



SWEDISH TAXONOMY INITIATIVE PROJECT REPORT

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FUNGI:

Taxonomy and phylogeny of the fungus genus *Psathyrella* (Psathyrellaceae)

Abstract

A four-gene data set, including 218 taxa, on Psathyrellaceae was analyzed by Maximum Parsimony, Maximum Likelihood and Bayesian methods.

The phylogenetic analyses recovered six major supported clades within Psathyrellaceae and we found support for recognizing the clades *Parasola*, *Coprinopsis*, *Homophron*, *Lacrymaria* and *gossypina* as distinct lineages. *Coprinellus* and *cordisporus* fall within the larger supported clade *Psathyrella* s.l..

The molecular support for the clade *Psathyrella* s.s., which includes the majority of species described in *Psathyrella*, is low. However, based on support from morphology, we suggest recognizing the clade as distinct.

Kauffmania is proposed as a monotypic genus for the species *P. larga* and *Typhrasa* for *P. gossypina*. The genus *Homophron* is formally validated and three combinations are proposed: *H. spadiceum*, *H. cernuum* and *H. camptopodum*.

The genus *Cystoagaricus* Singer is emended and the following new combinations are proposed: *C. hirtosquamulosus*, *C. squarrosiceps*, *C. olivaceogriseus*, and *C. silvestris*.

Based on morphology and sequence data, we have identified 18 species new to science, one in *Coprinellus*, two in *Coprinopsis*, one in *Typhrasa* and 14 in *Psathyrella*. Fourteen of these occur in Sweden.

We have identified nine new species for the Nordic countries, of which only two have so far been found in Sweden. We have sorted out eight synonymous names, proposed eleven new combinations and excluded one taxon name. See the provided taxon list.

In total this results in 91 species of *Psathyrella* in the Nordic countries.

An updated key to the 106 psathyrelloid species in Northern Europe is provided.

Neotypes was selected for seven species described by Fries.

Background

Psathyrellaceae is a group of brown-spored mushroom-forming fungi. Currently approximately 1100 species are known worldwide. A new classification recognizes Psathyrellaceae Vilgalys, Moncalvo & Redhead as a separate family (Redhead *et al.* 2001). This family comprises seven genera in Europe, viz. *Psathyrella* (Fr.) Quel. (1872), *Lacrymaria* Pat. (1887), *Coprinellus* P. Karst (1879), *Parasola* Redhead, Vilgalys & Hopple (2001), *Coprinopsis* P. Karst (1881), and the small genera *Macrometrula* Donk & Singer (1948) and *Stagnicola* Redhead & A.H. Sm. (1986).

There are two major monographic treatments of *Psathyrella*. Smith (1972) applied a narrow species concept and recognized over 400 taxa, most of which are reported from North America only. On the other hand Kits van Waveren (1985) applied a broad species concept and recognized 123 species in Europe. In addition, these two authors disagree on the intrageneric classification.

Psathyrella is characterized by a brownish-black or medium reddish-brown spore deposit and a fragile cap with a cellular pileipellis composed of ellipsoid more or less rounded cells. The species have a saprotrophic habit and most species occur on soil or on wood. A number of them grow on dung and a few occur on old bonfires or in swamps. Most species are thought to be cosmopolitan.

Molecular systematic studies based on ITS and LSU sequence data indicated that the limits of genera within Psathyrellaceae were unclear and that the status of *Coprinellus* was ambiguous. Several species currently belonging to *Psathyrella* seems to fall outside the *Psathyrella* clade. In addition, none of the morphology based infrageneric classifications of *Psathyrella* are supported by the molecular data (Padamsee *et al.* 2007, Vasutova *et al.* 2008, Larsson and Örstadius 2008). These studies were all based on a limited number of species and only ITS and LSU sequence data.

Several common species of *Psathyrella* are easy to identify. However, most species are quite rare and macroscopically more or less identical. Micromorphological characters are variable and sometimes hard to interpret and therefore identification relies heavily on personal experience. In our study (Larsson and Örstadius 2008) we identified fourteen coprophilous species in *Psathyrella* that occur in the Nordic countries. Three of these were found to be new to science, and the study also indicated that there could be more undescribed species in the genus.

The challenges in species identification, divergent species concepts, and the ephemeral nature of the fruiting bodies with phenotypically plastic morphologies emphasize the need for a molecular phylogenetic treatment of the genus and the support from ITS sequence data to identify and describe new species.

At the beginning of this study Leif had identified 28 potentially new species determined to *Psathyrella* sp. For many species he has found available Smith or Kits van Waveren names, which would then be recognized as new species to Europe. Five of them were expected to be new to science.

