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# The stipitate species of Hypocrea (Hypocreales, Hypocreaceae) including Podostroma

HOLLY L. CHAMBERLAIN, AMY Y. ROSSMAN, ELWIN L. STEWART, TAUNO ULVINEN
and GARY J. SAMUELS

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Stipitate species of *Hypocrea* have traditionally been segregated as the genus *Podostroma*. The type species of *Podostroma* is *P. leucopus* for which *P. alutaceum* has been considered an earlier synonym. Study of the type and existing specimens suggests that these two taxa can be distinguished based on morphology and biology. *Podostroma leucopus* is herein recognized as *Hypocrea leucopus* (P. Karst.) H. Chamb., comb. nov., thus *Podostroma* is a synonym of *Hypocrea*. The genus *Podocrea*, long considered a synonym of *Podostroma*, is based on *Sphaeria alutacea*, a species that is recognized as *H. alutacea*. A neotype is designated for *Sphaeria alutacea*. Both *H. alutacea* and *H. leucopus* are redescribed and illustrated. The new species *H. nybergiana* T. Ulvinen & H. Chamb., spec. nov. is described and illustrated. In addition to *H. leucopus*, seven species of *Podostroma* are transferred to *Hypocrea*, viz. *H. africana* (Boedijn) H. Chamb., comb. nov., *H. cordyceps* (Penz. & Sacc.) H. Chamb., comb. nov., *H. daisenensis* (Yoshim. Doi & Uchiy.) H. Chamb., comb. nov., *H. eperuae* (Rogerson & Samuels) H. Chamb., comb. nov., *H. gigantea* (Imai) H. Chamb., comb. nov., *H. sumatrana* (Boedijn) H. Chamb., comb. nov., and *H. truncata* (Imai) H. Chamb., comb. nov. A key to the 17 species of stipitate *Hypocrea* including *Podostroma* and *Podocrea* is presented.

Key words: Ascomycetes, Hypocreaceae, Hypocreales, *Podocrea*, systematics, *Trichoderma*

*H. L. Chamberlain* and *E.L. Stewart, Department of Plant Pathology, 3086 Buckhout Laboratory, The Pennsylvania State University, University Park, PA 16802, USA*

*A.Y. Rossman* and *G.J. Samuels, United States Department of Agriculture, Agricultural Research Service, Systematic Botany and Mycology Laboratory, Rm. 304, B-011A, Beltsville, MD 20705-2350, USA*

*T. Ulvinen, Kannuskuja 1 D1, FI-90540 Oulu, Finland*

## Introduction

Species of *Hypocrea* Fr. that have a stipe, especially those with a clavate to cylindrical stroma, traditionally have been segregated as the genus *Podostroma* P. Karst. (Karsten 1892, Doi 1967, Imai 1932, Rogerson & Samuels 1992, Rossman et al. 1999, Seaver & Chardón 1926). *Podostroma* was described for members of the Hypocreaceae having stipitate, clavate, erect, fleshy, bright-colored stromata within which perithecial ascomata are immersed. Originally *Podostroma* was described with only one species, *P. leucopus* P. Karst. (Karsten 1892). Later *Podocrea* Lindau (1897), based on *P. alutacea* (Pers. : Fr.) Lindau, was proposed for species having many of the same characteristics as *Podostroma*. Atkinson (1905) and authors since then (Clements & Shear 1931, Rossman et al. 1999) have regarded *Podostroma leucopus* to be synonymous with *P. aluta-*

*ceum* (Pers. : Fr.) G.F. Atk., thus *Podocrea* has long been considered a synonym of *Podostroma*. No comprehensive account of *Podostroma* exists, but several authors have published partial taxonomic treatments of the genus (Boedijn 1934, 1938, Doi 1966, 1967, 1973, Doi & Uchiyama 1987, Imai 1932, Seaver & Chardón 1926).

Considerable confusion has surrounded the type species of *Podostroma*, *P. alutaceum*, and its assumed synonym, *P. leucopus*. Karsten (1892) stated that *P. leucopus* was insecticolous but no evidence exists to support this claim. No species of *Podostroma* is known to be entomopathogenic although there is one insecticolous species of *Hypocrea*, viz. *H. dipterobia* Samuels & Rogerson (Samuels & Rogerson 1986). The synonymy of *P. leucopus* with *P. alutaceum*, first proposed by Atkinson (1905), has been accepted since then. For this study the type specimens of *P. leucopus* and *Sphaeria alutacea* Pers. : Fr. were examined as were numerous specimens identified as *P. alutaceum*. Based on morphological and biological characteristics, these two taxa are recognized as distinct species.

The stroma of species included in *Podostroma* is typically light in color, at least when fresh, and is fleshy. The centrum is typically hypocrealean, having apical paraphyses that dissolve at maturity. The asci and ascospores of *Podostroma* are indistinguishable from those of *Hypocrea*. The asci are cylindrical and the apex is only slightly thickened and has an obscure pore. The ascospores are hyaline, spinulose and bicellular. The two halves of each ascospore disarticulate early in development, giving the appearance that there are 16 spores in each ascus (Rossman et al. 1999). *Podostroma* is distinguished from *Hypocrea* only on the basis of gross morphology of the ascomata. The stipitate stromata of *P. alutaceum* and *P. leucopus* are macroscopically different from the type of *Hypocrea*, *H. rufa* (Pers. : Fr.) Fr., the stroma of which is broadly attached, appearing to be effused, becoming pulvinate.

*Trichoderma* Pers. or verticillium-like anamorphs have been attributed to some species included in *Podostroma*. Doi (1966) described a verticillium-like anamorph with hyaline conidia for *P. alutaceum*. Doi (1967) linked *P. cordyceps* (Penz. & Sacc.) Yoshim. Doi and *P. cornu-damae* (Pat.) Boedijn to a *Trichoderma* anamorph with pale green conidia and *P. solmsii* (E. Fisch.) Imai to a verticillium-like anamorph with hyaline conidia. Later Doi (1973) linked *P. cornu-damae* to a verticillium-like anamorph with subglobose, green conidia and in the same paper he attributed a verticillium-like anamorph with hyaline conidia to *P. giganteum* Imai. Samuels & Lodge (1996) described typical *Trichoderma* anamorphs for the turbinate species *H. brevipes* (Mont.) Sacc.) (≡*P. brevipes* (Mont.) Seaver), *H. poronioidea* A. Möller (= *P. orbiculare* Chardón) and *H. capitata* Samuels.

Neither *P. alutaceum* nor *P. leucopus* have been subjected to DNA sequence analysis. However, Chaverri and Samuels (2003) found that one unidentified, and probably undescribed, species of *Podostroma* with clavate stroma is derived from within *Hypocrea*, closely related to *Trichoderma minutisporum* Bissett. In the same paper they found that *Hypocrea pezizoides* Berk. & Broome, a discoidal species that has a minute central stipe, is phylogenetically close to *H. rufa*/*T. viride*. These results argue that the stipitate habit is not phylogenetically informative at the genus level in the Hypocreaceae.

Based on the similarities of microscopic and anamorphic characteristics, the type species of *Podostroma*, *P. leucopus*, and the type species of *Podocrea*, *P. alutacea*, are considered members of the genus *Hypocrea*. In the present paper the synonymy of these species is investigated and a new species is described. Species of *Podostroma* for which specimens are available are redescribed. A key is presented to seventeen stipitate *Hypocrea* species including those previously in *Podostroma* and *Podocrea*.

## Materials and methods

### *Collection and preservation of material*

Collection data and place of deposition for freshly collected material and herbarium specimens examined representative of their geographic distribution are listed after each species. Abbreviations of herbaria are taken from Holmgren et al. (1990).

### *Cultures*

Single ascospore isolations were made with the use of a micromanipulator where possible. Perithecia were crushed in a drop of 0.7% (w/v) sodium acetate; perithecial contents were picked up with a capillary tube and put onto cornmeal dextrose agar (CMD, Difco cornmeal agar + 2% dextrose). Ascospores were isolated when they had germinated. In other cases, following surface sterilization with alcohol, a portion of the inner stroma was aseptically removed with a scalpel and the tissue placed onto CMD. Cultures of *Podostroma* species were also obtained from the Centraalbureau voor Schimmelcultures (CBS) and Canadian Collection of Fungal Cultures (DAOM).

### *Phenotype analysis*

Stromata from herbarium specimens were rehydrated in a drop of 3% aqueous KOH. Reaction of stroma tissue to KOH was noted. Sections of stromata ca. 15 µm thick were made with a cryostat (International Equipment Co., Needham Heights, MA). Whole stromata or parts of stromata, were supported for sectioning by Tissue-Tek O.C.T. Compound (Miles Inc., Elkhart, IN). Sections of stromata were observed and photographed. Colors are taken from Kornerup and Wanscher (1978). Continuous measurements were made using the Scion Image 1.0 software package (Scion Corp., Frederick, MD). Where possible, thirty objects (e.g. asci, part-spores, etc.) were measured for each morphological character for each collection; it was rarely possible to measure thirty stromata or perithecia for any collection. All observations and measurements of asci, ascospores and anamorph morphological characters were made either from wet mounts in KOH or water. Means and standard deviations (SD) of the measurements of all collections were calculated and were computed using the Microsoft Excel 97-SR1 or Systat 10 (SPSS 2000). Measurements are reported by one of two methods. When fewer than ten objects were measured, the total range of the object is given. When more than ten objects were measured, the number of measured objects (N) is given and the measurements are recorded as extremes in brackets separated by the mean plus and minus the standard deviation.

Anamorph characters were taken from cultures grown on CMD for one wk or less at 20°C and 25°C, with alternating darkness and cool white fluorescent light. For microscopic examination, material was first wetted in a drop of KOH, which was replaced by water as the KOH evaporated. Thirty of each object for each culture were measured. Colony characters and growth rate were recorded from cultures grown on CMD and potato dextrose agar (PDA, Difco); pigment production was described from cultures grown on PDA. Growth rates were determined as follows. An actively growing culture was established on CMD. Before sporulation, 5 mm diam plugs were taken from the edge of the colony and placed, mycelium down, ca. 1.5 cm from the edge of freshly prepared PDA and CMD in vented plastic 10 × 15 mm Petri dishes containing 20 mL of freshly prepared medium. These were incubated in darkness at 15, 20, 25, 30, and 35°C. Cultures were measured every 24 h for 7 da (168 h total). Colony radii were measured from the edge of the disc of inoculum to the edge of the growing colony.

Four types of lighting were used for microscopy, viz. brightfield (BF), brightfield phase contrast (PC), Nomarski differential interference microscopy (DIC), and fluorescence microscopy (FL). Preparations studied for fluorescence microscopy were prepared by flooding preparations that had been used for measurements with Calcofluor (Sigma Fluorescent Brightener 28, C.I. 40622 Calcofluor white M2 in a 2 molar phosphate buffer at pH 8.0).

## Results

Most of the species studied possessed characters typical of *Hypocrea* including stromatic ascomata, cylindrical asci, and hyaline, spinulose, bicellular ascospores that disarticulated early in development into part-ascospores. Only ascospores of *H. solmsii* f. *octospora* did not disarticulate; they remained unicellular and appeared to have a blunt apiculus at each end. This species is treated below as a 'rejected species.' *Podostoma* and *Podocrea* could not be distinguished from each other; both are considered to be synonymous with *Hypocrea*. Species of these genera are recognized in or transferred to *Hypocrea*. The seventeen species of stipitate *Hypocrea* many of which had previously been included in *Podostroma* or *Podocrea* are distinguished in the key.

For *Podostroma alutaceum* and *P. leucopus* numerous Northern Hemisphere collections were studied. One group of collections form stromata on decaying wood while stromata of the second group arise from the ground. Although we were able to obtain cultures for only a few collections, there was a close correlation between substratum and anamorph. The anamorph of terricolous collections was verticillium-like with hyaline conidia, while conidia of the lignicolous specimens are green and the conidiophores are more irregularly branched and trichoderma-like. These differences coincide with the type specimens of *P. leucopus* and *P. alutaceum* respectively and serve to separate these two species.

The terricolous Northern Hemisphere specimens could also be divided into two groups based on the characters of their stromata and ascospores. In one group the stroma was 3–5 cm tall and beige. In contrast to the first group, stromata in the second group are much more robust, 2–15 cm tall and sometimes shallowly once-branched at the apex; they have red-brown to brown-orange scales on the stipe. Ascospore measurements coincide with stroma size. In the first group the distal part-ascospores are subglobose to conic, 2.5–3.0 µm diam, and the proximal part-ascospores are cuneate to ellipsoidal, 3.0–4.0 × 2.0–3.0 µm. Distal part-ascospores in the second group are globose to subglobose, 3.5–4.5 × 3.2–4.0 µm, and the proximal part-ascospores are ellipsoidal to wedge-shaped, 3.7–5.0 × 3.0–3.5 µm. Specimens having the former phenotype were collected in northern Europe and eastern North

America. Specimens of the second group were found in northern Europe (Finland, Sweden). Stromata of the first type conform to the type specimen of *H. leucopus*. For the second group, we describe a new species.

## Discussion

The most important characters for distinguishing species of stipitate *Hypocrea* include substratum, gross morphology, color of the stroma, internal anatomy of the stroma, extent of the fertile region of the stroma, pigmentation in the surface of the stroma, and ascospore shape, size and ornamentation. According to Samuels and Lodge (1996) there is nearly continuous variation in stromatal form within *Hypocrea*. Within *Hypocrea* stromata may vary from indefinitely effused, pulvinate but broadly attached at a central point, to stipitate, clavate. In four species of *Hypocrea*, *H. brevipes* (Mont.) Sacc., *H. capitata* Samuels, *H. pezizoides* Berk. & Broome, and *H. poronioidea* A. Möller, the fertile part of the stromata forms an expanded cap that is sharply delimited from the sterile stipe (Liu & Doi 1995; Samuels & Lodge 1996). Among stipitate species of *Hypocrea*, the base of the stroma is sterile to some degree. In *H. leucopus* the stroma is typically strongly constricted where the fertile part meets the sterile base and the sterile part comprises less than 50% of the total length of the stroma. In most species of stipitate *Hypocrea*, the sterile part comprises more than 50% of the total length of the stroma and the sterile base is not sharply delimited from the fertile upper part of the stroma. Several species of stipitate *Hypocrea* including *H. africana* (Boedijn) H. Chamb., *H. alutacea*, *H. eperuae* (Rogerson & Samuels) H. Chamb., and *H. grossa* Berk. have clavate stromata where the fertile part is not at all or only slightly differentiated from the sterile base. In general the stipitate species of *Hypocrea* are microanatomically the same as other species of *Hypocrea* with the exception of *H. brevipes* and *H. eperuae* in which the stroma in longitudinal section consists of elongated, brick-like cells (Rogerson & Samuels 1992, Samuels & Lodge 1996). Rogerson and Samuels (1992) suggest that these brick-like cells resulted from the extension of the stroma and do not indicate any relationship between these two species.

Anamorphic states are useful in determining relationships among genera and species of the Hypocreales (Samuels & Seifert 1987, Rossman 2000). Few species of stipitate *Hypocrea* species have been grown in pure culture and linked to anamorphs. Doi (1967, 1973), Liu and Doi (1995) and Tubaki (1958) have connected stipitate *Hypocrea* species to typical *Trichoderma* as well as to verticillium-like *Trichoderma* anamorphs. As part of this research *Trichoderma* and verticillium-like *Trichoderma* anamorphs were obtained for *H. alutacea* and *H. leucopus* (Figs. 28–37), confirming their relationship to *Hypocrea*. Samuels and Lodge (1996) linked two stipitate *Hypocrea*, *H. brevipes* and *H. poronioidea*, to *Trichoderma* anamorphs that they tentatively assigned to *Trichoderma* sect. *Pachybasium* (Sacc.) Bissett (Bissett 1991). The anamorph of *H. pezizoides* has very pale green conidia and verticillium-like conidiophores (Liu & Doi 1995).

## Taxonomy

Seventeen species of stipitate *Hypocrea* including those previously placed in *Podostroma* and *Podocrea* are included in the following key. Descriptions are provided for species with available type or authentic material as indicated in boldface. A list of excluded or doubtful species is found at the end.

### *Key to stipitate* Hypocrea *including* Podostroma and Podocrea

1. Stromata with an expanded cap greater than twice diameter of stipe and sharply delimited from stipe; tropical species ........ 2
   1. Stromata clavate or cylindrical, fertile part, at most, only slightly broader than stipe; temperate- and tropical ........ 5

2. Stromata discoidal, 6–16 mm diam, purplish red to reddish orange, stipe inconspicuous or lacking; distal part-ascospores obovate-subglobose, 4.3–4.5 × 3.5–4.2 µm, proximal part-spores obovate-ellipsoid, 4.8–6.7 × 3.5–4.2 µm; Asia (Liu & Doi 1995) ........ *H. pezizoides* Berk. & Broome
   2. Stromata convex, in shades of brown, stipe conspicuous; New or Old World ........ 3

3. Cap slightly tuberculate, 1.5–3 mm diam; distal part-ascospores globose to subglobose, 2.0–2.7 × 1.9–2.6 µm, proximal part-ascospores oblong to narrowly wedge-shaped, 2.4–3.0 × 1.8–2.2 µm; South America (Samuels & Lodge 1996) ........ *H. capitata* Samuels
   3. Cap plane, 2–8 mm diam; distal part-ascospores 2.6–4.3 × 1.9–3.9 µm, proximal part-ascospores 2.5–5.0 × 1.7–3.2 µm ........ 4

4. Cap 2–8 mm diam, dark to greyish brown; distal part-ascospores subglobose to conic, 3.5–4.3 × 3.1–3.9 µm, proximal part-spores wedge-shaped, 3.6–5.0 × 2.2–3.2 µm; on wood; South America (French Guiana), Puerto Rico, New Guinea (Samuels & Lodge 1996), Europe, and Japan (Doi 1975) ........ *H. brevipes* (Mont.) Sacc.
   4. Cap 3.0–6.5 mm diam, brown, yellowish-brown, pale brown or brownish-gray; distal part-ascospores globose to subglobose, 2.6–2.9 × 1.9–2.5 µm, proximal part-ascospores oblong, 2.5–3.5 × 1.7–2.0 µm; on wood and bark; pantropical (Samuels & Lodge 1996) ........ *H. poronioidea* A. Möller (= *Podostroma orbiculare* Chardón)

5. Stromata arising from 'eggs' of Phallales ........ 6
   5. Arising from leaves, seed pods, wood, or ground ........ 7

6. Ascospores bicellular, disarticulating into two part-ascospores; distal part-ascospores ovoidal, 5.0–5.5 × 3.2–3.7 µm, proximal part-ascospores 3.7–5.0 × 3.2–3.7 µm; Indonesia, Japan (Boedijn 1934, Doi 1967) ........ *H. solmsii* (E. Fish.) Imai
   6. Ascospores unicellular, remaining whole, 10–16 × 4.5–5.5 µm ........ *Podostroma solmsii* f. *octosporum*, see excluded species below.

