DNA-barcoding.

When sampling Leather lichens make sure that you only sample from mature specimens with well developed fruiting bodies (they are flask-shaped immersed structures named perithecia which have black coloured release openings for the spores which are visible under with a hand-lens as evenly spaced black dots on the upper surface). When you cut a piece for DNA-sampling please make sure that an area is covered where the perithecia are included.

Preservation of voucher specimens

Lichen thalli in general and leather lichens in particular can become fragile when dry. Before packing them please wrap the individual thalli in tissue paper and avoid pressure as far as possible. For posting samples, padded envelopes or a small flat box (e.g. a matchstick box) work best, but a fair amount of tissue paper usually also does the job. For small thalli or clippings of thallus fragments from large thalli an Eppendorf tube is also suitable.

How to recognize Leather lichen

Lichens of the genus *Dermatocarpon* are large (generally > 5 mm and some of the species up to 5 cm and more) and always “foliose”, e.g. they have a clearly defined upper and lower site and their attachment to the substratum is only local in one or several points but not uniformly over the entire lower surface. Among other foliose lichens they stand out as one of only two groups of large lichens in Europe which produce “umbilicate” bodies (thalli). The term “umbilicate” refers to the shape of the lichen which looks similar to a salad-bowl with only a single point of attachment to its substratum (the “umbilicus” of central holdfast), while most other European lichens have either a more flattened shape, multiple attachment points or both of these traits. *Dermatocarpon* lichens differ from other umbilicate lichens (e.g. the unrelated genus *Umbilicaria*) by the presence of minute spherical fruiting bodies (*perithecia*)) with a central opening at the top (ostiolum) which are *fully immersed in the surrounding lichen body*. Only the black opening structures (ostioli) are visible from above as evenly spaced tiny black dots. You can still see the full shape of the fruiting bodies (usually with a pale wall below and only the top being blackish) on broken or cut edges of the thallus. In the - otherwise similar looking - lichens formed by the genus *Umbilicaria* instead thalli are either sterile (no visible fruiting bodies) or the fruiting bodies are shaped like a circular flat (not spherical!) miniature cake *sitting on top of the surface of the lichen body*.

For FunDive please only collect umbilicate lichens with well developed perithecia (immersed pale fruiting bodies with black ostioli).

General structure of a Leather lichen

In many species of Leather lichens the body of the lichen is a more or less bowl shaped structure. In some species this shape can be modified to create a partially inverted structure with the margins bend downward and the shape of the thallus deviating from a circular to a more elongated shape which in some cases may cause an appearance which resembles a densely packed intestine.

The tissue of Leather lichen thallus consists of a white coloured and loosely interwoven central part (= medulla) which is covered by a layer with more densely packed hyphae and the green cells of the algal photobiont. This algal layer is covered by a highly

compacted layer of fungal cells (= cortex). The uppermost layers of this cortex consists of dead cells filled with air (= epinecral layer), which can either be compressed (with small cell lumina and a shape which is much more wider than high) or loose (large cell lumina with more or less equal width and height). Below the white medulla the thallus is sealed by a lower cortex which is formed by densely packed living fungal cells.

Embedded in the thallus are the spherical or flask-shaped fruiting bodies (perithecia) which contain the spore producing asci at the bottom and centre of the hymenium and a tiny pore for the release of the ripe spores from the perithecial cavity. The cavity of the perithecia is surrounded by a perithecial wall (= exciple), which has an opening at the top (=ostiole). In this uppermost part the the exciple is yellowish to blackish brown. This colouration is also visible as a dark dot in surface view.

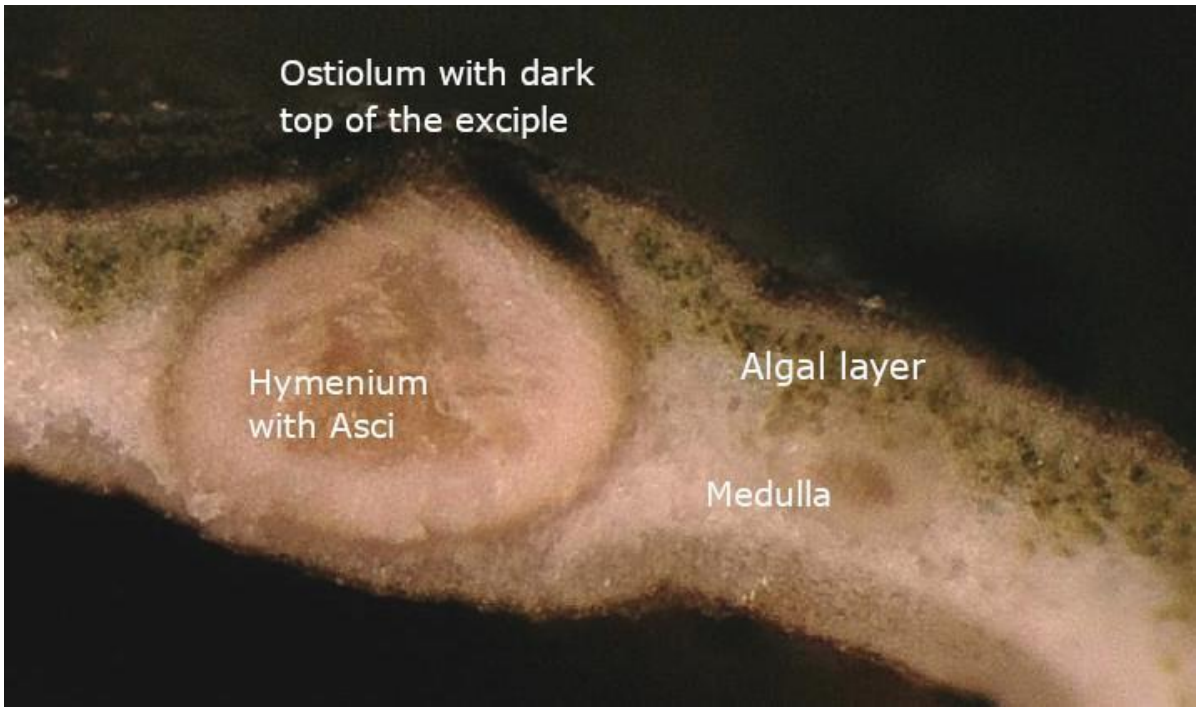

Fig. 2. Vertical section of the thalllus of *Dermatocarpon luridum*.

