

New species in *Cortinarius* section *Cortinarius* (Agaricales) from the Americas and Australasia

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Abstract

Five new species from *Cortinarius* sect. *Cortinarius* are formally described, four from the Americas (*Cortinarius palatinus* Harrower, **sp. nov.**, *Cortinarius atrotomentosus* Harrower, **sp. nov.**, *Cortinarius altissimus* Harrower & T.W. Henkel, **sp. nov.**, *Cortinarius neotropicus* Harrower, **sp. nov.**) and one from Australasia (*Cortinarius carneipallidus* Harrower & E. Horak, **sp. nov.**) based on molecular, morphological, and ecological circumscription. Additional collections of the Australasian species *Cortinarius hallowellensis* Wood and *Cortinarius kioloensis* Wood reveal wider host associations and geographic ranges than previously recorded. Morphological descriptions, photomicrographs and a dichotomous key to all species in *Cortinarius* sect. *Cortinarius* are provided. This work raises the number of species in sect. *Cortinarius* to twelve.

Key words

Australia, Costa Rica, Guyana, New Zealand, North America, South America, systematics, taxonomy

Introduction

Recent phylogenetic analyses of Harrower et al. (2015) have revealed greater species-level diversity in *Cortinarius* (Pers.) Gray sect. *Cortinarius* (also known as the *C. violaceus* group) than previously thought (Bougher and Syme 1998, Halling and Mueller

2005, Gasparini and Soop 2008). Phylogenetically defined species within the section exhibit continental scale disjunct distributions and form ectomycorrhizal associations with different plant partners (Harrower et al. 2015). Taking their morphological differences into consideration, a taxonomic revision of the section is warranted.

Cortinarius subgenus *Cortinarius* sect. *Cortinarius* is an easily identifiable section within the very large genus *Cortinarius*. All basidiomata have a deep violet color, the pigment of which has been identified as (R)-3',4'-dihydroxy- β -phenylalanine [(R)- β -dopa] in *Cortinarius violaceus* (L.) Gray (von Nussbaum et al. 1998). The pigment is vacuolar, encrusting (Brandrud 1983) and oxidizes quickly to brown (von Nussbaum et al. 1998). The following features for the section were noted by Brandrud (1983), the circumscription of which as based on European taxa only at the time. The pileus is tomentose to finely scaly (comprising a trichoderm), neither hygrophane nor viscid. KOH on any surface of a basidiome produces a red reaction. Pleurocystidia and cheilocystidia are present, none of which differ in size, shape and abundance and caulocystidia are present. The basidiospores of all species are verrucose and bear a plage.

Linnaeus (1753) described the first species in the section as *Agaricus violaceus* L. Persoon (1801) recognized *A. violaceus* ("ad margines sylvarum") and *A. hercynicus* Pers. ("in pinetis"). However, the latter was synonymized with *A. violaceus* by Fries (1821). Moser (1967; 1969) later recognized *Cortinarius hercynicus* (Pers.) M.M. Moser as an autonomous species. Brandrud (1983) treated the two species as varieties and later as a subspecies (Brandrud 1990), but Harrower et al. (2015) did not find a genetic or ecological basis for distinguishing these taxa.

Clements and Shear (1931) designated *C. violaceus* (L.) Gray as the type species of the genus *Cortinarius*. The subgenus *Cortinarius* was circumscribed by Orton (1958) to include *C. violaceus*, *C. orellanus*, *C. cotoneus* and other allied species. Moser (1967, 1969) transferred members of the *C. orellanus-cotoneus* group into subgenus *Leproclybe* sensu Moser, leaving subgenus *Cortinarius* represented by only *C. violaceus* and *C. hercynicus*. Niskanen et al. (2008) included sections *Cortinarius*, *Dermocybe*, *Veneti*, *Limonii*, *Orellani* and *Humicolae* within subgenus *Cortinarius*.

As many as twelve species have been recognized in sect. *Cortinarius*, but the inclusion of some these species is suspect. Members are known on every continent except for Africa and Antarctica (Moser 1968, Brandrud 1983). *Cortinarius violaceus* occurs throughout North America, Asia and Europe in association with members of the Fagales, Salicaceae and Pinaceae (Brandrud 1983; Nezdoininogo 1996; Harrower et al. 2015). Horak (1980) described *C. gayi* Horak from *Nothofagus* in Chile for *C. violaceus* Fr. sensu Montagne (Montagne 1989). Singer et al. (1983) described *Cortinarius kerrii* Singer & I.J.A. Aguiar from the Amazon in campinarana vegetation. Moser (1987) documented *C. violaceus* Fr. as occurring in mixed deciduous forests in Malaysia and Papua New Guinea. In the same paper, he described *C. atroviolaceus* M.M. Moser, *C. subcalypotrosporus* M.M. Moser and *C. paraviolaceus* M.M. Moser from Mt. Kinabalu, Sabah, Malaysia. Malaysian plant associates were likely in the plant families Fagaceae and Myrtaceae (Beaman et al. 2000, Beaman and Anderson 2004), and Moser also documented *C. atroviolaceus* and *C. subcalypotrosporus* as occurring with *Nothofagus* in

New Zealand (Moser 1987). He was uncertain whether *C. paraviolaceus* belonged in sect. *Cortinarius* due to the lack of cheilocystidia, atypical pleurocystidia, a pileus that is not strongly squarrose-fibrillose-squamulose and basidiomata that are less intensely violet (Moser 1987). Moser also described *C. atrolazulinus* M.M. Moser with *Nothofagus* in New Zealand (Moser 1987). Gasparini (2001) added *C. austroviolaceus* Gasparini from Australia. This species was excluded from the *C. violaceus* group by Harrower et al. (2015) due to a lack of pleurocystidia and phylogenetic placement outside the clade containing *C. violaceus*. Wood (2009) described *C. jenolanensis*, *C. kioloensis* and *C. hallowellensis* from *Eucalyptus* forests in Australia, but the former lacks pleurocystidia suggesting to us an alliance outside the *C. violaceus* group. Assuming *C. hercynicus* is treated as a synonym of *C. violaceus* then twelve species can be recognized in sect. *Cortinarius*.

Harrower et al. (2015) produced a multi-gene phylogenetic tree that delimited eight different species present in sect. *Cortinarius* in the Americas and Australasia. Species were separated by at least a 2% difference in the ITS region, which conforms to the benchmark in *Cortinarius* established by Stephani et al. (2014). Of the eight species level lineages detected, two new were found in Costa Rica, one in North America, one in New Zealand, and one in Guyana. Here we provide descriptions for all species recognized in this previous study (except for *C. violaceus*). Additional collections of *C. kioloensis* and *C. hallowellensis* (Wood 2009) have been examined extending their known host association and geographic ranges. The purpose of this study is to revise the taxonomy of species in the *C. violaceus* group found in Australasia and the Americas and refine sect. *Cortinarius* based on morphological data previously confirmed by molecular phylogenetic results. A key to twelve species in the section is provided.

Methods

Dried specimens of collections labeled as *C. violaceus*, *C. subcalyptrosporus*, *C. atroviolaceus*, *C. atrolazulinus*, and *C. austroviolaceus* were obtained from the TENN, ZT, HSC, NY, PDD and PERTH herbaria. Additional collections were provided from Ian Dodd (West Kempsey, Australia). Requests for type collections of *C. subcalyptrosporus*, *C. atroviolaceus*, *C. atrolazulinus* and *C. paraviolaceus* were denied from the IB herbarium. Previous attempts to sequence *C. subcalyptrosporus* and *C. paraviolaceus* were purportedly unsuccessful (Ursula Peintner, personal communication).

Morphological analysis

Macroscopic descriptions were taken from fresh material as described by collectors where possible. Color documentation of basidiocarps follows the Methuen Handbook of Colour (Kornerup and Wanscher 1967). When no descriptions were made from fresh material, macroscopic descriptions were assembled from dried material and from photographs of fresh material. By measuring the pileus diameter and stipe length of

MEL 2351101 (*C. kioloensis*) before and after drying, it was estimated that basidiomata were reduced by a factor of 1.75 upon drying. Macroscopic measurements were taken from dried specimens of *C. atrotomentosus* sp. nov., *C. neotropicus* sp. nov., *C. kioloensis* and *C. carneipallidus* sp. nov. Dry measurements were multiplied by a factor of 1.75.

Microscopic features were observed from sections of dried material rehydrated in 5% KOH on a Nikon Eclipse 80i microscope. Basidiospore measurements were taken from spores trapped in the cortina on the stipe. However, for specimens that did not have any remaining cortina, basidiospore measurements were taken from lamellar tissue, and mature basidiospores (judged by the presence and development of ornamentation) were measured at random. Measurements were taken with a Nikon DS-Fi1 camera and Nikon NIS Elements 3.1 software. Twenty-five basidiospores were measured per collection. Outliers are placed in parentheses. Five basidia, cheilocystidia, and pleurocystidia were measured per specimen. The following abbreviations are used: Q = quotient of length divided by width; Q mean = average value of Q values. Scanning electron microscope images were taken on a Zeiss Auriga scanning electron microscope. Lamellae were placed on double-sided carbon adhesive tape and covered with two layers of a gold sputter coating.

Phylogenetic study

Methods for DNA extraction, PCR amplification, and sequencing are given in Harrower et al. (2015). Fig. 2 in Harrower et al. (2015) is summarized here in part as Fig. 1, showing the phylogenetic relatedness of species within sect. *Cortinarius*.

Taxonomy

Cortinarius Fr. subgen. *Cortinarius* sect. *Cortinarius*

Synonyms: *Agaricus* (ser. *Cortinaria*) trib. *Inoloma* Fr.: Fr. 1821: 217. – *Agaricus* subgen. *Inoloma* (Fr.: Fr.) Loudon 1836: 1000. – *Cortinarius* Fr. 1836 trib. *Inoloma* (Fr.: Fr.) Fr. 1836: 279. – *Inoloma* (Fr.: Fr.) Wünsche 1877: 87. – Type species: *Cortinarius violaceus* (L.:Fr.) Gray.

Type species. *Cortinarius violaceus* (L.:Fr.) Gray

Basidiomata tricholomatoid, deep violet; pileus squamose to tomentose, rarely greasy, then simply innately fibrillose; KOH+ red; basidiospores subglobose, ellipsoid to amygdaliform, weakly to strongly verrucose, with suprahilar plage (may only be visible in SEM); pleurocystidia and cheilocystidia present; caulocystidia present or usually absent; pileipellis a trichoderm of hyphae (6–22 µm wide) or rarely an ixocutis with gelatinized hyphae (2–11 µm wide); pigment vacuolar and soluble in water, violet often turning brownish in age.

Key to species of *Cortinarius* sect. *Cortinarius*

- 1 Pileus smooth, greasy; pileipellis an ixocutis..... *C. hallowellensis*
- Pileus scaly, dry; pileipellis a trichoderm 2
- 2 Stipe more than two times longer than the width of the pileus ... *C. altissimus*
- Stipe less than twice as long as the width of the pileus 3
- 3 Basidiospores with a visible perispodium *C. subcalyptrosporus*
- Basidiospores without a loosening of the perispodium 4
- 4 Cheilocystidia 25–30 × 9.5–11.5 µm..... *C. kerrii*
- Cheilocystidia larger than above..... 5
- 5 Basidiospores 9–12.5 × 5.5–6.5 µm; Q=1.86; basidia 32–38 × 7.5–8 µm.....
- *C. atrolazulinus*
- Basidiospores often longer, less elongate; Q<1.86; basidia width > 8 µm 6
- 6 Growing on calcareous soil with *Quercus virginiana*..... *C. atrotomentosus*
- Growing on a variety of soils; not with *Quercus virginiana*..... 7
- 7 Basal mycelium white *C. neotropicus*
- Basal mycelium pale violet 8
- 8 Caulocystidia present..... *C. violaceus*
- Caulocystidia absent 9
- 9 Occurring with *Quercus* in Costa Rica *C. palatinus*
- Occurring with Myrtaceae or *Nothofagus* in Australasia or Fagaceae in Indonesia 10
- 10 With *Nothofagus* *C. carneipallidus*
- Not with *Nothofagus* 11
- 11 Occurring with Myrtaceae in Australia and New Zealand *C. kioloensis*
- Occurring with Fagaceae in Indonesia..... *C. atroviolaceus*

***Cortinarius kioloensis* Wood, 2009**

Figs 1, 2a, 3a, 4a

Type. AUSTRALIA. New South Wales: Batemans Bay, Kioloa State Forest, Eucalypt woodland, 22 Jun. 1980, S. Lowry (holotype: UNSW 83/781).

Description. Pileus 45–120 mm wide, convex to plano-convex with a low, broad umbo with age, surface dry, tomentulose-squamulose, dark violet (17F8), lighter concolorous (17E3) near margin, red in KOH; margin entire, split and broadly undulating with age. Lamellae close, sinuate, thick, broad to ventricose, deep blue (19D–E8). Stipe 105–165 mm long, 7–28 mm thick at apex, 9–31 mm thick at base, bulbous, light violet (18A3–5) turning deep blue (18F8) upon touch because of the copious universal veil. Universal veil pale violet (17A3). Basal mycelium pale violet (17A3). Context at apex dark violet to black (18F8).

(MEL 2351101). New South Wales: Swans Crossing State Forest (*Eucalyptus*), 21 May 2003, I. Dodd 70845 (TENN 069666). New Zealand. Auckland: Waitakere Ranges, Little Huia, Donald Mclean Track, 10 July 2010, C. Shirley AK375 (PDD 99307). Auckland: Waitakere, Piha Rd, Upper Nihotupu Dam track, (*Leptospermum*), 24 July 2010, C. Shirley AK373 (PDD 99309). Auckland: Waitakere, Mountain Rd, Opanuku Pipeline Track, (*Leptospermum*), 17 July 2010, C. Shirley AK370 (PDD 99308).

Discussion. The collections examined here match the protologue of *C. kioloensis* Wood in all particulars. One collection (TENN 069666) was seen to have dark purple, nearly black flesh at the apex. Flesh color at the base was not observed. We have not studied the type of this species (the collection was not readily available at UNSW) but are confident for now applying the name *C. kioloensis* to our material. As such, the species range has been extended from N. S. W. into Tasmania and New Zealand and a new host association with *Leptospermum* has been revealed. *Cortinarius atroviolaceus* and *C. kioloensis* cannot be distinguished morphologically, but the two are geographically separated and likely ecologically differentiated. *Cortinarius atroviolaceus* is found at 1700 m on Mt. Kinabalu, Malaysia where *Leptospermum* (Myrtaceae), *Trigonobalanus* (Fagales), *Quercus* (Fagales), *Lithocarpus* (Fagales), and *Castanopsis* (Fagales) may occur (Beaman et al. 2000; Beaman and Anderson 2004). *Cortinarius kioloensis* is found with *Eucalyptus* (Myrtaceae) and/or *Allocasuarina* (Casuarinaceae) in southeastern Australia and with *Leptospermum* (Myrtaceae) in New Zealand. Herbarium collections of *C. kioloensis* from New Zealand have been misidentified as *C. subcalyptrosporus*. *Cortinarius kioloensis* differs from *C. subcalyptrosporus* by the non-calyptrate basidiospores. It differs from *C. atrolazulinus* by association with Myrtaceae, not Nothofagaceae. *Cortinarius kioloensis* is also similar to *C. carneipallidus*, a *Nothofagus* association, but differs from this latter species by association with Myrtaceae. Phylogenetic results (Fig. 1) also support these separations. Unique molecular synapomorphies are present at pos. 11, 35, 203 (ITS1), 475, 554, 577, 578, 623 (ITS2) of our alignment. *Cortinarius kioloensis* was treated as “*C. sp.* AU1” in Harrower et al. (2015).

***Cortinarius palatinus* Harrower, sp. nov.**

Mycobank MB 811657

Figs 1, 2b, 3b, 4b

Diagnosis. Similar to *Cortinarius neotropicus* sp. nov. but differs in having shorter basidiospores and absence of caulocystidia. Unique molecular synapomorphies at pos. 39 (ITS1), 524, 618, 649, 651, 672 (ITS2) of our alignment.

Type. COSTA RICA. San Jose: Perez Zeledon, Villa Mills, CATIE Experimental Forest, 9°33'03"N; 83°40'56"W, 2880 m alt., (*Quercus costaricensis*), 21 June 2003, R.E.Halling 8411 (holotype: NY 796168).

Etymology. Named for the color palatinate, a shade of violet.



Figure 2. Habit of the following *Cortinarius* species: **a** *C. kioloensis* (TENN 069666, photo I. Dodd) **b** *C. palatinus* (NY 796168, TYPE photo R.E. Halling) **c** *C. atrotomentosus* (TENN 069922, photo A. Bessette); **d** *C. hallowellensis* (MEL 2300544) **e** *C. neotropicus* (NY 75934, photo R.E. Halling) **f** *C. carneipallidus* (PDD 71219, photo E. Horak) **g** *C. altissimus* (TENN 069829, TYPE photo T. Henkel); **h** *C. gayi* (ZT 75/82, ISOTYPE photo E. Horak) **i** *C. austroviolaceus* (MEL 2231689, photo K. Syme). Scale bar = 1 cm.

Description. Pileus 30–50 mm wide, convex to plano-convex, surface dry, densely squamulose, appressed toward margin, erect on disc, violet (15C5–8, 15D5–8, 15E5–8, 16C5–8, 16D5–8, 16E5–8), red with KOH. Lamellae adnexed, close, violet, concolorous with pileus, soon assuming brown colors, up to 1 cm broad, edges even to uneven. Stipe 80–120 mm long, 10–14 mm broad, equal or subclavate, strict or curved, dry, upper half violet, fibrillose-striate; lower half pale violet, fibrillose, base violet (15C5–8, 15D5–8, 15E5–8, 16C5–8, 16D5–8, 16E5–8). Universal veil pale violet. Context pale violet, unchanging. Smell mild. Taste mild.