7 On decaying leaves or seed pods, possibly endophytic on specific hosts ........ 8
   7. On wood or ground ........ 9

8. Arising from pods of the legume tree *Eperua;* stromata narrowly clavate to filiform, 15–35 mm tall, fertile portion 5–12 mm long, cylindrical to slightly flattened, pale brown to brown or brownish gray; distal part-ascospores subglobose to broadly ovoidal, 4–5.3 × 3.2–4.4 µm, proximal part-ascospores wedge-shaped, 5–6.2 × 2.7–3.8 µm; French Guiana, Guyana ........ *Hypocrea eperuae* (Rogerson & Samuels) H. Chamb., **comb. nov.**
   Basionym: *Podostroma eperuae* Rogerson & Samuels, Brittonia 44: 259. 1992.
   8. On fallen leaves of *Fagus crenata;* stromata 5–6 cm tall, 0.3 cm diam; brownish-orange with tinge of red, lower stipe pale pinkish; distal part-ascospores subglobose to ovoidal, 3.1–3.7 × 2.8–3.4 µm, proximal part-ascospores ovoidal to subcylindric, 3.2–4.6 × 2.2–2.9 µm; China, Japan, Java ........ *Hypocrea cordyceps* (Penz. & Sacc.) H. Chamb., **comb. nov.**
   Basionym: *Podocrea cordyceps* Penz. & Sacc., Malpighia 15: 229. 1901 (Penzig & Saccardo 1904: 52, Pl. 36: 4, as *Podocrea cordyceps*; Doi 1967 as *Podostroma cordyceps*)

9. Stromata long-cylindric, brownish-olive to black, 3–15 cm tall, 1.5–7.5 mm diam; distal part-ascospores 6.2–7.6 × 4–5 µm, proximal part-ascospores 7.0–9.2 × 3.7–4.5 µm*;* on soil, possibly associated with termite runs .......................... **1. *H. africana***

9. Stromata pale luteous, yellow, orange, red, to brown or black; part-ascospores less than 6 µm diam .......................... 10

10. On ground .......................... 11

10. On wood .......................... 14

11. Stromata mostly simple, clavate or branched at apex; north temperate .......................... 12

11. Stromata cylindrical, palmately lobed or dichotomously branched from base; SE Asia and Japan… .......................... 13

12. Stromata mostly simple, clavate, fertile part often conspicuously swollen, generally with a clear distinction between fertile and sterile parts, 1.5–8.0 cm tall, 0.5–5.0 cm diam; fertile part pale yellow to golden brown in mature specimens; stipe white to beige; distal part-ascospores 2.5–3.0 µm diam, proximal part-ascospores 3.0–4.0 × 2.0–3.0 µm; north temperate .......................... **6. *H. leucopus***

12. Stromata simple, clavate, reddish-brown to brownish orange, stipe white to beige, with conspicuous scales of rust pigment between area of fertile and sterile stipe, 2.2–22 cm tall, 1.0–6.5 mm diam; distal part-ascospores 3.5–4.5 × 3.2–4.0 µm, proximal part-ascospores 3.7–5.0 × 3.0–3.5 µm; northern Europe .......................... ***7. H. nybergiana***

13. Stromata buff-orange, cylindrical, narrowly clavate to flabelliform or antler-shaped, dichotomously branched, 7–9 cm tall; distal part-ascospores 3.5–4.0 × 3.0–3.2 µm, proximal part-ascospores 3.2–4.0 × 2.5–3.5 µm; trichoderma-like anamorph, olivaceous green conidia; SE Asia ..........................
**3. *H. cornu-damae***

13. Stromata cream-carnose, dichotomously branched from base, twisted, 5–18 cm tall, 3–7 mm diam, ostioles not distinct by naked eye; distal part-ascospores 2.7–3.3 × 2.3–3.1 µm, proximal part-ascospores 3.0–4.1 × 2.2–2.9 µm .......................... **4. *H. daisenensis***

14. Part-ascospores monomorphic, subglobose, 4–5 µm diam; stromata clavate or cylindrical with truncate, depressed apex, 1.5–3.0 cm tall, 5 mm diam; on wood; Japan ..........................
*Hypocrea truncata* (Imai) H. Chamb., **comb. nov.**
Basionym: *Podostroma truncatum* Imai, Trans. Sapporo Nat. Hist. Soc. 12: 117. 1932.

14. Part-ascospores dimorphic .......................... 15

15. Part-ascospores 5 mm or more; anamorph verticillium-like .......................... 16

15. Part-ascospores less than 5 µm; anamorph *Trichoderma* or unknown .......................... 17

16. Stromata yellowish brown, reddish brown to violet brown, often nearly black when dry, flatened, simple or branched, mostly without distinct stipe, 3.0–17.0 cm tall, 0.5–1.5 cm diam; distal part-ascospores 4.0–6.7 × 4.0–5.5 µm, proximal part-ascospores 4.2–6.5 × 3.7–4.7 µm, warted; on wood
**5. *H. grossa***

16. Stromata often bi-lobed, tan, 10–16 cm tall, 10–30 mm diam; ascospores globose to subglobose, 5–6 × 5 µm; verticillium-like anamorph, hyaline conidia; on wood; Japan ..........................
*H. gigantea* (Imai) H. Chamb., **comb. nov.**
Basionym: *Podostroma giganteum* Imai, Trans. Sapporo Nat. Hist. Soc. 12: 116. 1932.

17. Stromata single, cylindric, pale yellowish brown, 9–14 cm tall, 1–2 cm diam, dark ostioles distinctly protruding; distal part-ascospores cuboidal, 2.5–4.0 µm diam, proximal part-ascospores elongate, 4.0–5.0 × 2.5–3.0 µm; Indonesia. .......................... *Hypocrea sumatrana* (Boedijn) H. Chamb., **comb. nov.**
Basionym: *Podostroma sumatranum* Boedijn, Bull. Jard. Bot. Buitenzorg, ser. 3, 13: 271. 1934.

17. Stromata single or gregarious; clavate to grossly lobed or branched, sometimes fused, 0.5–8.0 cm tall, 0.5–1.8 cm diam, golden yellow, coffee to linoleum brown, if stipe visible, white to beige, ostioles visible as darker brown against a pale brown background; distal part-ascospores 2.7–3.7 × 2.5-3.5 µm, proximal part-ascospores 3.0–4.0 × 2.2–2.7 µm; *Trichoderma* anamorph, pale green conidia; on wood .......................... **2. *H. alutacea***

Figs. 1–9. Stipitate stromata of *Hypocrea* species. – 1. *H. africana*, from type specimen. Bar = 5 mm. – 2, 3. *H. alutacea*. 2 from *Rogerson 86-35*, 3 from *Spatafora 00-403b*. Bar = 0.5 mm. – 4–6. *H. cornu-damae*, from type. Bars: 4, 5 = 1 cm, 6 = 0. 5 mm. – 7–9. *H. grossa* from BPI 745647. Bars: 7, 8 = 1 cm; 9 = 1 mm.

## *Descriptions of species*

**1. Hypocrea africana** (Boedijn) H. Chamb., **comb. nov.** Figs. 1, 10–19.
Basionym: *Podostroma africanum* Boedijn, Ann. Mycol. 36: 314. 1938.
Anamorph. Unknown.
Stromata simple or dichotomously branched, long-cylindrical, with more or less developed, sterile basal part, sometimes slightly attenuated, not different from rest of stroma; stroma 3–15 cm tall, 0.15–0.75 cm wide. Fertile part finely warted with protruding perithecial papillae, thus appearing undulating, greyish-green to dull green when young to olive brown to black when mature (30 E6 to 4 F6), KOH–; consistency of dried material horny. In cross-section stromal tissue dark dirty brown, sometimes nearly black; these cells nearly hyaline, but in center of stroma dirty brown cells present, forming loose network between other cells. Surface cells in surface view of vertically oriented hyphal elements, 3.5–5.0 µm wide; in cross section 25–50 µm wide; surface cells 5.0–7.5 µm long × 3.5–6.0 µm wide; cell walls visibly thickened, 0.5–1.0 µm thick. Perithecia subglobose to elliptical, 300–375 µm high × 145–200 mm wide; perithecial wall 6.5–8.0 µm wide; ostiolar canal 55–100 µm long × 35–50 µm wide; perithecial papilla of chains of thick-walled, pigmented cells; ostiolar canal periphysate. Tissue below perithecia of loosely arranged hyphal elements 5–10 µm long × 3.5–6.5 µm wide. Asci cylindrical, (118–) 125-150(–163) × (4.0–)4.7–6.0(–6.5) µm (n=14), apex conspicuously thickened; ascospores disarticulating into 16, uniseriate part-spores. Part-ascospores hyaline, heavily verrucose, noticeably tuberculate at top and bottom of each spore pair, dimorphic. Distal part-ascospores cuneate and subacute at tip to ellipsoidal, (6.0–) 6.2–7.2(–7.7) × 4–5 µm (n=30), proximal part-ascospores cuneate, oblong to narrowly ellipsoidal, (6.5–)7.0–8.2(–9.0) × 3.7–4.5(–5.0) µm (n=30).

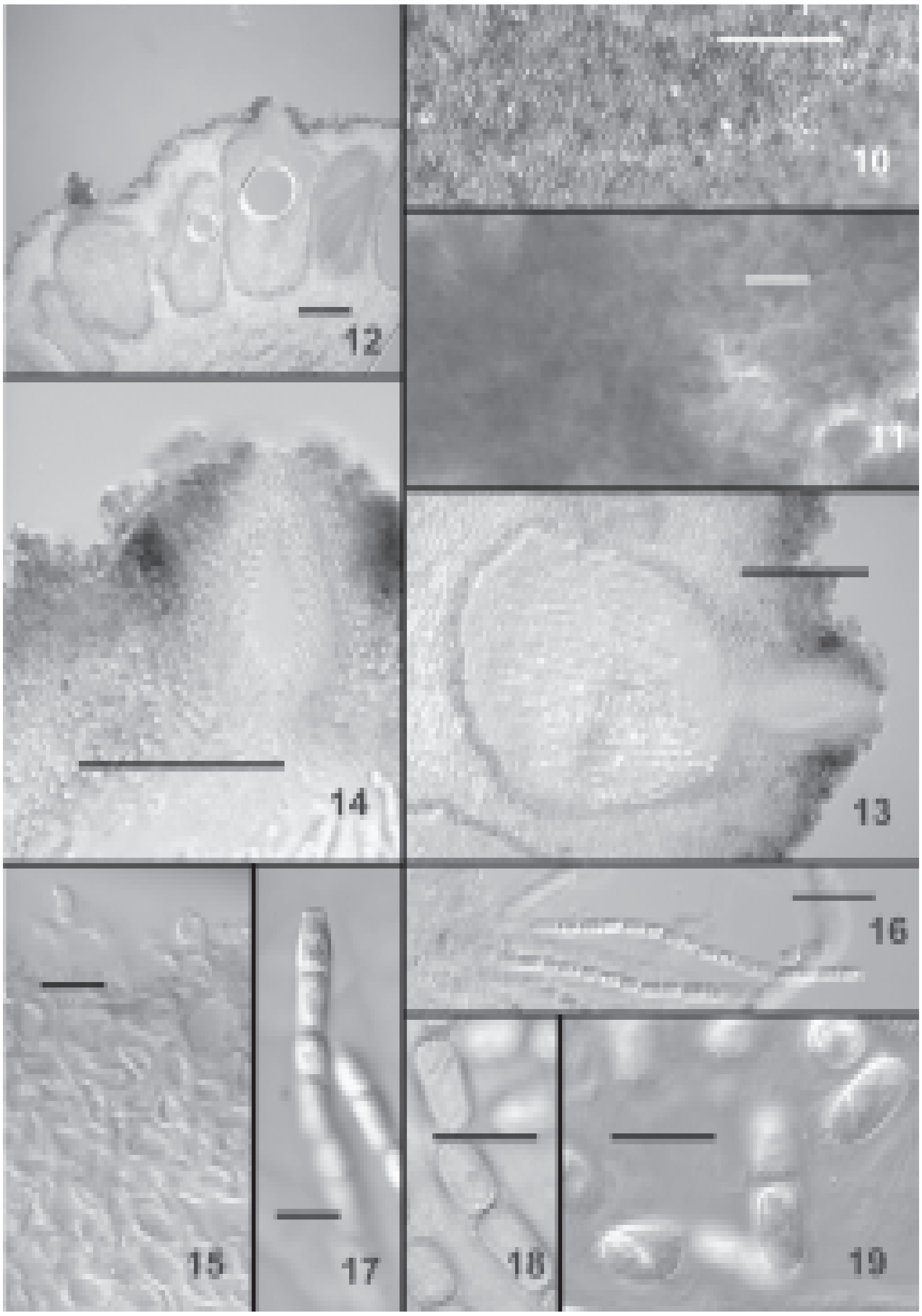
*Habitat*. On ground, possibly associated with termite runs.

*Known distribution*. Sierra Leone, known only from a single collection.

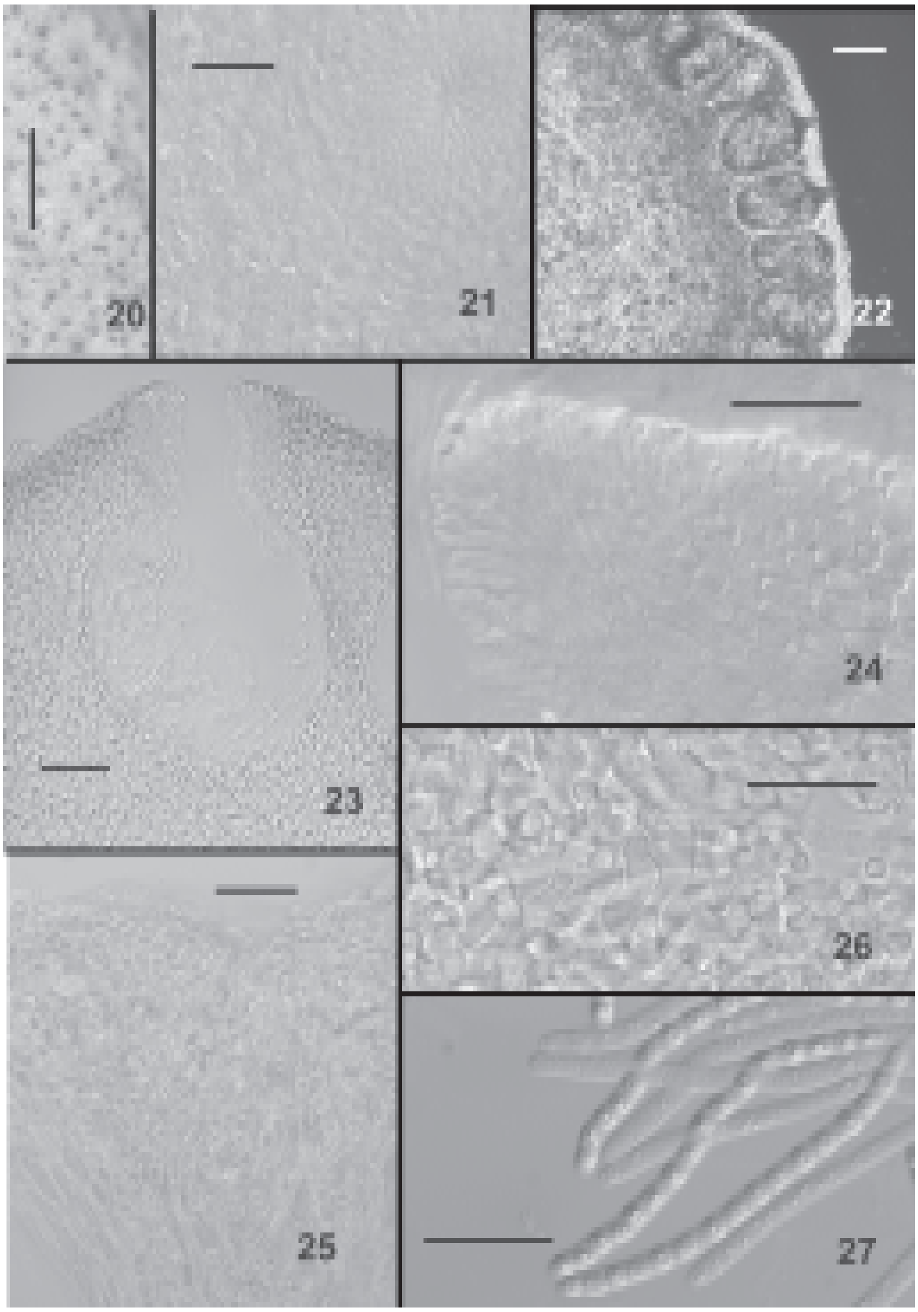
HOLOTYPE. Sierra Leone. Njala, associated with termites in forest, 18 Nov 1935 *F.C. Deighton M882* (IMI 43922!).

*Notes*. The fresh stromata of this species are described as "...chrome yellow when young, becoming olive-brown and finally almost black with olive base..." (Boedijn 1938). The several stromata that make up the type specimen are almost black. The thick-walled cells of the stromatal surface and the protruding perithecial papilla of chains of thick-walled cells are distinctive. This unusual anatomy is also found in *H. nigrovirens* Chaverri & Samuels (Chaverri et al. 2001). This species is also characterized by the presence of pigmented cells interwoven with hyaline cells in the internal tissue of the stroma below the perithecia. These pigmented cells give the internal tissue a discolored appearance. The ascospores are large in *Hypocrea africana*.

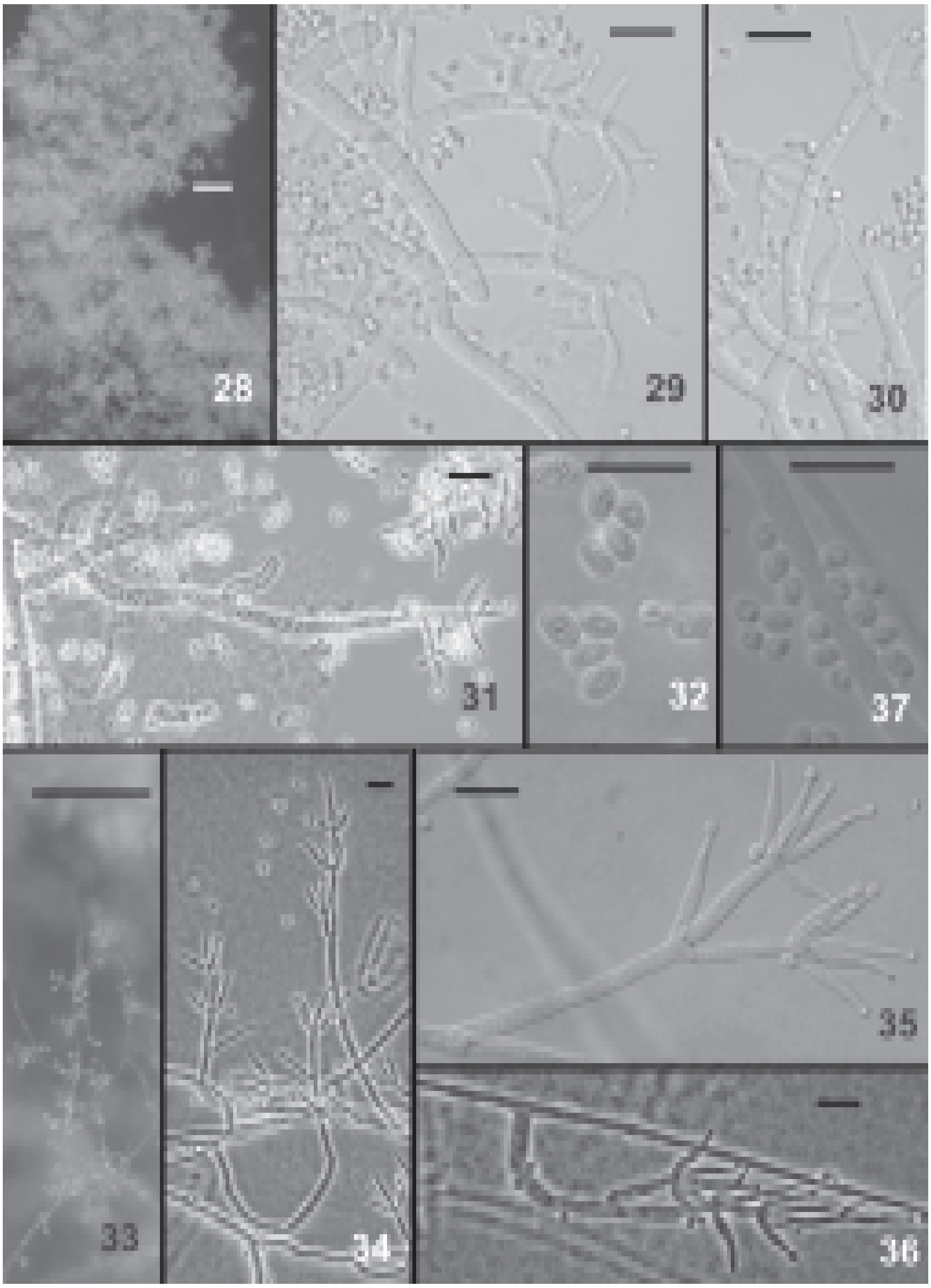
**2. Hypocrea alutacea** (Pers. : Fr.) Tul. & C. Tul., Sel. Fung. Carp. 1: 63. 1861. Figs. 2, 3, 20–32.
= *Sphaeria alutacea* Pers. : Fr., Commentatio de fungis clavaeformibus: 12. 1797 : Syst. Mycol. 2: 325. 1823.
= *Cordiceps alutaceus* (Pers. : Fr.) Link, Handbuch 3: 347. 1833, '*Cordiceps*'.
= *Claviceps alutacea* (Pers. : Fr.) Bail, Nova Acta Acad. Caes. Leop. 29: 22. 1861.
= *Fracidia alutacea* (Pers. : Fr.) Fr., Bot. Zeit. (Berlin) 22: 189. 1864.
= *Podocrea alutacea* (Pers. : Fr.) Lindau *in* Engler & Prantl, Natürl. Pflanzenfam. 1(1): 364. 1897.
= *Podostroma alutaceum* (Pers. : Fr.) G.F. Atk., Bot. Gaz. 40: 401. 1905.
= *Clavaria simplex* Schmidel, Icon. Pl. (ed. Keller): 18. 1763 ('1762') p. p. according to Tulasne & C. Tulasne (1865).
= *Sphaeria clavata* Sowerby, Col. Fig. Engl. Fung. 2: 159. 1799.
= *Sphaeria alutacea β turgida* Fr., Syst. Mycol. 2: 325. 1823.
Anamorph. *Trichoderma* sp.
Stromata clavate, typically gregarious, single or sometimes fused, sometimes appearing to be branched or lobed, fully to mostly fertile. Total stroma length (0.5–)2.5–4.5(–8.0) cm (n=28), delineation between fertile and sterile parts sometimes evident. Fertile portion 1.4–3 cm long (n=7) × 0.5–1.8 cm wide (n=29); KOH–, golden yellow, coffee to linoleum brown (5 B6–F7), surface glabrous, sometimes wrinkled, perithecial elevations not evident or surface slightly tuberculate, ostiolar openings visible as small dark brown dots against a pale coffee background. Sterile stipe white to beige, velvety or not, 0.5–2.0 cm long × 0.5–1.0 cm wide (n=7); adjacent stipes often appearing to have fused, with fissures demarcating



Figs. 10–19. *Hypocrea africana,* from type. – 10. Stroma surface seen with stereo microscope. Bar = 0.5 µm. – 11. Pseudoparenchymatous cells at stroma surface. Bar = 10 µm. – 12, 13. Median, longitudinal section through a perithecium embedded in the stroma. Bars: 12 = 100 µm, 13 = 50 µm. – 14. Median longitudinal section through the perithecial papilla showing dark, thick-walled cells. Bar = 50 µm. – 15. Thick-walled, pseudoparenchyma of the interior of the stroma below perithecia. Bar = 10 µm. – 16. Ascus with ascospores. Bar = 20 µm. – 17. Ascus with thickened apex pierced by a pore. Bar = 10 µm. – 18. Ascospores in an ascus. Bar = 10 µm. – 19. Discharged ascospores. Bar = 10 µm.