A central holdfast is present in all *Dermatocarpon* lichens and attaches the “bowl” of the lichen thallus to the substratum. The thallus in these species may be more or less incised on the margins but remains as a clearly distinguishable single element within the colony of neighbouring thalli (it consists of only one lobe = unilobate). Species with less circular thalli often have multiple secondary holdfasts, neighbouring thalli may become inseparable and appear as one extensive individual with multiple lobes (= multilobate).

The colour of the upper surface may be of either (light) grey, brown or even blackish in dry condition. When wet the colours change a bit with a hint of greenish visible in most species, a truly bright green colour instead is characteristic only for the aquatic to subaquatic species *D. luridum.*

When dry some species may look as if they were coated with a whitish powder (pruina) while others remain plain brown (to brown-black). Anatomically (in microscopic sections of the thallus) the whitish pruina corresponds to the uppermost layer of the cortex being a layer of dead cells (epinecral layer) with large air-filled lumina, while the non-pruinose brown species have an epinecral layer composed of flattened (compressed) cells with only small lumina.

The thickness of the thallus is measured on vertical sections (cut with a razor blade) under the compound microscope, but striking differences can sometimes be already recognizable by eye when different species grow side by side. Please note that measurements taken for using the identification key below should be taken with dry sections (without a mountant below the cover slip). Some species are also notably more brittle when dry than others (e.g. *D. miniatum* var. *miniatum* compared to *D. arnoldianum* auct.).

The lower surface of the Leather lichens can be either smooth, covered in small low warts (papillae) or structured by a distinctive veine-like reticulate pattern.

Hair-like outgrowths (rhizinomorphs) on the lower surface are present in only one of the European species (*D. moulinsii*), a very rare species only known from Southern Europe, the Southern Alps and the Caucasus. Reports from more northern regions have been based on mixups with species of the unrelated genus *Umbilicaria* which often have hairy lower surfaces, but never contain perithecia as fruiting bodies.

Chemical reactions are not relevant for the identification of most Leather lichens, except for the confirmation of morphologically aberrant forms of *D. luridum*, e.g. those which display only a weak colour change when wet. In these cases a tiny drop of Meltzer's Reagent can be applied to the white central tissue (medulla), it turns intensively deep orange-red in *D. luridum,* weakly reddish or brownish-reddish in *D. polyphyllizum* and the colour of the stain from the reagent remains unchanged (+/- yellowish) in most of the other species.

In some cases (e.g. differentiation of *D. miniatum* var. *miniatum* versus *D. leptophyllum*) the shape and size of the ascospores (length and width) are helpful characters which require microscopic examination. It is important to measure at least 10 spores per thallus to obtain a sufficient sample size and measurements should be taken and recorded individually (not just the range min-max) to allow for statistical analysis. You can either send us your measurements or we will carry out the measurements based on your submitted vouchers before processing them for DNA-barcoding.

(Preliminary) Identification Key for the European species of *Dermatocarpon*

(the key below is a compilation of couplets from Nimis 2024, and Heidmarsson 2017, with additions and modifications to the wording from both publications to make it accessible also for non-lichenologists):

1 Thalli forming distinctly separated circular elements (lobes). Each of them is attached with a single holdfast to the substratum (umbilicate growth type = it is easy to fit a knife edge below most of the thallus down to the central holdfast). 2

1* Thalli forming an extended colony with many +/- merging individuals of various shapes (not strictly circular), hard to distinguish delimitation between the individuals. Each of them is attached to the substratum with multiple attachment points (usually one main holdfast plus several secondary holdfasts, it is near impossible to fit a knife edge below most of the thallus except for a very short distance at the margin until the first holdfasts are reached). 7

2 Upper surface +/- grey, with whitish pruina. In microscopic sections: uppermost layer of cells (epinecral layer) composed of wide air-filled cell wall remains. On dry to wet or temporarily inundated limestone or siliceous rocks. 3

2* Upper surface brown, never with whitish pruina. In microscopic sections: uppermost layer of cells (epinecral layer) composed of compressed flattened cell wall remains. On wet or temporarily inundated siliceous rocks

3 Thallus small (4-16mm), in wet or temporarily inundated sites in Scandinavia and the British Isles ***Dermatocarpon deminuens***

3* Thallus larger, in wet or dry habitats, not restricted to Scandinavia and the British Isles 4

5 Lower surface with an extensive cover by thick hair-like rhizinomorphs (always check if there are perithecia present - if they are missing confusion with sterile forms of various *Umbilicaria* species may occur!). In Europe only known from the South and South-West of the continent. ***Dermatocarpon moulinsii***

5* Lower Surface smooth to reticulate, but always lacking thick hair-like structures (*Dermatocarpon miniatum* agg.) 6

6 Thallus leathery, rather robust even when dry and very thick (0.4-0.7), often with somewhat wrinkled and sometimes intertwined thalli, margins often bend downwards. Usually on wet or temporarily inundated siliceous rocks in cold upland areas of Central Europe and from a wider range of elevations in Northern Scandinavia 7