Basidiospores $11\text{--}15\ \mu\text{m} \times 7\text{--}9.5\ \mu\text{m}$, means = $12\text{--}13\ \mu\text{m} \times 8\text{--}8.5\ \mu\text{m}$, $Q = 1.39\text{--}1.59$, Q means = $1.40\text{--}1.53$ (150 spores, 6 specimens). Amygdaloid, strongly verrucose, plage present under SEM. Basidia 2- and 4-spored, clavate, (20–) $30\text{--}40 \times 10\text{--}15\ \mu\text{m}$. Cheilocystidia present but not abundant in younger specimens, lageniform, brown or grey in KOH, (35–) $60\text{--}95\text{--}(100)\ \mu\text{m} \times (11\text{--})\ 13\text{--}25\text{--}(30)\ \mu\text{m}$. Pleurocystidia abundant, lageniform, brown or grey in KOH, (40–) $50\text{--}80\text{--}(105)\ \mu\text{m} \times (10\text{--})\ 15\text{--}25\text{--}(40)\ \mu\text{m}$. Pileipellis a trichoderm composed of hyphae up to $20\ \mu\text{m}$ wide, multi-septate, with brown contents in KOH, terminal hyphae blunt-ended, sometimes aciculate. Clamp connections present.

Ecology and distribution. Known from Perez Zeledon and San Gerardo de Dota in Costa Rica. Associated with *Quercus copeyensis*, *Q. seemannii*, and *Q. costaricensis* on acidic soils. Occurring mid-June to mid-July. Elevation 2220–2280 m.

Other specimens examined. Costa Rica, San Jose, Perez Zeledon, Villa Mills, CATIE Experimental Forest, $9^{\circ}33'03''\text{N}$; $83^{\circ}40'55''\text{W}$, 2880 m, (*Quercus costaricensis*), 22 June 1995, R.E.Halling 7450 (NY 79537). San Jose, San Gerardo de Dota, Albergue de Montana, Savegre, ~5 km SW of Cerro de la Muerte, $9^{\circ}33'02''\text{N}$; $83^{\circ}48'27''\text{W}$, 2500 m, (*Quercus copeyensis*, *Q. seemannii*), 20 June 1994, R.E.Halling 7307 (NY 34724). San Jose, Perez Zeledon, Villa Mills, CATIE Experimental Forest, $9^{\circ}41'56''\text{N}$; $83^{\circ}56'31''\text{W}$, 2850 m, (*Quercus costaricensis*), 12 June 2000, R.E.Halling 8184 (NY 795933). San Jose, San Gerardo de Dota, Albergue de Montana, Savegre, ~5 km SW of Cerro de la Muerte, $9^{\circ}33'02''\text{N}$; $83^{\circ}48'27''\text{W}$, 2220 m, (*Quercus copeyensis*, *Q. seemannii*), 10 July 2001, R.E.Halling 8004 (NY 460906). San Jose, Perez Zeledon, Villa Mills, CATIE Experimental Forest, (*Quercus costaricensis*), 23 June 2001, E. & A. Horak (ZT 10422).

Discussion. *Cortinarius palatinus* sp. nov. is treated as ‘*C. sp. CR2*’ in Harrower et al. (2015). It occurs in the same oak forests and at the same elevation as *Cortinarius neotropicus* sp. nov. It can be distinguished from *C. neotropicus* sp. nov. by its larger and more heavily verrucose basidiospores and pale violet context. Caulocystidia were found in *C. violaceus* and *C. neotropicus* sp. nov., but not in *C. palatinus* sp. nov. *Cortinarius atrotomentosus* sp. nov. differs from *C. palatinus* sp. nov. by its wider and olive colored stipe. These two species appear to be most closely related (Fig. 1). *Cortinarius atrotomentosus* sp. nov. occurs on limestone soil and *C. palatinus* sp. nov. on acidic soil. This is the same species that was referred to as *C. violaceus* by Halling and Mueller (2005) from the Talamanca Mountains of Costa Rica (NY795933 illustrated).

***Cortinarius altissimus* Harrower & T.W. Henkel, sp. nov.**

MycoBank MB 811658

Fig 1, 2g, 3c, 4c

Diagnosis. Similar to *Cortinarius kerrii* Singer & I.J.M.Araujo but differs by its larger basidia and less frequent, much larger pleurocystidia. Unique molecular synapomorphies at pos. 46, 108, 156, 212, 216, 259, 260, 261, 262, 264 (ITS1), 440, 503, 506, 532, 545, 554, 583, 617 (ITS2) are present in our alignment.

Type. GUYANA. Region 8 Potaro-Siparuni: Pakaraima Mountains, Upper Potaro River Basin, vicinity of Potaro base camp at 5°18'04"N; 59°54'40"W, 710 m alt., on lateritic soils; 2 km southeast of base camp near *Dicymbe* plot 1, on humic mat of forest floor under *Dicymbe corymbosa*, May 25 2001, T.W.Henkel 8211 (holotype: BRG 41220; isotype TENN 069829, HSU G1168)

Etymology. Refers to the exceptionally tall basidiomata of the species, due to the long stipe.

Description. Pileus 24–56 (–87) mm wide, 17–29 mm tall, convex to plano-convex with a low, broad umbo with age, surface dry, erect tomentulose-squamulose throughout, especially over disc, under hand lens squamules subpyramidal and sub-acuminate, 0.5 mm tall, dark violet (16F7–16F8, 17F7–17F8), lighter concolorous (16E8) near margin, red in KOH; margin entire, broadly undulating with age. Lamellae subclose, shallowly adnexed with short decurrent tooth, subthick, 2 mm broad at margin, 8–10 mm centrally, 7 mm at stipe, concolorous (16F5–17F5), browning with basidiospore development; edges concolorous, hispid under hand lens; lamellulae usually 3 (2 short at 1–3 mm, 1 long at 6–21 mm), occasionally 5, rarely 7. Stipe 132–220 (–263) mm long, (2–) 5–11 mm thick at apex, (3–) 7–17 mm thick at center, (7–) 12–24 mm thick at base, subequal, tapering gradually from base to apex, concolorous (16F5–16F6) or slightly lighter concolorous (16D7–16E7, 17D7–17E7) over lower 4/5, apex slightly more greyish violet (15D6–15D7), finely longitudinally striate throughout, with appressed longitudinal fibrils visible under hand lens, cartilaginous, snapping easily, red with KOH. Partial veil cortinate, rather scant, concolorous, minimally retained as scattered, rust-brown fibrils on upper stipe and occasionally pileus margin. Basal mycelium a pale purple (16B3–16B4) matted tomentum. Pileus context subsolid, off white to light purple (17A4–17B4), unchanging, 0.5–1 mm thick at margin, 1–1.5 mm centrally, 6 mm above stipe. Stipe context cartilaginous and concolorous in outer rind, core hollow and off-white, reddening instantly with KOH. Smell mild, slightly fruity to musty. Taste minimal, indistinct.

Basidiospores dark orange–brown (7E7–7E8) in heavy deposit, 10–16 × 8–11 (–13) µm, means = 12–14 × 9.5–11 µm, $Q = (1.0–) 1.10–1.44$ (–1.56), Q means = 1.18–1.33 (70 spores, 5 specimens), ellipsoid to amygdaloid, verrucose, plage present under SEM. Basidia 4-spored, clavate, (40–) 50–60 (–65) × (8–) 9–15 (–16) µm.

Cheilocystidia scattered to abundant, ventricose-rostrate to lageniform, opaque greyish or brown in KOH, (60–) 70–90 (–100) $\mu\text{m} \times$ (10–) 20–30 (–40) μm . Pleurocystidia infrequent, ventricose to ventricose–rostrate, grey or rarely brown in KOH, (60–) 70–110 (–125) \times (10–) 25–40 (–45) μm . Pileipellis a trichoderm, organized into discrete, suberect fascicles; hyphae (10–) 15–30 (–35) μm wide, (225–) 270–500 (–550) μm high, light brown in KOH, multiseptate; terminal cells undifferentiated, rounded at apex, or occasionally subclavate. Clamp connections present.

Ecology and distribution. Solitary to scattered on humic mat of forest floor in forests dominated by *Dicymbe corymbosa* (Caesalpinioideae) on lateritic soils; also occurring in forests dominated by *Dicymbe altsonii*, *Aldina insignis* (Papilionoideae), and *Pakaraimaea dipterocarpacea* (Dipterocarpaceae) and *Dicymbe jenmanii* on white sand soils; known only from the Upper Potaro and Upper Mazaruni River Basins in the Pakaraima Mountains of Guyana, in the central Guiana Shield.

Other specimens examined. Guyana, Region 8 Potaro-Siparuni: Pakaraima Mountains, Upper Potaro River Basin, within a 15 km radius of Potaro base camp at 5°18'04"N; 59°54'40"W, 710 m alt., on lateritic soils; 1 km SE of Potaro base camp on Benny's Ridge, (*Dicymbe corymbosa*), 7 July 2003, T.W.Henkel 8539 (BRG; HSU G1169; TENN 069831). ~15 km E of Potaro base in vicinity of Tadang base camp, (*Dicymbe altsonii*, *Aldina insignis*), 30 Dec 2009, T.W.Henkel 9180 (BRG; HSU G1170; TENN 069830). 200 m southwest of Tadang base camp (*Dicymbe corymbosa*, *Dicymbe altsonii*, *Aldina insignis*), 6 June 2013, T.W.Henkel 9752 (BRG; HSU G1171). Region 7 Mazaruni-Cuyuni: Pakaraima Mountains, Upper Mazaruni River Basin, within 1 km radius of base camp at 5°26'21"N, 60°04'43"W, ~800 m alt., on white sand soils; 1 km SW of base camp in monodominant stand of *Pakaraimaea dipterocarpacea*, 25 Dec 2010, T.W.Henkel 9543 (BRG; HSU G1172). Pakaraima Mountains, Upper Mazaruni River Basin, within 1 km radius of base camp at 5°26'21"N, 60°04'43"W, ~800 m alt., on white sand soils; 1 km SW of base camp in monodominant stand of *Pakaraimaea dipterocarpacea*, 5 June 2012, T.W.Henkel 9690 (BRG; HSU G1173).

Discussion. *Cortinarius altissimus* was treated as '*Cortinarius* sp. SA1' in Harrower et al. (2015). The species has an exceptionally long stipe compared to the width of its pileus, and overall one of the longest stipe lengths recorded in the genus. The size of its basidiospores overlaps with that of *C. kerrii*, which is known from Amazonia. However, the size of the basidia and cystidia are twice that of *C. kerrii*. Additionally, pleurocystidia are infrequent in *C. altissimus* sp. nov. whereas they are abundant in *C. kerrii*. *Cortinarius altissimus* sp. nov. is a prominent member of the ECM fungal assemblage associated with *Dicymbe* monodominant forests in Guyana. In a long-term *D. corymbosa* plot study of Henkel et al. (2012), basidiomata of *C. altissimus* sp. nov. occurred in 5.2% of 630 quadrats sampled during the May–July rainy seasons over seven years. Phylogenetically (Fig. 1), *C. altissimus* sp. nov. is most closely related to other taxa of the *C. violaceus* group that also occur in the Americas.

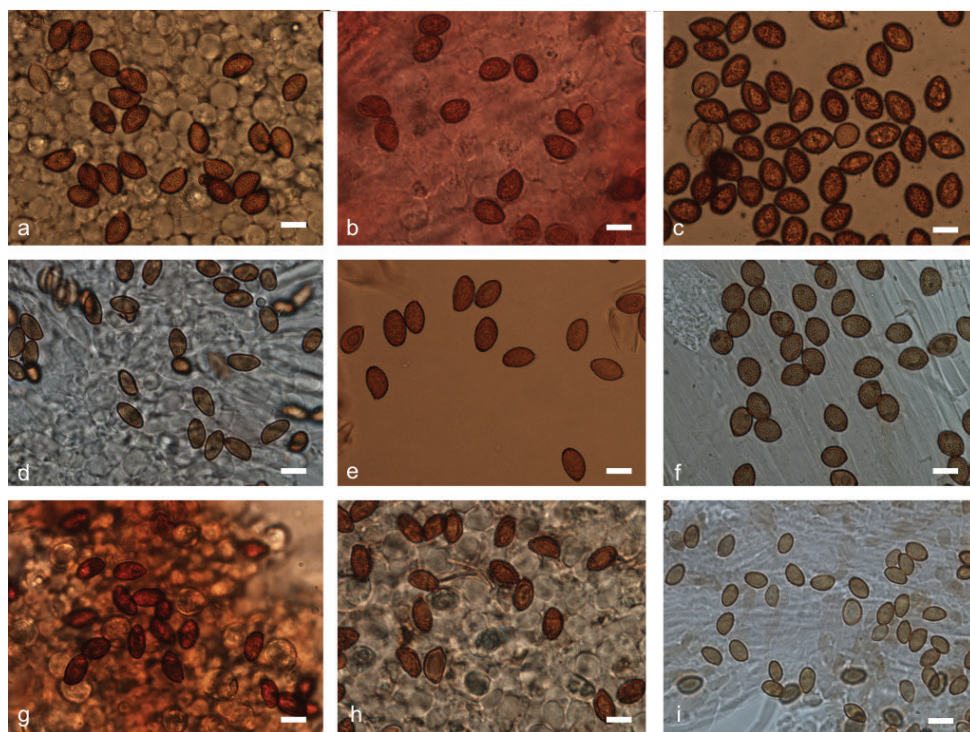


Figure 3. Light micrographs of basidiospores from the following *Cortinarius* species: **a** *C. kioloensis* (PDD 99307) **b** *C. palatinus* (NY 00795933) **c** *C. altissimus* (TENN 069830) **d** *C. hallowellensis* (MEL 2300544) **e** *C. neotropicus* (NY 34729 TYPE) **f** *C. carneipallidus* (PDD 95444 TYPE) **g** *C. atrotomentosus* (TENN 065535 TYPE) **h** *C. violaceus* (TENN 062899) **i** *C. austroviolaceus* (MEL 227499). Scale bar = 10 μ m.

Cortinarius hallowellensis Wood, 2009

Figs 1, 2d, 3d, 4d

Type. AUSTRALIA. Western Australia: Mount Hallowell Reserve, (*Eucalyptus*) 22 May 1993 K. Syme (holotype: PERTH005506794).

Description. Pileus 34–90 mm wide, not velvety or velvety smooth, not at all squamulose, greasy when wet, radially innately fibrillose when dry, dark violet (18F4), red in 5% KOH. Lamellae broadly adnexed to adnate, 4–9 mm deep, subdistant, dark violet (16F5), edge smooth, entire, lamellulae abundant in 2 tiers. Stipe 37–80 mm long, 10–30 mm thick, dry, longitudinally fibrillose, cylindrical to clavate with a swollen base, 16F4 (dark violet). Universal veil deep violaceous. Context firm in pileus, fibrous in mature stipe, pallid, tinged purplish (16A2) especially near outside; purple slate/deep purple in stipe and middle of pileus surrounded by speckled white in pileus; yellow-brown at base of stipe. Basal mycelium whitish. Odor not distinctive. Taste none.

Basidiospores (8.5–) 10–13.5 μ m \times (5–) 6–7.5 μ m, means = 10–12 μ m \times 6–7 μ m, Q = 1.55–1.95, Q means = 1.55–1.94, (150 spores, 6 specimens), ellipsoid to

subamygdaliform, moderately verrucose, plage barely noticeable under SEM. Basidia 4-spored, clavate, (25–) 30–50 (–65) $\mu\text{m} \times 9\text{--}12\ \mu\text{m}$. Cheilocystidia abundant, narrowly fusiform, purple or brown in KOH, (50–) 55–95 (–130) $\mu\text{m} \times 10\text{--}20\ \mu\text{m}$. Pleurocystidia abundant, narrowly fusiform, purple or brown in KOH, (40–) 50–90 (–105) $\mu\text{m} \times (5\text{--}) 10\text{--}15\ \mu\text{m}$. Caulocystidia not observed. Pileipellis an ixocutis, of even thickness throughout. Hyphae 2.5–11.0 μm wide. Clamp connections present.

Ecology and distribution. With *Eucalyptus*, *Corymbia*, *Melaleuca*, *Allocasuarina*, *Agonis*, and/or *Leptospermum* in Western Australia and Tasmania. Fruiting May and June.

Other specimens examined. Australia. Tasmania: Scamander, Winifred Curtis Scamander Reserve, near Boundary Track (*Allocasuarina verticillata* and *Eucalyptus*), 8 June 2003, D.A. Ratkowsky (MEL 2350466). Hobart, Peter Murrell Nature Reserve. Site HEG. [55G, 524296, 5258469], (*Allocasuarina monilifera*, *Eucalyptus amygdalina*, *Leptospermum scoparium*), 10 July 2001, S. McMullan-Fischer (MEL 2300544). Western Australia: Two Peoples Bay Nature Reserve, Moates Lake access road (*Allocasuarina monilifera*, *Eucalyptus amygdalina*, *Leptospermum scoparium*), 7 May 1991, K. Syme (PERTH 3978729). Cemetery Road near Walpole-Nornalup National Park (*Eucalyptus marginata*, *Corymbia calophylla*, *Agonis flexuosa*, *Agonis parvceps*, *Agonis hypericifolia*, *Allocasuarina fraseriana*, *Melaleuca* sp.), 3 May 1992, K. Syme, N.L. Bougher & M. Hart (PERTH 7581696).

Discussion. *Cortinarius hallowellensis* was treated as ‘*Cortinarius* sp. AU2’ in Harrower et al. (2015). Based on sequencing the type, we have demonstrated that this species occurs in Tasmania as well as Western Australia. *Cortinarius hallowellensis* is unique in the *C. violaceus* group in that it has an ixocutis instead of a trichoderm and is the deepest diverging lineage in the *C. violaceus* clade (Fig. 1). Macroscopically, the pileus is not at all squamulose. The suprapellis is mucilaginous imparting a greasy appearance when wet. The only other species in the *C. violaceus* group found in Australia – *C. kioloensis* is readily distinguished from *C. hallowellensis* by its dry, tomentulose-squamulose pileus. *Cortinarius jenolanensis*, *C. paraviolaceus* and *C. austroviolaceus* lack a squamulose pileus, but unlike *C. hallowellensis*, they lack pleurocystidia and/or cheilocystidia. *Cortinarius hallowellensis* is also referred to as *C. violaceus* by Bougher and Syme (1998) (PERTH 5506794 illustrated). Unique molecular synapomorphies are found at pos. 63, 100, 101, 123, 132, 148, 163, 164, 180, 228 (ITS1), 462, 532, 540, 546, 577, 602, 611, 614, 643 (ITS2) in our alignment.