Figs. 20–27. *Hypocrea alutacea*. – 20. Stroma surface seen with stereo microscope. From *Rogerson 86-35*. Bar = 0.5 mm. – 21. Pseudoparenchymatous cells at stroma surface. From *H. Harmaja* 19 Aug 1979. Bar. = 20 µm. – 22. Section through a stroma showing embedded perithecia. From *Rogerson 84-36*. Bar = 100 µm. – 23. Median longitudinal section through a perithecium. From *Samuels 86-538*. Bar = 20 µm. – 24. Section through perithecial apex showing cells of the papilla and of the stroma surface. From *L. Siivonen* (H 63261). Bar = 20 µm. – 25. Stroma surface with hyphal cells below. From *H. Harmaja* 19 Aug 1979. Bar = 20 µm. – 26. Hyphal cells of the stroma interior below perithecia. From *Rogerson 86-35*. Bar = 20 µm. – 27. Asci with ascospores. From 6 Oct 1968 *V. Haikonen*. All DIC except 20. Bar = 20 µm.



Figs. 28–37. Anamorphs of *Hypocrea alutacea* and *H. leucopus* on CMD. – 28–32. *H. alutacea*, from CBS 332.69. – 28. Conidiophores in aerial mycelium seen with stereo microscope. – 29–31. Conidiophores. – 32. Conidia. All DIC except 28, 31 (PC). Bars = 10 µm. – 33–37. *H. leucopus*, from DAOM 226070. – 33. Conidiophores in aerial mycelium seen with stereo microscope. – 34–36. Conidiophores. – 37. Conidia. All DIC except 28, 36 (PC). Bars: 33 = 100 mm, 34–37 = 10 µm.

the individual stipes. Cells of stroma surface in surface view elongated and hyphal, 4–17 µm long × 3–11 µm wide. Stromal surface region pale brown, in section, 28–72 µm wide, cells pseudoparenchymatous, 3–8 × 2.5–6.0 µm long, walls 0.1–1.2 µm thick. Perithecia crowded below stromal surface, mostly globose to subglobose, 150–400 µm high × 50–287 µm wide; perithecial wall 10–35 µm wide; cells at perithecial apex around ostiolar opening, at most, slightly differentiated from stromal tissue, pigmented pale brown; ostiolar canal 30–90 µm long × 20–57 µm wide, ostiolar canal periphysate. Tissue below perithecia of vertically oriented, thick-walled hyphal cells 4–10 µm long × 2.5–11.0 µm wide, walls 0.5–1.5 µm thick, hyaline. Asci cylindrical, (45–)65–90(–113) × (2.2–) 2.5–4.5 (–5.4) µm, apex slightly thickened; 16-spored, ascospores uniseriate. Part-ascospores (n=330), hyaline, finely verrucose, dimorphic; distal part globose to subglobose (2.2–)2.7–3.7(–4.5) × (2.2–)2.5–3.5(–4.5) µm; proximal part subglobose to conic (2.2–)3.0–4.0(–6.0) × (1.5–)2.2–2.7(–3.7) µm.

Culture: On CMD > 2 cm diam after 6 d; aerial mycelium lacking, diffusing pigment lacking; conidia forming in 2–3 concentric rings. Aggregates cottony with fertile branches protruding, easily removed from agar surface; greyish to almost dark green (28 E6) fading to pistachio green (27 C3 to 28 C4) to near white at margin. Colonies on PDA faster than on CMD. On PDA > 3 cm diam after 6 d; no diffusing pigment formed; conidia formed profusely in dense concentric rings alternating with mycelial production, uniformly cottony, greyish to dull green (28 E6 to 27 C3) with age, progressively lighter green toward the margin; noticeably sweet odor. Conidiophores formed on PDA, fertile branches 35–72 mm long ($\bar{x}$=56.92, SD±14.82, n=5, R=36.99), less frequently rebranched; phialides arising singly along length of branches and in cruciate whorls of ca. 3 at branch tips. Phialides (n=30) lageniform, tapering uniformly from base to tip, at most only slightly swollen toward middle (7.5–)9.5–13.5(–15.7) µm long, at base (1.7–)2.2–3.2(–3.5) µm wide, arising from a cell (1.7–)3.0–4.0(–4.7) µm wide. Conidia oblong to ellipsoidal (2.2–)2.7–4.5(–5.2) × (1.0–) 1.2–1.7(–2.0) µm (n=60), lacking a visible basal abscission scar, smooth, green. Chlamydospores not seen.

*Habitat*. On corticated, but typically wet, rotten wood; also found on wood chips.

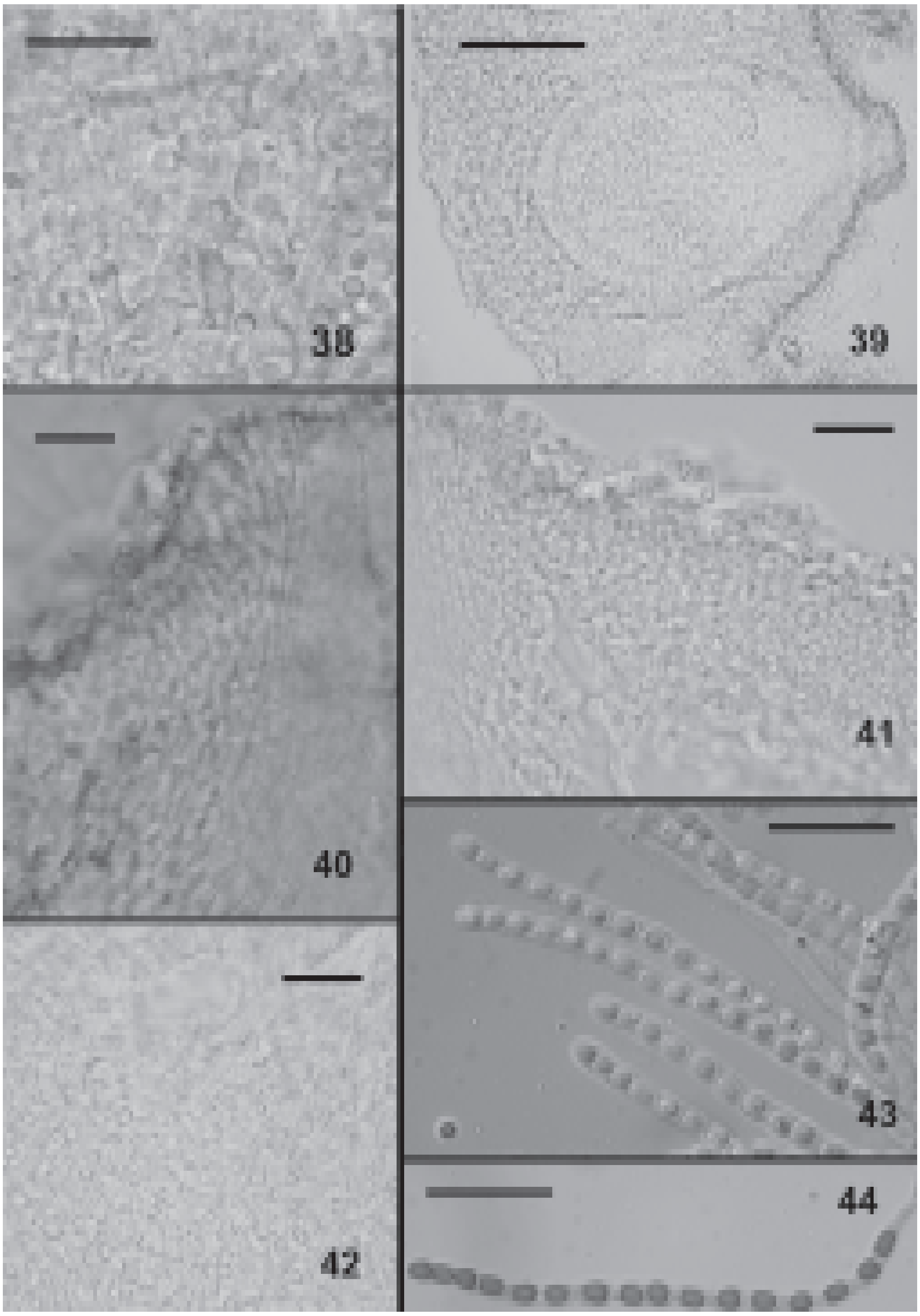
*Known distribution*. Europe, North America.

*NEOTYPE designated herein*. Illustration in Persoon, C.H. (1800): Observ. Mycol. 2: 66. Tab. I, fig. 2 a–c, reproduced at http://nt.ars-grin.gov/sbmlweb/OnlineResources/FungiOnline.cfm.

*Representative specimens examined:* **Denmark.** Aarhus, vic. Skormollen, Moesgaard forest, on branches of probably *Fagus sylvatica*, on ground, 30 Aug 1999 *C. Lange* (BPI 843824); Falster, Sønder Alslev, on rotten wood in beech forest, 16 Sep 1980 *A. Pohjola* (OULU F 49648). **Finland.** Etelä-Häme. Hattula, Ilamo, substratum not known, 3 Aug 1981 *L. Siivonen* (H 63261); Lahti, Mukkula, 61, 02–425, 40, substratum not known, 6 Oct 1968 *V. Haikonen* (H). Keski-Pohjanmaa. Kälviä, Luoto, 7092:323, on timber, 19 Aug 1979 *H. Harmaja* (H). **Germany.** Teutoburger Wald, Beller Holz, on decaying wood (CBS 199.73). **Japan.** Locality unknown (culture CBS 332.69). **Sweden**. Södermanland, Överselö par., Tynnelsö Island, W of castle, on decayed wood in mixed forest, 8 Sep 1979 *N. Lundqvist 12* (UPS). **United States**. Maryland. Montgomery Co., Cabin John, on wood, 7 Sep 1919 *C.H. Kauffman* (BPI 630178). Massachusetts. Chester-Blandford Park, Berkshires, on fallen log, Sep 1978 *J. Gailun* (NY). Michigan. Iron Co., Upper Peninsula, N Iron River, on rotten wood, 31 Aug 1997 *A. D. Parker 102 MI* (Parker Herbarium). New York. Cattaraugus County, Allegany State Park, on wood, 15 Sep 1984 *R.P. Korf*, det. C.T.Rogerson 84-36 (NY); Cortland County, Hoxie Gorge, on log, 1 Oct 1986 *A. Methven*, det. C.T. Rogerson 86-35 (NY); Hamilton County, Racquette Lake, on wood, 6 Sep 1986 *G.J. Samuels & K.F. Rodrigues*, det. G.J. Samuels 86-538 (NY); Warren Co., Lake Sherman, on log, 25 Sep 1969 *C.T. Rogerson & S.J. Smith* (NY). North Carolina. Macon Co., Nantahala National Forest, on wood, 8 Sep 1988 *K.F. Rodrigues*, det. G.J. Samuels 88-60 (NY).

*Notes*. *Hypocrea alutacea* is characterized by the following features: (1) occurrence on woody substratum and gregarious habit, (2) dark brown perithecial ostioles contrasting with pale tan to greyish brown stroma and a creamy white sterile stipe, (3) tendency for stromata to become spathulate or branched, and (4) *Trichoderma* anamorph with green conidia. Another distinguishing character is the thickness of cell walls of the stroma surface and hyphal elements of the inner stroma. The formation of brown pigment in the cells of the ostiolar canal and in the cells of the stroma surface as seen in cross section is unusual in *Hypocrea*.

The original gathering of *Sphaeria alutacea* has apparently been lost and no potential neotype specimen exists in Persoon's herbarium (L), thus a neotype of *S. alutacea* is designated as the original illustration of *S. alutacea* by Persoon (1800) examined in the copy at the U.S. National Fungus Collections, BPI.



Figs. 38–44. *Hypocrea cornu-damae*, all from type. – 38. Stroma surface showing hyphae with free ends. – 39. Median longitudinal section of a perithecium embedded in a stroma. – 40. Perithecial papilla. – 41. Perithecial papilla and surface region of stroma showing hyphal region below the surface. – 42. Internal region of stroma below perithecia showing intertwined hyphae. – 43, 44. Asci and ascospores. 44 stained in cotton blue. All DIC. Bars = 20 µm except 39 (= 100 µm).

**3. Hypocrea cornu-damae** Pat., Bull. Soc. Mycol. France 11: 198. 1895. Figs. 4–6, 38–44.
= *Podocrea cornu-damae* (Pat.) Lindau *in* Engler & Prantl, Natürl. Pflanzenfam. 1(1): 365. 1897.
= *Podostroma cornu-damae* (Pat.) Boedijn, Bull. Jard. Bot. Buitenzorg, ser 3, 13: 274. 1934.
Anamorph: Unknown.

Stromata simple and cylindrical to narrowly clavate to flabelliform or antler-shaped and dichotomously branched below the tip, 7–9 cm tall, flattened, 0.5–0.7 cm thick, largest stroma in type collection ca. 1 cm broad at base, spreading to 8 cm at top, several cylindrical stromata arising from a common base, buff-orange, stipe sterile; surface glabrous, smooth, perithecial elevations not visible, ostiolar openings appearing as minute orange dots, KOH–. Cells of stroma in surface view appearing as intertwined hyphae with some short, free ends. Surface region of stroma ca. 35 mm thick in section, of intertwined, 2.5–3.5 µm wide, thin-walled hyphae. Tissue below surface region intertwined hyphae. Perithecia elliptical in section, 280–340 µm tall, 130–200 µm wide. Tissue below perithecia intertwined, 6–7 µm wide, thin-walled hyphae. Perithecial papilla formed of rows of small, thin-walled cells, papilla barely protruding through stroma surface. Asci cylindrical, (131–)135–158(–180) × (5.0–)6.5–8.2(–9.8) µm, apex thickened, with a ring. Part-ascospores hyaline, finely spinulose, dimorphic; distal part subglobose to slightly conical, (3.0–)3.5–4.0(–4.5) × (2.8–) 3.0–3.2(–4.0) µm; proximal part ellipsoidal to cuneate or subglobose, (3.0–)3.2–4.0(–5.0) × (2.3–)2.5–3.2(–4.0) µm.

*Habitat*. Growing on rotten wood.

*Known distribution*. Reported from Japan (Doi 1967) but confirmed only for type collection from China (Tibet).

HOLOTYPE. China. Tibet. Su-tschuen (date and collector not known) (FH!).

*Notes*. Boedijn (1934) reported that the ascospores of this species are smooth. The ascospores in the type collection are very finely spinulose, thus could have appeared smooth to Boedijn. Doi (1967) reported a *Trichoderma* anamorph for this species but the description given by Doi for that teleomorph suggests *H. grossa* rather than *H. cornu-damae*.

**4. Hypocrea daisenensis** (Yoshim. Doi & Uchiy.) H. Chamb., **comb. nov.**
Basionym: *Podostroma daisenense* Yoshim. Doi & Uchiy., Bull. Nat. Sci. Mus. Tokyo 1, ser. B, 13: 129. 1987.
Anamorph. Unknown.

*Habitat*. Growing on ground, possibly from dead, underground wood.

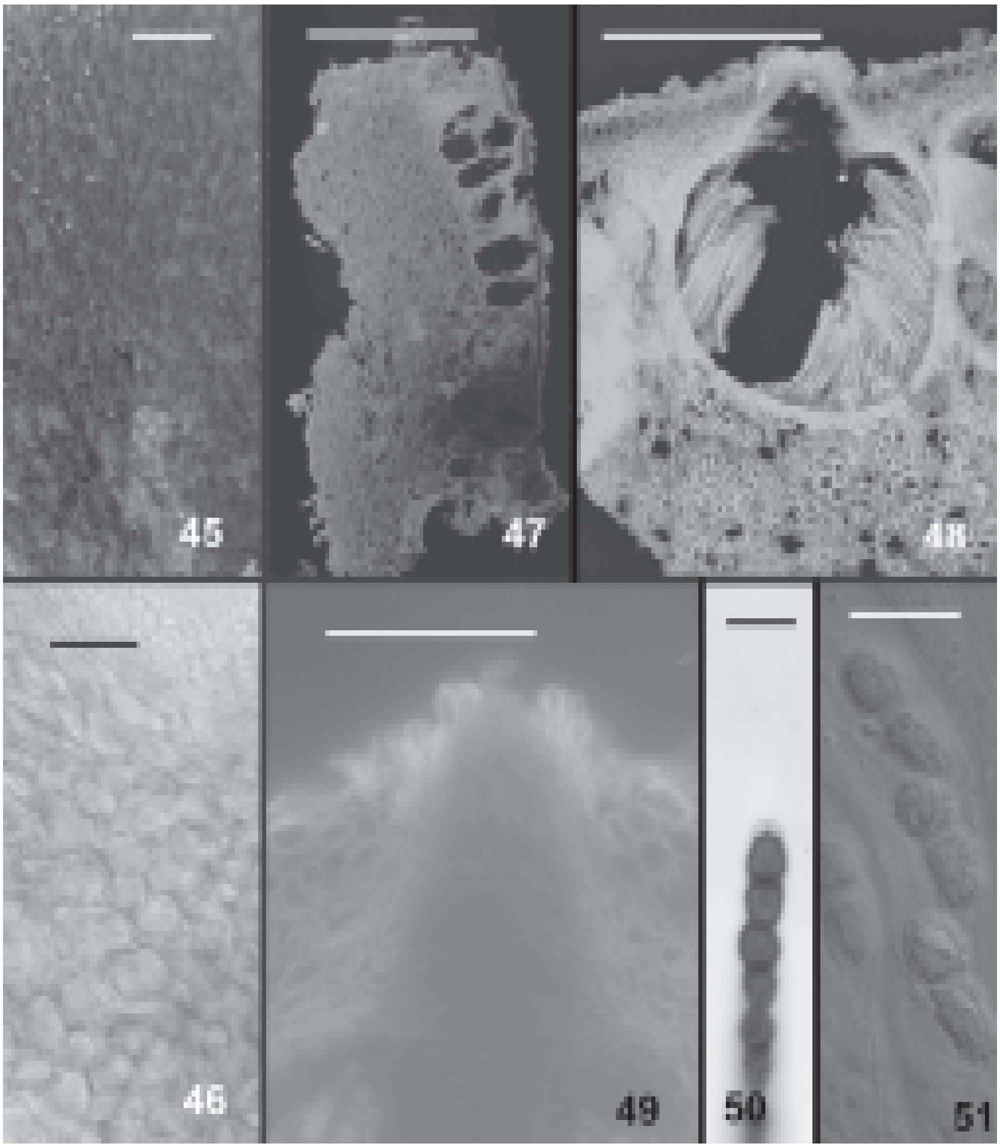
*Known distribution*. Known only from type locality.