6* Thallus small to large, but rather brittle and thin when dry, usually forming colonies of well separated circular individuals with more or less upward facing margins. On limestone or (alkaline) siliceous rocks.
8

7 Lower surface smooth, usually on wet or temporarily inundated siliceous rocks in cold upland areas of Central Europe ***Dermatocarpon arnoldianum* auct.**

7* Lower surface distinctly reticulate, known from Scandinavia to Central Europe ***Dermatocarpon bachmannii***

8 Lower surface not reticulate, always with small knob-like outgrowths (papillae), usually in rather dry habitats ***Dermatocarpon miniatum*** var. ***cirsodes***

8* Lower surface smooth to moderately reticulate, without knob-like outgrowths (papillae). On rather dry to wet rocks, also common on seeping rocks but very rarely at regularly inundated sites. 9

9 Thallus small to medium sized (>3 cm), spores subglobose to broad ellipsoid, always (?) on limestone ***Dermatocarpon leptophyllum***

9* Thallus small to very large (>5 cm), spores ellipsoid, on limestone and (alkaline) siliceous rocks ***Dermatocarpon miniatum*** var. ***miniatum***

10 Thallus brown, thick (dry: 0.36-0.62 mm), more or less circular in outline, lower surface smooth or finely granulose, rare but widespread (more frequent in areas with oceanic climate) from low elevations to upland areas.
Dermatocarpon meiophyllizum

10* Thallus dark brown to blackish-brown, thin (dry: 0.24-0.42), often of rather irregular shape or with intertwined neighbouring thalli, lower surface distinctly reticulate, in Central and Southern Europe only at high elevations, lower in northern parts of Scandinavia. ***Dermatocarpon rivulorum***

11 Thallus bright green when wet, often in large colonies (> 5cm diameter). Usually without whitish pruina when dry. Growing in at least temporarily wet to inundated habitats (seeping rocks, streams, lake margins etc.), Medulla turning blood-red to deep orange when treated with Meltzer's Reagent. Widespread on hard siliceous rocks from near sea level to high elevations. ***Dermatocarpon luridum***

11* Thallus not changing colour to bright green when wet. Thalli more or less brown or grey when dry, with or without distinct withish pruina. Medulla without reaction to treatment with Meltzer's reagent or only weakly (reddish to reddish-brown) reaction.
12

12 Thallus composed of low and small (1-4 mm) densely packed brown (no grey tinge) elements forming an almost even flat crust-like colony
Dermatocarpon leptophyllodes

12* Thallus composed of higher and wider elements with light grey to brown-grey colour 13

13 Thallus composed of intestine-like elements with margins often bend downwards
Dermatocarpon intestiniforme

13* Thallus composed of more or less rounded elements with usually upwards facing margins ***Dermatocarpon miniatum*** var. ***complicatum***

Species Profiles for European Leather lichens (*Dermatocarpon*)

The morphological descriptions below are compiled mostly from Breuss (1995), Heidmarsson (2001, 2017), Nimis (2024), Nimis et al. (2018), Orange (2023) and Shivarov et al. (2018). Distributional and ecological data were also extracted from Printzen et al. (2023), Roux et al. (2020), Thüs (2002), Thüs & Schultz (2008) and Wirth et al. (2011).

1. *D. arnoldianum* auct. (non Degel.)

A lineage from the *D. miniatum* complex with very thick, leathery-robust and large lobes (2 to 5 cm) from high elevation streams of the Alps, Carpathian Mts. and possibly also the Pyrennees and other high mountain ranges, characteristic for stretches with high stability and usually +/- constant water supply on siliceous rocks. It is commonly referred to as *D. arnoldianum*, but according to Heidmarsson (2017) it is not identical with *D. arnoldianum* Degel. from Scandinavia. Large sized specimens from the *D. miniatum* group with very thick thalli are particularly welcome from anywhere in Europe, in order to test the hypothesis that *D. arnoldianum* auct. really is a genetically, morphologically and ecologically distinct taxon, which may merit formal recognition.

Fig. 4. *Dermatocarpon arnoldianum* auct., colony in the splash water zone of a subalpine stream.

Fig. 5. *Dermatocarpon arnoldianum* auct., left: upper surface, right: lower surface, dried fungarium specimen SMNS-STU-F-0001482.

2. *Dermatocarpon bachmannii* Anders

Characterized by large (9-40 mm) and thick (dry: 0.31-0.51 mm**)** grey, unilobate (only a single holdfast per thallus) thalli, with distinctive reticulation on the dark coloured lower surface (Heidmarsson 2001). Known mostly from southern Scandinavia but also with scattered occurrences in Central Europe (Heidmarsson 2017).

3*.* *Dermatocarpon deminuens* Vain.

Small (4-16 mm) and thin (0.26-0.38 mm) grey, unilobate thalli, lower surface variable from smooth to reticulate and light to dark brown. Differs from *D. meiophyllizum* (with similarly sized thalli) by its grey surface (formed of an epinecral layer with air-filled hyphae), slightly thinner and smaller lobes and occasionally reticulate lower surface. Widespread in the Nordic countries (Heidmarsson 2017) but only a single known site in the British Isles (Orange 2023), but none from Central or Southern Europe. Some forms may be confused with *D. meiophyllizum* in the field and vouchers should be checked by carefully examining a thallus section for the structure of the epinecral layer under a microscope and/or DNA-barcoding.

4. *Dermatocarpon intestiniforme* (Körb.) Hasse

Characterised by its densely packed multilobed thalli which are difficult to remove in one piece from the substratum due to the many attachment points of the thallus lobes. Lobes are light grey (pruinose) often in extensive colonies with an intestine-like appearance. Lower surface dark brown-black and more or less smooth.