***Cortinarius neotropicus* Harrower, sp. nov.**

Mycobank MB 811660

Figs 1, 2e, 3e, 4e

Diagnosis. Similar to *Cortinarius palatinus* Harrower sp. nov. but differs by its longer basidiospores and presence of caulocystidia. Unique molecular synapomorphies are found at pos. 58, 161, 200, 205 (ITS1), 467, 566 (ITS2) in our alignment.

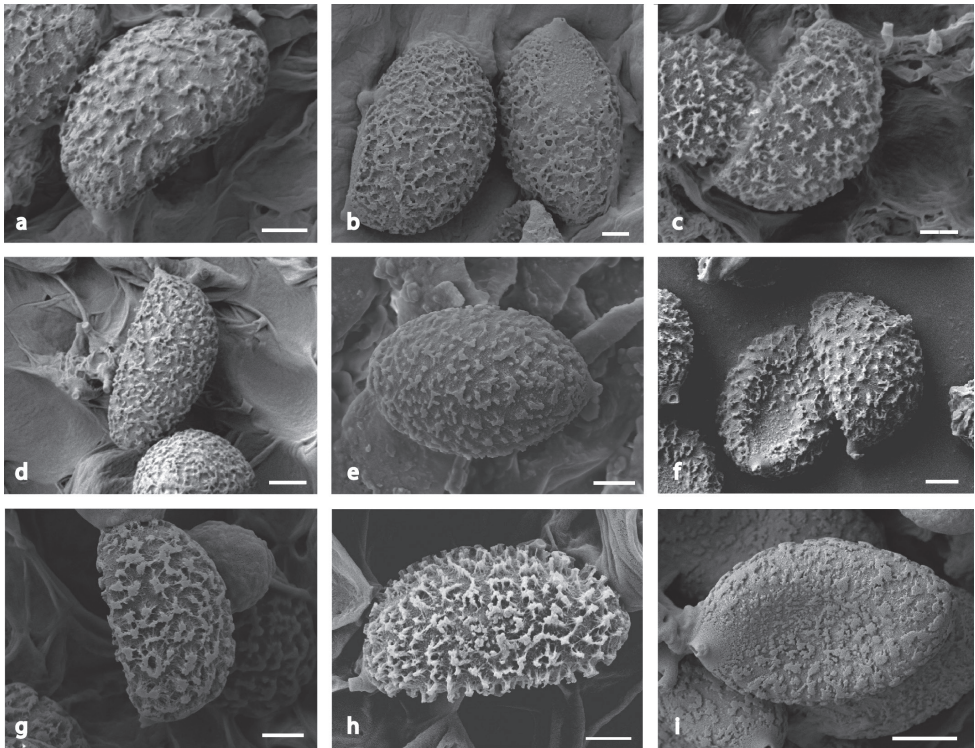


Figure 4. SEM micrographs of basidiospores from the following *Cortinarius* species: **a** *C. kioloensis* (MEL 2351101) **b** *C. palatinus* (NY 796168 TYPE) **c** *C. altissimus* (TENN 069830) **d** *C. hallowellensis* (MEL 2300544) **e** *C. neotropicus* (NY 34729 TYPE) **f** *C. carneipallidus* (PDD 71219) **g** *C. atrotomentosus* (TENN 065535 TYPE) **h** *C. violaceus* (TENN 063104) **i** *C. austroviolaceus* (MEL 2121961 PARATYPE). Scale bar = 2 μ m.

Type. COSTA RICA. San Jose: Perez Zeledon, Villa Mills, CATIE Experimental Forest, 9°33'03"N; 83°40'55"W, 2880 m, (*Quercus costaricensis*), 22 June 1994, R.E.Halling 7330 (holotype: NY 34729).

Etymology. Refers to where it is found: the neotropics.

Description. Pileus 28–88 mm wide, convex to plano-convex, surface dry, not hygrophanous, squamulose to appressed squamulose, (18D3-6, 18E3-6), dull violet to greyish violet, red with KOH. Lamellae subdistant, adnexed to adnate, average thickness, ventricose, dark violet (17F2). Stipe 61–149 mm long, 4–16 mm thick at apex, 7–48 mm thick at base, tapering gradually from base to apex, sometimes clavate, dry, 18(D–E)(3–6), dull violet to grayish violet. Universal veil pale violet. Basal mycelium white. Odor mild. Taste mild.

Basidiospores (11.5–) 13–17 μ m \times 7–10 μ m, means = 13–15 \times 8–9 μ m, Q = 1.53–1.77, Q means = 1.59–1.78, (200 spores, 8 specimens), ellipsoid to amygdaloid, finely verrucose, plage present under SEM. *Basidia* 4-spored, clavate, (25–) 30–45 (–55) μ m \times 10–15 μ m. *Cheilocystidia* abundant, narrowly fusiform to lageniform, brown

or grey in KOH, (40–) 50–75 (–95) $\mu\text{m} \times$ (10–) 15–20 (–30) μm . Pleurocystidia abundant, narrowly fusiform to lageniform, sometimes subcapitate, brown or grey in KOH, (35–) 50–90 (–120) $\mu\text{m} \times$ 10–25 (–40) μm . Caulocystidia present. Pileipellis a trichoderm, composed of interwoven smooth hyphae, these 9–20 μm wide, 265–415 μm high, multiseptate, with brown contents in KOH, terminal hyphae mostly blunt-ended, some lanceolate. Clamp connections present.

Ecology and distribution. Known from Costa Rica and Colombia. With *Quercus copeyensis*, *Q. seemannii*, and *Q. costaricensis* in Costa Rica and with *Q. humboldtii* and *Trigobalanus* in Colombia. 2200–2880 m alt. Fruiting late May to the end of August in Costa Rica and November in Colombia.

Other specimens examined. Colombia. Huila: Finca Merenberg, (*Quercus humboldtii*), 21 May 1987, R.E.Halling 5284 (NY). Valle del Cauca: Municipio de Pance, Parque Nacional Los Farallones, above El Topacio, (*Trigonobalanus*), 17 Nov. 1988, A.E.Franco-Molano 151 (NY). Costa Rica. San Jose: Perez Zeledon, Villa Mills, CATIE Experimental Forest, 9°33'03"N 83°40'60" W (*Quercus costaricensis*), 30 June 1998, R.E.Halling 7787 (NY 75934). Perez Zeledon, Villa Mills, CATIE Experimental Forest, 9°33'03"N; 83°40'60"W, 2840 m, (*Quercus costaricensis*), 27 June 2000, R.E.Halling 7946 (NY 460484). San Gerardo de Dota, Albergue de Montana, Savegre, ~5 km SW of Cerro de la Muerte, 9°33'02"N; 83°48'27"W, 2200 m alt., (*Quercus copeyensis* and *Q. seemannii*), 9 June 2001, R.E.Halling 8154 (NY 795935). San Gerardo de Dota, Albergue de Montana, Savegre, ~5 km SW of Cerro de la Muerte, 9°33'02"N; 83°48'27"W, 2500 m alt., (*Quercus copeyensis* and *Q. seemannii*), 8 June 1997, R.E.Halling 7709 (NY 181476). La Guaria, 9°35'60"N; 83°58'60"W, 2300 m alt., (*Quercus copeyensis* and *Q. seemannii*), 21 Aug. 1995, A.E.Franco-Molano 1393 (NY).

Discussion. *Cortinarius neotropicus* sp. nov. was treated as '*Cortinarius* sp. CR1' in Harrower et al. (2015). This species can be distinguished from *C. palatinus* sp. nov., with which it co-occurs in Costa Rica, by its smaller and finely verrucose basidiospores. In addition, *C. neotropicus* sp. nov. and *C. violaceus* both have caulocystidia, whereas other species in the *C. violaceus* group (such as *C. palatinus* sp. nov. and *C. atrotomentosus* sp. nov.) do not. Colors of the basal mycelium and context have not been recorded. There are no microscopic characters that can be used to distinguish it from *C. violaceus*, and the two species are supported as sister lineages (Fig. 1).

***Cortinarius carneipallidus* Harrower & E. Horak, sp. nov.**

Mycobank MB 811661

Figs 1, 2f, 3f, 4f

Diagnosis. Similar to *Cortinarius kioloensis* but differs by its association with *Nothofagus*. Unique molecular synapomorphies at pos. 33, 157, 170, 190, 233, 249 (ITS1), 472, 480, 489, 525, 607, 670 (ITS2).

Type. NEW ZEALAND. Ruapehu: Tongariro National Park, Mt. Ruapehu, Blyth Track, (*Nothofagus solandri*) 21 April 2009, J.A. Cooper (holotype: PDD 95444).

Etymology. Means ‘pale flesh’, referring to the relative lack of purple pigment in the center context of this species compared to *C. violaceus*, *C. atrotomentosus*, *C. atrolazulinus*, *C. atroviolaceus* and *C. subcalyptrosporus*.

Description. Pileus 49–100 mm wide, surface dry, convex then plano-convex, tomentose to fine scaly, dark violet (16D5–8), paler at margin, red in KOH. Lamellae crowded, emarginate-adnexed, average thickness, broad, deep violet. Stipe 96–175 mm long, 5–11 mm thick at apex, 12–30 mm thick at base, subequal, sometimes slightly bulbous, tapering gradually from base to apex, pale violet (17C3–6), covered in copious veil material. Universal veil pale violet (same color as stipe), leaving bands on the stipe. Basal mycelium pale violet. Context white flecked with violet in pileus and lower half of stipe, upper half of stipe violet flecked with white, sometimes white with violet cortex, younger specimens violet flecked with white and only fully white in the base.

Basidiospores (9–) 10–12 (–13) $\mu\text{m} \times$ (7–) 8–9 (–9.5) μm , means = 10.5–12 $\mu\text{m} \times$ 8–8.5 μm , $Q = 1.19\text{--}1.64$, Q means = 1.30–1.45, (224 spores, 8 specimens). Ellipsoid to amygdaloid, strongly verrucose, plage present. Basidia 4 spored, clavate, (35–) 40–50 (–55) $\mu\text{m} \times$ (9–) 10–12 (–13) μm . Cheilocystidia abundant, narrowly fusiform to lageniform, brown in KOH, 60–90 (–100) $\mu\text{m} \times$ 15–20 (–25) μm . Pleurocystidia abundant, narrowly fusiform to lageniform, sometimes subcapitate, brown in KOH, (40–) 55–80 (–100) $\mu\text{m} \times$ (10–) 15–25 (–30) μm . Caulocystidia not seen. Pileipellis a trichoderm, composed of smooth hyphae 10–25 μm wide, 350–370 μm long, multiseptate, brown content in KOH, terminal cells bottle-shaped, clavate, lanceolate or ending bluntly. Clamp connections present.

Ecology and distribution. Under *Nothofagus* in New Zealand. Fruiting April to June.

Other specimens examined. New Zealand. Wellington: Kapiti Coast, Tararua Forest Park (*Nothofagus*), 16 May 2009, K. Hosaka (PDD 98057). Canterbury: Selwyn Klondyke Corner (*Nothofagus cliffortioides*), 5 June 2010, P. White (PDD 95823). Waikato: Taupo, Erua Forest National Park, Erua Forest rest area (*Nothofagus*), 8 Apr. 2005, L. Fischer (PDD 82693). Taupo, Mt. Ruapehu, Tongariro National Park, Whakapapanui Track, Buller 28 Apr. 2001, E. Horak (PDD 72636). West Coast: Buller, Springs Junction, Lake Christabel Track, 14 Apr. 2000, E. Horak (PDD 71219). Buller, Reefton, Victoria Forest Park, Tawhai Walk, (*Nothofagus*) 13 May 2006, E. Horak (PDD 88638). Buller, South Charleston, Tiropahi Track (*Nothofagus*) 8 May 2010, A. Roberts (PDD 88995).

Discussion. *Cortinarius carneipallidus* sp. nov. differs from *C. subcalyptrosporus* by the absence of calyptrate basidiospores. The association with *Nothofagus* distinguishes this species ecologically from *C. atroviolaceus*, which likely associates with members of the Myrtaceae and/or Fagaceae in Malaysia. The context is hygrophanous purple in young specimens. In older specimens, it is hygrophanous grey or white in the pileus and base and only purple at the stipe apex. The only other species described from Indonesia or Australasia to have whitish flesh is *C. kioloensis*. It differs from *C. kioloensis*, with which it forms a sister group relationship (Fig. 1), by its association with *Nothofa-*

gus. *C. carneipallidus* has a wider pileus and longer stipe than *C. atrolazulinus*. The width of the basidiospores is wider than those in *C. atrolazulinus* as well.

Cortinarius carneipallidus sp. nov. has been variously identified as *C. atroviolaceus*, *C. atrolazulinus*, *C. subcalyptosporus*, *C. violaceus* and *Cortinarius* sp. The species was treated as '*C. violaceus* sensu Moser 1986' in Harrower et al. (2015) but differs from north temperate *C. violaceus* by the absence of caulocystidia and association with *Nothofagus*. However, the name '*C. violaceus* sensu Moser 1986' was applied based on interpretation of the protologue only, and as no specimens of '*C. violaceus* sensu Moser 1986' were examined, we do not intend to synonymize the former with *C. carneipallidus*.

***Cortinarius atrotomentosus* Harrower, sp. nov.**

Mycobank MB 811662

Figs 1, 2c, 3g, 4g

Diagnosis. Similar to *Cortinarius violaceus* (L.: Fr.) Gray but differs by having smaller spores and shorter basidia as well as an absence of caulocystidia. Unique molecular synapomorphies at pos. 71 (ITS1), and 606 (ITS2) are present in our alignment.

Type. USA, Florida: Wakulla Co., Crawfordville, Apalachicola National Forest (30°12'06"N; 84°26'33"W), on soil under *Quercus virginiana*, 4 Dec. 2010, TFB 13848, (holotype: TENN 065527).

Etymology. Meaning 'dark-tomentose' in reference to the dark coloration of the fruiting body.

Description. Pileus 26–91 mm wide, surface dry, tomentose to fine scaly, dark violet (17F3) to dark brown in age (7F3), red in KOH. Lamellae adnexed, not sinuate, close to subdistant, thin, ventricose, dark violet (17F3). Stipe 75–131 mm long, 8–18 mm thick at apex, 17–26 mm thick at base, ventricose, silky-glabrous, olive brown (4E6) to brownish grey in age (5D2). Basal mycelium lilac (16B4) to greyish magenta (14D3). Context purple grey (13E2) to reddish brown (10D4). Smell mild. Taste none. Basidiospores (9–) 10.5–13 (–14.0) $\mu\text{m} \times$ (6–) 7–8 μm , means = 10.5–12 $\mu\text{m} \times$ 6–8 μm , $Q = 1.43\text{--}1.67$, Q means = 1.50–1.53, (70 spores, three specimens), ellipsoid to amygdaloid, strongly verrucose, plage present under SEM. Basidia 4-spored, clavate, 20–30 \times 10–12 μm . Cheilocystidia abundant, narrowly fusiform to lageniform, brown in KOH, 50–70 (–80) $\mu\text{m} \times$ 15–25 μm . Pleurocystidia abundant, narrowly fusiform to lageniform, brown in KOH, 43–65 (–70) \times 15–20 μm . Caulocystidia not seen. Pileipellis a trichoderm, hyphae 6–20 μm wide, 185–370 μm high, multiseptate, brown content in KOH, terminal hyphae mainly blunt-ended, some lanceolate or acuminate. Clamp connections present.

Ecology and distribution. Under *Quercus virginiana*. Known only from Apalachicola National Forest, Crawfordville, Florida, USA. Fruiting early December.

Other specimens examined. USA, Florida: Wakulla Co., Crawfordville, Apalachicola National Forest (30°12'07"N; 84°26'33"W), (*Quercus virginiana*), 2 Dec. 2010, D.Lewis & B.Petty TFB 13840 (TENN 065527).

Discussion. *Cortinarius atrotomentosus* sp. nov. was treated as ‘*Cortinarius* sp. NA1’ in Harrower et al. (2015). This species can be differentiated from *C. violaceus* by its dark violet to dark brown pileus and the olive brown to brownish grey stipe. The context of *C. violaceus* is violet to greyish, not mauve as is *C. atrotomentosus* sp. nov. Caulocystidia were not found on this species whereas they are present in *C. neotropicus* sp. nov. and *C. violaceus*. The current Gulf Coast geographic distribution of *C. atrotomentosus* sp. nov., where it associates with *Quercus*, does not overlap with the more northerly distribution of *C. violaceus*. The species differs from *C. palatinus* sp. nov., with which it appears to be most closely related (Fig. 1), by its location (Gulf Coast region) and its dark exterior. The basal mycelium is the only part of the fruiting body that could be described as pale violet.

Species inquirendae

Cortinarius hercynicus (Pers.) M.M.Moser 1967

Cortinarius hercynicus differs from *C. violaceus* s.s. by having smaller and broader basidiospores and occurrence in coniferous forests. Harrower et al. (2015) did not find a molecular difference between *C. hercynicus* and *C. violaceus*, but taxon sampling of *C. hercynicus* was not adequate. Brandrud (1983) treated *C. hercynicus* as a variety of *C. violaceus*. However, in Harrower et al. (2015) samples of *C. violaceus* s.l. recorded from coniferous forests and separately in hardwood forests failed to form monophyletic groups suggesting that host association is of no taxonomic significance. Thus, current data suggest *C. hercynicus* is synonymous with *C. violaceus*.

Species excludendae

Cortinarius austroviolaceus Gasparini 2001

Fig 2i, 3i, 4i

This species is phylogenetically placed outside of *Cortinarius* sect. *Cortinarius* (Harrower et al. 2015). In comparison to species within the section, the basidiospores lack a plage (Fig. 3i), the basidiospore ornamentation differs (less coarsely ornamented) at the SEM level, and pleurocystidia are absent.