HOLOTYPE. Japan. Tottori Pref., Saihaku-gun, Mt. Houki-Daisen, Masumizugahara, 4 Sep 1974 *S. Uchiyama 168* (TNS-F-243748, not available for examination).

*Notes*. In the protologue, Doi and Uchiyama (1987) state that *H. daisenensis* resembles *H. africana* in the shape and size of stroma, and that the part-spores are generally “pusticulate” but tuberculate at the poles. The stromata of *H. daisenensis* are cream-carnose, while those of *H. africana* become almost black at maturity. Doi & Uchiyama (1987) stated that the perithecia and hyphae of stromal tissue are larger in *H. africana* than in *H. daisenensis*. In addition, the part-ascospores described for *H. daisenensis* (distal part 2.7–3.3 × 2.3–3.1 µm, proximal part 3.0–4.1 × 2.2–2.9 µm) are much smaller than those of *H. africana*, which are always larger than 4 µm.

**5. Hypocrea grossa** Berk. *in* Hooker’s J. Bot. and Kew Gard. Misc. 3:206. 1851. Figs. 7–9, 45–51.
= *Podocrea grossa* (Berk.) Lloyd, Mycol. Writ. 7: 1259. 1924.
= *Podostroma grossum* (Berk.) Boedijn, Bull. Jard. Bot. Buitenzorg, ser. 3, 13: 273. 1934.
Anamorph. Possibly *Trichoderma*.

Stroma branched or unbranched, flattened or elliptical in section, cylindrical to more or less flabelliform or dichotomously branched, sometimes several arising from a single point, variable in stature, 3.0–17.0 cm tall, 0.5–1.5 cm wide, 0.5–0.7 cm thick, yellowish-brown, reddish brown to violet brown (9 E8 to 10 E7), often nearly black when dry, KOH–, ostiola barely visible as minute, dark dots. Surface of stroma plane, longitudinally wrinkled or furrowed (possibly from drying). Cells at surface of stroma in face view pseudoparenchymatous, 5–20 µm diam, thin-walled. Surface region of stroma ca. 35 µm wide, cells angular to subglobose, 5–10 × 2–8 µm, thin-walled, walls dark orange. Tissue below surface loosely intertwined, hyaline, thin-walled hyphae. Perithecia mostly subglobose, (226–)245–280(–300) µm tall, (110–)125–185(–250) µm wide; cells of perithecial papilla protruding through stroma surface, clavate; ostiolar



45–51. *Hypocrea grossa*, all from BPI 745647 except 51 (OULU F 30071). – 45. Surface of stroma seem in stereo microscope. Bar = 1 mm. – 46. Surface of the stroma showing pseudoparenchymatous cells. DIC. Bar = 20 µm. – 47. Section through the outer region of a stroma showing perithecia. FL. Bar = 0.5 mm. – 48. Median longitudinal section through a perithecium. FL. Bar = 100 µm. – 49. Perithecial papilla. PC. Bar = 50 µm. – 50. Ascus apex, thickened and with a pore. Cotton blue. DIC. Bar = 1 µm. – 51. Warted ascospores. DIC. Bar = 10 µm.

canal 45–75 µm long, periphysate. Tissue below perithecia of compact, thin-walled hyphae. Asci cylindrical, (43–)55–75(–82) × (2.5–) 3.0–4.0(–4.5) µm, ascospores filling entire ascus, apex thickened, with a ring. Part-ascospores hyaline to yellow (when discharged), heavily tuberculate as seen in cotton blue, flattened at point of disarticulation; distal part-spores subglobose to conical, (2.7–)4.0–

6.7(8.0) × (2.7–)4.0–5.5(–6.0) µm; proximal part-spores conical to ellipsoidal or cuneate, (3.0–)4.2–6.5(–9.0) × (2.5–)3.7–4.7(–5.7) µm.

*Habitat*. On ground.

*Known distribution*. India, Japan, Thailand.

HOLOTYPE. India. Sikkim, Darjeeling, July (date, collector not known) *no. 99* (K!).

*Additional specimens examined*. **Japan.** Tottori Pref. Saihaku-Gun, Motodani, Mt. Houki-Daisen, near a large, decayed stump of *Quercus mongolica*, 5 Oct 1970 *Y. Doi D.876* (OULU F 30071 ex TNS-F-223564). **Thailand.** Saraburi Prov. Khao Yai National Forest, on buried wood, 8 Aug 1997 *P. Chaverri* (*Samuels 8342)* (BPI 745674).

*Notes*. The description given here is a composite of the specimens cited above and the description provided by Boedijn (1934). The measurements of perithecia, asci and ascospores are taken from the cited specimens. The type specimen of *H. grossa* comprises two blackened stromata glued to a piece of stiff paper. No perithecia were seen in either stroma.

Boedijn (1934) reported this fungus to be highly variable in size and shape, fleshy, mostly without distinct stipe. He illustrated unbranched, lanceolate to cylindrical stromata and dichotomously branched stromata arising from a single base, sometimes with a broadened apex bearing a number of short branches. Stromata were described as 3.5–18 cm long, 0.5–1.5 cm broad, side branches 0.4–0.7 cm broad, flattened apex 1–2 cm broad; vivid to dark red. He also illustrated the ascospores as being conspicuously warted. The concept of *H. grossa* that we accept here is possibly too broad. There are considerable differences in stroma stature and in ascospore sizes.

In size, degree of branching and terricolous habit *H. grossa* strongly suggests *H. cornu-damae*, which is also known from Asia. However, significant differences in stromal anatomy and ascospore morphology separate the two species. The surface of the stroma of *H. grossa* (as represented by BPI 745674) is formed of conspicuous, pseudoparenchymatous cells and the perithecial papilla is formed of clavate cells; the ascospores are obviously warted. The surface of the stroma in the type specimen of *H. cornu-damae* is formed of intertwined hyphae and the perithecial papilla is formed of parallel rows of small cells; the ascospores are finely spinulose and smaller than in *H. grossa*. The stroma of *H. grossa* is a shade of red while the stroma of *H. cornu-damae* is yellowish.

Doi (1967) reported a *Trichoderma* anamorph with green conidia for *H. cornu-damae* (as *P. cornu-damae*). However, the illustrations of stromatal anatomy and ascospores strongly suggest that he had *H. grossa*. We have not examined a specimen from which he derived the anamorph, but the Japanese collection cited above as *H. grossa* was identified by Doi as *H. cornu-damae*.

Boedijn (1934) synonymized *Podocrea cordyceps* with *H. grossa*. However, Doi (1967) reported *P. cordyceps* to be on fallen leaves of *Fagus crenata* suggesting a host preference or endophytic relationship as for *H. eperuae*, whereas *H. grossa* is known from the ground, not associated with a specific plant host.

**6. Hypocrea leucopus** (P. Karst.) H. Chamb., **comb. nov**. Figs. 33–37, 52–56, 61–67.

Basionym: *Podostroma leucopus* P. Karst., Hedwigia 31: 294. 1892.

= *Sphaeria alutacea* Pers. : Fr. *β albicans* Pers., Syn. Meth. Fung. 2: 2. 1801.

= *Hypocrea lloydii* Bres. in Lloyd, Mycol. Notes 9 (176): 87. 1902.

Anamorph. *Trichoderma* sp. (Hypocreanum group) verticillium-like.

Stromata clavate, single, sometimes fused or branching; stroma separated into fertile and sterile parts by marked attenuated stipe, sometimes slightly confluent with stipe. Total stroma length (1.5–)3.0–5.0(–8.0) cm tall (n=23), KOH–. Fertile part pale yellow to golden brown (4 A4–B8) to (5 B6–D7), KOH–, surface glabrous, sometimes wrinkled, slightly tuberculate from perithecial elevations, ostiolar openings visible as small viscid dots slightly darker than background. Sterile part white to beige, slightly velvety or not, (0.5–)1.5–3.7(–5.0) cm long (n=18) × 1.0–1.5 cm diam (n=16), adjacent stipes often fused, with fissures demarcating individual stipes, KOH–. Cells of stromal surface in surface view pseudoparenchymatous, (4–)5–11(–18) µm long × (2.0–)3.5–6.5(–7.5) µm wide . Stromal surface in section 25–45 µm wide, cells pseudoparenchymatous, 2–11 µm long × 2–10 µm wide, walls 0.2–0.5 µm thick, pale yellow. Perithecia crowded below stromal surface, mostly subglobose to elliptic, 137–330 µm long × 57–255 µm wide (n=241); perithecial wall 14–27 µm wide; ostiolar canal 30–90 µm long; cells at perithecial apex around ostiolar opening small, clavate, thin-walled; periphysate. Tissue below perithecia of loosely intertwined hyphal elements, (3–)4–7(–11) µm wide , hyphal, nodose elements lacking. Asci cylindrical, (62–)70–90(–114) × (2.7–) 3.7–4.7(–6.7) µm, apex slightly thickened, with a pore; 8-spored, ascospores uniseriate, often with overlapping ends, completely filling each ascus. Part-ascospores (n=180) hyaline, finely spinulose, dimorphic; distal part subglobose to conic, (2.0–) 2.5–3.0(–4.0) µm diam; proximal part cuneate to ellipsoidal (2.0–)3.0–4.0(–5.0) × (1.7–)2.0–3.0(–3.5) µm.

Culture. Colonies grown on CMD at 20 C for 14 d under 12 h cool white fluorescent light/12 h darkness 60 mm; aerial mycelium scant; lacking a distinctive odor, diffusing pigment lacking; conidiophores arising directly from surface of agar or from aeral mycelium, forming in a single broad continuous band around margin or in 2–3 concentric rings; conidia held in a drop of hyaline liquid at tip of each phialide. Colonies on PDA faster than on CMD, ca 60 mm diam after 7 d at 25–30 C in darkness, greyish or canary yellow (1 B6 to 2 B6), when dried, to dull yellow (3 B3) when fresh diffusing pigment produced; conidia formed profusely in dense concentric rings alternating with mycelial production, uniformly cottony; pale, sun, or pastel yellow (1 A3–4 or 2 A4–5) conidia formed in aggregates on rings; distinct odor. Conidiophores (n=24) formed on CMD (55–)70–130(–200) µm long, (2.5–)3.5–6.0(–7.5) µm wide at base, straight, smooth, uniformly thin-walled or sometimes wall conspicuously thickened toward base, sparingly branched over upper half, branches arising at angles of ca. 45°, ca 15 µm long × 2–4 mm wide, cylindrical, each terminating in a verticil of 3–5 phialides or phialides arising directly from conidiophores or from fertile branches. Phialides tapering uniformly from base to tip, 10–17 µm long, 1.7–2.5 µm wide at base, straight. Conidia ellipsoidal, 2.7–3.7(–4.5) × 2.0–2.5(–3.0) µm (n=90), lacking a visible basal abscission scar, smooth, hyaline. Chlamydospores not seen.

*Habitat*. On ground among litter, typically in mixed forest type.

*Known distribution*. Northern Europe, North America.

HOLOTYPE. Finland. Etelä-Häme. Tammela, Syrjä (in larvis), 30 Sep 1892 *P.A. Karsten 3247* (H!).

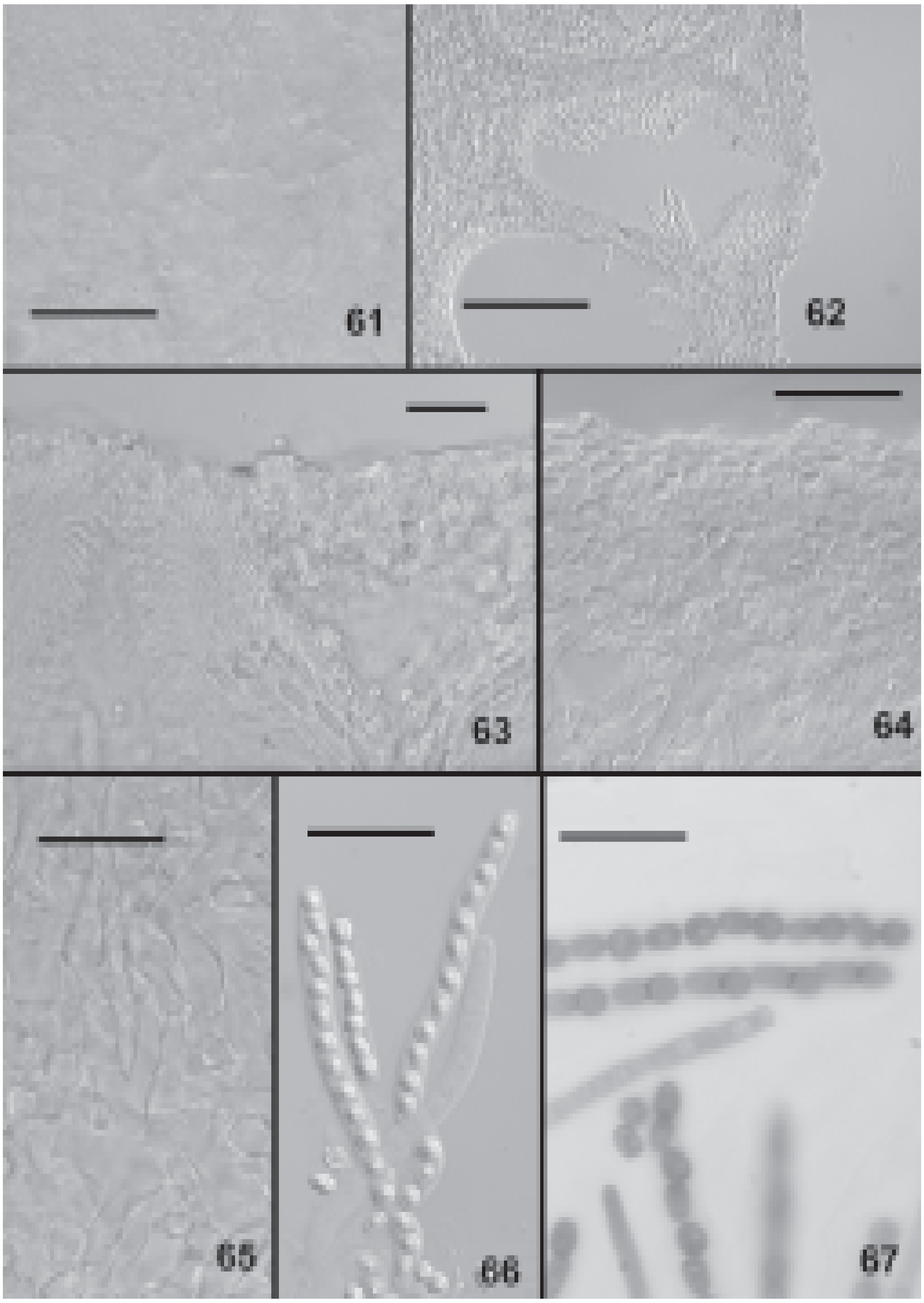
*Representative specimens examined*. **Canada.** British Columbia. Queen Charlotte Islands, in old spruce grove, 24 Oct 1998 *S.A. Redhead 8201* (DAOM 226147). Locality not known, on soil, *S. Redhead 8125* (DAOM 226070, culture and specimen). **Denmark.** Locality not known, on soil, 23 Jul 2000 *C. Lange* (BPI 843826, culture A.Y. Rossman 3784); Central Jutland. Vilhola near Sdr. Vissing, in litter of *Fagus sylvatica*, 2 Oct 1999 *F. Jensen* (BPI 843825). **Estonia.** Tartumaa County. Järvselja Forest Reserve, on soil, 19 Sep 2003 *M. Vaasma & K. Põldmaa* (TAA 170630, culture G.J. Samuels 03-09). **Finland.** Uusimaa. Sipoo, Hindsby, forest rich in herbs (*Betula, Corylus, Picea, Populus tremula, Oxalis acetosella, Salix caprea),*on leaf litter, among mosses, humous soil, Grid 27ºE 6694:402, 25 Jul 1984 *R. Saarenoksa 22084* (H). Etelä-Häme. Lammi, Hauhiala, substratum unknown, 5 Sep 1984 *K. Törmäkangas* (H); Tammela, Mustiala, versus Särkjärvi, 8 Sep 1897 *J. Lindroth* (H, Herb. Karsten 3248). Pohjois-Karjala. Värtsilä, Savikko, Grid 27ºE 69077:6888, elev. 75–85 m, substratum unknown, 3 Sep 1993 *H. Väre* (OULU F 49644). Keski-Pohjanmaa. Kruunupyy, 8 Sep 1981 *R. Storbacka* (OULU F 49572). Oulun Pohjanmaa. Kiiminki, Hannus, Grid 27°E 72280:4470, elev. 43 m, 4 Sep 1997 *E. Ohenoja* (OULU F 32112). **Sweden.** Värmland. Nyed sn, Rudsberg, 7 Oct 1945 *K.G. Ridelius* (UPS). **United States.** New York. Delaware Co., Arkville, Aug 1916 *W.A. Murrill* (NY); St. Lawrence Co., 28 Aug 1988 *G. Bills* (NY, culture G.J. Samuels 88-25); North Carolina, Swain Co., Indian Creek, 14 Aug 1968 *C.T. Rogerson* CTR 68-81 (NY). Pennsylvania. Pocono Lake Preserve, Aug 1935 *C.B. Stifler* (BPI 630175). Tennessee. Sevier Col., LeConte Creek, 12 Aug 1968 *C.T. Rogerson* (NY); Great Smoky Mts. National Park, Cherokee Orchard, 8 Aug 1934 *A.J. Sharp* (TENN). Vermont. Bennington, Coleville Rd., 29 Aug 1981 *P. Raften*, det. C.T. Rogerson 81-92 (NY). Virginia. Giles Co., Mountain Lake, 3 Sep 1936 *D. Linder* (FH).

*Notes*. When young, the stromata of *H. leucopus* are pale yellow to butter yellow, becoming golden brown with time. North American specimens of *H. leucopus* tend to be more golden brown than those found in Europe, but in other characters they are indistinguishable. The color of the stroma, the strong constriction between fertile and sterile parts of the stroma, and its occurrence on ground distinguish this species from *H. alutacea* and other stipitate species of *Hypocrea*. Moreover, the respective anamorphs separate *H. leucopus* and *H. alutacea*.