This taxon is part of the *D. miniatum* species complex and not distinguished at species level by Heidmarsson 2017, but retained by most Central European lichenologists (Nimis 2024). More sequenced collections from a wide range of countries are important to clarify the question how many genetic lineages in the *D. miniatum* complex can develop look-alike forms with this morphology and under which environmental conditions they are formed or if there are geographically distinct patterns for each lineage. Orange (2023) pointed out that material with this morphology is genetically uniform among collections from the British Isles but different

to collections from Austria. Due to the ambiguity of the current application of this name it would be particularly valuable to get access to fresh collections from the type locality in Austria, Vorarlberg, at the Lüner See above the village Brand (close to Bludenz). If sequencing attempts for the historic type material should fail, fresh collections from this side could serve as a source for epitypification. It should also be noted that *Dermatocarpon decipiens* (A. Massal.) Dalla Torre & Sarnth.,originally described from Italy and currently seen as a possible synonym to *D. intestiniforme* (Nimis et al. 2018), may be the correct name for the second lineage mentioned by Orange (2023). Collections from the Italian Alps are very much needed to clarify if there is only one lineage within the *D. miniatum* complex with "*D. intestiniforme*"-morphology in the Alps or if there are several look-alikes.

When collecting this taxon or candidates for *D. decipiens* please try to describe the habitat as specific as possible, e.g. include information where on the rock (bottom, top, in between, in cracks) it was found, if there are signs of temporary water seepages or inundation, and if it is growing in a lichen community with distinct signs of eutrophication (e.g. with many orange or yellow coloured Teloschistaceae or Physciaceae such as *Physcia caesia* in the direct vicinity).

Fig. 6. *Dermatocarpon intestiniforme*, dried fungarium specimen voucher SMNS-STU-F-0001454.

5. *Dermatocarpon leptophyllodes* (Nyl.) Zahlbr. (= *D. lorenzianum* Anders)

A small multilobed species with brown surface colour and almost squamulose appearance, with colonies of particularly small (1-4 mm) and densely packed lobes more or less ending at the same height, giving a rather even appearance of the surface of the entire colony. Known occurrences are scattered across the North and Central

part of the continent (Heidmarsson 2017, Thüs & Schultz 2008), but with the highest density in the west of Britain (Orange 2023). It may also have been overlooked due to its almost crustose appearance.

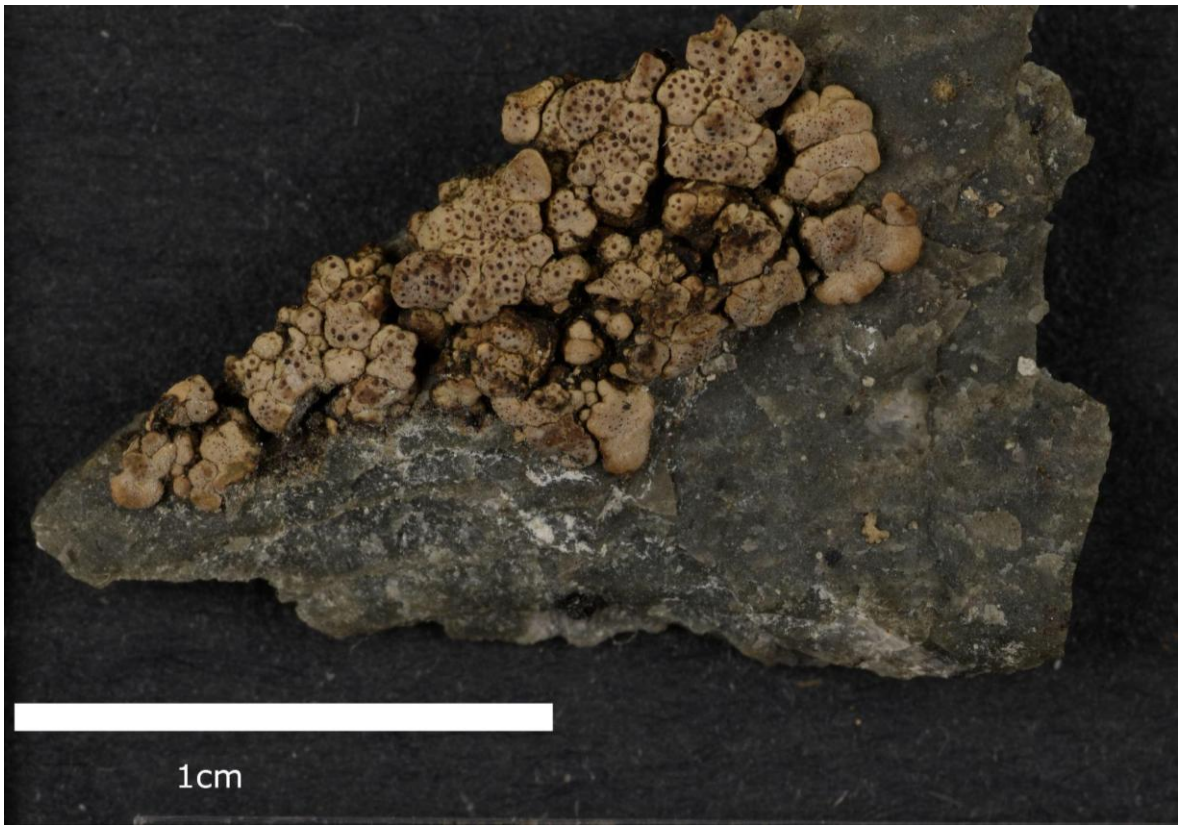

Fig. 7. *Dermatocarpon leptophyllodes* (Nyl.) Zahlbr. = *D. lorenzianum* Anders, Isotype specimen SMNS-STU-F-0007797.