Cortinarius gayi E. Horak 1980

Fig 2h

The purple color and densely squamulose or fibrillose pileus is consistent with most other species in sect. *Cortinarius*. However, *C. gayi* lacks both pleurocystidia and

cheilocystidia, and a plage is reportedly absent from the basidiospores. This species may have closer to affinities to *C. austroviolaceus* than sect. *Cortinarius*.

***Cortinarius paraviolaceus* M.M.Moser 1987**

This species is described as having a pileus that is “rather intensely violaceus...the center becoming dull tawny ochraceus” (Moser 1987). The stipe is described as “violaceus tomentose at the base, otherwise brownish fibrillose with the cortina”. Pleurocystidia are rare and no cheilocystidia were observed (Moser 1987). The pileus is “not strongly squarrose-fibrillose-squamulose”. These characters, taken together, are not consistent with the *C. violaceus* group.

***Cortinarius jenolanensis* Wood 2009**

This species has a smooth pileus and cheilocystidia, but lacks pleurocystidia. This species may have closer to affinities to *C. austroviolaceus* than sect. *Cortinarius*.

***Cortinarius atrolazulinus* M.M. Moser sensu Soop 2008**

Known collections (not examined by the authors): New Zealand. Southland: Southland, Fiordland, Lake Gunn Track, (*Nothofagus*), 5 May 2001, K. Soop KS CO1223 (PDD103879; GenBank KF727372; KF727328). Taupo: Taupo, Kaimanawa Forest Park, Cascade Hut Track, (*Nothofagus*) 9 May 2009 K. Soop KS CO1917 (PDD97542).

C. atrolazulinus was described by Moser (1987) from *Nothofagus* forest in New Zealand. These two collections match Moser’s description well, which includes the presence of cheilocystidia and pleurocystidia. Phylogenetic analyses (not shown) place it in an unknown clade outside of *Cortinarius* sect. *Cortinarius*. Further morphological and genetic analyses are needed to correctly classify this species. Attempts to sequence the type collection of *C. atrolazulinus* (ZT 69-276) were unsuccessful.

***Cortinarius atroviolaceus* M.M. Moser sensu Shirley**

New Zealand: Auckland, Kauri Point Reserve. (*Leptospermum*) *C. Shirley* AK 369 (PDD; GenBank KT444633; KT444634).

Pileus fibrillose, not tomentose. Epicutis not a trichoderm, hyphae 6-14 µm wide, blue extracellular pigment clumps. Purple intracellular pigment readily dissolving in KOH. Spores 7.5-8.5 x 4-5 µm. Cheilocystidia and pleurocystidia present. This species shares 90% ITS sequence identity with one member of *Cortinarius* sect. *Cortinarius* (*C. carneipallidus*) at best. It shows higher sequence identity to members outside of the

section. Phylogenetic analyses (not shown) could not place it within the section with confidence. *Cortinarius jenolanensis* has wider spores and lacks pleurocystidia, compared to this species. *Cortinarius atrovioleaceus* M.M. Moser has much longer and wider spores. As there is only one collection of this species, with inadequate documentation, more work needs to be done to document and classify this species.

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Contemporary documentation of the rare eastern North American species *Inocybe insignis* (Inocybaceae, Agaricales)

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Abstract

Inocybe insignis, an eastern North American species with greenish blue staining basidiomes, is documented for the first time since its original description circa 75 years ago in the Great Smoky Mountains. Here, we provide a detailed macroscopic and microscopic description and photographs of this rarely collected species, based on material collected in an Illinois oak-hickory forest. Analysis of molecular phylogenetic data strongly supports an evolutionary alliance with Asian and Australasian species of the *Inocybe asterospora* group. The combination of stellate basidiospores, marginate stipe base, entirely pruinose stipe, rimose pileus, and strong distinctive odor corroborates the molecular results, but the closest relatives of *I. insignis* lack the greenish blue staining characteristic of *I. insignis*.

Key words

Bluing species, rare fungi, systematics, taxonomy

Introduction

Inocybe insignis Smith was described in 1941 on the basis of a collection of a single basidiome, made in Aug. 1938 (AHS 9781, held in MICH) in the Great Smoky Mountains National Park in Tennessee. Smith noted that “[t]he species is known only from the

type,” and that it “possesses so many unusual characters that it would be difficult to confuse it with any other *Inocybe*” (p. 12). The combination of stellate basidiospores, presence of pleurocystidia, and green to blue bruising is apparently unique; better-known bluing species like *I. calamistrata* (Fr.: Fr.) Gill. feature smooth spores and lack pleurocystidia. Other bluing species with smooth basidiospores and pleurocystidia include *I. corydalina* Quél. and allies and *I. aeruginascens* Babos (Kosentka et al. 2013); these species, however, exhibit their bluing reaction due to presence of hallucinogenic secondary metabolites (Kuyper 1986). Beyond the holotype collection, we find no records of further *Inocybe insignis* collections in American herbaria, despite Smith’s inclusion of the species in a popular identification resource, *How to Know the Gilled Mushrooms* (Smith et al. 1979). The collection described in the present work was made in 2011 from central Illinois and consists of about a dozen basidiomes.

Methods

Collection of fresh basidiomes followed methods in Kuo and Matheny (2014). Colors were recorded and codified following HEX codes displayed on a 2013 iMac with Intel Iris Pro graphics, using GNU Image Manipulation Program (GIMP) 2.8.10. Microscopic features were studied using hand sections of fresh material, and of dried specimens rehydrated in water after immersion in 90% alcohol. Sections were mounted in 2% KOH, Melzer’s reagent, and lactophenol and cotton blue, and viewed using a Nikon Alphaphot YS microscope. Specimens are deposited in the New York Botanic Garden (NY) and the University of Tennessee Fungus Herbarium (TENN). Herbaria are cited according to Thiers (continuously updated).

DNA was extracted and sequenced from a recently dried basidiome following protocols outlined in Judge et al. (2010). Three nuclear gene regions were amplified: the internal transcribed spacers (ITS) of the ribosomal RNA operon, the first 1350 bp of the large subunit ribosomal RNA (nLSU), and the second largest subunit of RNA polymerase II (*rpb2*) between conserved domains six and seven. For the LSU region, primers LR0R and LR7 were used for PCR and sequencing, in addition to use of LR5 as a sequencing primer, as in Baroni and Matheny (2011). DNA sequences of *I. insignis* have been released on GenBank (KP170913, KM245989). Destructive sampling of the holotype collection at MICH was avoided since the collection is represented by a single specimen.

All sequences were concatenated into a DNA sequence alignment in MacClade (Maddison and Maddison 2005). Based on BLASTn searches of sequences available in GenBank, taxa were sampled with affinities to *Inocybe asterospora* Quél. Sequences of *Inocybe mixtilis* (Britzelm.) Sacc. were used for rooting purposes as it is known this species diverged outside the *I. asterospora* group (Matheny et al. 2009, Ryberg et al. 2012). A GTR model of molecular evolution was used, together with an invariant proportion of sites parameter and gamma distributed rate heterogeneity, using Maximum Likeli-

hood (ML) in the program RAxML 7.2.8 (Stamatakis 2006). 500 bootstrap replicates were employed to evaluate the statistical significance of groupings within the resulting best ML tree. The concatenated alignment is available at http://www.bio.utk.edu/matheny/Site/Alignments_%26_Data_Sets.html or by request from the authors.

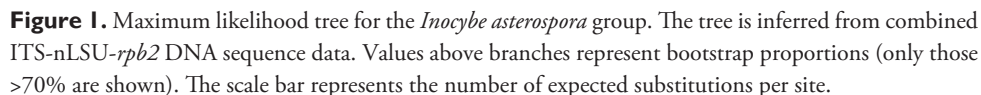
Results

Although an ITS amplicon was produced for *I. insignis*, heterogeneity in both spacers precluded direct sequencing of this product. Eight coding sites within the *rpb2* gene region sequenced were found to be polymorphic, seven of which are silent. One polymorphic site was observed in the nLSU gene region sequenced.

The molecular dataset contains sequences from 19 vouchered specimens (Table 1) and 2874 included sites. 28 sites of the ITS region were too ambiguous to align and were thus omitted before phylogenetic analysis. ML analysis supports the autonomous status of *Inocybe insignis* in the *I. asterospora* group (Fig. 1). The species is most closely related to a well-supported cluster of Australasian and southeast Asian species (Horak et al. 2015) characterized by a suite of similar characteristics: stellate basidiospores, entirely pruinose stipe, marginate stipe base, thick-walled pleurocystidia, rimose or strongly rimose pileus surface, and generally distinctive odor (spermatic).

Table 1. Taxon sampling and DNA sequences used in this study.

Species	Specimen-voucher	GenBank accession no.		
		ITS	LSU	<i>rpb2</i>
<i>I. asterospora</i> aff.	DJLTN06-58 (TENN)	—	JN974975	—
	PBM3309 (TENN)	—	KM197215	KM245976
<i>I. asterospora</i> cf.	MR00015	AM882897	AM882897	—
	PBM2453 (TENN)	DQ404390	AY702015	—
<i>I. insignis</i>	MK07101101 (TENN)	—	KP170913	KM245989
<i>I. mixtilis</i>	HL2002 (CANB)	KP308781	KP170952	KM406195
	PAM05103003 (TENN)	HQ585870	HQ641113	KM406197
	PAM07110104 (LIP)	HQ586872	HQ641115	KM406196
	PBM1315 (WTU)	—	AY380387	AY337395
	NLB972 (PERTH)	KP308790	KP170960	KM406203
<i>I. nobilissima</i> ined.	NLB974 (PERTH)	KP308791	KP170961	KM406204
	PBM3772 (TENN)	KP308789	KP170959	KM406202
	DED8058 (SFSU)	EU600838	EU600838	KM406219
<i>I. pileosulcata</i>	DED8164 (SFSU)	GQ892996	GQ892951	—
	TBGT10742	KP308810	KP170979	KM406218
<i>I. pileosulcata</i> aff.	DED8163 (SFSU)	GQ892997	GQ892952	KM406219
<i>I. vagata</i> ined.	PBM3187 (CANB)	KP641639	KP171091	KM656135
	PDD72861	HM060326	HM060325	—
<i>Inocybe</i> sp.	DED8044 (SFSU)	GQ892995	GQ892950	KM656121



MycoBank 278222

Type. United States of America. Tennessee, Sevier County: near Keener House, Great Smoky Mountains National Park, under mixed beech and hemlock, 3 Aug 1939, A. H. Smith 9781 (MICH 11068, *non vide*).

Pileus 30–60 mm broad; conic to obtusely conic at first, becoming broadly conic to applanate, with a broad, low umbo; surface dry, radially appressed fibrillose, becoming radially rimose, finely squamulose over the disc, dull brown (664139) to medium orangish brown (784333), with a slightly darker center, bruising greenish blue (445253), negative with the application of 15% KOH; context up to 7 mm thick

on the disc, whitish, unchanging or slowly turning greenish blue on exposure; odor strongly sweet and fragrant, with a spermatic component; taste not assessed. **Lamel-lae** adnate to uncinata; close; with several tiers of lamellulae; at first buff (ded1e2), becoming dull cinnamon brown (904e2e); occasionally staining greenish blue where bruised; edges concolorous, not conspicuously fimbriate. **Stipe** 50–70 × 3–4 mm; equal above a rimmed, bulbous base; surface dry, densely pruinose the entire length; cortina not observed and presumably absent; dull brown (664139) to pinkish brown (ad8796), bruising greenish blue to blackish blue (33363d); basal bulb 6–8 mm broad, subglobose, rimmed, whitish; basal mycelium whitish; context dull cinnamon brown (735c3a), unchanging or slowly turning greenish blue on exposure, becoming hollow.

Basidiospores 8–11 × 6–9 μm (including nodules); average $Q = 1.23$; subelliptic to subcruciate or irregular in outline; stellate or prominently nodulose, with 7–11 conic to subconic nodules visible; ochraceous to golden or brownish in KOH; orangish in Melzer's reagent; not cyanophilic. **Basidia** 35–40 × 8–11 μm ; clavate to subclavate; 4-sterigmate; hyaline in KOH; not reviving well after sporulation. **Pleurocystidia** 50–65 × 15–23 μm ; widely lageniform or, less commonly, subcylindric, subutriform, or subglobose, with a short basal pedicel; thick-walled (walls 1–3 μm thick), hyaline in KOH; apices crystalliferous; frequent. **Cheilocystidia** similar to pleurocystidia, frequent; paracystidia 20–30 × 5–8 μm , clavate to abruptly clavate, thin-walled, hyaline in KOH, basally clamped. **Lamellar trama** parallel, hyphae 4–15 μm wide, hyaline in KOH; elements of subhymenium narrow and cylindric, 1–2 μm wide. **Caulocystidia** 55–75 × 12–20 μm , similar to hymenial cystidia, in fascicles with paracystidia, frequent near stipe apex, less frequent near stipe base; elements of stipe trama parallel, 3–10 μm wide, smooth, hyaline in KOH. **Pileipellis** a radially oriented cutis; hyphae cylindric, 2–7 μm wide, walls smooth or finely encrusted, hyaline to brown in KOH, often clamped; cells of pileal trama 5–15 μm wide, cylindric to somewhat inflated, smooth, hyaline to brownish in KOH, septate, clamped, walls 0.5–1 μm thick. **Clamp connections** present.

Distribution. Eastern North America; central Illinois and east Tennessee.

Ecology. Growing scattered and gregariously on mossy soil under *Carya glabra* (Mill.) Sweet, *Acer saccharum* Marsh., *Quercus velutina* Lam., *Quercus imbricaria* Michx., and *Carya ovata* (Mill.) K. Koch. July. Fruiting in June (type recorded in August).

Conservation status. None. Known only from two collections.

Specimen examined. United States of America. Illinois: Shelby County, Hidden Springs State Forest, 39°18.59'N; 88°41.29'W, 10 Jun 2011, M. Kuo 07101101 (NY, TENN 066447).

Discussion. The Illinois collection described agrees with the macroscopic description of Smith (1941) in all details except the “somewhat bulbous base” recorded by Smith (basidiomes in Kuo 07101101 feature prominent, rimmed basal bulbs) and the color of the bruising, recorded by Smith as “greenish,” “sordid green,” and “sordid greenish gray” (basidiomes in Kuo 07101101 bruised greenish blue to blackish blue). The microscopic features recorded by Smith are also in agreement with those of Kuo 07101101, except for a slight difference in basidiospore morphology; Smith recorded

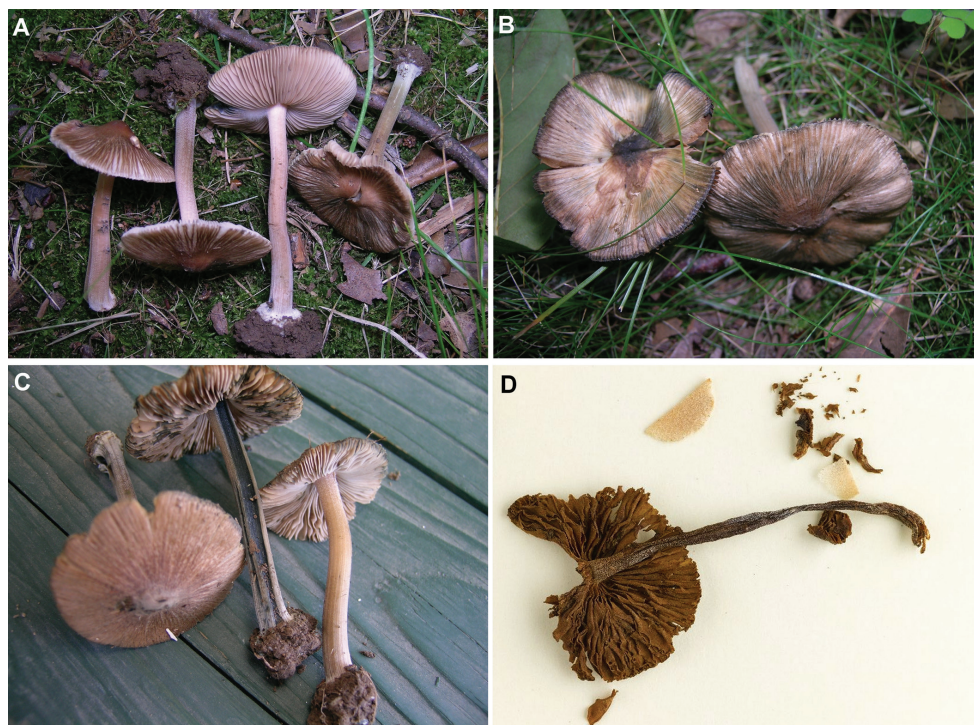


Figure 2. Basidiomes of *Inocybe insignis* (Kuo 07101101). **A–C** Kuo 07101101 **D** Holotype collection (A.H. Smith 9781, held in MICH); The Regents of the University of Michigan, Ann Arbor, MI 48109. Used with permission. Contact the University of Michigan Herbarium for details.

spores with dimensions of “(8) 9–12 × (6) 7–10 μ ” and 9–13 nodules, somewhat larger than the Illinois collection. Aside from these subtle differences, we find our current collection in complete agreement with the description of the type, which consists of but a portion of a single basidiome. While it is not possible to draw conclusions about the demographics of this species (now known from only two collections), we did observe genetic heterogeneity in all three gene regions sequenced.