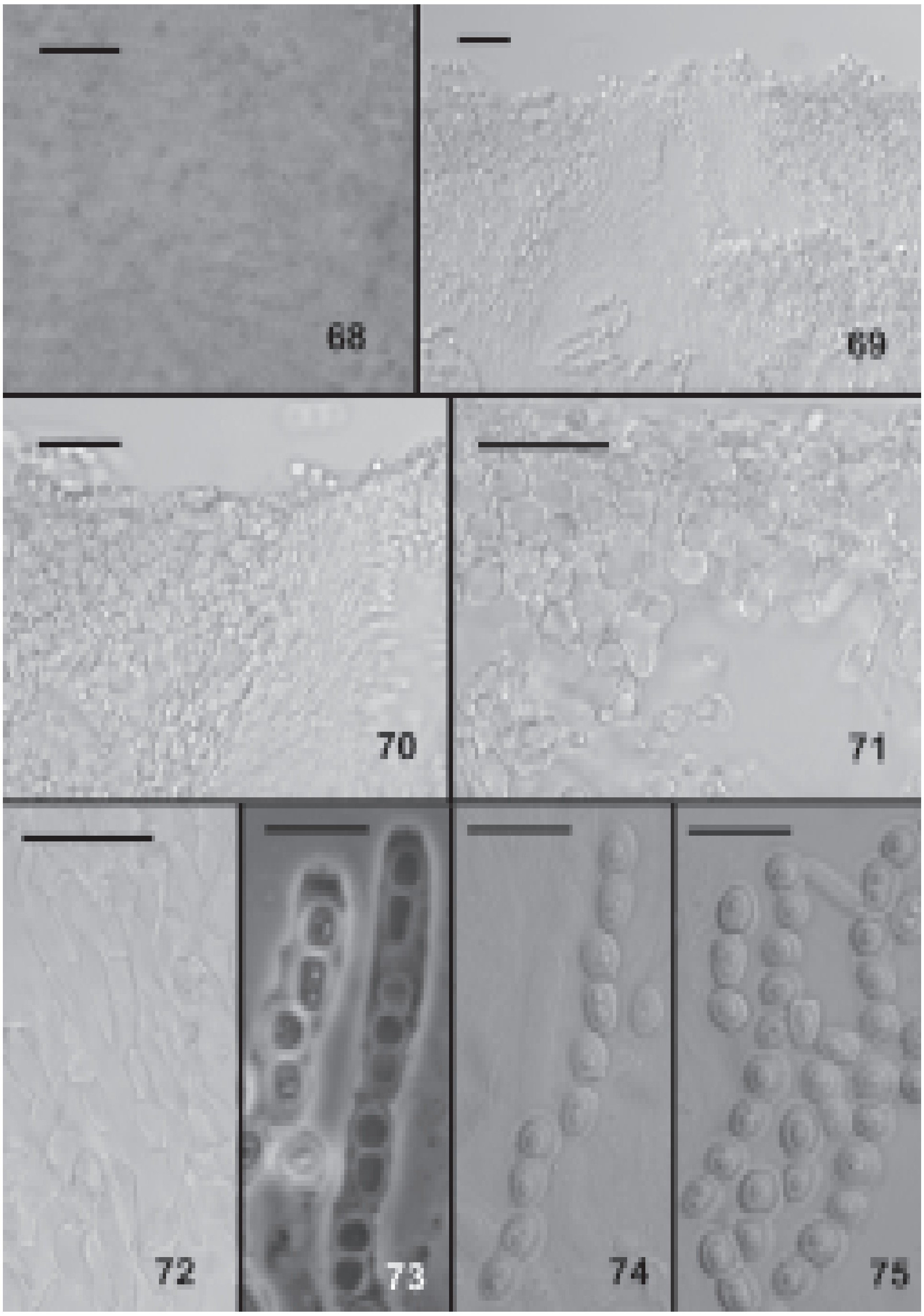
*Podostroma leucopus* has been overlooked in the literature since Atkinson (1905) synonymized it with *P. alutaceum*. Although he listed this synonymy with a question mark, succeeding authors have accepted this (Doi 1966, Imai 1932, Rossman et al. 1999). Among specimens previously identified as *P. aluteaceum* and examined for this study, three species of *Hypocrea* are recognized. Two of the species already have names, specifically *H. leucopus* and *H. alutacea*. The following

Figs. 52–60. Stipitate stromata of *Hypocrea* species. – 52–56. *H. leucopus*. 52 from 5 Sep 1984 *K. Törmäkangas*; 53 from *Saarenoksa 22084*; 54 from Jul 2000 *C. Lange*; 55 from OULU F 49644; 56 from DAOM 226070. – 57–60. *H. nybergiana*. 57 from OULU F 49597 (type); 58 from *Korhonen 4117*; 59 from OULU F 49620; 60 from OULU F 49572.

morphological characteristics distinguish these two species: (1) *H. leucopus* has smaller ascospores than those of *H. alutacea*, (2) the stromatal color of *H. leucopus* tends to be paler and more yellowish than *H. alutacea*, (3) the surface cells and tissue below the perithecia of *H. leucopus* are thin-walled whereas they are thick-walled in *H. alutacea*, and (4) *H. leucopus* typically occurs on the ground while *H. alutacea* develops on woody substrata. The third entity is described as a new species, *H. nybergiana*, which is similar to *H. leucopus*, but is differentiated by the red-



Figs. 61–67. *Hypocrea leucopus*. – 61. Stroma surface showing pseudoparenchymatous cells. – 62. Median longitudinal section through a perithecium. – 63. Perithecial apex and adjacent stroma surface. – 64. Stroma surface region formed of pseudoparenchyma, loosely disposed hyphae below. – 65. Internal tissue of stroma below perithecia. – 66. Asci. – 67. Ascospores in asci warted. Cotton blue. Figs. 61, 63 from 5 Sep 1984 *K. Törmäkangas*; 62 from OULU F 32112, 64–67 from OULU F 49644. Bars = 20 µm except 63 = 100 µm.



Figs. 68–75. *Hypocrea nybergiana*. – 68. Stroma surface showing elongated cells. – 69, 70. Section through perithecial papilla and adjacent stroma surface. — 71. Stroma surface showing pseudoparenchymatous cells; loosely disposed hyphae forming below the surface. – 72. Internal tissue of stroma below perithecia. – 73. Ascus apex with apical ring. Cotton blue. PC. Bar = 10 µm. – 74. Ascus with ascospores. DIC. Bar = 10 µm. – 75. Discharged ascospores. Bar = 10 µm. All DIC except 73 (PC). Bars = 20 µm except 73–75 = 10 µm. Fig. 68, 73–75 from OULU F 49603; 69–72 from KUO 14577.

dish-brown to brownish orange stromata and conspicuous scales of rust pigment between the fertile and sterile areas on the stipe.

**7. Hypocrea nybergiana** T. Ulvinen & H. Chamb., **spec. nov.** Figs. 57–60, 68–75.
[=*Podostroma nybergianum* T. Ulvinen, Suursieniopas: 291. 1976, *nom. inval*., Latin description lacking.]
Stromata cinnamomea vel fulva, clavata. Stipites squamati ad medium, 2.2–15(–22) cm alta, 2.5–4.1 cm crassa. Perithecia 180–450 µm alta, × 65–315 µm lata. Asci cylindrici, 59–100 × 2.5–5.5 µm, ad apicem incrassati. Ascosporae bicellulares, hyalinae, minute verrucosae, ad septum disarticulatae; parte distali globosa vel subglobosa, (3.0–)3.5–4.5(–6.0) × (3.0–)3.2–4.0(–4.5) µm, parte proximi oblonga vel cuneiformi, (3.0–)3.7–5.0(–6.0) × (2.5–)3.0–3.5(–4.5) µm.

HOLOTYPE. Finland. Oulun Pohjanmaa. Haukipudas, Kello, Kalimenkylä, Kalimenoja, 1½ km upstream of Saarela, in spruce forest in mouth of Suo-oja-brook, on *Hylocomium*-covered ground mixed with spruce needles and twigs, 24 Aug 1967 *T. Ulvinen* (OULU F 49597, isotype OULU F 49596).

*Anamorph*. Unknown.

Stromata narrowly clavate and slender to shallowly branched and robust, 2.2–15(–22) cm long, 0.2–0.9(–7) cm wide at apex, fertile part 1.0-6.5 cm wide, sterile part 1.5-5.5 cm long × 0.1–0.4 cm wide, reddish brown to brownish orange, 6C–D8; rust-pigmented scales covering median section of stromata, reaching middle of sterile base, stipe beige, KOH–. Stroma surface glabrous, slightly tuberculate from papillate perithecial elevations, ostiolar openings visible as large darker orange dots against slightly lighter colored background; transverse striations sometimes visible in stroma surface. Cells of stromal surface in surface view longitudinally arranged, often rectangular cells, 5.5–11.5 µm long × 2.5–8 µm wide. In section, stroma surface 30–70 µm wide, cells at surface pseudoparenchymatous, 3–10 µm diam, walls visibly thickened and pigmented orange to rust-colored clearly differentiated from underlying tissue by orange brown or rust pigment. Tissue immediately below surface region of compact to loosely intertwined hyphal elements. Perithecia globose to elliptical, 180–450 µm tall × 65–315 µm wide (n=88); perithecial wall red-brown in 3% KOH; ostiolar canal of small, thin-walled cells, ostiolar canal 37–100 µm long, periphysate. Tissue below perithecia of loose hyphal elements vertically oriented, 4.0–8.5 µm long × 3.5–11.0 µm, walls ca. 0.5 µm thick. Asci cylindrical, (63–)75–100(–130) × (3.2–)4.0–6.2(–7.5) µm (n=89); ascospores partly biseriate above or uniseriate, filling entire ascus. Part-ascospores hyaline, becoming conspisuously verrucose and slightly thick-walled, dimorphic; distal part-ascospores globose to subglobose, (3.0–)3.5–4.5(–6.0) × (3.0–)3.2–4.0(–4.5) µm (n=149); proximal part-ascospores ellipsoidal to wedge-shaped, (3.0–)3.7–5.0(–6.0) × (2.5–)3.0–3.5(–4.5) mm (n=149).

*Habitat*. On ground among forest litter, typically associated with moss.

*Known distribution*. Northern Europe.

*Etymology*. Named in honor of Mr. Wolmar Nyberg (1870–1958), a Finnish bank manager and amateur mycologist who made significant contributions to knowledge of Finland's mycobiota.

*Representative specimens examined*. **Finland.** Pohjois-Savo. Siilinjärvi, ca. 200 m NE of N end of Pahkalampi, moist old *Picea abies* forest, on decaying twigs of *Picea abies*, Grid 27ºE 7009:538, 5 Aug 1974 *H. Heikkilä 606* (KUO 14577). Kainuu. Puolanka, Väyrylä, Pääkkö, Iso Vuorlampi, E side, coniferous spruce dominated forest on mossy ground with *Geranium*, Grid 27°E 7185:537, 9 Sep 1986 *T. Ulvinen & H. Väre* (OULU F 49603). Oulun Pohjanmaa. Kiiminki, Piikkikoskenkangas, W-margin, mixed spruce forest, Grid 27°E 72262:4453, 8 Sep 1973 *E. Ohenoja* (OULU F 49620). Koillismaa. Kuusamo, Oulanka, Kiutaköngäs, Haaralampi, eutrophic forest, Grid 27ºE 7365:605, 30 Aug 1981 *M. Korhonen 4117* (H). Perä-Pohjanmaa. Tervola, Palokivalo, on calcareous ground, 5 Sep 1996 *M. Ohenoja & E. Ohenoja* (OULU F 31634). **Sweden.** Jämtland. Bracke commune, 5 Sep 1997 *D. Laber* (H).

*Notes*. In young stages, the stromata are pale brown to brownish orange, becoming more reddish golden with time. Some stromata become very large and fully fertile with scales lacking. This species is differentiated from other stipitate *Hypocrea* species based on the presence of rusty-pigmented scales and large stature.

## Doubtful species

*Podocrea solmsii* (E. Fisch.) Lindau var. *corniformis* Bres., Ann. Mycol. 5: 241. 1907.
The type specimen was not examined. Based on the type description this taxon is reported to occur on wood and has stromata that are dull yellow with a mixture of grey and brown, appearing

dark tawny suggesting that it is similar to *Hypocrea gigantea*. Boedijn (1934) synonymized this name with *Podostroma grossum* (≡ *Hypocrea grossa*).

*Podocrea zeylanica* Petch, Ann. Roy. Bot. Gard. Peradeniya 6: 230. 1917.

After examination of the type specimen at K, this species appears to be closely related to *H. alutacea*, if not the same. It shares a similar habitat on wood and the stromata are often clustered, simple, clavate, or cylindric, sometimes compressed, with apex often irregularly lobed, rufous or pale brown with darker ostioles. However, the specimen is in poor condition lacking asci and ascospores and an exact determination was difficult from available material.

## Excluded taxa

*Podocrea anomala* Lloyd, Mycol. Notes 6 (65): 1053, pl. 180 (f. 1960, 1961). 1921.

Based on the type specimen this fungus is not a member of the Hypocreaceae, rather the stromata resemble those of the Xylariaceae in being darkly colored. Lloyd reported having seen *Hypocrea*-like spores. Although the asci are immature and contain no ascospores, the ascal apex is blue in Melzer's reagent, a characteristic that is typical of the Xylariaceae and is unknown in the Hypocreaceae.

HOLOTYPE. Philippines. Luzon, Mt. Maquiling, on wood, 22 Sep 1920 *E. Collado* (BPI 631731).

*Podocrea cornu-bovi* R. Heim & T. Herrera, Rev. Mycol. 25: 215. 1960.

This species is known only from type description; the type specimen could not be found and is considered lost. The protologue suggests that this fungus is an immature Xylariaceae rather than a member of the Hypocreaceae based on the following: 1) cortex of the perithecia black with a white fertile stroma; 2) stromata having a black, hardened base; and 3) large, ovoid to subglobose, hyaline, non-septate spores, 7–11 × 6–8,5 µm, that do not separate into part-spores.

*Podostroma solmsii* (E. Fish.) Imai f. *octosporum* Yoshim. Doi, Bull. Nat. Sci. Mus. Tokyo B 4: 24. 1978, '*octospora*'. Figs. 76–84.

Type material of this forma was not made available to us. A Japanese specimen of *P. solmsii* f. *octosporum* was examined: **Japan.** Ishikawa Pref. Kanagawa City, Bessho-cho, Gando-Yama, in bamboo forest, on 'eggs' of *Phallus* sp., 22 Oct 1978 *Y. Ikeda 493-3* (OULU F 30072 ex TNS-F-193041). This specimen is not a *Hypocrea* and may represent an undescribed genus of the Hypocreaceae. The specimen conforms to what was described and illustrated by Doi (1978) for the forma. The ascospores are fusiform to ellipsoidal, unicellular and warted; they do not become septate. On many ascospores there appears to be a blunt apiculus at each end. The perithecia completely cover the surface of a beige stroma, ca 3 cm tall that arises from the 'egg' of a *Phallus* species. We cannot state unequivocally that the 'stroma' is not a part of the *Phallus* covered with perithecia of the parasite. The combined characters of mycoparasitism and fusiform warted, possibly apiculate ascospores suggest that this taxon is derived from *Hypomyces*.

*Podocrea xylarioides* Lloyd, Mycol. Notes 5(57): 844, fig. 1412. 1919.

The type specimen has characteristics typical of the Xylariaceae rather than Hypocreaceae. The stromata are darkly colored and hard when dried rather than soft or brittle. Although asci in the specimen at BPI are immature, the apex turns blue in Melzer's reagent.

HOLOTYPE. Japan. Ishikari Prov., 18 Jul 1918, *A. Yasuda* (BPI 631733).

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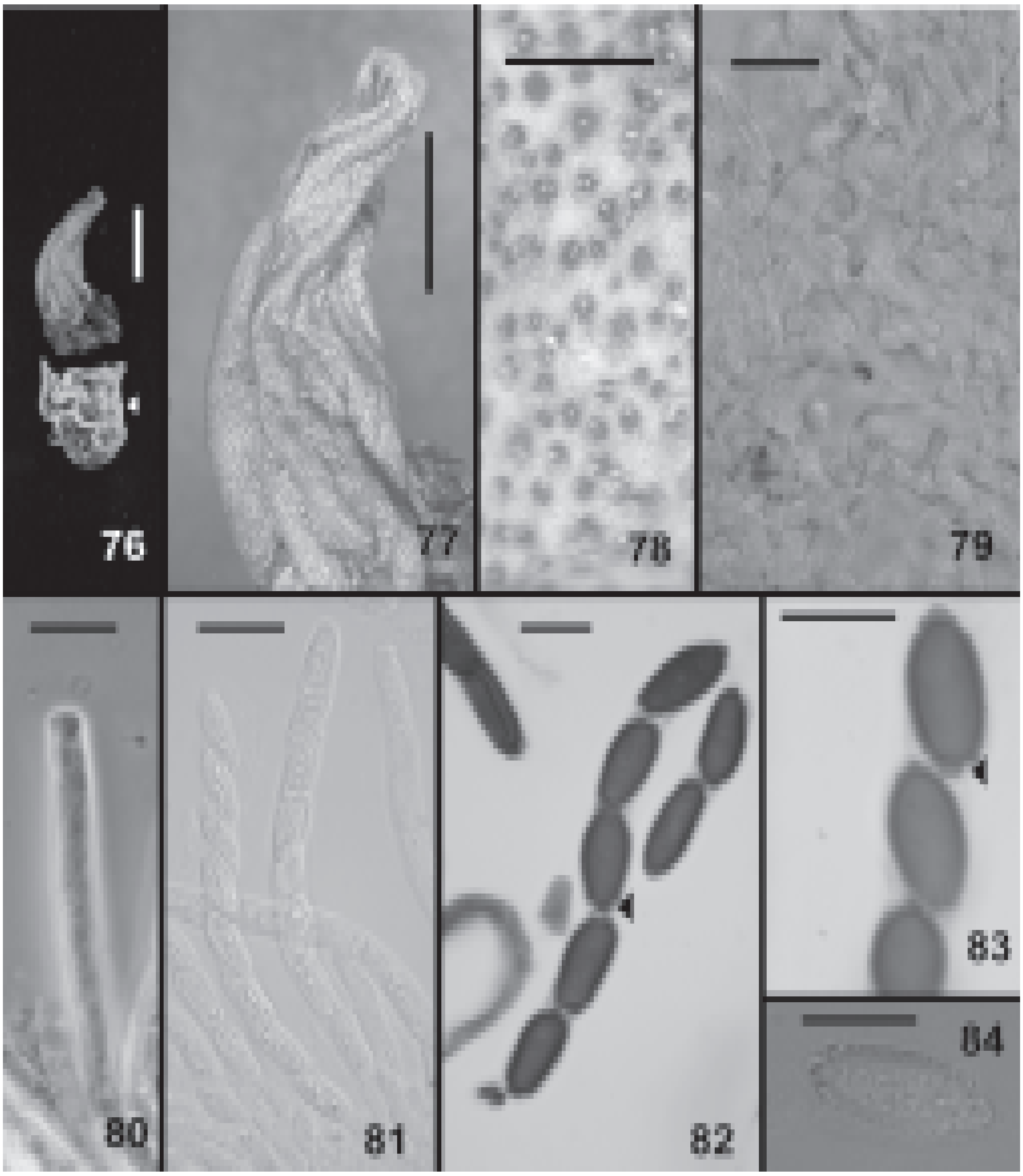

Figs. 76–84. ‘*Podostroma*’ *solmsii* f. *octosporum*, all from OULU F 30072. – 76. Habit of stroma arising from ‘egg’ of a *Phallus* sp. (arrow). Bar = 2 cm. – 77. Stroma of *Hypocrea*. Bar = 1 cm. – 78. Stroma surface as seen in stereo microscope. Bar = 0.5 mm. – 79. Stroma surface, hyphae with free ends. Bar = 20 µm. – 80. Immature ascus with apical ring. Bar = 20 µm. – 81. Ascus with developing ascospores. Bar = 20 µm. – 82, 83. Nearly mature spores in asci. Cotton blue. Arrow shows possible apiculus. – 84. Discharged ascospore. Bar = 10 µm. Figs. 76–78 stereo microscope; 79, 81–84 DIC; 80 PC.

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*Karstenia 44: 25–34, 2004*

# Notes on the taxonomy and occurrence of some species of Gyromitra in Finland

SEPPO HUHTINEN and JUHANI RUOTSALAINEN

HUHTINEN, S. & RUOTSALAINEN, J. 2004: Notes on the taxonomy and occurrence of some species of Gyromitra in Finland. – Karstenia 44: 25-34, 2004. Helsinki. ISSN 0453-3402.

New finds of *Gyromitra longipes* Harmaja have revealed that this species is more variable than earlier realized. The material previously reported as *Gyromitra splendida* Raitv. from Finland is shown to be conspecific with *G. longipes*. Based on a study of a topotype from Estonia, *G. splendida* is shown to differ from Finnish material mainly by its clearly larger spores. The variability in the macromorphology of *G. longipes* is treated and illustrated. Both taxa are characterized by broadly folded pilei and subfusiform spores with prominent perisporium. The type of *G. bubacii* Velen. was studied and the taxon is recognized at the specific level. It is macroscopically close to typical *G. esculenta* (Pers. : Fr.) Fr. with clearly gyrose pilei. The variability of *G. esculenta* in its spore characteristics is also treated. Colour photographs of *G. longipes* and *G. splendida* are provided.

Key words: *Gyromitra,* taxonomy

*Seppo Huhtinen, Herbarium, University of Turku, FI-20014 Turku, Finland*

*Juhani Ruotsalainen, Metsätie 12 A4, FI-71310 Vehmersalmi, Finland*

## Introduction

Harmaja (1979a, 1979b) discussed the variability of Finnish specimens of *Gyromitra esculenta* (Pers. : Fr.) Fr. coll., recognizing three types mainly on spore characteristics. Type I, possessing ellipsoid spores with less pronounced perisporium, was treated as *G. esculenta* s. str. Typically, most spores are lacking a perisporium and if present, it reaches only 0.5 µm in thickness at spore ends. Type II was characterized by dominance of subfusiform spores, almost all of which were stated to have a perisporium reaching 0.3 – 1.0 µm at spore ends. This type was not given any taxonomic name. Type III was treated as *G. splendida* Raitv., with fusiform to subfusiform spores and with perisporial spore ends measuring 0.6 – 1.5 µm in thickness. Oil drops in spores were reported (in MLZ = Melzer's reagent) to show differences in diameter; they are smallest in the Type I and larger in the other types. The Type III was also reported to have a slightly longer stipe than in the other two types (Harmaja 1979a).