Material and methods

In this study two additional genes, partial translation elongation factor 1 *a* (Tef-1 *a*) and B-tubulin (B-Tub), were added to our previous ITS and LSU sequence data set (Larsson and Örstadius 2008) that included 65 specimens of Psathyrellaceae, of which the majority were *Psathyrella* species. The new genes were included with the aim to increase the basal branch resolution and support in the phylogenetic analyses.

We received loans and permission to generate sequence data from 30 type specimens, mainly *Psathyrella* species described by Arnolds, Smith and Kits van Waveren. In total we generated sequence data from about 130 additional specimens of psathyrelloid species, and all four gene regions if possible. The ITS region that is now agreed upon as the bar coding gene for fungi was generated for all specimens.

All sequenced specimens were deposited in Herbarium GB. Sequence data have been submitted to GenBank.

The final four-gene sequence data set included 218 taxa and about 3604 characters. It was analyzed using Parsimony and Bayesian methods.

Results

Based on the phylogenetic results, *Kauffmania* is proposed as a monotypic genus for the species *P. larga* and *Typhrasa* for *P. gossypina* and the new described species *T. nanispora*.

The genus *Homophron* is formally validated and three combinations are proposed: *H. spadiceum*, *H. cernuum*, and *H. camptopodum*. The genus *Cystoagaricus* Singer is emended and the following new combinations are proposed: *C. hirtosquamulosus*, *C. squarrosiceps*, *C. olivaceogriseus*, and *C. silvestris*.

Based on morphology and sequence data, we have identified 18 species as new to science, one in *Coprinellus*, two in *Coprinopsis*, one in *Typhrasa* and 14 in *Psathyrella*.

Neotypes have been selected for seven species described by Fries, and ITS sequence data for these were generated.

The following new combinations are proposed: *Coprinopsis canocephs*, *C. cineraria*, *C. melanthina*, *C. submicrospora*, *C. uliginicola*, and *Typhrasa gossypina*, see list of taxonomical novelties below.

Psathyrella ornatispora were found not to belong in *Psathyrellaceae*.



Three rather rare species in *Psathyrella*: *P. clivensis*, *P. microrrhiza* and *P. rostellata*. The presence of veil on the cap and stipe can be copious to scanty, persistent but often fugacious. Photo: Leif Örstadius

LIST OF PUBLICATIONS AS OUTCOME OF THIS PROJECT

- Nagy, L., Urban, A., Örstadius, L., Papp, T., Larsson, E. & Vagvölgyi, C. 2010. The evolution of autodigestion in the mushroom family Psathyrellaceae (Agaricales) inferred from Maximum Likelihood and Bayesian methods. *Molecular Phylogenetics and Evolution* 57:1037-1048
- Örstadius, L. & Henning, K. 2012. *Psathyrella* (Fr.) Quel. In: Knudsen H, Vesterholt J. (Eds.) *Funga Nordica*. Agaricoid, boletoid, cyphelloid and gasteroid genera, Nordsvamp, Copenhagen, pp.692-728
- Örstadius, L. & Larsson, E. 2013. *Bolbitius excoriatus*, flagnande guldskeivling, funnen på spillning i Sverige. *Svensk Mykologisk Tidskrift* 34: 2-6
- Battistin, E., Chiarello, O., Vizzini, A., Örstadius, L. & Larsson, E. 2014. Morphological characterization and phylogenetic placement of the very rare species *Psathyrella sulcatotuberculosa*. *Sydowia* 66:171-181.
- Örstadius, L., Ryberg, M. & Larsson, E. 2015. Molecular phylogenetics and taxonomy in Psathyrellaceae (Agaricales) with focus on psathyrelloid species: introduction of three new genera and 18 new species. *Mycological Progress* 14:25.
<http://link.springer.com/article/10.1007%2Fs11557-015-1047-x>

Taxonomical novelties as outcome of this project

- Coprinellus christianopolitanus* Örstadius & E. Larss.
Coprinopsis musae Örstadius & E. Larss.
Coprinopsis udicola Örstadius, A. Melzer & E. Larss.
Psathyrella arenosa Örstadius & E. Larss.
Psathyrella carminei Örstadius & E. Larss.
Psathyrella fennoscandica Örstadius & E. Larss.
Psathyrella ichnusae Örstadius, Contu, E. Larss. & Vizzini
Psathyrella lilliputana Örstadius & E. Larss.
Psathyrella lyckebodensis Örstadius & E. Larss.
Psathyrella madida Örstadius & E. Larss.
Psathyrella rybergii Örstadius & E. Larss.
Psathyrella sabuletorum Örstadius & E. Larss.
Psathyrella scanica Örstadius & E. Larss.
Psathyrella siccophila Örstadius & E. Larss.
Psathyrella stridvallii Örstadius & E. Larss.
Psathyrella sublatispora Örstadius, S.-Å. Hanson & E. Larss.
Psathyrella vesterholtii Örstadius & E. Larss.