6. *Dermatocarpon leptophyllum* (Ach.) K. G. W. Lång

Medium- to large sized single-lobed taxon (but thalli can be growing either solitarily or in high density). Characteristic are the broadly ellipsoid to subglobose spores, and a rather thin thallus (and the restriction to limestone?), while other lineages within the *D. miniatum* complex have more elongated spores and can occur on limestone or alkaline siliceous rocks. This taxon is considered a synonym of *D. miniatum* (Heidmarsson 2000, 2017) in Scandinavia, but based on sequenced specimens from Germany at least at the regional level there seems to be only a single lineage with this spore shape and it seems to occupy a different ecological niche compared to other lineages in the *D. miniatum* complex, hence it is recognized as a separate species in the German checklist (Printzen et al. 2022). More sequenced specimens from limestone and alkaline siliceous rocks as well from a wide range of European countries (particularly Central- and Southern Europe) are required to test, if there are more than a single lineage with broad ascospores on limestone rocks and which distribution pattern and ecology is occupied by these lichens.

Fig.8. *Dermatocarpon leptophyllum* (Ach.) K. G. W. Lång. on an old wall.

7. *Dermatocarpon luridum* (Dill. ex With) J.R. Laundon var. *luridum*

This is a distinctly hydrophilic species which is usually easily recognized already in the field by the colour change from grey or brown in dry condition to vivid green when wetted or inundated – the colour change in combination with a multilobed thallus with many secondary holdfasts attaching the colonies firmly to the substratum is diagnostic. If in doubt a test of the white medulla for a reaction with Meltzer's Iodine (not Lugol!) helps to separate it from all taxa in the *D. miniatum* complex which occasionally can occur in similar habitats (although usually never quite as often inundated) or *D. rivulorum* in streams, springs and seepages of upland areas of Central and Southern Europe, or regions in the cool high North of the continent. This species is classified as threatened in parts of (Central) Europe due to its sensitivity to river acidification, silting and its very localised distribution in stretches with particularly hard rocks which may get targeted for the construction of hydroelectric plants and reservoirs (Thüs 2002, Wirth et al. 2011). While there are still many confirmed sites from North- West-, and Central Europe, the distribution and threat status in Southern Europe is very poorly known and it should be looked for in mountain ranges with permanent streams on hard but not too acidic bedrock types.

Fig. 9. *Dermatocarpon luridum* (Dill. ex With) J.R. Laundon, dry colony.

Fig. 10: *Dermatocarpon luridum* (Dill. ex With) J.R. Laundon, wet colony.

8. *Dermatocarpon meiophyllizum* Vain.

A distinctive species of streams and lake margins with a rather small (4-31 mm) brown single-lobed thallus with thick lobes (dry: 0.36-0.62) and more or less smooth, always much darker lower surface. It has clearly declined or became extinct in recent years at most of its previously occupied sites in Germany, but little is known about the population dynamics in other parts of Europe, except for the UK, where it is considered as of least concern but nationally scarce (BLS 2024).

Fig. 11. *Dermatocarpon meiophyllizum* Vain., left: upper surface, right: lower surface, dried fungarium specimen SMNS-STU-F-0006882.

9. *Dermatocarpon miniatum* (L.) W. Mann var. *miniatum*

The circumscription of this taxon is subject to widely different concepts and no reference sequence for its nominate variety has been chosen yet. Within the *D. miniatum* complex large unifoliate thalli with smooth lower surface and elongated ascospores have evolved several times. If these occurrence of populations from these lineages have distinct geographical patterns or if they favour specific ecological conditions is not yet known and requires an extensive sampling from a wide range of habitats across the continent. In the French region of Brittany a morphological variant with deeply incised and overlapping lobes has received the informal name *Dermatocarpon miniatum* var. *miniatum* “morpho *imbricatum*” (Gerault 2024). It is unknown if specimens with this morphology represent a distinct genetic lineage and if they occur elsewhere in Europe. In Germany it has been observed that populations of *D. miniatum* have decreased substantially, particularly populations growing on anthropogenic substrates such as castle walls, due to recent restoration works and for populations on rocky pasture slopes due to the lack of grazing and re-forestation. Populations on cliffs can be severely affected by recreational rock climbing. It is unknown if the affected populations represent widespread lineages or specialised genotypes, which may be more threatened by specific types of habitat alteration.