In a separate paper (Harmaja 1979b), a macromorphologically different collection was reported as a new species, *G. longipes* Harmaja. It was mainly compared to *G. ambigua* (P. Karst.) Harmaja, but also to the *G. esculenta* aggregate, from which *G. longipes* was distinguished by darker pileus, fairly distinctly violaceous stipe, much wider paraphysis tips and larger oil drops in spores. Although not univocally stressed by Harmaja (1979b), the broadly folded pileus and the lack of gyrose habit were recognized as macroscopic differences from *G. esculenta*. This is obvious from his comparison of the type to *G. ambigua* with a similar, non-gyrose pileus.

More material of *G. longipes* has since been collected in Finland. Problems in naming a recent collection made by the second author (K. & J. Ruotsalainen 5933F) revealed the need to re-examine all the relevant material. Therefore, the types of *G. longipes*, *G. splendida* (topotype studied) and G*. bubacii* Velen. (mentioned as a possible name for Type III by Harmaja 1979a) were restudied. In addition to the above mentioned JR-collection, the new material consists of one specimen of *G. longipes* and one determined as *G. splendida*, kindly sent for study by Dr. Harmaja.

## Methods

The observations discussed below are based on a light microscope study of spores using lactic acid, Cotton blue (CB) and Congo red (CR) as reagents. Paraphyses were studied in 10% KOH. All drawings were made in CB with a camera lucida, unless otherwise indicated. All spore measurements were made in CB excluding perisporium. Spores were measured at random. All spore sizes, numerical or illustrated, include 90% of the total variability. 5% of maximal and minimal values are excluded, but occasional maximal values are given in parentheses.

## ***Gyromitra longipes*** Harmaja

In 1979 Harmaja published *G. longipes* with a photograph of dried specimens well worthy of the specific epithet. In addition to the type specimen, the authors also studied a more recent collection by Harmaja from Finland. Both collections were soon realized to be a perfect match to what had been collected by the second author JR (Fig. 1). On the basis of these three collections, *G. longipes* is without doubt a clearly recognizable taxon. In the field it is recognized by the gently folded pileus on top of a long stipe. Another recent collection from Norway was reported by Carlsen and Stensrud (2003), with exactly the same morphology to the above mentioned Finnish material. They illustrated a long-stiped fruitbody topped by a broadly folded pileus. Judging from the excellent photograph, the fungus presented as *G. esculenta* from Japan by Imazeki et al. (1998) might also be *G. longipes.*

However, problems in Finnish material arouse we tried to delimit the specimens earlier recognized as *G. splendida* by Harmaja (1979a). Ap-

Fig. 1. *Gyromitra longipes*, Vehmersalmi 13.V.2002. Photo J. Ruotsalainen.

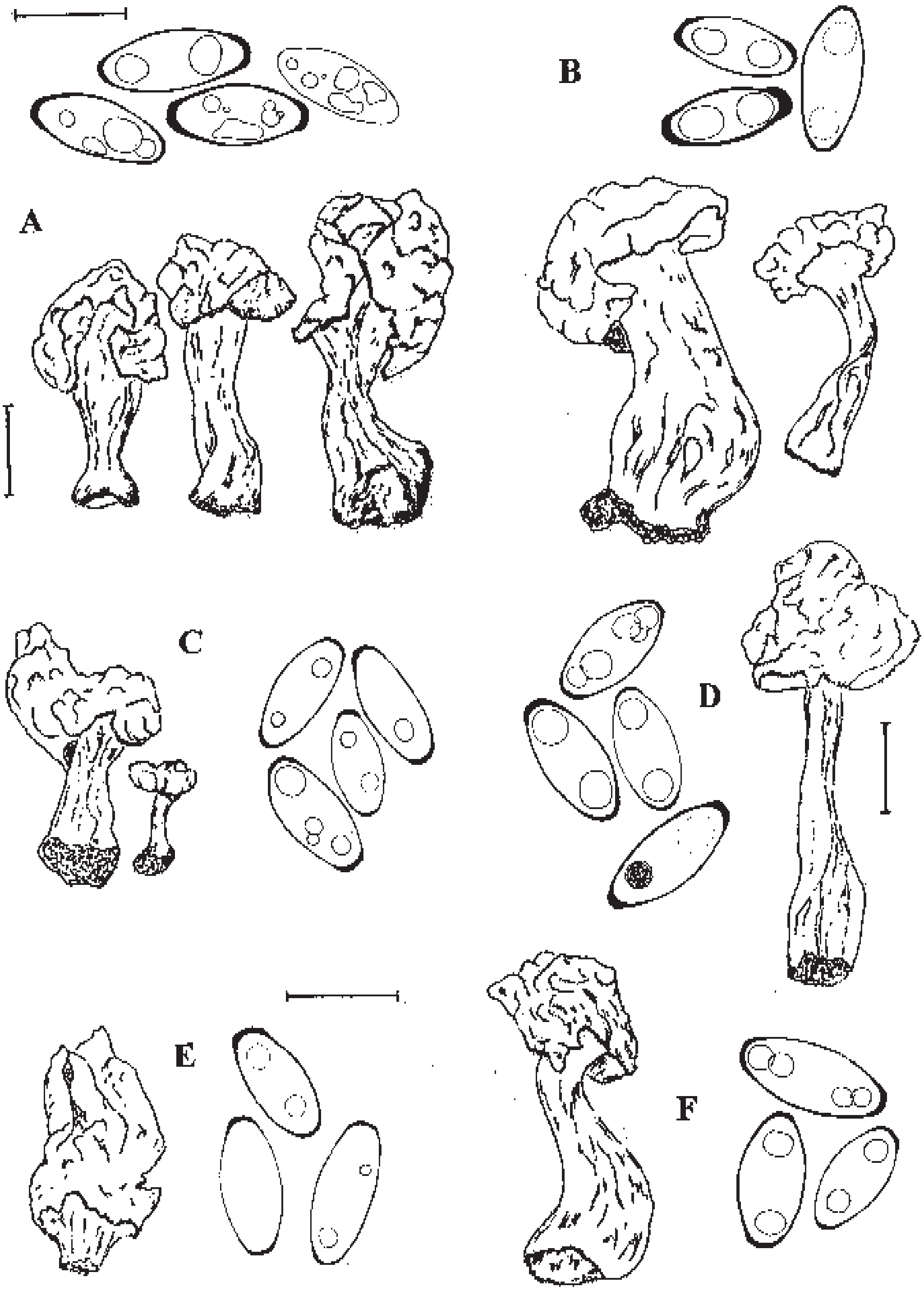

Fig. 2. Dried fruitbodies and spores of *Gyromitra longipes*. – A) type. – B) *K. & J. Ruotsalainen 5933F.* – C) *Harmaja* 1977 (sub *splendida*). – D) *Harmaja* 1996 (sub *longipes*). – E) *Uotila 24969* (sub *splendida*). – F) *Ohenoja* 9.VI.1986 (sub *splendida*). Scale for apothecia 2 cm, for spores 20 µm.

parently the striking habit in the type of *G. longipes* led Harmaja (1979b) to treat this specimen as a clear-cut species and at the same time suspect that the Type III (= *G. splendida* sensu Harmaja 1979a) is only a race. Harmaja noted, however, that stipes in these other collections were slightly longer than in *G. esculenta*. When dry, all six collections form a continuum not easy to break in a logical manner even when using macromorphology only (Fig. 2). The colouring of hymenium and the colour hues on stipe are a good match. All specimens are lacking a clearly gyrose pileus and have a crispy texture, untypical for dry specimens of *G. esculenta*. Pileus shape shows some difference: in one collection the sole apothecium is almost bilobate (Fig. 2E). But as a whole, stipe length and prominence seems to be the main variable character between the collections. The far ends of this variability look admittedly quite different.

This observation led us to have a closer look on spore variability. As can be seen from Fig. 3, the type specimen shows the smallest spores in the three macroscopically identical, "typical" *G. longipes* specimens. Thus, macromorphology binds together both the "untypical" spores of the type and the larger spores of later collections. When total spore variability of these three specimens is plotted together with material of *G. splendida* sensu Harmaja, the distributions and means are almost identical (Fig. 4). Hence, identical spores bind together the variability in stipe length and prominence. As also paraphyses are alike, we feel that Harmaja's *G. splendida* -material is conspecific with *G. longipes*. The true *G. splendida* remains to be found from Finland. Ryman and Holmåsen (1984) cited several Swedish specimens with *splendida* -type spores, but since spore size was not given, the conspecifity with the type of *G. splendida* needs to be rechecked.

## ***Gyromitra splendida*** Raitv.

This species was described on the basis of one collection from Estonia (Raitviir 1974). The given differences from *G. esculenta* are distinct. Macroscopically *G. splendida* has darker colour of stipe and hymenium and the long stipe is bearing a relatively narrow cap. Hymenial colour was described as dark brown to almost blackish brown and stipe as ochraceous to fulvous with fleshy tinge. Raitviir's spore drawings show clearly the drastic difference in spore shape when compared to *G. esculenta*. On the other hand, Raitviir admitted the presumed overlap in macromorphology by stating that "*G. splendida* occurs in the same habitat as *G. esculenta* and is superficially so similar to it that they might be easily confused macroscopically." We received an unpublished colour slide of *G. splendida* from Dr. Raitviir, which strengthened our view that in the field one should pay attention especially to the gently fold-

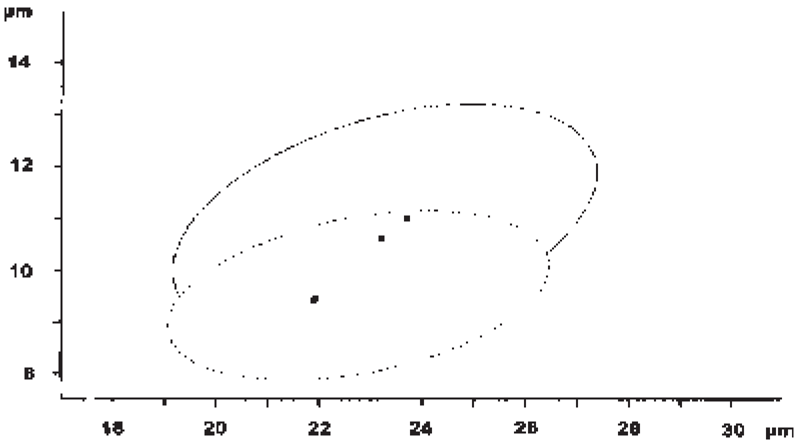

Fig. 3. Spore variability and average sizes in three morphologically typical specimens of *Gyromitra longipes*. Holotype (broken line, n= 100), *K. & J. Ruotsalainen* 5933F (even line, n= 100), *Harmaja* 1996 (dotted line, n= 100).

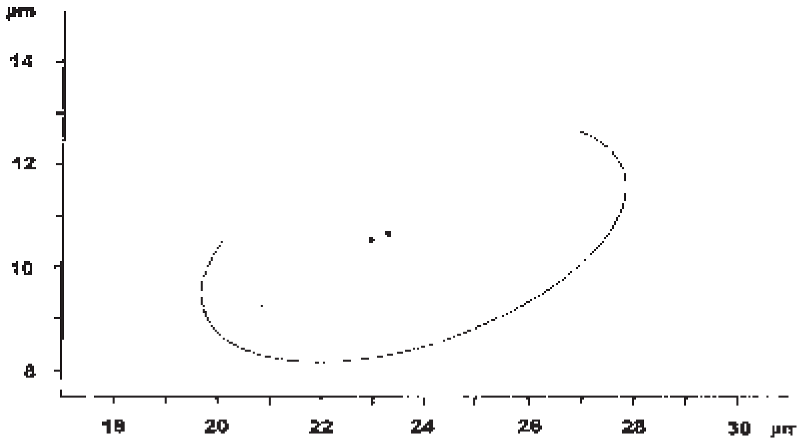

Fig. 4. Spore variability and average sizes in three specimens of *G. longipes* (even line, n= 300) and three specimens of *G. splendida* sensu Harmaja (dotted line, n= 100).

ed hymenium. This photo was taken two years after the type collection, representing a topotype, from which we also received pieces of hymenium for study. The typical clearly gyrose habit of *G. esculenta* is lacking. Raitviir's photo (our Fig. 5) deviates somewhat from the holotype specimen in showing a relatively short stipe together with broad cap. This variability is discussed further below. However, it is clear that Raitviir published a taxon which is clearly separate from *G. esculenta*.

The material reported and determined as *G. splendida* from Finland differs from the type in spore size. The spores are of similar shape, they have a similarly pronounced perisporium surrounding the whole spore. Oil globules are also prominent. The spore size distribution and spore mean size separate the material into two entities. The topotype specimen has a mean spore size value of 27.7 × 11.7 µm (n = 100). The three Finnish specimens have a mean value of 23.3 × 10.6 µm (n = 100) and they show the following individual means: 22.8 × 11.4 µm, 21.7 × 9.6 µm and 24.4 × 10.1 µm. As seen from spore drawings, their shape and general appearance is identical (Fig. 2C, 2E, 2F and Fig. 6B).

The spore size range in the topotype is wide: 23.5 – 32.2 (–35.0) × 10.6 – 13.5 (–15.0) µm (n= 100). These figures differ slightly from those given in the original diagnosis. For Finnish specimens (under *G. splendida*) the size range is following: 21.0 – 26.6. (–30.8) × 9.5 – 12.2 (–13.5) µm (n= 100). Difficulties arise due to the differencies in hymenium age. It is possible that the spores reach their maturity extremely slow. Both in the type and the other studied specimens all free spores are CB+. The presence of a continuous perisporium does not univocally prove their more or less similar developmental stage. Differency in spore size seems to be the main distinguishing character, the type of *G. splendida* possibly representing a fully mature collection. Fruit-body size

Fig. 5. *Gyromitra splendida*, topotype *in situ*. Photo: A. Raitviir.

Fig. 6. *Gyromitra* spores. – A) type of *G. bubacii*, fruitbody redrawn from Velenovský (1934), scale unknown. – B) topotype of *G. splendida*. – C) "Type II" of *G. esculenta*, *Hintikka* 1962. Scale: 20 µm.

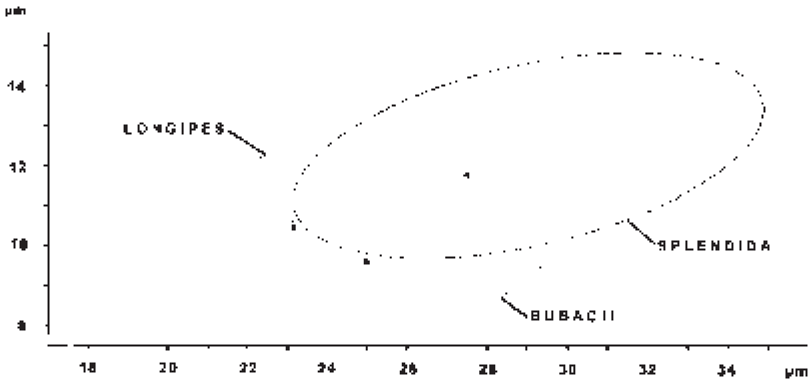

Fig 7. Spore variability and average sizes in three species of *Gyromitra*. *G. longipes* is represented by the whole Finnish material (n= 400) and the other two by their type specimens (n= 100 for both).

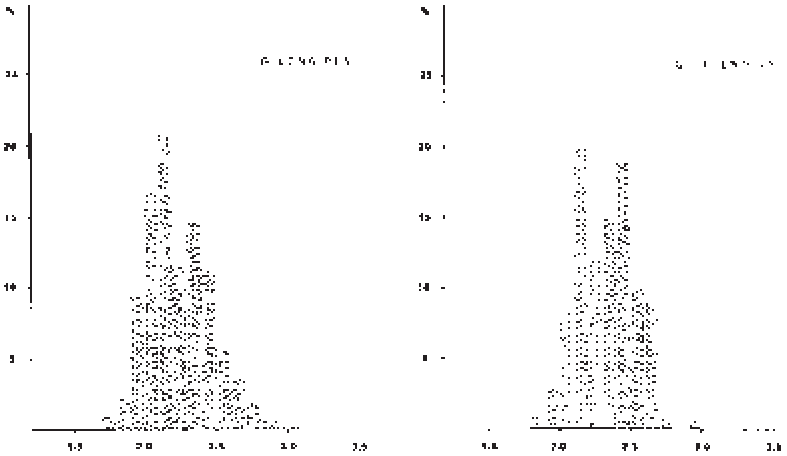

Fig. 8. The distribution of spore Q-values in two species of Gyromitra (n= 400 for *longipes* and n= 100 for *splendida*).

given in the original diagnosis shows, however, that type material has not been clearly larger than the Finnish collections. We have not seen full fruitbodies. But even from the pieces the broadly folded pileus and the crispy texture are obvious. A comparison of paraphyses from all collections revealed no differencies between the type of *G. splendida* and Finnish material.

As seen in Fig. 7, the Finnish specimens clearly differ in spore size from the topotype of *G. splendida*, whereas the distributions of Q -values are alike (Fig. 8). The most recent collection from Vehmersalmi contained fruit-bodies which were mature to partly overmature. Hence, at least their spore size reflects the size of fully mature spores. Unless intermediate material is collected, one can only state that *G. splendida* is a different taxon, known only from the type locality in Estonia. Should there later prove out to be a continuum in spore size, *G. longipes* would fall into synonymy of *G. splendida*.

## ***Gyromitra bubacii*** Velen.

The species was described in Ćeské houby (Velenovský 1922) based on one collection, which was later illustrated by Velenovský (1934). The type was preserved in formaldehyde solution and later dried. Due to Velenovský's plate showing a long-stiped fungus, here redrawn in Fig. 6A, part of the type was restudied. Harmaja (1979a) tentatively hinted on *G. bubacii* being an earlier name for *G. splendida*, but he did not study the types. Thereafter, the type of Velenovský's species has been studied twice (Moravec 1986, Abbott & Currah 1997).

Moravec compared the spores of the type to a large material collected as *G. esculenta* mainly from Bavaria and Slovakia. He came to the conclusion that *G. bubacii* can be recognized only as a variety of *G. esculenta*. Moravec found no macroscopic differences. He also stated that the spore size of typical *G. esculenta* quite often reaches the maximum of 29.5 µm whereas *G. esculenta* var. *bubacii* (Velen.) J. Moravec shows a range from 20 to 35.5 µm, the width remaining unchanged. Judging from the text, Moravec recognized two additional collections of *G. bubacii*. The variety is illustrated in one plate. Comparing his notes within the type packet and the drawing, we conclude that Moravec's illustration is not from the type. His illustration shows even more inaequilateral spores than those seen in the type as illustrated here (Fig. 6A). Such spores have not been seen in Finnish material of *G. esculenta*. To us they represent a clear-cut difference to all other *Gyromitras* treated in this paper.

Abbott and Currah (1997) listed *G. bubacii* as a synonym of *G. esculenta* and commented on Harmaja's (1979a) three spore types in this complex. They studied the type of Velenovský's species and noted the large spores, but erroneously concluded that *G. esculenta* would be a continuum of uncorrelated characters. For them the dif-

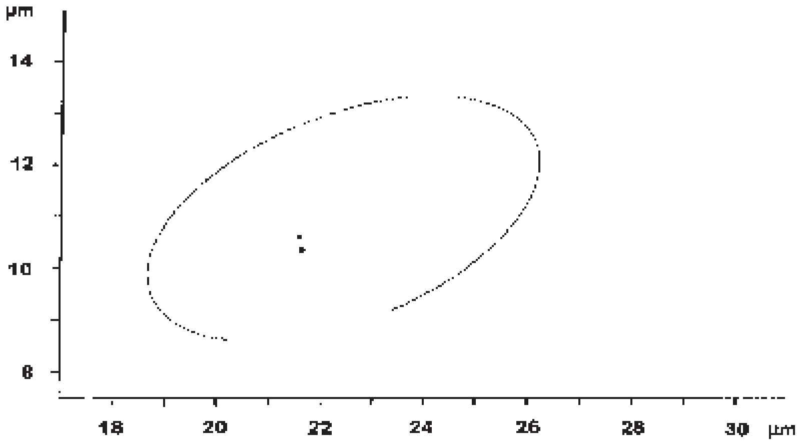

Fig 9. Spore variability and average sizes in *G. esculenta* s. str. (even line, n= 100 from 11 populations) and *G. esculenta* "Type II" (broken line, n= 100 from 1 population).