- Kauffmania* Örstadius & E. Larss.
Kauffmania larga (Kauffman) Örstadius & E. Larss.

- Cystoagaricus* Singer emend. Örstadius & E. Larss.
Cystoagaricus squarrosiceps (Singer) Örstadius & E. Larss.
Cystoagaricus olivaceogriseus (A.H. Sm.) Örstadius & E. Larss.
Cystoagaricus silvestris (Gillet) Örstadius & E. Larss.
Cystoagaricus hirtosquamulosus (Peck) Örstadius & E. Larss.

- Typhrasa* Örstadius & E. Larss.
Typhrasa gossypina (Bull.: Fr.) Örstadius & E. Larss.
Typhrasa nanispora Örstadius, Hauskn. & E. Larss.

Homophron (Britzelm.) Örstadius & E. Larss.
Homophron spadiceum (P. Kumm.) Örstadius & E. Larss.
Homophron cernuum (Vahl: Fr.) Örstadius & E. Larss.
Homophron camptopodum (Sacc.) Örstadius & E. Larss.

Additional new combinations

Coprinopsis caniceps (Kauffman) Örstadius & E. Larss.
Coprinopsis cineraria (Har. Takah.) Örstadius & E. Larss.
Coprinopsis melanthina (Fr.) Örstadius & E. Larss.
Coprinopsis submicrospora (Heykoop & G. Moreno) Örstadius & E. Larss.
Coprinopsis uliginicola (McKnight & A.H. Sm.) Örstadius & E. Larss.

Neotypes selected for species described by Fries

Parasola conopilus (Fr.) Örstadius & E. Larss., Mycol. Res. 112(10):1180, 2008. *Agaricus conopilus* Fr., Syst mycol (Lundae) 1:504, 1821 – Neotype [MBT200684]: Sweden, Skåne, Ivetofta, Krogstorp, 2002-10-22, L. Örstadius 186-02 (GBI, GenBank no. DQ389725).

Psathyrella candolleana (Fr.) Maire apud Maire, Mém. Soc. Sci. Nat. Maroc. 45:112, 1937. [Agaricus candolleanus](#) Fr., Observ. mycol. (Havniae) 2:182, 1818 – Neotype [MBT200683]: Sweden, Bohuslän, Lysekil, Bro, SO Kibbestens torvemyr, 1973-08-17, L. & A. Stridvall 73/030 (GBI, GenBank no. KM030175)

Psathyrella caput-medusae (Fr.) Konrad & Maubl., Encyclop. Mycol. 14: 127, 1949 [1948]. *Agaricus caput-medusae* Fr., Epicr. syst. mycol. (Upsaliae):216, 1838 [1836-1838] – Neotype [MBT200681]: Sweden, Västergötland, Trollhättan, Lextorp, 1993-08-30, L. & A. Stridvall 93/062 (GBI, GenBank no. KM030174)

Psathyrella fatua (Fr.) Konrad & Maubl., Encyclop. Mycol. 14(1):125, 1949 [1948]. *Agaricus stipatus* y. *fatuus* (Fr.) Fr., Syst. mycol. (Lundae):296 (1821). – Neotype [MBT 200685]: Sweden, Skåne, Österslöv, Lövhall, 1997-10-11, L. Örstadius 132-97 (GBI, GenBank no. DQ389681)

Psathyrella noli-tangere (Fr.) A. Pearson & Dennis, Trans. Br. mycol. Soc. 31(3-4): 184, 1948 [1947]. *Agaricus noli-tangere* Fr., Epicr. syst. mycol. (Upsaliae):234, 1838 [1836-1838] – Neotype [MBT200686]: Sweden, Skåne, V. Vram, Stackedala, 2003-09-14, L. Örstadius 83-03 (GBI, GenBank no. DQ389713)

Psathyrella pennata (Fr.) A. Pearson & Dennis, Trans. Br. mycol. Soc. 31(3-4):184, 1948 [1947]. *Agaricus pennatus* Fr., Syst. mycol. (Lundae) 1:297, 1821 – Neotype (designated here) [MBT200687]: Sweden, Skåne, Kiaby, Kjugekull, 1984-10-01, L. Örstadius 216-84 (GBI, GenBank no. KJ939633)

Psathyrella prona (Fr.) Gillet, Hyménomycètes (Alençon): 618, 1878. *Agaricus pronus* Fr., Epicr. syst. mycol. (Upsaliae):239, 1838 [1836-1838]. – Neotype (designated here) [MBT200688]: Sweden, Skåne, Trolle-Ljungby, Fårabäck, 2000-10-17, L. Örstadius 237-00 (GBI, GenBank no. KJ939634).

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