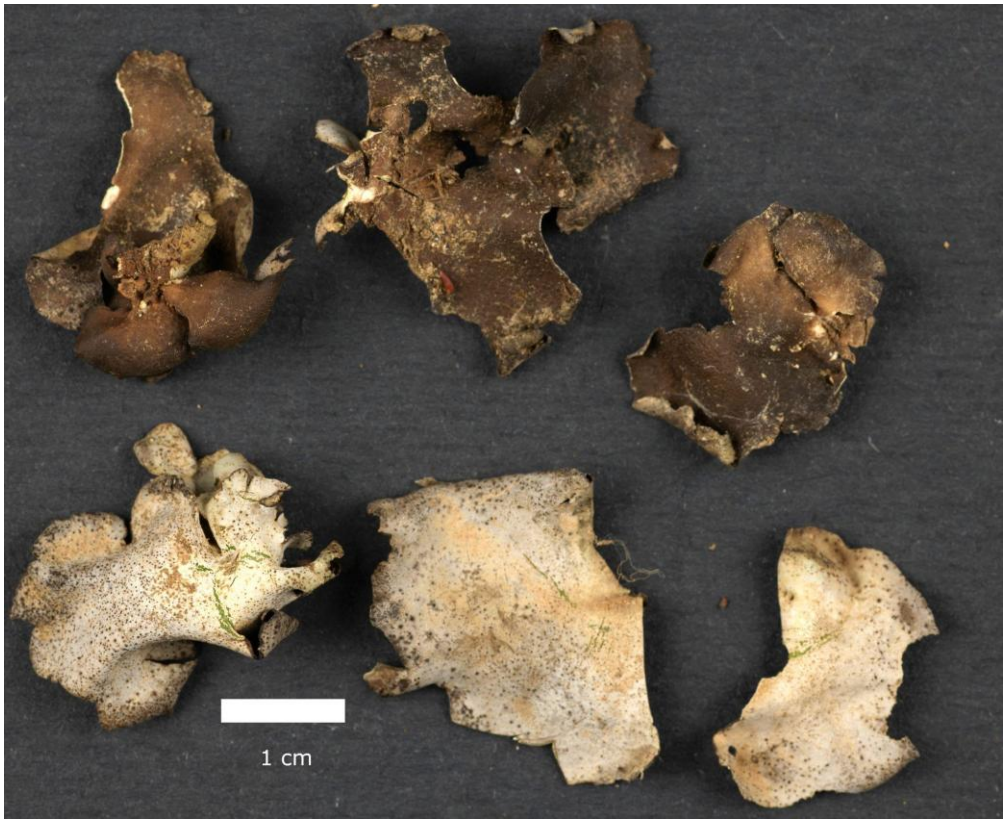

Fig. 12. *Dermatocarpon miniatum* (L.) W. Mann var. *miniatum*, top: lower surface, bottom: upper surface, dried fungarium specimen SMNS-STU-F-0000280 (leg. V. Shivarov).

Fig. 13. *Dermatocarpon miniatum* (L.) W. Mann var. *miniatum*, slightly moist thallus on a cliff.

10. *Dermatocarpon miniatum* var. *cirsodes* (Ach.) Zahlbr.

The name *D. miniatum* var. *cirsodes* is applied to specimens with rather large and thick thalli with a distinctive cover of small papillae on the lower surface. It is still unknown if this morphological trait is restricted to a single genetic lineage within the *D. miniatum* complex, or if it is formed under specific ecological conditions by various different genotypes. Any collections with this trait are therefore highly valuable for sequencing.

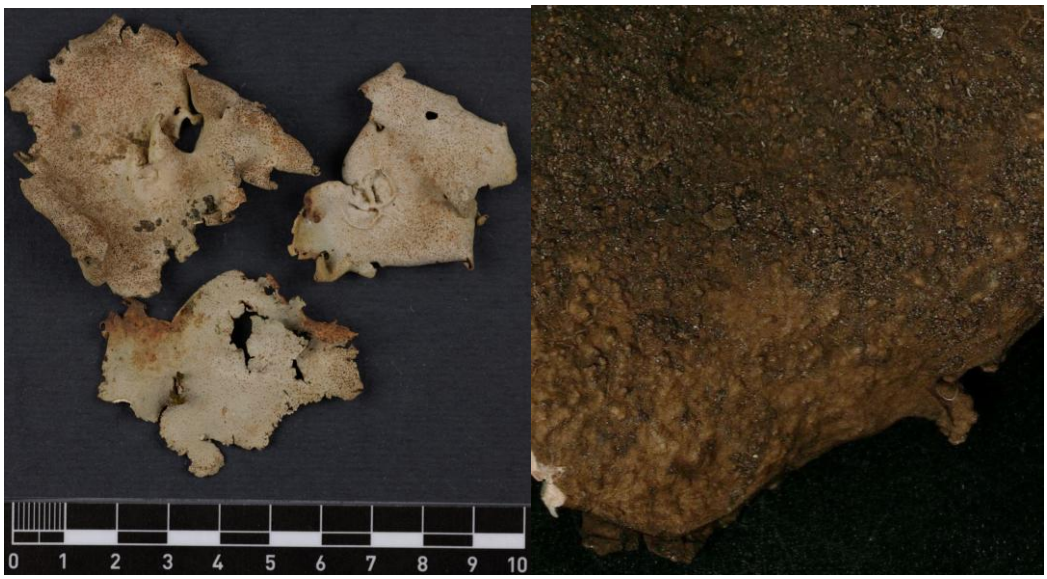

Fig. 14. *Dermatocarpon miniatum* var. *cirsodes* (Ach.) Zahlbr., left: upper surface, right: lower surface with wart-like papillae, dried fungarium specimen SMNS-STU-F-0000281 (leg. V. Shivarov).

11. *Dermatocarpon miniatum* var. *complicatum* (Lightf.) W. Mann

(incl. *Dermatocarpon luridum* var. *decipiens* ?)

This name has been applied to multilobed forms in the *D. miniatum* complex with densely packed but more or less circular thallus lobes with upward facing lobe margins (not elongated “intestine-like” with downwards facing margins as in *D. intestiniforme*). Roux et al. (2020) include most older upland records of *D. decipiens* from France to this taxon, but preliminary molecular data from other parts of Europe have shown morphologically indistinguishable specimens which could be identified as *D. miniatum* var. *complicatum* belong to different genetic lineages within the *D. miniatum* complex. It is unclear to which of them the name *D. miniatum* var. *complicatum* should be attached and opinions differ, if it is best recognized at variety or species level. Although this taxon is still listed as an infraspecific taxon of *D. luridum* in some recent checklists (Printzen et al. 2022), molecular data indicate that at least one of the lineages corresponding to this morphologically defined taxon is not closely related to *D. luridum* var. *luridum* and instead is a member of the *D. miniatum* complex (Fontaine et al. 2012).