Based on a multi-gene phylogenetic analysis (Fig. 1), *I. insignis* is most closely related, and indeed the sister group to, a small consortium of species from southeast Asia and Australasia. *Inocybe pileosulcata* E. Horak, Matheny & Desjardin has been recorded from Thailand and Malaysia in association with a wide assortment of ectomycorrhizal plant associates (*Dipterocarpus*, *Shorea*, *Castanopsis*, *Pinus*) in tropical lowland and montane forests (Horak et al. 2015). We are also aware of this species from dipterocarp forests in tropical regions of India. The two provisionally named Australasian species, *I. vagata* Matheny & Bougher ined. (= *I. asterospora* sensu E. Horak) and *I. nobilissima* Matheny & Bougher ined., occur in Australia and/or New Zealand, and have been recorded in forests dominated by sclerophyll vegetation (*Eucalyptus*, *Leptospermum*, *Allocasuarina*, *Acacia*) and/or mixed with *Nothofagus* in New Zealand. Despite the wide geographical disjunction in this group, all of these species share the presence of

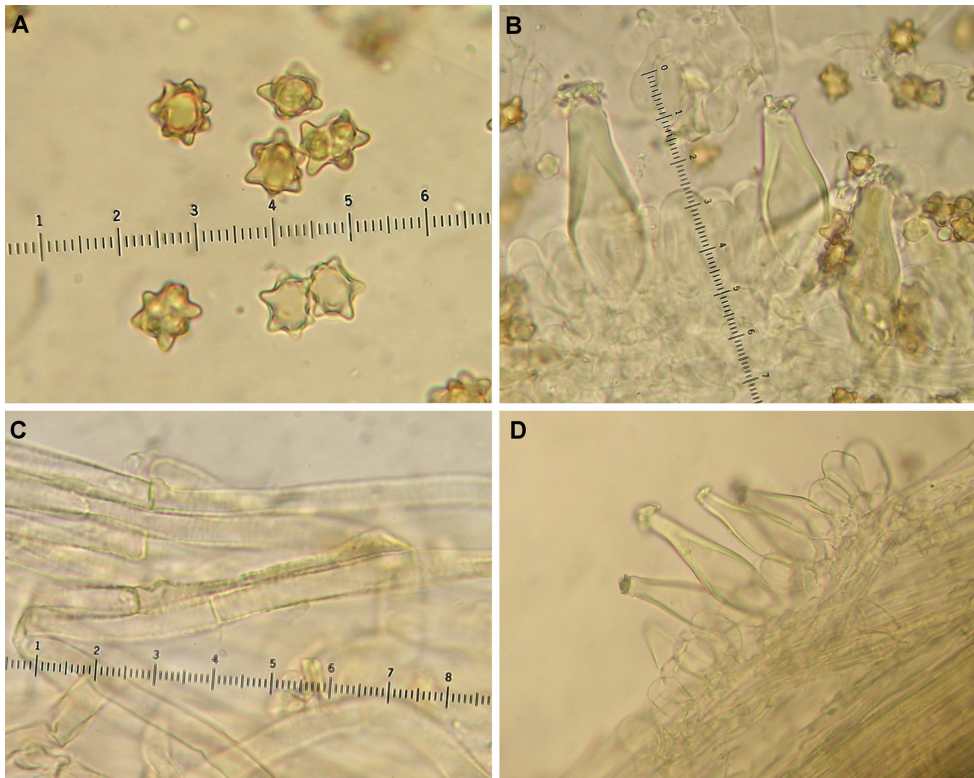


Figure 3. Microscopic features of *Inocybe insignis* (Kuo 07101101). **A** Basidiospores **B** Basidiospores and cheilocystidia **C** Pileipellis hyphae **D** Caulocystidia and cauloparacystidia.

stellate-shaped basidiospores, distinct marginate basal bulb, and conspicuous odor, typically spermatic. All three Australasian and Asian species discussed above lack the strong sweet smell (but with a spermatic component) and the greenish blue staining of basidiomes that characterize *I. insignis*.

Collections of *Inocybe xanthomelas* Boursier & Kühner could possibly be confused with *I. insignis* due to their discoloration to a fuscous or grayish black color especially after drying. However, *I. xanthomelas* does not discolor greenish blue or blackish blue, nor is it closely related phylogenetically to *I. insignis*. Other species from Europe have been documented with nodulose spores, a marginate stipe base, and flesh that changes color, particularly upon drying. The taxonomic status of these species has been addressed by Esteve-Raventós et al. (2015), but none of these have the stellate spores that characterize *I. insignis*, and all are phylogenetically remotely related to the *I. asterospora* group (Ryberg et al. 2010).

The biogeographical relationship exhibited here (Fig. 1) – a disjunct relationship between eastern North America and southeast Asia and Australasia – is one not often recorded in mushroom-forming fungi. Disjunct relationships between eastern North America and temperate east Asian species have been suggested in various groups of

macrofungi (Wu and Mueller 1997; but see Mueller et al. 2001) and between eastern North America and the Caribbean (Baroni et al. 1997). In other groups some cohesion between Asia and western North American macrofungal species has been reported (Petersen and Hughes 2003). A group worthy of investigation that might share a similar southeast Asia/Australasia-eastern North American disjunct is *Gloeocantharellus* (Corner 1969, Giachini et al. 2010). However, northern South American species have also been ascribed to *Gloeocantharellus*, and this element is apparently missing from the *I. asterospora* group.

Conclusion

The combination of outstanding taxonomic features—the greenish blue staining of basidiomes, stellate spores, rimose pileus, stipe with a marginate basal bulb, and strong odor—affirms the identity of this rare agaric as *Inocybe insignis*. This is the first report of this unusual species since it was described in 1941 from east Tennessee. Molecular phylogenetic analysis confirms close evolutionary relationships to Australasian and Asian species in the *Inocybe asterospora* group.

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New records of lichenized and lichenicolous fungi in Scandinavia

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Abstract

Fourteen species of lichenized or lichenicolous fungi are reported new to either Norway or Sweden or both countries. Several of these are rare and almost unknown. The reported species are: *Acarospora insignis* (new to Norway), *A. pyrenopsoides* (Norway, Sweden), *A. versicolor* (Norway), *Calvitimela perlata* (Sweden), *Lecideia degeliana* (Sweden), *Nephroma helveticum* (Sweden), *Peltula placodizans* (Norway), *Phacographa protoparmeliae* (Norway), *Rhizocarpon pycnocarpoides* (Norway, Sweden), *Sarcogyne algoviae* (Sweden), *Sarcogyne hypophaeoides* (Norway, Sweden), *Tephromela grumosa* (Norway), *Tremella lobariacearum* (Norway) and *Tremella wirthii* (Sweden). In addition *Cladonia albonigra* is confirmed from Sweden. *Sarcogyne hypophaeoides* is lectotypified and is also reported new to Austria.

Key words

Acarosporaceae, barcode, floristics, ITS, lichens

Introduction

Although studies of the biodiversity in Scandinavia have a long and continuous tradition, several thousands of species remain to be discovered, many of which are likely to be common. Among many of those discovered, almost nothing is known about where they occur, how they live and what their functional roles in the ecosystems are. To explore this poorly known biodiversity, the Swedish Taxonomy Initiative (STI) was established in 2002, with the aim to have all multicellular plants, fungi and animals in Sweden identified and described. Numerous taxonomic projects have been funded by the STI to investigate poorly known groups of organisms. Since 2002, almost 2000 species have been found new to Sweden and almost 1000 are new to science (Sundin 2014). In 2009, a similar project was established in Norway (the Norwegian Taxonomy Initiative, NTI), aimed at mapping all organisms in the country. Although the NTI does not provide funding for taxonomic research-projects, around 260 new species to science had been discovered in Norway until 2013 and the number of species new to Norway was approaching 1200 (<http://www.artsdatabanken.no/Article/Article/133228>). The two countries have signed a declaration of cooperation to increase the knowledge of and level of competence on biodiversity in Scandinavia, and collaborative projects have emerged. Several projects in both countries have focused on groups of lichenized and lichenicolous fungi, such as Acarosporaceae (funded by STI), lecideoid lichens (NTI, STI), Tremellales (STI), etc. During the last three years, lichen research groups in Oslo and Stockholm have collaborated and arranged workshops for lichenologists involved in these projects and beyond. Crustose, saxicolous lichens are in general very poorly known. Here, we add ten saxicolous lichens to the Scandinavian flora, mainly found in the still poorly investigated montane areas of Scandinavia. Also new macrolichens are continuously discovered in Scandinavia (Frödén 2010, Hultengren et al. 2011, Klepsland 2013, Klepsland and Timdal 2010) and here we report *Nephroma helveticum* new to Sweden, a rare and declining species in Europe that needs attention and possible conservation actions. In addition we confirm the presences of *Cladonia albonigra* in Sweden. Lichenicolous fungi are understudied and a lot of research is needed on this group (Ihlen and Wedin 2008). We have found three new species to the Nordic countries, one ascomycete, *Phacographa protoparmeliae* and two heterobasidiomycetes, *Tremella lobariacearum* and *T. wirthii*. These new records were collected during the last field seasons by some of the people involved in the different research projects funded by the STI and the NTI.

Material and methods

Material. We studied material collected during field surveys (2011–2014) funded through STI and NTI projects as well as specimens of the same species on loan from various herbaria (GB, GZU, LD, O, S, STU, UPS). All specimens collected during these field trips are deposited in the herbaria O and S.

Table 1. List of sequenced specimens with Accession numbers in the European Nucleotide Archive or GenBank.

Species	Origin	Voucher	Acc. No. (ITS)
<i>Acarospora insignis</i>	Norway, Oppland	Haugan 10022 (O L-173397)	LN890273
	Norway, Oppland	Westberg (S F265207)	LN890274
<i>Acarospora pyrenopsoides</i>	Norway, Aust-Agder	Timdal 11308 (O L-163369)	LN890275
<i>Acarospora versicolor</i>	Norway, Buskerud	Westberg 08-092 (S F268460)	LN890276
	Norway, Oppland	Westberg 08-205 (S F268463)	LN890277
<i>Nephroma helveticum</i>	Sweden, Västerbotten	Jonsson 4200 (UPS L-193714)	LN890278
	Norway, Oppland	Klepsland JK11-L559 (O L-181601)	KT800006
	Norway, Buskerud	Hofton 13176 (O L-196491)	KT800007
<i>Rhizocarpon pycnocarpoides</i>	Norway, Sør-Trøndelag	Bendiksby et al. 12630 (O L-179560)	KR780560
	Norway, Oppland	Rui & Timdal 12665 (O L-179903)	KT800002
	Norway, Buskerud	Rui & Timdal 12854 (O L-184267)	KT800003
	Norway, Nordland	Haugan 11125 (O L-183808)	KT800004
	Norway, Nord-Trøndelag	Haugan 11128 (O L-183810)	KT800005
<i>Tephromela grumosa</i>	Sweden, Bohuslän	Haugan 11501 (O L-184061)	KR303667

Morphology. Macromorphological traits were observed using a Zeiss Stemi 2000-C dissecting microscope. Microscopical examinations were carried out using squash preparations, hand-cut sections and freezing microtome sections cut at 16 µm. The preparations were observed in distilled water, lactophenol cotton blue, or 10% KOH (K). Microscopic structures in heterobasidiomycetes were studied using handmade sections stained with Phloxin (1% in water) after pre-treatment with KOH (5%), following the methods of Diederich (1996), and observed with a Zeiss Axioscope-2 microscope. Macro- and microscopic photographs were taken with a Nikon Coolpix 995 camera fitted to both microscopes or with a Nikon D300 with a macrolens with bellows. The macrophotos were processed using focus stacking with the programs Helicon Focus and Combine ZP.

Secondary chemistry. Selected specimens were examined by thin-layer chromatography (TLC), performed in accordance with the methods of Culberson (1972), as modified by Menlove (1974) and Culberson and Johnson (1982).

DNA barcoding. Some specimens (Table 1) were DNA barcoded for the nuclear ribosomal internal transcribed spacer region (ITS) through the Norwegian Barcode of Life project (<http://www.norbol.org/>) or projects funded by the STI.

The species

Acarospora insignis H.Magn, 1924

Mycobank: MB 375596

Acarospora insignis H.Magn. Svensk Bot. Tidskr. 18: 329. 1924.

Holotype. SWEDEN. Härjedalen: Viken. 1878, *P. J. Hellbom* (GB 0129823!). TLC: gyrophoric acid.

Distribution. New to Norway. This species has until now only been known from the type collection from central Sweden. Magnusson (1935) also mentioned a specimen from East Greenland. At first glance it appears to be an odd form of the common and well-known *A. fuscata* with pale brown to reddish brown areoles and a black lower surface that is typically spreading onto the edges of the upper surface (Fig. 1). The C+ red reaction of the cortex (gyrophoric acid) is also present in *A. fuscata*. However, the round, mostly scattered areoles with a single round apothecium and a very low hymenium, only between 50–65 µm tall, identifies *A. insignis*. A preliminary analysis of ITS sequences indicates that it is a close relative to the North American species *A. thamnina* (ID of specimens in GenBank of that species was confirmed by Kerry Knudsen, pers. comm.).

The Norwegian specimens were both collected on siliceous boulders in open spruce forests. The type specimen grows on *Aspicilia cinerea* and Magnusson (1924) concluded that it is a saprophyte. However, the newly found specimens do not grow in direct association with other species. Among other species seen in the specimens, *Aspicilia* cf. *cinerea*, *Rhizocarpon grande* and *Trapelia obtegens* were noted.

Specimens examined. NORWAY. Oppland: Lillehammer, Døsgrenda, between Kinnlia and Åsen, alt. 500 m, 61°05.21'N, 10°20.32'E. 1 June 2011, Haugan 10022 (O L-173397); Lom municipality, Runningsgrenda, Klypa, 61,7236°N, 8,0262°E. 28 June 2013, Westberg (S F265207), TLC: gyrophoric acid.

Acarospora pyrenopsoides H.Magn, 1926

Mycobank: MB 375684

Acarospora pyrenopsoides H.Magn. Acta Horti Gothob. 2: 74. 1926.

Holotype. GREENLAND. Nennese. [undated], *J. Vahl* (UPS L-067474!).

Distribution. New to Norway and Sweden. This is another poorly known species that has received very little attention since Magnusson (1926) discovered it. It has until now been known from scattered records from Greenland, Germany, Finland and Austria (Magnusson 1935, Wirth et al. 2013). It has also been reported from Denmark and Canada but those finds are considered erroneous (Søchting and Alstrup 2008, Knudsen and Kocourková 2010). This is a characteristic species that has a thallus composed of rounded, fairly large squamules (fertile squamules 0.5–3 mm wide), with an incised or almost lobate margin (Fig. 2). The upper surface is flattened with a brownish grey colour. The lower side as well as the steep, vertical sides of the squamules are jet black and somewhat shiny. The apothecia are immersed, at first deeply sunken but later almost level with the thallus. The disc is brown, somewhat shiny and can become somewhat uneven in larger apothecia. Magnusson (1926) thought that the apothecia resembled those in certain species of *Pyrenopsis* from which the epithet is derived. The diagnostic characters include a thin poorly delimited cortex (10–15 µm), an uninterrupted algal layer, a tall (120–140 µm), euamyloid (I+ blue), hymenium and narrow spores (4–5 × 1.5 µm). *Acarospora pyrenopsoides* is a peculiar *Acarospora* not similar to any other species

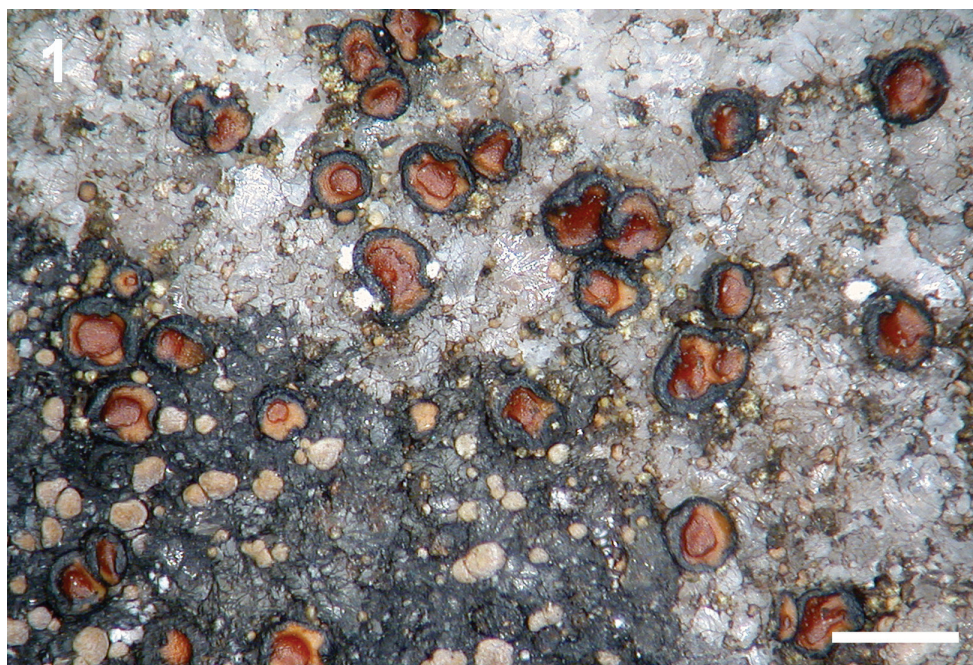


Figure 1. *Acarospora insignis* (O L-173397). Scale: 1 mm.



Figure 2. *Acarospora pyrenopsoides* (O L-163369). Scale: 1 mm.

in the genus. Magnusson (1926) considered its position in the genus to be isolated because of its unusual characters but speculated that it may be closest to *A. nitrophila*. The specimen from Norway was sequenced and a preliminary analysis (not shown) indicates that it belongs to a group with *A. peliscypha*, *A. molybdina* and *A. wahlenbergii* within *Acarospora* in a restricted sense (see Westberg et al. 2015). There is however, as far as we can see, no particular character of its morphology that indicates this relationship.

Acarospora pyrenopoides appear to prefer humid localities. The locality in Norway reported here, lies near a waterfall where the species was found on sloping rocks. It is the only European site of the North American *Rhizocarpon bolanderi* (Tuck.) Herre, and was found during an inventory of that species. The two Swedish localities are located on or near lakeshores in the province of Värmland in central Sweden.

Specimens examined. NORWAY. Aust-Agder: Valle, Hallandsfossen. 28 July 2010, Timdal 11308 (O L-163369); SWEDEN. Värmland: Stora Kil par., W steep towards the lake Fryken, S of Prästhamna. 15 May 1960, Sundell 1915a (UPS L-126715); Trankil par., Guppviksön. 22 Aug. 1976, Sundell 11217 (UPS L-515137).