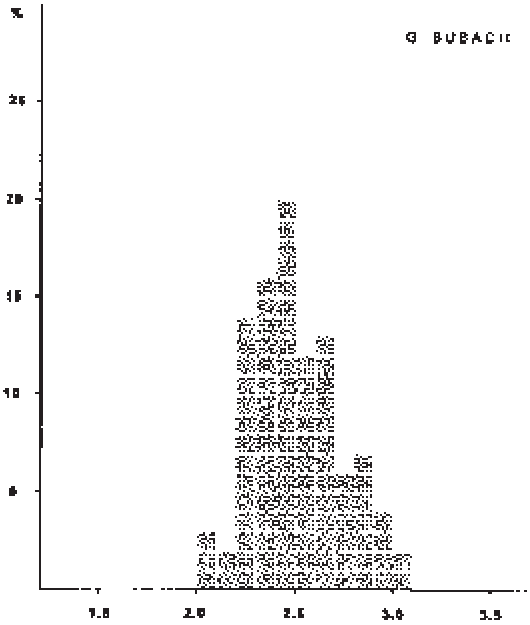

Fig. 10. The distribution of spore Q-values in the type specimen of *Gyromitra bubacii* (n= 100).

ferences between the cylindrical – ellipsoid -inequilateral spores of the type lacking prominent apiculi and the ellipsoid -subfusiform spore of Type III depicted by Harmaja – passed unnoticed. To us, exactly here lie the marked differences (compare Fig. 7 and Fig. 9).

A study of a random selection of Finnish specimens of typical and mature *G. esculenta* gave results somewhat different from those by Moravec (1986). Randomly measured spores show a mean of 21.7 × 10.7 µm (n= 100, from 11 populations) and the range of 20.0 – 24.6 × 9.6 – 11.7 µm. The mean spore quotient was 2.03. Our random measurements from the type of *G. bubacii* gave the mean of 24.9 × 9.7 µm (n = 100) and the range of 21.4 – 28.0 (–30.8) × 8.8 – 10.6 (–11.0) µm. Mean spore quotient was 2.61. The clear difference in the distribution of Q-values can be seen in Fig. 10 and Fig. 11. The spores of *G. bubacii* have a continous, but very thin perisporium. The perisporium may have suffered from formaldehyde solution but was still present in type material. Moravec (1986) did not observe or illustrate any apiculi in recent material (not preserved in formaldehyde); hence the apiculi illustrated in Fig. 6A apparently represent the maximum for this species.

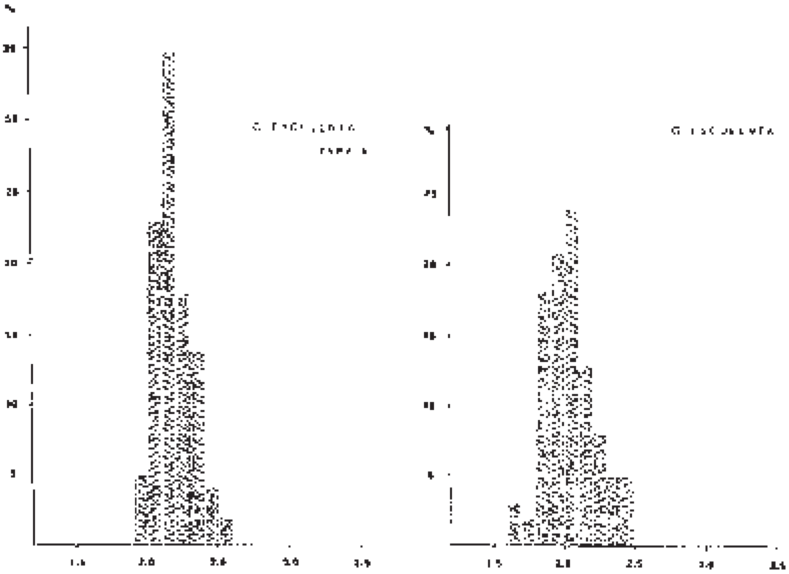

Fig. 11. The distribution of spore Q-values in *G. esculenta* s. str. (n= 100) and *G. esculenta* “Type II” (n= 100)

## *Gyromitra esculenta*, spore type II

We also received one collection from H, which was determined by Dr. Harmaja as "Type II". This collection showed tough consistency and gyrose pileus and was macroscopically similar to material of *G. esculenta*. As noted by Harmaja (1979a), spore shape varies from ellipsoid to fusiform. "Type II" was defined to embrace populations where most spores are subfusiform.

Our observations from comparing 11 populations of typical *G. esculenta* with the sole available collection of "Type II" revealed only a very slight difference in mean spore quotient: for "Type II" it was 2.08 (n = 100, one population) and for *G. esculenta* 2.03 (n = 100, 11 populations). A comparison of the total distribution of Q-values in both types shows a slight difference. In "Type II" the lowest Q-values from 1.6 to 1.8 are totally lacking and in *G. esculenta*, 23 % of the randomly measured spores belong to this more ellipsoid type (Fig. 11). From Fig. 9 it is obvious that there is no true difference in spore size. From Fig. 6C one can see the maximal prominence of apiculi in "Type II", which is the same as illustrated by Harmaja (1979a). The interpopulational difference pointed out by Harmaja (1979a) seems to be present, but like he we also are unable to weigh the taxonomic level and value of this difference. We found two additional Finnish collections, coming close to this spore type, the other collection with mean Q-value of 2.17.

## *Gyromitra longipes* in fresh

The most recent collection from Finland was made during a regular collection trip for false morel. The specimens were first collected as somewhat atypical, less folded and fragile *G. esculenta*. When spore differences were recognized by JR, also the macromorphological differencies became more clear. *Gyromitra longipes* has a hymenium which is not shiny as it is in false morel. The material from Vehmersalmi was abundant, in all 40 fruitbodies. The matt hymenium and gently folded pileus were characteristic for all of them. In fresh condition the fragrant texture, also typical for dried specimens, was obvious. The hymenium was also characterized by small areas where the whole ascal layer was eroded and the light inner excipulum was exposed. The odour was also recorded from fresh material. Carlsen and Stensrud (2003) reported the odour to be spermatic for Norwegian material. In material from Vehmersalmi the odour was clearly less *esculenta* –like (often also characterized as "spermatic") than in typical *esculenta*s. The odour was noted by two persons to be less prominent and to have a pleasant component, originally noted to be somewhat close to the odour of *Boletus edulis*.

A single, interesting case of variability in pileus structure was recently reported by Kosonen (2003). Amongst hundreds of normal fruitbodies of *Gyromitra infula* (Schaeff. : Fr.) Quel. He found one fruitbody showing the typical clearly gyrose pileus of *G. esculenta*. This is the first reported case from Finland. It seems that variability from gyrose to less gyrose (as in *G. esculenta*) is much more common than typically folded pilei being clearly gyrose. But nevertheless, *G. longipes* can be recognized in the field even when the prominence of stipe does not match the epithet.

In Vehmersalmi the population was collected in a small clear-cut area, which had been mechanically treated by ploughing and removal of stumps. Some of the fruit-bodies were found in an adjoining, only partially cut stand. The cutting was made in a mesic, mixed spruce forest. The intermixed trees were aspens and birches. In all, the site was not considered as particularly lush. From the label data of other Finnish collections of *G. longipes* the ecological amplitude seems to embrace the following: (1) old and rich mixed spruce forest with *Betula*, *Populus*, *Tilia*, *Lonicera*, *Ribes alpinum* and *Lathyrus vernus*, (2) clear-cut in a mixed spruce and pine forest with *Vaccinium myrtillus* and *V. vitis-idaea*, (3) mixed, mesic spruce forest with *Betula*, *Oxalis*, *Vaccinium myrtillus*, (4) mesic heath forest with *Picea*, *Pinus*, *Alnus incana* and *Betula*, and (5) dry spruce and pine forest in a calcareous area. In all but one collection, the fruitbodies were found in a site where the mineral soil was more or less exposed. The soil seems to vary from sand to till.

**Material studied:** *Gyromitra longipes*. **Finland.** Etelä-Häme. Hattula, Mervi, Parolanharju, Marttaristi, 6.VI.1976 *Uotila 24969* (H, sub. *G. splendida*). Lammi, Jahkola, 22.V.1977 *Harmaja* (H, sub. *G. splendida*). Lammi, Porkkala, Mustasuppa, 9.VI.1996 *Harmaja* (H, sub. *G. longipes*). Virrat, Hauhuu, 22.V.1979 *Kytövuori 4179* (H, holotype of *G. longipes*). – Pohjois-Savo. Vehmersalmi, Räsälä, Pajumäki, 11–13.V.2002 *K. & J. Ruotsalainen 5933F* (KUO, TUR). – Perä-Pohjanmaa. Tervola, Könölä, Yli-Paakkola, Torniokumpu, 9.VI.1986 *Ohenoja* (H, sub. *G. splendida*).

*Gyromitra splendida*. **Estonia.** Viljandimaa. Soomaa National Park, Iia between Kõpu and Tipu, 10.V.1975 *Raitviir* (TAA, topotype of *G. splendida*).

*Gyromitra bubacii*. **Czech Republic.** Dobrís, 15.V.1921 *Jedlicka* (PRC, holotype of *G. bubacii*).

*Gyromitra esculenta*, spore type II. **Finland.** Varsinais-Suomi. Paimio, Epistenkylä, 23.V.1973 *Alho* (TUR). – Perä-Pohjanmaa. Rovaniemi rural parish, Sinettä, 16.VI.1968 *A. & K. Pohjola* (TUR). **USA.** Michigan. Ogemaw County, 6.V.1962 *Hintikka* (H, det *H. Harmaja*).

*Gyromitra esculenta* s. str. **Finland.** Varsinais-Suomi. Kemiö, Norrlångvik, Långsandabacken, 3.V.1990 *Alho* (TUR). Koski, Liipola, 7.VI.1998 *M.-L. & P. Heinonen 272/1998* (TUR). Mietoinen, Mynäjoen metsätie, 1.VI.1973 *Alho* (TUR). Mynämäki, 27.V.1969 *Pohjola* (TUR). Parainen, Lenholm, 17.V.1995 *M.-L. & P. Heinonen 108/95* (TUR). Sauvo, 28.V.1967 *Mäkinen* 67/44 (TUR). Uusikaupunki, Kalanti, Vellua, 7.V.1989 *Alho* (TUR). – Perä-Pohjanmaa. Ylitornio, Meltosjärvi, 17.VI.1968 *A. & K. Pohjola* (TUR). Rovaniemi rural parish, Pokka, 19.VI.1968 *A. & K. Pohjola* (TUR). – Sompion Lappi. Sodankylä, Kakslauttanen, 30.VI.1965 *Mäkinen* (TUR). – Inarin Lappi. Ivalo, 15.VII.1968 *Mäkinen 68/261* (TUR).

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*Karstenia 44: 35–56, 2004*

# Polypores and associated beetles of the North Karelian Biosphere Reserve, eastern Finland

DMITRY S. SCHIGEL, TUOMO NIEMELÄ, MAARIT SIMILÄ, JUHA KINNUNEN and OLLI MANNINEN

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Polypores (poroid Basidiomycota) and associated beetles were inventoried in the Koitajoki Natura 2000 area (Ilomantsi municipality) and the Kitsi forest fire area (Lieksa), both belonging to the North Karelian Biosphere Reserve of the EU. As a result 105 polypore species were collected; together with earlier reports by other authors, the amount of species totals 121. This is a high number, surpassed in Finland by a few first-rank nature reserves only. Of the species found, 29 are red listed: 2 endangered (EN: *Antrodia crassa* (P. Karst.) Ryvarden, *Piloporia sajanensis* (Parmasto) Niemelä), 11 vulnerable (VU), and 16 near-threatened (NT). *Hyphodontia latitans* (Bourd. & Galz.) E. Langer has been found in Finland only once from the same area; now it was recollected. The research area is in a way a meeting-point of some northerly species (e.g. *Daedaleopsis septentrionalis* (P. Karst.) Niemelä, *Trichaptum laricinum* (P. Karst.) Ryvarden), those with an eastern distribution in Fennoscandia (e.g. *Trichaptum pargamenum* (Fr.) G. Cunn.), and some southern ones (e.g. *Pycnoporellus fulgens* (Fr.) Donk). Remarkably numerous were some species which indicate old growth forests of high conservation value (e.g. *Amylocystis lapponica* (Romell) Singer, *Antrodia albobrunnea* (Romell) Ryvarden, *A. crassa*, *Fomitopsis rosea* (Alb. & Schwein. : Fr.) P. Karst., *Phellinus nigrolimitatus* (Romell) Bourd. & Galz., *Skeletocutis stellae* (Pilát) Jean Keller). Beetle imagines were collected from polypore basidiocarps, and their larvae from basidiocarps and underlying decay, and then reared into adults. Special attention was paid to beetles living on rare polypore species. The polypore-associated beetle fauna totals 115 species, including 24 previously unrecorded from the Reserve. Our paper includes beetle records from ca. 30 such polypore species of which no previous beetle finds have been reported in the literature. The ecology of beetles living on fungal basidiocarps is discussed. Polypores can be divided into different ecological groups according to which beetles they attract; a division into *basidiocarp consistency classes* is proposed to describe such groups. Furthermore, the freshness or decomposition of a basidiocarp determines the amounts of beetles and their larvae, and their species composition.

Key words: *Basidiomycota, Coleoptera, Hyphodontia latitans, basidiocarp consistency class, beetles, Finland, polypores, ecology*

*Dmitry S. Schigel, Tuomo Niemelä, Juha Kinnunen, Olli Manninen, Botanical Museum (Mycology), P. O. Box 7, FI–00014 University of Helsinki, Finland. Correspondence e-mail: dmitry.shchigel@helsinki.fi*

*Maarit Similä, Finnish Forest and Park Service, Natural Heritage Services, Urheilukatu 3 A, FI–81720 Lieksa, Finland.*

## 1. Introduction

The Koitajoki river and its surroundings in the commune of Ilomantsi, Finnish North Karelia, make up the easternmost Natura 2000 site of the European Union. It is about 7400 ha wide and consists of protection areas with different protection statuses. There are the Koivusuo Strict Nature Reserve, protection areas for peatlands (Ruosmesuo – Hanhisuo and Ristisuo) as well as a reserve for old-growth forests. About 900 ha of the area are under restrictions of the Finnish forest law; there forest management operations are allowed outside of the important key habitats. The remaining 6500 ha belong to the Nature Reserve without forest management.

The Koitajoki Natura 2000 site is an important wilderness area in eastern Finland (Figs. 1, 2). It is situated in the transition zone of northern mires (pohjoiset aapasuot) and southern raised bogs (eteläiset keidassuot). In the area there are relatively large and natural mires and bogs with mosaic-like forests on mineral soil. Most of the forests are seminatural and old, with plenty of dead wood but with some old signs of previous selective cuttings. An important element of this Natura 2000 site is the Koitajoki, a shallow and meandering river with sandy banks (Figs. 3, 4). The Koitajoki Natura 2000 site maintains important rare and threatened species of polypores (Bondarceva et al. 1995; Bondartseva et al. 1998, 1999, 2001, Niemelä et al. 2002), beetles (Yakovlev et al. 2001) and other organisms.

Fig. 1. The research area in easternmost Finland, North Karelian Biosphere Reserve. The Jäkäläkangas Natura 2000 site is marked with an asterisk, rectangular box marks the Koitajoki Natura 2000 site, enlarged on Fig. 2.

Fig. 2. The Koitajoki Natura 2000 site, eastern Finland. Light grey covers the protected area, dark grey the Koivusuo Strict Nature Reserve. Black dots mark the centres of studied plots.

Fig. 3. Meanders of the Koitajoki in the North Karelian Biosphere Reserve near Polvikoski. Photograph TN.

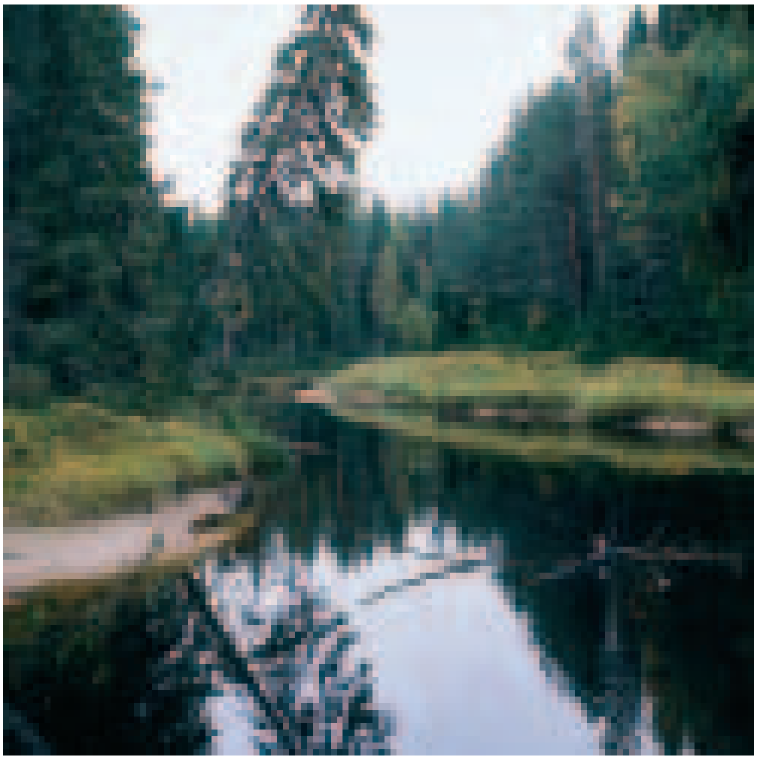

Fig. 4. Old-growth forest in Liekkuaho, the Koitajoki Natura 2000 site. Photograph TN.

The Jäkäläkangas Natura 2000 site (224 ha) is situated in the municipality of Lieksa. Parts of the Jäkäläkangas area were burned by a wildfire in 1992. So the area includes about 143 ha of naturally burnt forests and peatlands which were protected immediately after the forest fire. About 17 ha were burnt completely to become a very interesting area with plenty of charred dead wood. Polypores were surveyed in the parts of less intensive fire.

Both areas surveyed in September – October 2002 and September 2003 are located inside the North Karelian Biosphere Reserve around Kitsi (63°16' N, 30°44' E). This first area of the Finnish Biosphere Reserves was established in 1992 (Hokkanen & Ieshko 1995). Biosphere Reserves are an essential part of UNESCO’s Man and Biosphere (MAB) programme. They make up a backbone of the international network of research areas for sustainable development.

The inventory of the poroid Basidiomycete fungi (polypores) belongs to a multi-year study on Finnish polypores in various nature reserves, organized by the Finnish Forest and Park Service. It was started by Niemelä and Dai (1998, 1999) in the Luosto range, and continued in Korouoma (Niemelä & Kinnunen 2001), Ylläs – Aakenus (Niemelä & Kinnunen 2002) and Pisavaara (Niemelä & Kinnunen 2003), all of them in northern Finland. This paper is partly based on the 2002 inventory report (Niemelä et al. 2002), but additional collections were made in 2003, and our research materials were further worked out later. Data from the Repovesi National Park, Central Finland (Table 4) derive from an inventory in 2004 (unpublished). Although the polypores of Finland are rather well known, there is still a need in species inventories for better understanding of fungal ecology and nature protection.

European studies in the biology of saproxylic beetles started in the beginning of the 20th century in Scandinavia (Saalas 1917, 1923) and other parts of Europe (Donisthorpe 1931, 1935). From the 1950s the topic was favoured by many coleopterists (e.g. Benick 1952, Palm 1951, 1959, Paviour-Smith 1960). For an overview on Russian saproxylic beetles see Nikitsky and Schigel (2004).

Of more than 30 excellent papers published on the topic from 1990 onwards the most important ones by Økland (1995), Andersen et al. (2000), Thunes et al. (2000), Komonen et al. (2001), Martikainen (2001), Siitonen et al. (2001), Ehnström and Axelsson (2002), Jonsell and Nordlander (2002), describe the fauna and ecology of Fennoscandian saproxylic beetles. Window and trunk beetle trappings (Yakovlev et al. 2001) showed the diversity of the saproxylic beetles of the Reserve. An emphasis of our study was put on search for previously unknown fungus – beetle interactions and details of their life cycles.

## 2. Materials and methods

Polypores and beetles were collected in forest compartments (geoinformation data of the Finnish Forest and Park Service). These compartments have been outlined so as to include fairly uniform stands of forest, and their areas and shapes vary according to the terrain.