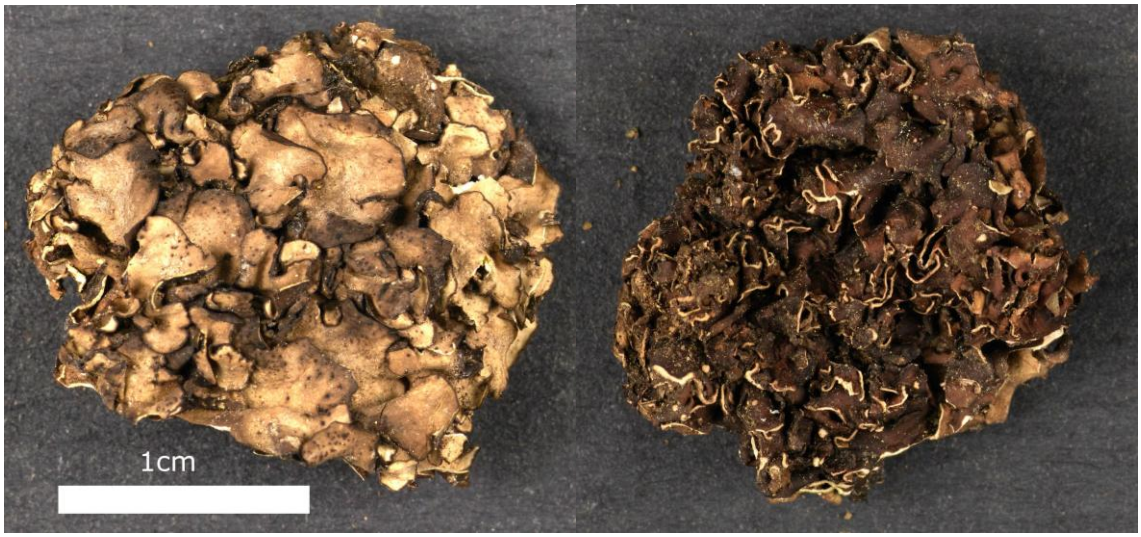

Fig. 15. *Dermatocarpon miniatum* var. *complicatum* (Lightf.) W. Mann, left: upper surface, right: lower surface, dried fungarium specimen SMNS-STU-F-0000283 (leg. V. Shivarov).

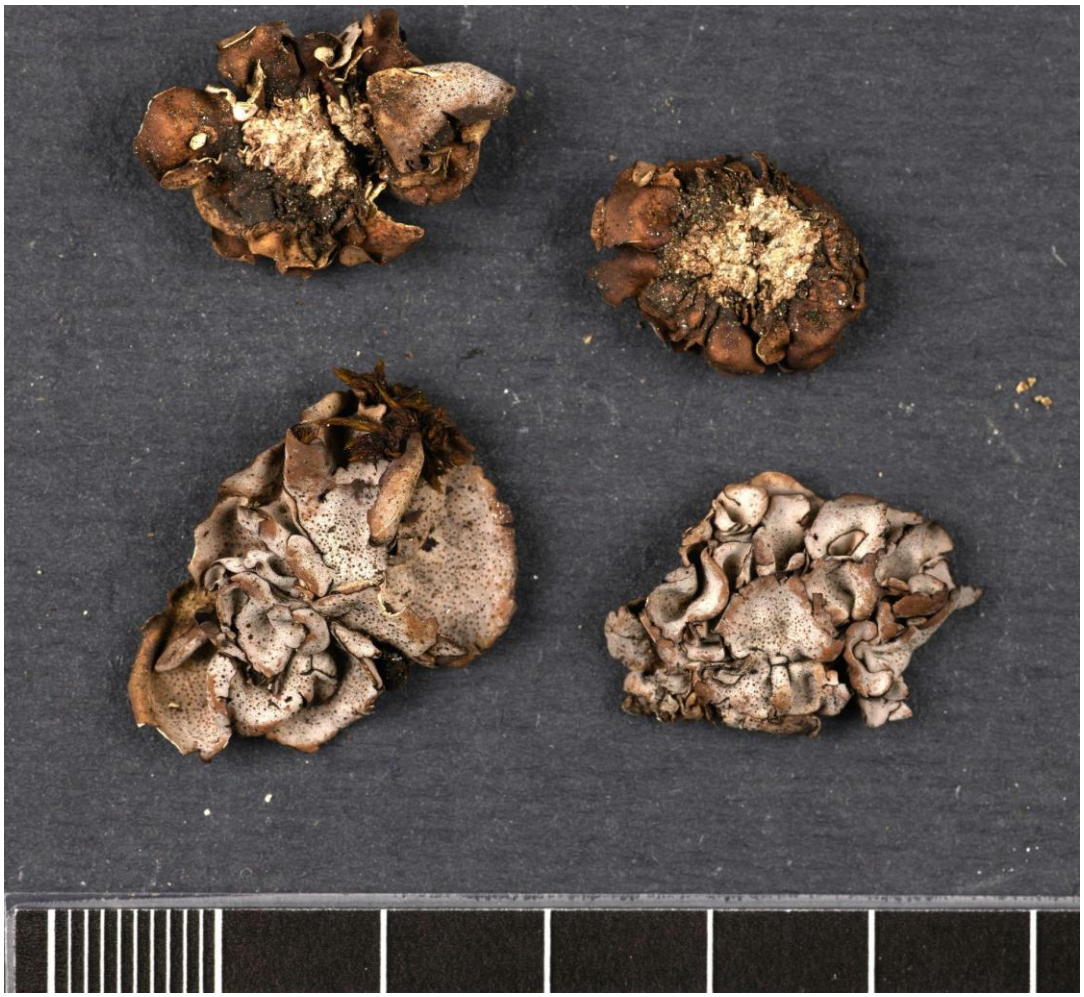

Fig. 16. *Dermatocarpon miniatum* var. *complicatum* (Lightf.) W. Mann, top: lower surface, right: upper surface, dried fungarium specimens SMNS-STU-F-0007796 (leg. R.Türk & J. Hafellner).