***Acarospora versicolor* Bagl. & Carestia, 1863**

MycoBank: MB 375773

Acarospora versicolor Bagl. & Carestia. Comm. Soc. Critt. Ital. 1: 440. 1863.

Type. ITALY. Piemonte. *F. Baglietto* s.n. (the location of the type is unknown according to Knudsen et al. in press).

Distribution. New to Norway. *Acarospora versicolor* is widespread on both siliceous and calcareous rocks in Europe and western Asia and is in the Nordic countries known from one locality in Finland and one unconfirmed report from Denmark (Alstrup et al. 1990, Knudsen et al. in press).

Acarospora versicolor belongs to the morphological group of brown *Acarospora* species lacking secondary metabolites. There are many names and many taxonomical problems in this group but *A. versicolor* was recently discussed and described in detail by Knudsen et al. (in press). *Acarospora versicolor* is identified by its white pruinose thallus and the negative C-reaction of the cortex. The thallus in *A. versicolor* is areolate and can become somewhat squamulose when well developed. It is mostly recognized by the presence of a white pruina on at least parts of the thallus (Fig. 3), but the pruina is sometimes lacking completely. The apothecia usually have a distinct margin and both the disc and the margin are typically darker than the thallus, sometimes almost black. It may then remind of a small form of *A. badiofusca* but the apothecia are not sessile as the mostly are in that species and there are several other character separating these species.

The Norwegian specimens reported here all grow calcareous rocks in sun-exposed habitats in the southern parts of the country. It is as far as we know the only one in this group of species in Scandinavia growing on calcareous rocks. However, elsewhere in Europe it also grows on non-calcareous rocks (Knudsen et al. in press).



Figure 3. *Acarospora versicolor* (S F268463). Scale: 1 mm.

Specimens examined. NORWAY. Buskerud: Hole, west side of the island Storøya, 60,04685°N, 10,2376°E. 8 June 2008, Westberg 08-092 (S F268460); Oppland: Dovre, Hjelle, 62°03.21'N, 9°08.40'E, alt. 650 m. 10 Aug. 2010, Timdal 11757 (O L-163814, filed under *Lecidea degeliana*); Vågå, c. 300 m NE of the farm Viste, 61,86671°N, 9,02391°E. 13 June 2008, Westberg 08-198, 08-203, 08-205 (S F268461, F268462, F268463).

***Calvitimela perlata* (Haugan & Timdal) R. Sant, 2004**

Mycobank: MB 478956

Calvitimela perlata (Haugan & Timdal) R. Sant. Lichen-forming and lichenicolous fungi of Fennoscandia: 73. 2004.

Basionym. *Tephromela perlata* Haugan & Timdal, Graphis Scripta 6(1): 22 (1994).

Holotype. NORWAY. Sør-Trøndelag: Oppdal municipality, Drivdalen, by the rapids in the lower part of the river Kaldvella, 62°17'N, 9°35'E, alt. 940–980 m, exposed rock face in the subalpine region. 23 July 1993, E. Timdal 7535 (O L-125!), TLC: rangiformic acid, norrangiformic acid, unknown substances.

Distribution. New to Sweden. The species was previously known only from Norway and Greenland (Haugan and Timdal 1994). It resembles the more common *C. aglaea* (Sommerf.) Hafellner, but differs in forming white areolae (Fig. 4), slightly longer ascospores



Figure 4. *Calvitimela perlata* (O L-195661). Scale: 5 mm.

(11.5–17 × 5–7.5 µm; Haugan and Timdal 1994), and in the presence of rangiformic and norrangiformic acids in the thallus. In *C. aglaea*, the areolae are usually pale yellow, the ascospores shorter (9–13.5 × 5–7.5 µm), and the thallus contains atranorin, bourgeanic acid, usnic acid (rarely lacking), and sometimes stictic acid (Haugan and Timdal 1994).

In Norway, the species grows on sun-exposed, more or less sloping rock surfaces, often where water is trickling or near rivers or waterfalls in the subalpine and alpine regions. The Swedish locality is a boulder in the alpine region.

Specimen examined. SWEDEN. Torne Lappmark: Låktatjåkka, 68°24.87'N, 18°19.07'E, alt. 640 m, steep face of boulder in the low alpine region. 8 July 2014, Timdal 13464-1 (O L-195661), TLC: rangiformic acid (major). norrangiformic acid (minor), unknown substances (minor).

***Cladonia albonigra* Brodo & Ahti, 1996**

MycoBank: MB 415621

Cladonia albonigra Brodo & Ahti. Canad. J. Bot. 74: 1152. 1996

Holotype. CANADA. British Columbia: Queen Charlotte Islands, Graham Island, 2 mi. SE of Port Clements. 1971, Brodo 18104 & Wong (CANL).

Distribution. Confirmed for Sweden. The species is reported from the province Torne Lappmark in northernmost Sweden by Ahti and Stenroos (2013), but no speci-



Figure 5. *Cladonia albonigra* (O L-195662). Scale: 5 mm.

men was cited and there are no specimens from Sweden in S or UPS. We here confirm its presence in Sweden and that province. The specimen (Fig. 5) was found on the same rock as *Calvitimela perlata* referred to above.

Specimen examined. SWEDEN, *Torne Lappmark*: Låktatjåkka, 68°24.87'N, 18°19.07'E, alt. 640 m, steep face of boulder in the low alpine region. 8 July 2014, Timdal 13464-2 (O L-195662), TLC: fumarprotocetraric acid (major).

***Lecidea degeliana* Hertel, 1970**

MycoBank: MB 342410

Lecidea degeliana Hertel. Herzogia 2: 41. 1970.

Holotype. NORWAY, Troms: [Harstad, Hinnøy], Sandtorg Nordvik, *ad saxum mica-cei-schistosum aeneum fuscigrum tinctum*. 14 July 1953, G. Degelius (UPS L-108141!).

Distribution. New to Sweden. *Lecidea degeliana* was described by Hertel (1970) from material collected by Degelius in northern Norway. Degelius himself (1982) reported a second find from the island of Vega in northern Norway but no further localities was mentioned by Hertel (1995) and we have not found any other literature reports of this species although collections have slowly been accumulating in the herbarium in Oslo. During an excursion to Sør-Trøndelag in Norway 2012, Swedish lichenologists had the opportunity to study the species in the field, and it was thereafter discovered in

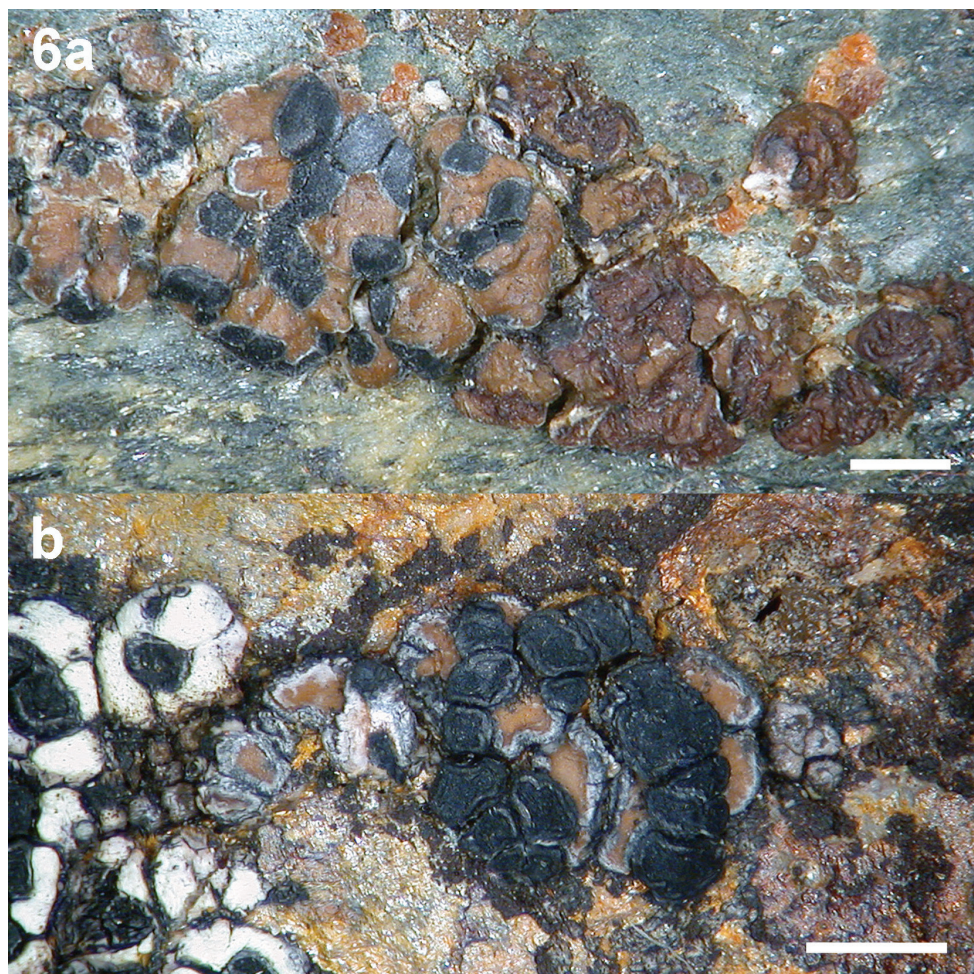


Figure 6. *Lecidea degeliana*. **a** With the host, *Acarospora* sp., still visible (S F265204) **b** Independent thallus (S F265201). Scale: 1 mm.

the Abisko area in northern Sweden in 2013 and on a second locality a few kilometers from the first in 2014. The species is so far only known from Scandinavia.

This small species may easily be overlooked or mistaken for a poorly developed *L. fuscoatra*. It is, however, a quite distinct species once discovered. The species is initially developing as a parasite on *Acarospora* spp. (Fig. 6). The thallus of *L. degeliana* is areolate, up to 3 mm wide, and frequently fertile with black, rounded or angular apothecia that are immersed in, or somewhat raised from the areoles; up to 0.2–0.6(–0.7) mm diam. In the microscope the apothecia have a greenish or bluish green hymenium, a black or greenish black epihymenium, and a dark brown hypothecium. The excipulum has a yellowish inner part, and the outer part is dark grey. The ascospores are ellipsoid–subglobose, $5.5\text{--}7 \times 4\text{--}5 \mu\text{m}$ in the studied samples. The thallus contains the gyrophoric acid syndrome (Hertel 1995); thallus cortex in section K–, C+ red, excipulum in section K–, C– or C+ red.

Hertel (1968) described *Lecidea grummannii* from Kärnten, Austria, another species growing parasitically on small brown *Acarospora* sp. That species is as far as we know only known from the type. According to Hertel (1995), *L. grummannii* differs from *L. degeliana* in having broader spores (5.2–5.5 vs 3.5–5.5 μm in *L. degeliana*), a paler hypothecium, (pale brown vs dark to blackish brown); a blue-green epithecium (vs olive- or greyish green in *L. degeliana*) and a paler thallus (cream coloured–whitish to beige vs beige to pale brown). In our experience of *L. degeliana* these characters are not so clear-cut and only the dark brown hypothecium seem to be a consistently different character compared to the description of *L. grummannii*.

Lecidea degeliana has mostly been found on calcareous rocks in exposed, subalpine habitats but also on siliceous and iron-containing rocks. There seem to be several different species of *Acarospora* involved as hosts but they are often sterile and mostly unidentified by us. They all belong to the small brown species of *Acarospora* s. str., and are in one case identified as *A. versicolor* through sequencing of the ITS and in another case tentatively identified morphologically as *A. rugulosa*.

Specimens examined. NORWAY. Hedmark: Ringsaker, the islet Holmen S of Helgøya in lake Mjøsa, 60°43'N, 11°01'E, alt. 125–130 m. 11 Apr. 1982, Timdal 3230 (O L-37925), TLC: gyrophoric acid; Ringsaker, Helgøya, the islet Holmen in lake Mjøsa, 60°43'N, 11°01'E, alt. 125 m. 27 March 1994, Haugan 3699 (O L-37924); Nordland: Vega, Vega Is., Holand, Exposed blasted rock (clay schist) at the road near Kirköy. 4 July 1979, Degelius V-2406 (UPS L-143256); Oppland: Dovre, Verkensætri, rock outcrop by the houses, 62°03.8'N, 9°32.7'E, alt. 1010–1020 m. Calciferous schist. 3 July 1995, Haugan & Timdal 8035 (O L-15096); Dovre, Hjelle, 62°03.21'N, 9°08.40'E, alt. 650 m. 10 Aug. 2010, Timdal 11757 (O L-163814); Lom, Runningsgrende, Klypa. Alt. 720–850 m. 61.7158°N, 8.2342°E. 28 June 2013, Westberg (S F265203), Lunner, Råsted, 60°18'N, 10°37'E, alt. 330 m. S-facing, steep rock face. 19 June 1983, Timdal 3844 (O L-37926), TLC: gyrophoric acid; Vågå, hill E of Svarthåmårbekken, 61°52.10'N, 8°59.21'E, alt. 690 m. 30 June 2013, Bendiksby, Haugan & Timdal 12978 (O L-184391); Westberg (S F265204). SWEDEN. Torne Lappmark: Jukkasjärvi par., Björkliden, N side of the river Rakkasjohka, just N of the trail from Björkliden Fjällby to Nuolja, alt. 495 m. 68.4053°N, 18.6698°E. 6 Aug. 2013, Westberg (S F265201); Björkliden, just W of the road E10 at its crossing over the river Rakkasjohka. 68.4029°N, 18.6944°E. 6 July 2014, Westberg VAR152 (S F265198).

***Nephroma helveticum* Ach, 1810**

Mycobank: MB 357157

Nephroma helveticum Ach. Lich. Univ.: 523. 1810.

Lectotype. 'In montibus Helvetiae, Schleicher' (H-ACH 1470B, James & White 1987).

Distribution. **New to Sweden.** *Nephroma helveticum* is a cosmopolitan species complex with a wide ecological amplitude and a large morphological and chemical



Figure 7. *Nephroma helveticum* (O L-196491) Scale: 5 mm.

variation. In Europe, however, the species is very rare and appears to have declined considerably (Klepsland 2103, James and White 1987). There are very few recent finds, among them a locality in Oppland in Norway, which is the first find in that country (Klepsland 2013). In the Nordic countries it is elsewhere known from a few old localities in Finland (Vitikainen 2007). Here we report it from one locality found in 2009 in Västerbotten and in addition we have found an old specimen in the herbarium in Stockholm from Västerbotten collected by Sten Ahlner in 1945 but never reported in the literature. The two localities are located 2.5 kilometers apart. We also report a second find of this species in Norway. The species is recognized by its tomentose lower surface without papillae (Fig. 7) and its chemistry of secondary metabolites, including the terpenoid T4 (James and White 1987). The most similar species *N. resupinatum* also has a tomentose lower surface but has white papillae between the tomentum and lacks secondary metabolites. One of the recently collected specimen from Västerbotten has been barcoded and the ITS sequence confirms the identity as *N. helveticum*.

On Ahlner's locality, Borstaberget, the bedrock consists of greenstone (porphyrite) and the mountain has long southwest facing slopes with steep cliffs. Ahlner collected, together with *N. helveticum*, also the rare lichen *Heterodermia speciosa*. On the mountain Mitti-Skansberget *N. helveticum* was found in 2009 in two places 200 meters apart. It was found growing on conglomerate cliffs in the southwest facing precipices. Other species that were found on the cliffs were *Peltigera rufescens*, *Lobaria scrobiculata*, *L. pulmonaria*, *Fuscopannaria leucophaea* and *Biatora vernalis*.

Specimens examined. NORWAY. Buskerud: Nes municipality, Gardnosberget, MGRS: 32V NN 0230, 2309, alt. 300 m, east-facing, steep slope below high mountain wall, open spruce forest over rock field, on boulder. 10 September 2013, Hofton 13176 (O L-196491), TLC: series of terpenoids, including T4 (major). SWEDEN. Västerbotten: Jörn par., Borstaberget. 24 June 1945, Ahlner (S L-54838); Norsjö par., Mitti-Skansberget SE precipice, SE of Klöverjärnen, 9.7 km NW of Petiknäs church. 28 Sept. 2009, Jonsson 4200 (UPS L-193714).

***Peltula placodizans* (Zahlbr.) Wetmore, 1970**

Mycobank: MB 343163

Peltula placodizans (Zahlbr.) Wetmore, Ann. Missouri Bot. Gard. 57: 179. 1970.

Basionym. *Heppia placodizans* Zahlbr., Bull. Torrey Bot. Club 35: 299 (1908).

Holotype. U.S.A. Arizona, Tucson, Tumamoc Hill. 1908, Blumer (W, holotype, not seen).

Distribution. New to the Nordic countries. The species is widely distributed in arid areas of both the Northern and Southern Hemispheres (Egea 1989). The nearest locality is found in Northern Italy (Vinschgau in South Tyrol; Buschardt 1979), and the species fits in the element of continental lichens with a widely disjunct distribution from the Alps to the upper valleys of southeast Norway. Other species with a similar disjunction include *Buellia elegans* Poelt, *Gyalolechia desertorum* (Tomin) Søchting et al., *Psora vallesiaca* (Schaerer) Timdal, *Toninia sculpturata* (H. Magn.) Timdal, *T. taurica* (Szatala) Oxner, *T. tristis* (Th. Fr.) Th. Fr., and *Xanthocarpia tominii* (Savicz) Frödén et al. The species is recognized by the crustose to subsquamulose, dark olivaceous brown thallus composed of areolae, which are up to 1 mm diam. and with marginal, black, granular soralia. The Norwegian material is sterile. The other *Peltula* species in the Nordic countries, *P. euploca* (Ach.) Poelt, differs in forming much larger, pel-tate squamules, up to 5 mm diam. The Norwegian specimen of *Peltula placodizans* is identified with some uncertainty, as the material for comparison (17 specimens from Europe, Africa, Australia, and North and South America, borrowed from GZU), was often more olivaceous brown than the dark brown Norwegian material (Fig. 8). Wetmore (1970) indicates that the species is probably a complex of several taxa.

In Norway, the species was found on a vertical wall of calcareous rock in a steep, west-facing hillside. The site has apparently previously been an open or sparsely wooded pasture, but is now in the process of being transformed into spruce forest. Other remarkable lichens collected at the site include *Metamelanea caesiella* (Th.Fr.) Henssen, *Physcia dimidiata* (Arnold) Nyl., *Thallinocarpon nigritellum* (Lettau) P.M.Jørg., and *Toninia alutacea* (Anzi) Jatta.

Specimen examined. NORWAY. Oppland: Sør-Fron municipality, Harpefoss, along the trail W of farm Tåkåstad towards Mt. Lundin, 61°34.95'N, 9°52.55'E, alt. 490 m. 1 Oct. 2007, Timdal 11054 (O L-158470), TLC: no lichen substances.



Figure 8. *Peltula placodizans* (O L-158470). Scale: 1 mm.

***Phacographa protoparmeliae* Hafellner, 2009**

MycoBank: MB 513175

Phacographa protoparmeliae Hafellner. Bibl. Lich. 100: 106. 2009.

Holotype. AUSTRIA, Kärnten: Hohe Tauern, Kreuzeck-Gruppe, Kalkschieferwände in den SE-Hängen der Sensenspitze N der Turgger Alm, c. 200 m. 17 July 1978, Hafellner 603 (GZU).

Distribution. New to the Nordic countries. *Phacographa* was described by Hafellner 2009 who included three species in the genus. It belongs in the newly described family Lecanographaceae within the Arthoniales (Frisch et al. 2014). *Phacographa protoparmeliae* (Fig. 9) was originally reported from Austria and Spain (Hafellner 2009), and a specimen was later discovered in the Murmansk region in arctic Russia (Fryday 2011). Here we report it for the first time from the Nordic countries from two localities in Norway. Both are at old copper mines in subalpine habitats in the mining district of Røros in central Norway.

Phacographa protoparmeliae (Fig. 9) is a lichenicolous fungus growing on the common and widespread saxicolous lichen *Protoparmelia badia*. The apothecia of *Phacographa* have a black margin around a dark brown disc; they are up to 1.2 mm wide in the Norwegian material and form clustered groups of 2–6 apothecia. Microscopically it is characterized by its 3-septate, spores, $22\text{--}25 \times 6\text{--}7\text{--}(8) \mu\text{m}$ that are



Figure 9. *Phacographa protoparmeliae* (S F265200). Scale: 1 mm.

colourless but have a perispore sheath that becomes brown with age. More detailed descriptions can be found in Hafellner (2009) and Fryday (2011).

Specimens examined. NORWAY. Sør-Trøndelag: Røros, Storwartz, at the site of the old copper-mine, 62°37.63'N, 11°31.19'E. 15 June 2012, Westberg 12-030 (S F265199); Røros, Klasberget, old copper mine NE of farm Svensvollen, 62°39.25'N, 11°34.06'E. 16 June 2012, Westberg 12-052 (S F265200).

***Rhizocarpon pycnocarpoides* Eitner, Jahresbericht der Schles, 1911**

MycoBank: MB 404075

Rhizocarpon pycnocarpoides Eitner, Jahresbericht der Schles. Gesellschaft für vaterl. Cultur 88, 2: 46. 1911.

Holotype. CZECH REPUBLIC, Krkonoše Mts, “an den alten Bergwerken im Riesen-grunde” (not seen).

Distribution. **New to the Nordic countries.** The species is apparently previously known only from the type locality in the Krkonoše Mts, where it was collected by Eitner about 1910 and by Kuťák in 1927. We have not seen the type material, but rather one duplicate of the material distributed by Kuťák in his exsiccate (Flechtensamml. Böhmen No. 520, O-L-184255).



Figure 10. *Rhizocarpon pycnocarpoides* (O L-184267). Scale: 1 mm.

The species grows on rocks with a high content of iron and the thallus is rust coloured (Fig. 10). It resembles *R. oederi* (Weber) Körb., which may be found in the same localities, but differs primarily by forming larger ascospores (mainly muriform, $24\text{--}30 \times 10\text{--}15 \mu\text{m}$ in *R. pycnocarpoides* vs. mainly 3-septate, $12\text{--}18 \times 3\text{--}7 \mu\text{m}$ in *R. oederi*). Furthermore, the apothecia are more sessile, more regularly rounded, and with a thicker margin in *R. pycnocarpoides*, not in level with the areolae and angular to flexuose as in *R. oederi*. An unpublished phylogenetic analysis of the genus *Rhizocarpon* (Bendiksby et al. in prep.), which includes four Norwegian specimens of *R. pycnocarpoides*, places the two species in sister position and well separated in the ITS marker.

Rhizocarpon pycnocarpoides has been found at five localities in Norway and one in Sweden. All localities are rich in rust stained rock and most sites are in or near old copper or zinc mines.

Specimens examined. CZECH REPUBLIC. Krkonose. 1927, V. Kuťák, Kuťák, Flechtensamml. Böhmen No. 521 (O L-184255). NORWAY. Buskerud: Ringerike municipality, the old mine Ertlien, $60^{\circ}04.14'\text{N}$, $10^{\circ}02.89'\text{E}$, alt. 160 m. 18 May 2013, Rui & Timdal 12854 (O L-184267), TLC: No lichen substances; Nord-Trøndelag: Namsskogan municipality, S bank of river Namsen just W of Storholmen, $64^{\circ}55.60'\text{N}$, $13^{\circ}08.72'\text{E}$, alt. 200 m. 8 Aug. 2012, Haugan 11128 (O L-183810), TLC: no lichen substances; Nordland: Fauske municipality, Sulitjelma, Furuhaugen, site of old copper mine (in operation 1896–1921), $67^{\circ}09.02'\text{N}$, $15^{\circ}57.92'\text{E}$, alt. 260 m. 11 Aug. 2012, Haugan 11125 (O L-183808), TLC: no lichen substances; Oppland: Lunner municipality, the old zinc mine Nysetergru-

vene (in use 1889–1931), 60°15.69'N, 10°41.62'E, alt. 520 m. 16 July 2012, Rui & Timdal 12665 (O L-179903); Sør-Trøndelag: Røros municipality, by river Orva upstreams from the bridge at Litlstuvollen, 62°38.78'N, 11°21.22'E, alt. 700 m. 16 June 2012, Bendiksby et al. 12630 (O L-179554, L-179560), TLC: no lichen substances; Røros, Klasberget, old copper mine NE of the farm Svensvollen. 62°39.25'N, 11°34.06'E. 16 June 2012, Westberg 12-061 (S F265205), TLC: no lichen substances. SWEDEN. Torne lappmark: Karesuando par., Pältsan (Bealccan), N-facing slope of the middle peak (1444 m). Alt. 1240 m. 69,0106°N, 20,2366°E. 3 Aug. 2011, Westberg P122 (S F265206).

***Sarcogyne algoviae* H.Magn, 1935**

MycoBank: MB 411790

Sarcogyne algoviae H.Magn. Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 9(5.1): 78. 1935.

Holotype. [GERMANY, Bayern] Obere Seealpe in der Allgäuer Alpen bei Oberstdorf, c. 5000'. 1860, H. Rehm (S L2741!).

Distribution. New to Sweden. This is a little known species rarely reported in the literature. *Sarcogyne algoviae* belongs to the morphological group in *Sarcogyne* with a strongly carbonized margin (Westberg et al. 2015). The apothecia vary considerably in size (0.3–1.8 mm) and has a raised, often glossy margin that is incised at short and fairly regular intervals (Fig. 11a, b) forming 5–15 segments. The disc is brown to dark reddish brown and often has one or two small carbonized accretions on the surface. Further characters include a euamyloid hymenium, 65–105 µm tall and narrow, 1–1.5 µm wide paraphyses, ellipsoid to narrowly ellipsoid spores, 2.5–4 × 1.5 µm and a colorless hypothecium (Fig. 11c). It can primarily be confused with *S. clavus* and *S. hypophaea* (syn. *S. privigna*, see Knudsen et al. 2013) but is apparently not closely related to either of these species (see phylogeny in Westberg et al. 2015). *Sarcogyne clavus* in its current sense (e.g. Magnusson 1935) always grows on siliceous rocks, has larger apothecia (up to 6 mm wide) with a margin that is irregularly cracked and crenulate and has a yellowish, to pale brownish hypothecium. *Sarcogyne hypophaea* grows on both siliceous and calcareous rocks and has generally smaller apothecia 0.3–0.7(1.3) mm, with a different appearance. The margin can be without or with rather indistinct incisions or with fewer (3–8) incisions at irregular intervals.

We have found *Sarcogyne algoviae* on several localities in Scandinavia, two in the continental parts of southern Norway and two in the Abisko area in northernmost Sweden. In addition we have found a few specimens from the Swedish mountains under the name *S. clavus* in the herbarium UPS. In all localities it grows on soft, calcareous schist in alpine–subalpine habitats. *Sarcogyne algoviae* is already included in the checklist for Fennoscandia, originally based on a specimen from Finnmark in northernmost Norway (Santesson et al. 2004). That specimen, however, has broadly ellipsoid spores and stout paraphyses, c. 2.5 µm wide, and belongs to *Polysporina urceolata* (specimen in

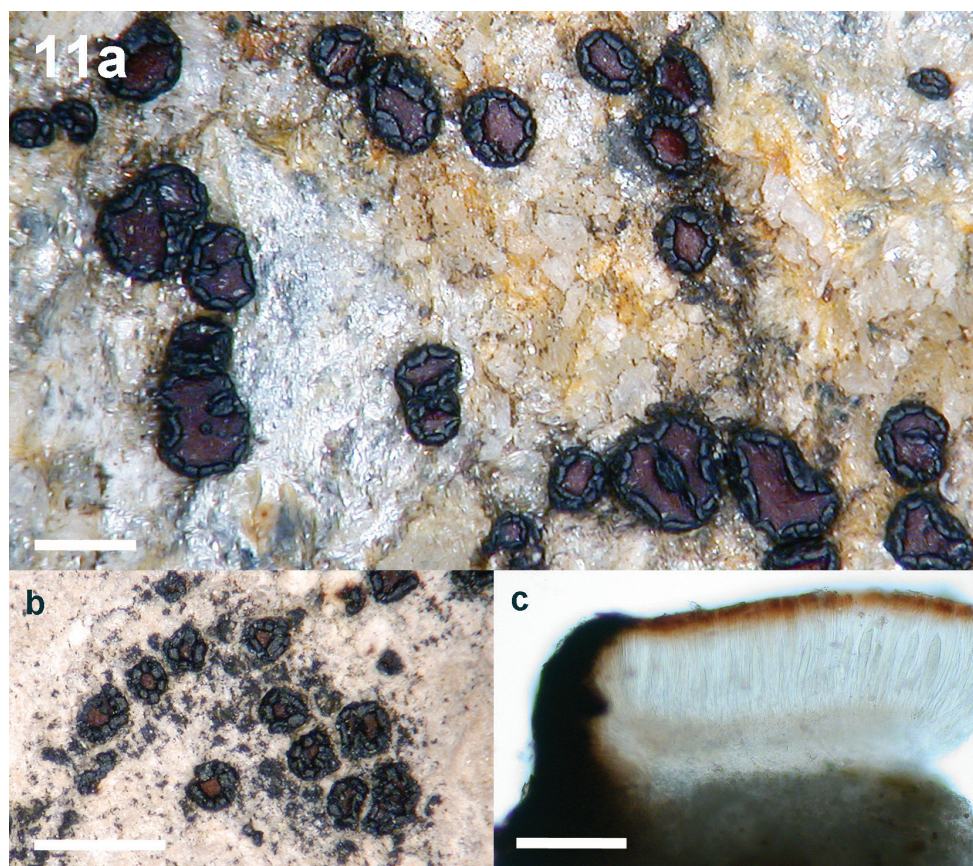


Figure 11. *Sarcogyne algoviae*. **a** Apothecia (S F122537) **b** Apothecia (S L2741, holotype) **c** Section of an apothecium showing a strongly carbonized margin and a colourless hypothecium (S F122537). Scale: 1 mm (**a–b**); 100 μ m (**c**).

O, L-38325). Other literature or database records of *S. algoviae* from Norway must be considered unreliable but here we also confirm its presence in Norway.

Specimens examined. NORWAY. Oppland: Dovre, Jønndalen, Mt Nonshaugen, S precipice of the mountain, NE of farm Jønndalen, alt. 700–800 m. 12 June 2008, Westberg 08-276 (S F122564) Lom, Bøvertun, just W of the lake Bøvertunvatnet. Alt. 954 m. 12 June 2008, Westberg 08-165, 08-168, 08-169 (S F122535, F122537); Lom, Runningsgrenda, Klypa. Alt. 700–760 m. 61.7237°N, 8.0262°E. 28 June 2013, Westberg (S F265202); Nordland: Vega Island, farm Dalen. 22 June 1974, Degelius V-683 (UPS L-516318); Troms: Insula Rollöen. [undated], Norman (UPS L-680378). SWEDEN. Härjedalen: Tännäs par., Mt Stora Mittåkläppen, the southern slope. 15 Aug. 1962, Santesson 14987b (UPS L-516445); Jämtland: Åre par., Storlien. 24 July 1950, Magnusson 22128a (UPS L-515993); Lule lappmark: Gällivare par., Vastenjaure. 4 Aug. 1965, Gilenstam 1186a (UPS L-103743); Torne lappmark: Jukkasjärvi par., Björkliden, N side of the river Rakkasjohka, just N of the trail from Björkliden Fjällby to Nuolja, alt. 495 m. 68.4053°N, 18.6698°E. 6 Aug. 2013, Westberg (S F265208);

Latnjajaure field station, by the lake Latnjajaure c. 15 km W of Abisko. 68°20'N, 18°30'E, alt. 980–1000 m. 3 Aug. 1998, Westberg 2572 (LD).

***Sarcogyne hypophaeoides* Vain. ex H.Magn, 1935**

MycoBank: MB 411805

Sarcogyne hypophaeoides Vain. ex H.Magn. Rabenh. Krypt.-Fl., Edn 2 (Leipzig) 9(5.1): 84. 1935.

Lectotype. FINLAND. Tavastia australis, Luhanka, Keihäsniemi. 1873 (TUR-Vainio 25683, designated here, TUR-Vainio 25682 isotype!).

Distribution. New to Norway, Sweden and Austria. *Sarcogyne hypophaeoides* has until now been known from the type material in central Finland and from one collection in Germany (Magnusson 1935). It is a characteristic but overlooked lichen that appears to be widespread in Scandinavia. The apothecia are 0.5–1.2 mm wide, with a reddish brown to almost black disc sometimes with a central carbonized accretion. The margin is typically finely striated (Fig. 12a, b) and is softer and more leather-like in texture and not as strongly carbonized and brittle as the margin in e.g., *S. clavus*. The degree of carbonization varies however and in sections the central parts of the exciple may be rather weakly coloured (Fig. 12c). The hymenium is 70–90 µm tall and has a euamyloid reaction (I+ blue) and the spores are narrow and almost bacilliform, 3.5–5.5 × 1.0 µm. *Sarcogyne hypophaeoides* can mainly be confused with *S. clavus* or *S. hypophaea* but has a dark, brownish black to black hypothecium (Fig. 12c), which is a characteristic and diagnostic feature of this species. *Sarcogyne clavus* has a very uneven, cracked, crenulate margin and a yellowish to pale brown hypothecium. *Sarcogyne hypophaea* on the other hand, has a smooth margin, which usually appears segmented due to 2–3 deep incisions in the margin and a colorless hypothecium.

Sarcogyne hypophaeoides grows exclusively on siliceous rocks. We have found it on exposed, horizontal or sloping seashore rocks on the west coasts of Sweden and Norway, on lakeshores and on semi-exposed, vertical rocks or boulders in open coniferous forests. It is often growing with scattered apothecia on smooth rock surfaces or along cracks in the rock in a similar way to *S. clavus* and the two species have been found growing together on at least two localities. Difficulties to collect it and a superficial similarity to *S. clavus* are possibly reasons why this species has been overlooked. It appears to be fairly common in humid habitats in the boreal region of Fennoscandia but its distribution is incompletely known.