12. *Dermatocarpon moulinsii* (Mont.) Zahlbr.

According to Breuss (1995) this is a lichen with small (up to 3cm) and thin (up to 0.4mm) lobes which are light grey. It is the only taxon in the genus which in Europe appears to have a distinctly southern distribution eg. in the Pyrenees, southern Alps and the Caucasus. Morphologically it is separated from all other European taxa in the genus by the presence of thick hair-like outgrowths (rhizinomorphs) which makes it superficially similar to some of the light grey coloured *Umbilicaria* species (from which it is easily separated under the microscope by the presence of perithecia instead of apothecia or pycnidia). The historic type material is from Saint Justin in the French Central Pyrenees and any fresh collections from that area would be particularly valuable, but collections from anywhere else are also highly welcome because there are no molecular data for this species from the European continent yet.

Fig 17. *Dermatocarpon moulinsii* (Mont.) Zahlbr., upper surface, note the black ostioli of the perithecia on the specimen on the right, dried fungarium specimens (leg. E. Klotz).

Fig. 18. *Dermatocarpon moulinsii* (Mont.) Zahlbr., lower surface, with scattered to dense cover of unbranched “hairs” = rhizinomorphs, dried fungarium specimens (leg. E. Klotz).

13. *Dermatocarpon polyphyllizum* (Nyl.) Blomb. & Forssell

An apparently strictly Nordic species somewhat similar to *D. luridum*, but with less extensive colonies (< 5 cm) which do not change colour to a vivid bright green when wet and show a less intense colour reaction after application of Meltzer's Reagent (reddish to reddish-brown instead of blood-red). Also more often with single- or few-lobed thalli and usually with distinctive reticulate pattern at least on parts of its lower surface. Ecologically similar to *D. luridum*, but only in colder regions of Northern Europe.

14. *Dermatocarpon rivulorum* (Arnold) Dalla Torre & Sarnth.

This is a characteristic species of streams and springs in cold regions of high elevations in the mountains of Central and Southern Europe and high latitude areas in the north of the continent. The thalli are dark brown, with a distinctively reticulate lower surface. The thalli are unilobate (only one central holdfast) but can grow in dense colonies with intertwined individual lobes which can make it difficult to discern the individuals at a glance. Its ecological niche is similar to that of *D. luridum*, but it occurs in colder regions, although there is a wide overlap with co-occurrence of both species. The colour of dry thalli in *D. rivulorum* changes only slightly from dark brown to greenish-yellowish, but never to the vivid bright green of *D. luridum*. The thalli of *Dermatocarpon luridum* are further distinguished by a blood-red colour reaction after application of Meltzer's Iodine to the medulla (yellowish in *D. rivulorum*), a lighter - often pale whitish to yellowish or orange - lower surface and the absence of a reticulate structure. The species seems to be characteristic for stretches with long physical stability and may be sensitive to the effects of climate warming. Decreases of frequency and size of its colonies at its lower distribution limit have been suspected as effects of warming climate in Bulgarian stream systems (Shivarov et al. 2018).

Fig. 19. *Dermatocarpon rivulorum* (Arnold) Dalla Torre & Sarnth., left: dry thalli from fungarium with brown upper surface and black lower surface, right: wet thalli, note the slightly greenish tinge, which is not as vividly green as in *D. luridum*.

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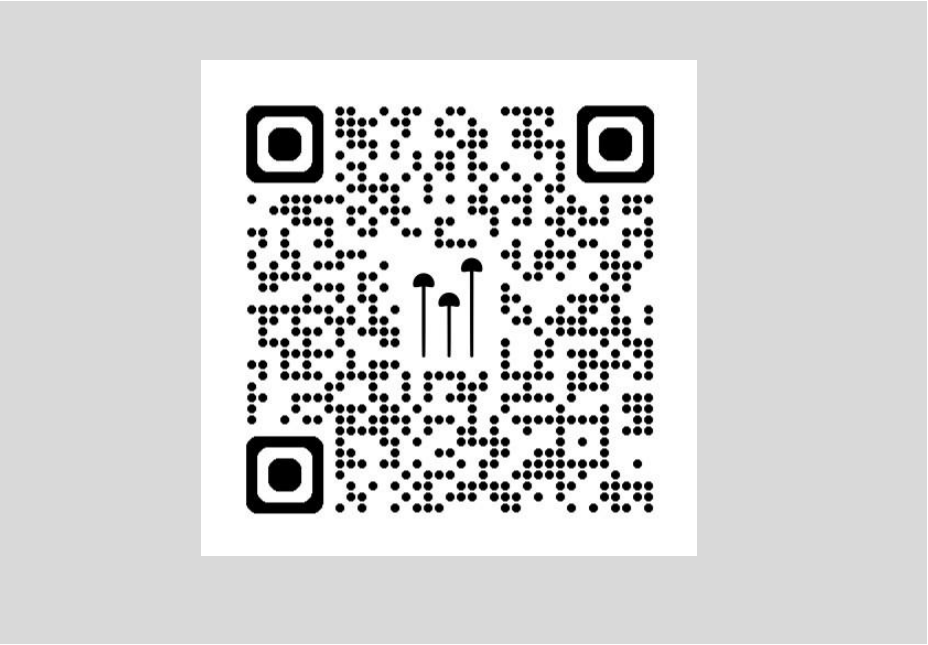

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