Specimens examined. AUSTRIA. Steiermark: Steirisches Randgebirge, Fishbacher Alpen, im Feistritzal, ca 2 km E von Rettenegg. 14 Nov. 1998, Kocourkova & Hafellner 46366 (GZU); NORWAY. Rogaland: Rennesøy, Fjøløy, ca 200 m. NE of the lighthouse. 11 June 2008, Westberg 08-139 (S F123697). SWEDEN. Bohuslän: Ljung par., Skarsjön. 31 Aug. 1916, Magnusson 17466 (UPS L-175686); Naverstad par., Tyftefjäll. 22 July 1917, Magnusson (UPS L-516234); Brastad par., Stora Bornö,

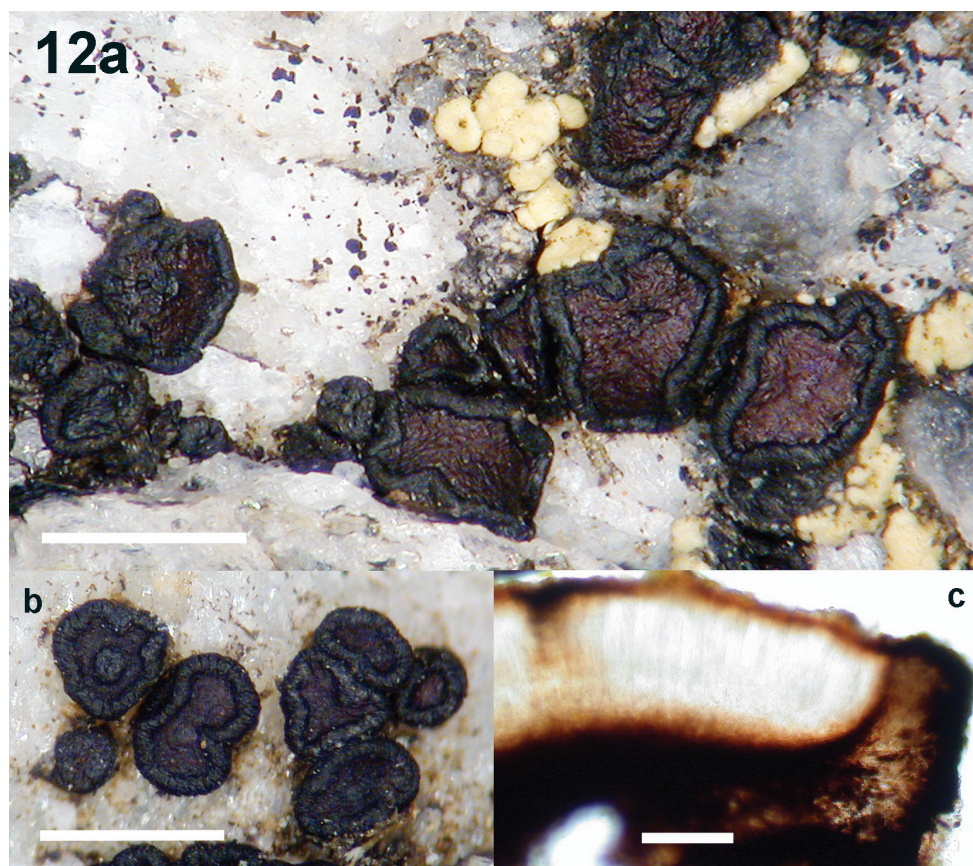


Figure 12. *Sarcogyne hypophaeoides*. **a** Apothecia (S F123697) **b** Apothecia (Kocourkova & Hafellner 46366 (GZU)) **c** Section of an apothecium showing a carbonized margin and a brownish black hypothecium (S F265197). Scale: 1 mm (**a–b**); 100 μ m (**c**).

just S of Källviken on the E side of the island, c. 750 m SE of the research station. 58.3750°N, 11.5902°E. 4 Oct. 2013, Westberg (S F265197); Dalarna: Leksand par., Draggberget. Hermansson 14488 (UPS L-564677); Dalsland: Skållerud par., c. 5.5 km N of Skållerud church, SW slope of Skälåsen. 58.8268°N, 12.4435°E. 5 June 2008, Westberg 08-078 (S F120302); Gästrikland: Hille par., Iggön. 13 Aug. 1946, Ahlner (S F90566); Lycksele lappmark: Tärna par., Ume älv, Över-Umans sydvästligaste vik. 18 Aug. 1960, Du Rietz 927 (UPS L-115656); Pite lappmark: Arvidsjaur par., Pite älv, Trollforsen, nedre delen, N-sidan uppströms bron. 24 Aug. 1962, Du Rietz 486b (UPS L-113499); Uppland: Djurö par., Runmarö, S of Kasviken, along a forest-trail. 59,2612°N, 18,7666°E. 11 May 2009, Westberg, Millanes & Wedin 09-308 (S F265196), Värmland: Gustav Adolf par., NW of Uddeholmshyttan. 2 Sept. 1981, Sundell 14905a (UPS L-516265); Västmanland: Grythyttan par., c. 1400 m S of Loka Brunn, at the south tip of the lake S. Loken. 59.5926°N, 14.4844°E. 1 May 2008, Westberg 08-002 (S F119718).

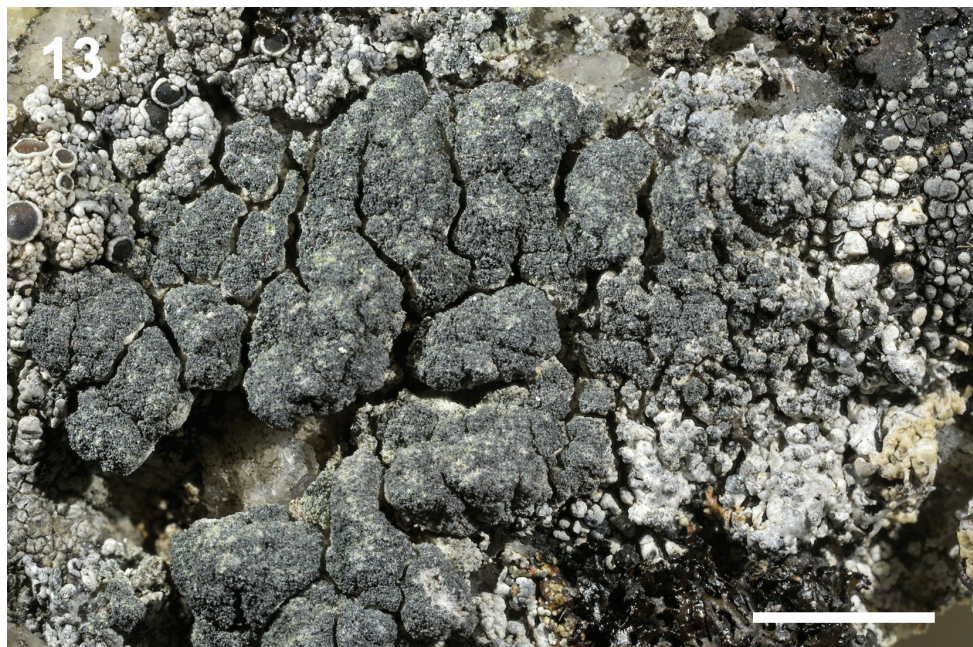


Figure 13. *Tephromela grumosa* (O L-190787). Scale: 5 mm.

***Tephromela grumosa* (Pers.) Hafellner & Cl. Roux, 1985**

MycoBank: MB 103854

Tephromela grumosa (Pers.) Hafellner & Cl. Roux. Bulletin de la Société Botanique du Centre-Ouest 7: 829. 1985.

Basionym. *Lichen grumosus* Pers., Ann. Bot. Usteri 14: 36. 1795. Nom. nov. *Lichen caerulescens* Pers., Ann. Bot. Usteri 11: 15. 1794. Nom. illeg. (non *Lichen caerulescens* Hagen 1782).

Type. Sine loc., „ad saxa arenaria (rubicunda), a Dom. Heyder primo observatus“ (Not seen).

Distribution. New to Norway. *Tephromela grumosa* has been expected to occur in Norway, as it is known from a number of provinces in Sweden and Finland. It occurs in West, Central, and North Europe and in Asia (Lambley and Purvis 2009). The species is rather closely related to the type species of the genus, *T. atra* (Huds.) Hafellner & Kalb, but it is always sorediate and rarely fertile (Fig. 13). In contrast to the genetically very heterogenous *T. atra* s. lat., *T. grumosa* seem to be genetically rather consistent compared to its morphology (Muggia et al. 2008, 2014). The species is furthermore separated by their chemistries, i.e., by the presence of lichesterinic acid in *T. grumosa*. The chemistry of the Norwegian specimen was confirmed by TLC. According to Muggia et al (2008) *T. grumosa* is a cooltemperate species found on steeply inclined, acidic siliceous rocks. In the locality in Norway, luxuriant, partly fertile specimens grew on

steep faces of a large boulder in a stabilized S-facing talus. The rock is schistose, and probably somewhat calciferous. The locality is situated in one of the driest areas in Scandinavia, with an annual precipitation of c. 350 mm. In other habitats, e.g. on hard, granitic rocks in coastal heath on the Swedish west coast, specimens of this species are much thinner and less prominent.

Specimens examined. NORWAY. Oppland: Lom municipality, Runningsgrenda, Klypa. 61°43.41'N, 8°15.67'E, alt. 730 m. 28 June 2013, Bendiksby et al. 12357 (O L-190787); TLC: atranorin, lichesterinic acid. SWEDEN. Bohuslän: Sotenäs municipality, Ramsviklandet nature reserve, W of Haby. 58°24.50'N, 11°14.55'E, alt. 20 m. 25 Mar. 2012, Haugan 11501 (O L-184061).

***Tremella lobariacearum* Diederich & M. S. Christ, 1996**

MycoBank: MB 415289

Tremella lobariacearum Diederich & M. S. Christ. Bibl. Lichenol. 61: 103. 1996.

Type. PORTUGAL. *Madeira*: Rabaçal, on *Lobaria pulmonaria*. 8 Apr. 1992, P. Diederich 4935 (LG – holotype; herb. Diederich – isotype; S F102418 – isotype!).

Distribution. New to the Nordic countries. *Tremella lobariacearum* was described by Diederich (1996) and is currently known from Africa (Ile de la Réunion), Asia (Japan, Philippines, and Russia), Europe (British Isles, France, and Portugal), Macaronesia (Canary Islands and Madeira), Oceania (Papua New Guinea) and South America (Bolivia, Colombia, Ecuador, and Peru), growing on *Lobaria* and *Pseudocyphellaria* species (Diederich 1996, 2003, van den Boom and Etayo 2000, Etayo 2002, 2010, Coppins et al. 2012, Flakus and Kukwa 2012). The species induces the formation of pale-brown to dark-brown galls on the isidia or soredia of the host (Fig. 14), or occasionally also directly on the thallus. The basidia are 2-celled. Two asexual morphs, consisting of lunate conidia and asteroconidia, are often found within the galls. *Tremella lobariacearum* is here reported from Norway and from the Nordic Countries for the first time, growing on *Lobaria pulmonaria*. The species is associated to habitats with high humidity and oceanic influence. The only specimen reported was collected, together with other non-infected *L. pulmonaria* thalli in an area with mixed and rich populations of *Lobaria*, in a *Fraxinus*-dominated open broad-leaved deciduous stand.

Tremella includes mainly mycoparasitic taxa that grow on a wide range of fungal hosts, including lichenized hosts. However, mycologists and lichenologists in general did not look much at the lichenicolous species until the first comprehensive study by Diederich (1996). Since then, several new species have been described (Diederich 2003, Sérusiaux et al. 2003, Diederich 2007, Zamora et al. 2011, Diederich et al. 2014, Millanes et al. 2012, 2014), and an increased interest has resulted in numerous new records, especially in the Nordic countries (Holien and Tønsberg 1994, Alstrup et al. 2004, 2008, Pippola and Kotiranta 2008, Westberg et al. 2008, Svensson and Westberg 2010, Knutsson and Johansson 2011, Millanes et al. 2014, Thell et al. 2014,



Figure 14. *Tremella lobariacearum*. Galls induced by *Tremella lobariacearum* on *Lobaria pulmonaria* (S F263902). Scale: 1 mm.

Westberg and Thor 2014). Nevertheless, both the actual diversity and the distribution area of most species are still largely unknown.

Specimen examined. NORWAY. Hordaland: Tysnes municipality, Støle, 59°59.14'N, 05°29.84'E, alt. 60 m. 6 Apr. 2008, Asplund & Larsson (S F263902).

***Tremella wirthii* Diederich, 1996**

MycoBank: MB 415310

Tremella wirthii Diederich. Bibl. Lichenol. 61: 164. 1996.

Holotype. GERMANY. Bayern: Neu-Ulm, Holzheim, Obstgarten WSW Steinheim, MTB 7626/2. 6 Feb 1991, V. Wirth 21713 (STU)

Distribution. New to the Nordic countries. *Tremella wirthii* was described by Diederich (1996) based on material from four localities in Germany, growing on an unidentified sterile corticolous lichen. The host was later described as *Protoparmelia hypotremella* (Aptroot et al. 1997), a species similar to *P. oleagina*, from which it differs by its paler colour and its isidia-like granules. Both species are among the few corticolous *Protoparmelia* species, and grow on old wooden fences and buildings, and on deciduous and coniferous trees (Aptroot et al. 1997, 2001, 2004, Clerc 2004, Diederich and Sérusiaux 2000,

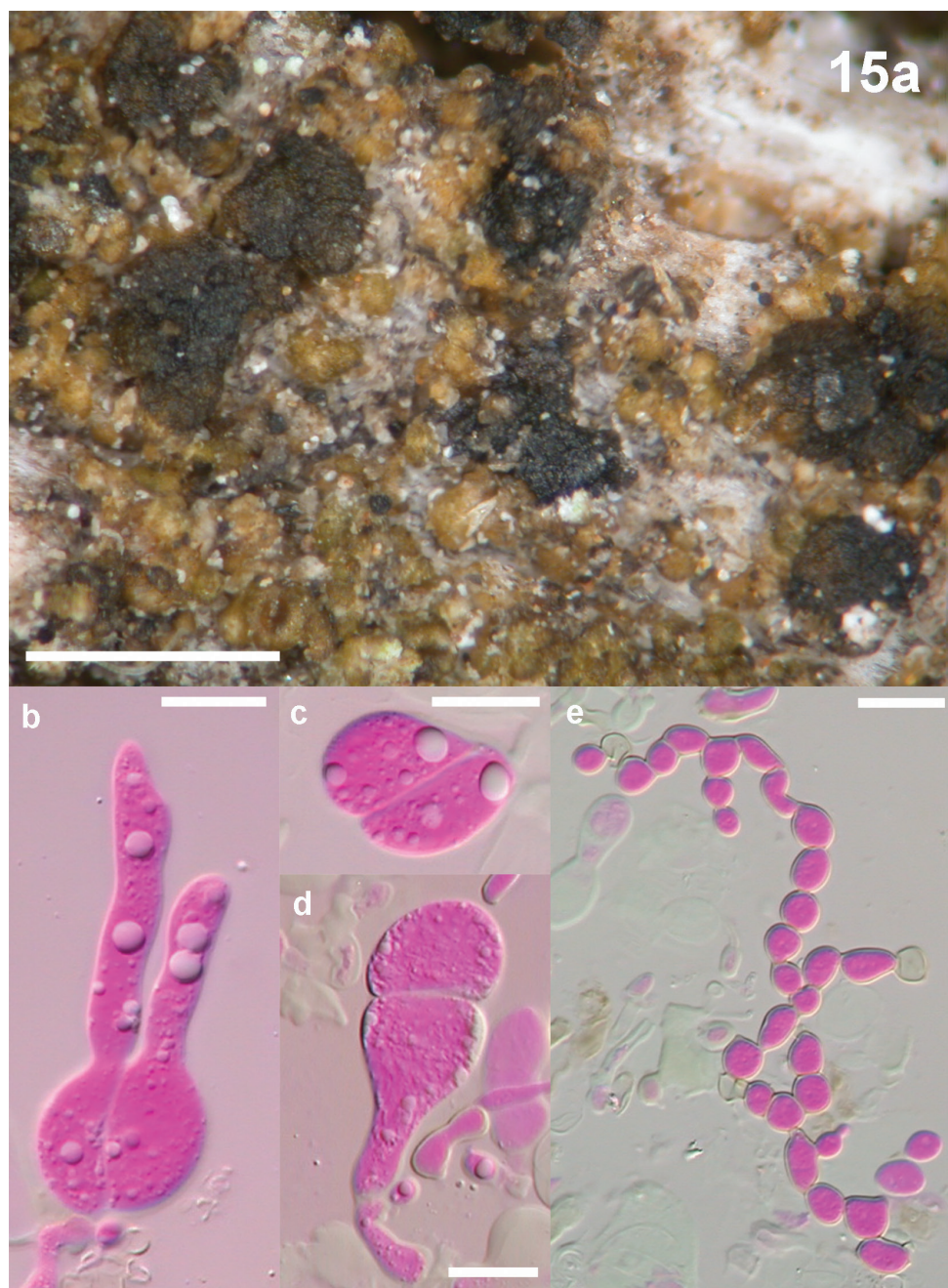


Figure 15. *Tremella wirthii*. **a** Basidiomata on the thallus of *Protoparmelia oleagina* (S F262967) **b** Basidium with one longitudinal septum (S F262963) **c** Basidium with one oblique septum (S F262963) **d** Basidium with one transverse septum (S F262963) **e** Catenulate conidia (S F262963). Scale: 0.5 mm (**a**); 10 mm (**b–e**).

Scholz 2000, Hafellner and Türk 2001, Palice et al. 2006, van den Boom et al. 2007, Kubiak et al. 2010, Kukwa et al. 2012, Himelbrant et al. 2014). Aptroot et al. (1997) reported the presence of *Tremella wirthii* on specimens of *P. hypotremella* from Austria and the Netherlands. In the type locality of *Protoparmelia hypotremella*, in the Netherlands, *T. wirthii* was found both on *P. hypotremella* and *P. oleagina*. The three Scandinavian specimens grow on *Protoparmelia oleagina*. They were collected on wood of an old hay drying rack in the agricultural landscape of the Siljan Ring, an area with a calcareous bedrock, and the only locality in Sweden where *P. hypotremella* has been reported. Here, however, *Tremella wirthii* has not yet been found on that host. In the Nordic countries *Protoparmelia oleagina* occurs in Norway and Sweden (Nordin et al 2015). *Tremella wirthii* forms dark basidiomata, which are rarely bigger than 0.5 mm in diam., on the host thalli (Fig. 15a). Some micromorphological differences have been found between Swedish and Central European material. The specimens studied in the original description had 2–4 celled, longitudinally septate basidia, and no asexual morph was reported (Diederich 1996). The three specimens collected in Dalarna show typical basidia with 2 or 4 cells and longitudinal septa (Fig. 15b), but also basidia with oblique (Fig. 15c) or transverse (Fig. 15d) septa are present within the same basidioma. Moreover, in some cases there is an anamorph consisting of catenulate conidia (individual conidia $3\text{--}6 \times 3\text{--}6 \mu\text{m}$; Fig. 15e). Despite these differences, we consider the material from Sweden and Central Europe to be conspecific. The basidium morphology is extremely variable in many species of *Tremella* (Zamora et al. 2011, Millanes et al. 2012), and, when present, the occurrence of conidia is not constant in all specimens of the same species. Since the original description was based on four specimens only, the morphological variation within the taxon may well be greater than originally observed. *Tremella wirthii* is probably overlooked in Sweden, and additional field and herbarium surveys could reveal its presence in places where *Protoparmelia oleagina* is abundant.

Specimens examined. SWEDEN. Dalarna: Orsa municipality 61°11.25'N, 14°52.43'E, alt. 255 m. 1 Oct. 2014, Jonsson FU5955 (S F262967); Dalarna: Orsa municipality 61°11.32'N, 14°52.45'E, alt. 253 m. 1 Oct. 2014, Jonsson FU5956 (S F262963); Mora municipality 60°55.67'N, 14°37.08'E, alt. 204 m. 2 Oct. 2014, Jonsson FU5957 (S F262952).

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