In the field a complete list of polypore species was made from each forest compartment visited. These basic data were used to estimate the prevalences (frequencies of occurrence) of the species. The commonest, easily identified species were recorded *in situ*, but rare and difficult species and members of critical genera were collected for a closer scrutiny. Collected specimens were preliminarily studied in the microscope before drying. Collections were dried in mushroom dryers with ventilated air at +40–45°C. When needed, the identifications were later reconfirmed in laboratory with a research microscope, sections mounted in Cotton Blue or Melzer’s reagent, and studied at ×1250 magnification and phase contrast illumination. In addition to polypores, also other wood-inhabiting fungi were observed and collected, in particular rare and threatened species.

*Phellinus igniarius* is treated here in a wide sense (including *P. alni, P. cinereus, P. nigricans*), and *Postia lactea* and *P. tephroleuca* are listed collectively under the name *P. tephroleuca*.

Beetle imagines and larvae were collected separately and preserved in 70% alcohol for further identification. Ecological parameters were recorded in the field: basidiocarp hardness, which is both a characteristic of each polypore species and a result of decomposition process; moisture conditions; the presence of anamorphic fungi; decomposition stages of the basidiocarps (Thunes 1994). We used four visually defined successive stages of decomposition (Table 1, Figs. 5–8), omitting stage V in sampling, i. e. when detached basidiocarps are already dwelled by soil organisms. We would propose the use of subdivisions D (dry) and W (wet) for classes II–IV, while they were adopted by Thunes (1994) for the class IV only. Insect impact seems to be a result of insect attraction rather than pre-colonizing condition, so we modified the definitions of decomposition stages (Table 1).

Fruit bodies with beetle larvae were taken in plastic bags and boxes together with substrate for rearing, kept for 2–3 months in +4°C, and then exposed in room temperature for further two months before the checking of the rearing results. Breeding records meet the criteria set by Lawrence (1973: 165). The commonest Finnish polypores (Niemelä 2003a) with comparatively well known coleopteran fauna were not surveyed.

Table 1. Decomposition stages of polypore basidiocarps, according to Thunes (1994), modified. Subdivision D (dry) and W (wet) can be used for classes II–IV, if relevant.

| Decomposition stage | Description |
|---|---|
| I | Alive, fresh and still actively growing basidiocarp. |
| II | Alive, fully grown, mature basidiocarp. |
| III | Dead, but fairly well-preserved basidiocarp; original outer and inner structures are still easily seen. |
| IV | Dead, strongly decomposed basidiocarp, structure transformed into unorganised mass. |
| V | Dead, detached and fallen basidiocarp, in transition of becoming incorporated in soil. |

Figs. 5–8. Consecutive stages (I–IV) in the decomposition of the fruit body of *Haploporus odorus*. Photographs DSS, Pisavaara Strict Nature Reserve, northern Finland, 2003.

Fungal collections are preserved in the Herbarium of the Botanical Museum, Finnish Museum of Natural History, University of Helsinki (H); their nomenclature follows Niemelä (2004). Beetles will be donated after their investigation to the Zoological Museum, Finnish Museum of Natural History, University of Helsinki; single specimens have been given to identifiers (see Acknowledgements). Beetle nomenclature follows Silfverberg (1992), but the Ciidae are according to Müller et al. (2001). Authors of the Latin names of both fungi and beetles are given in Tables 2 and 3, respectively, and they are not repeated in the text.

All authors took part in the field work. This paper was prepared so that DSS wrote most of the text and all entomological sections. MS wrote parts of Introduction, and TN supervised the writing and wrote sections on fungal taxonomy.

## 3. Results

### 3.1 Polypores

Of the 105 polypore species collected by the authors, 29 are red-listed (Rassi et al. 2001) as belonging to different IUCN threat categories (2 EN – *Piloporia sajanensis, Antrodia crassa*; 11 VU; 16 NT; for details see Table 2). The list of species found by us is presented in Table 2, completed with some additional information. Our data together with finds published before (Bondarceva et al. 1995; Bondartseva et al. 1998, 1999, 2001) make a total of 121 polypore species known by now from the region of study.

### 3.2 Beetles

In our study 115 polypore-associated beetle species were found (Table 3), including 24 species previously unrecorded for the Reserve, in addition to the 91 known ones (Yakovlev et al. 2001). 2614 beetle adults and larvae were collected. No red-listed beetles were found or reared from polypores. Beetles or their larvae were found in 52 (49.5%) polypore species, while 53 polypore species appeared uninhabited (Table 2).

## 4. Discussion

### 4.1 Polypores and other fungi

The number of polypores found by us, 105 species (supplemented by 16 further species reported by others), is very high for any Finnish forest area. A recent inventory and herbarium study from the Pisavaara Strict Nature Reserve (Niemelä et

Table 2. Polypores (plus selected other Basidiomycota) and their beetles in the North Karelian Biosphere Reserve. Polypore species are given in an alphabetical order. IUCN threat categories according to Rassi et al. (2001) specified after polypore names if present. N = number of compartments where found; A/B = number of fruit bodies inhabited/studied. Numbers of insect specimens found or reared are given in parentheses after the beetle species name. Imagines collected in nature indicated light face; insect records of larvae or reared imagines in ***bold face***. Beetle – fungus associations meeting the Lawrence (1973) criterion are marked with “10+” instead of the number of larvae or reared imago specimens.

| Fungus species | | N | A/B | Insect records |
|---|---|---|---|---|
| 1 | *Amylocystis lapponica* (Romell) Singer VU | 23 | 5/16 | *Hapalarea linearis* (1), *Quedius xanthopus* (1 male), *Rhizophagus dispar* (1), *R. bipustulatus* (4), *Ostoma ferruginea* (2), *Dendrophagus crenatus* (1), ***Cis comptus* (10+), *Hallomenus* sp. (10+ larvae)** |
| 2 | *Anomoporia bombycina* (Fr.) Pouzar NT | 3 | 0/3 | |
| 3 | *Anomoporia kamtschatica* (Parmasto) M. Bondartseva | 19 | 0/19 | |
| 4 | *Antrodia albobrunnea* (Romell) Ryvarden NT | 15 | 1/15 | *Ostoma ferruginea* (3) |
| 5 | *Antrodia crassa* (P. Karst.) Ryvarden EN | 1 | 0/1 | |
| 6 | *Antrodia infirma* Renvall & Niemelä VU | 4 | 0/4 | |
| 7 | *Antrodia macra* (Sommerf.) Niemelä | 6 | 0/6 | |
| 8 | *Antrodia mellita* Niemelä & Penttilä VU | 2 | 0/2 | |
| 9 | *Antrodia primaeva* Renvall & Niemelä VU | 2 | 0/2 | |

| Fungus species | | N | A/B | Insect records |
|---|---|---|---|---|
| 10 | *Antrodia pulvinascens* (Pilát) Niemelä VU | 7 | 2/7 | *Stenus carbonarius* (1 female), **_Cis hispidus_ (10+), _Dolichocis laricinus_ (2)** |
| 11 | *Antrodia serialis* (Fr.) Donk | 43 | 1/8 | **_Cis dentatus_ (3)** |
| 12 | *Antrodia sinuosa* (Fr.) P. Karst. | 42 | 0/42 | |
| 13 | *Antrodia xantha* (Fr. : Fr.) Ryvarden | 52 | 0/52 | |
| 14 | *Antrodiella faginea* Vampola & Pouzar | 2 | 0/2 | |
| 15 | *Antrodiella semisupina* (Berk. & M.A. Curtis) Ryvarden | 10 | 3/10 | *Acrulia inflata* (3 males), *Rhizophagus dispar* (1), **_Cis boleti_ (1)** |
| 16 | *Bjerkandera adusta* (Willd. : Fr.) P. Karst. | 8 | 0/8 | |
| 17 | *Byssoporia mollicula* (Bourdot) Larsen & Zak | 6 | 0/6 | |
| 18 | *Ceriporia viridans* (Berk. & Broome) Donk | 2 | 0/2 | |
| 19 | *Ceriporiopsis resinascens* (Romell) Domański | 7 | 1/7 | **_Cis hispidus_ (10+), _Octotemnus glabriculus_ (2)** |
| 20 | *Cerrena unicolor* (Bull. : Fr.) Murrill | 17 | 1/17 | *Dromius sigma* (1) |
| 21 | *Coltricia perennis* (L. : Fr.) Murrill | 2 | 0/2 | |
| 22 | *Daedaleopsis septentrionalis* (P. Karst.) Niemelä | 1 | 0/1 | |
| 23 | *Dichomitus squalens* (P. Karst.) D.A. Reid NT | 8 | 2/8 | *Scaphisoma boreale* (1), **_Ennearthron cornutum_ (10+)** |
| 24 | *Diplomitoporus crustulinus* (Bres.) Domański NT | 3 | 0/3 | |
| 25 | *Diplomitoporus lindbladii* (Berk.) Gilb. & Ryvarden | 4 | 0/4 | |
| 26 | *Fomes fomentarius* (L. : Fr.) Fr. | 59 | 1/1 | **_Bolitophagus reticulatus_ (10+)** |
| 27 | *Fomitopsis pinicola* (Sw. : Fr.) P. Karst. | 57 | 3/57 | *Ostoma ferruginea* (10+), *Rhizophagus dispar* (2), *Atomaria affinis* (2) |
| 28 | *Fomitopsis rosea* (Alb. & Schwein. : Fr.) P. Karst. NT | 33 | 5/33 | *Ostoma ferruginea* (4), **Tineidae G. sp. (1)** |
| 29 | *Ganoderma lipsiense* (Batsch) G.F. Atk. | 6 | 0/6 | |
| 30 | *Gelatoporia pannocincta* (Romell) Niemelä NT | 9 | 4/9 | *Rhizophagus dispar* (2), *Acrulia inflata* (1 male, 1 female), *Sepedophilus testaceus* (1 female), *Agathidium* sp. (1), **Tineidae G. sp. (5)** |
| 31 | *Gloeophyllum odoratum* (Wulfen : Fr.) Imazeki | 1 | 0/1 | |
| 32 | *Gloeophyllum sepiarium* (Wulfen : Fr.) P. Karst. | 30 | 1/3 | **_Cis comptus_ (9), _Sulcacis affinis_ (1)** |
| 33 | *Gloeoporus dichrous* (Fr. : Fr.) Bres. | 15 | 6/8 | *Scaphisoma agaricinum* (1) **_Cis comptus_ (11)** |
| 34 | *Gloeoporus taxicola* (Pers. : Fr.) Gilb. & Ryvarden | 4 | 0/4 | |
| 35 | *Hapalopilus rutilans* (Pers. : Fr.) P. Karst. | 5 | 0/5 | |
| 36 | *Heterobasidion parviporum* Niemelä & Korhonen | 2 | 0/2 | |
| 37 | *Hyphodontia latitans* (Bourd. & Galz.) E. Langer | 1 | 0/1 | |
| 38 | *Inonotus obliquus* (Pers. : Fr.) Pilát | 50 | 0/50 | *Rhizophagus bipustulatus* (1), *R. dispar* (1), **_Dorcatoma dresdensis_ (10+), _Triplax russica_ (1) Elateridae G. sp. (1 dead larva), _Abdera affinis_ (2), _Mycetophagus quadripustulatus_ (1)** |
| 39 | *Inonotus radiatus* (Sowerby : Fr.) P. Karst. | 2 | 0/2 | **_Abdera affinis_ (3)** |
| 40 | *Inonotus rheades* (Pers.) P. Karst. | 11 | 5/11 | *Corticaria rubripes* (1), *Epuraea variegata* (1), **_Cis lineatocribratus_ (10+), _Dorcatoma dresdensis_ (1)** |
| 41 | *Ischnoderma benzoinum* (Wahlenb.: Fr.) P. Karst. | 11 | 0/11 | |
| 42 | *Junghuhnia luteoalba* (P. Karst.) Ryvarden | 13 | 1/13 | *Sepedophilus testaceus* (1 male) |
| 43 | *Lenzites betulinus* (L. : Fr.) Fr. | 1 | 1/1 | *Dinaraea aequata* (1 male), **_Cis hispidus_ (10+)** |
| 44 | *Leptoporus mollis* (Pers. : Fr.) Quél. | 5 | 0/5 | |

| Fungus species | N | A/B | Insect records |
|---|---|---|---|
| 45 *Oligoporus rennyi* (Berk. & Broome) Donk | 1 | 0/1 | |
| 46 *Oligoporus sericeomollis* (Romell) M. Bondartseva | 25 | 0/25 | |
| 47 *Parmastomyces mollissimus* (Maire) Pouzar VU | 1 | 0/1 | |
| 48 *Perenniporia subacida* (Peck) Donk NT | 4 | 0/4 | |
| 49 *Phaeolus schweinitzii* (Fr.) Pat. | 2 | 2/2 | *Atheta boleticola* (1 male, 1 female), ***Dorcatoma* sp. (6)** |
| 50 *Phellinus chrysoloma* (Fr.) Donk | 29 | 5/7 | *Abdera flexuosa* (1), ***Ennearthron cornutum* (10+)** |
| 51 *Phellinus conchatus* (Pers. : Fr.) Quél. | 13 | 4/13 | *Rhizophagus dispar* (1), ***Sulcacis affinis* (2), *Cis hispidus* (2), *Dorcatoma* sp. (10+), Tineidae G. sp. (1)** |
| 52 *Phellinus ferrugineofuscus* (P. Karst.) Bourdot NT | 27 | 1/4 | **Ciidae G. sp. (4 larvae)** |
| 53 *Phellinus igniarius* (L. : Fr.) Quél. | 51 | 3/4 | ***Ennearthron cornutum* (10+) *Dorcatoma dresdensis* (10+)** |
| 54 *Phellinus laevigatus* (P. Karst.) Bourdot & Galzin | 27 | 2/4 | *Rhizophagus dispar* (4), *Acrulia inflata* (1 male), *Orthoperus atomus* (1), ***Dorcatoma* sp. (3)** |
| 55 *Phellinus lundellii* Niemelä | 21 | 2/21 | ***Ennearthron cornutum* (1), *Dorcatoma dresdensis* (3), Tineidae G. sp. (1)** |
| 56 *Phellinus nigrolimitatus* (Romell) Bourdot & Galzin | 17 | 0/17 | |
| 57 *Phellinus pini* (Brot. : Fr.) A. Ames | 40 | 6/14 | *Phloeocharis subtilissima* (3 females + 2), *Hallomenus binotatus* (1), ***Ennearthron cornutum* (10+)** |
| 58 *Phellinus populicola* Niemelä | 10 | 0/10 | ***Dorcatoma dresdensis* (10+)** |
| 59 *Phellinus punctatus* (P. Karst.) Pilát | 2 | 0/2 | *Rhizophagus dispar* (1) |
| 60 *Phellinus tremulae* (Bondartsev) Bondartsev & Borisov | 44 | 0/5 | |
| 61 *Phellinus viticola* (Schwein. ex Fr.) Donk | 45 | 1/7 | *Cis boleti* (1), *Octotemnus glabriculus* (3), ***Ennearthron cornutum* (10+)** |
| 62 *Physisporinus vitreus* (Pers. : Fr.) P. Karst. | 2 | 0/2 | |
| 63 *Piloporia sajanensis* (Parmasto) Niemelä EN | 1 | 0/1 | |
| 64 *Piptoporus betulinus* (Bull. : Fr.) P. Karst. | 47 | 1/1 | *Glischrochilus hortensis* (1), ***Cis bidentatus* (10+), *Diaperis boleti* (10+)** |
| 65 *Polyporus brumalis* (Pers. : Fr.) Fr. | 8 | 2/8 | *Scaphisoma agaricinum* (1), **Tineidae G. sp. (1)** |
| 66 *Polyporus ciliatus* Fr. : Fr. | 3 | 0/3 | *Rhizophagus dispar* (1) |
| 67 *Polyporus leptocephalus* (Jacq. : Fr.) Fr. | 10 | 3/10 | *Orthoperus corticalis* (1), ***Dolichocis laricinus* (1), *Cis jacquemartii* (2), *Cis lineatocribratus* (1)** |
| 68 *Postia alni* Niemelä & Vampola | 15 | 2/15 | ***Hallomenus* sp. (2 larvae), Tineidae G. sp. (2)** |
| 69 *Postia caesia* (Schrad. : Fr.) P. Karst. | 11 | 0/11 | |
| 70 *Postia fragilis* (Fr.) Jülich | 5 | 2/5 | *Hapalarea linearis* (1), ***Hallomenus* sp. (2 larvae)** |
| 71 *Postia guttulata* (Peck) Jülich NT | 7 | 0/7 | |
| 72 *Postia hibernica* (Berk. & Broome) Jülich NT | 1 | 0/1 | |
| 73 *Postia lateritia* Renvall VU | 6 | 3/6 | *Hapalarea linearis* (1), *Lordithon lunulatus* (1 male), ***Hallomenus ?binotatus* (2 larvae)** |
| 74 *Postia leucomallella* (Murrill) Jülich | 19 | 3/19 | *Hapalarea linearis* (1 male), *Rhizophagus dispar* (1), ***Hallomenus* sp. (7 larvae)** |

| Fungus species | | N | A/B | Insect records |
|---|---|---|---|---|
| 75 | *Postia placenta* (Fr.) M.J. Larsen & Lombard NT | 10 | 1/10 | *Ischnoglossa prolixa* (1),<br>*Rhizophagus dispar* (1),<br>***Hallomenus* sp. (2 larvae)** |
| 76 | *Postia septentrionalis* (Vampola) Renvall NT | 1 | 0/1 | |
| 77 | *Postia stiptica* (Pers. : Fr.) Jülich | 2 | 1/2 | ***Hallomenus* sp. (2 larvae)** |
| 78 | *Postia tephroleuca* (Fr.) Jülich | 16 | 2/16 | *Acrulia inflata* (1 female),<br>*Atrecus pilicornis* (1),<br>*Rhizophagus dispar* (3),<br>***Hallomenus binotatus* (2),**<br>***H.* sp. (7 larvae)** |
| 79 | *Postia undosa* (Peck) Jülich | 4 | 0/4 | |
| 80 | *Protomerulius caryae* (Schwein.) Ryvarden VU | 5 | 0/5 | |
| 81 | *Pycnoporellus fulgens* (Fr.) Donk | 2 | 0/2 | |
| 82 | *Pycnoporus cinnabarinus* (Jacq. : Fr.) P. Karst. | 9 | 4/9 | ***Sulcacis affinis* (11)** |
| 83 | *Rigidoporus corticola* (Fr.) Pouzar | 28 | 9/12 | *Agathidum pisanum* (2),<br>*Rhizophagus dispar* (1),<br>*Acrulia inflata* (3 males, 1 female),<br>**Staphylinidae G. sp. (10+ larvae),**<br>**Elateridae G. sp. (1)** |
| 84 | *Sarcoporia salmonicolor* (Berk. & M.A. Curtis) Teixeira NT | 2 | 1/2 | ***Cis dentatus* (6)** |
| 85 | *Skeletocutis amorpha* (Fr.) Kotl. & Pouzar | 13 | 0/13 | |
| 86 | *Skeletocutis biguttulata* (Romell) Niemelä | 14 | 0/14 | |
| 87 | *Skeletocutis brevispora* Niemelä VU | 6 | 0/6 | |
| 88 | *Skeletocutis carneogrisea* A. David | 4 | 0/4 | |
| 89 | *Skeletocutis kuehneri* A. David | 4 | 0/4 | |
| 90 | *Skeletocutis lenis* (P. Karst.) Niemelä VU | 2 | 0/2 | |
| 91 | *Skeletocutis odora* (Sacc.) Ginns NT | 6 | 1/6 | **Staphylinidae G. sp. (10+ larvae)** |
| 92 | *Skeletocutis papyracea* A. David | 5 | 0/5 | |
| 93 | *Skeletocutis stellae* (Pilát) Jean Keller VU | 4 | 0/4 | |
| 94 | *Trametes hirsuta* (Wulfen : Fr.) Pilát | 1 | 1/1 | ***Cis hispidus* (10+),**<br>***Octotemnus glabriculus* (10+)** |
| 95 | *Trametes ochracea* (Pers.) Gilb. & Ryvarden | 38 | 5/5 | ***Cis boleti* (10+), *Cis hispidus* (10+),**<br>***Octotemnus glabriculus* (10+),**<br>**Tineidae G. sp. (1)** |
| 96 | *Trametes pubescens* (Schumach. : Fr.) Pilát | 10 | 4/4 | ***Cis boleti* (10+), *Cis hispidus* (10+)** |
| 97 | *Trametes velutina* (Fr.) G. Cunn. | 4 | 3/4 | ***Cis boleti* (10+), *Octotemnus glabriculus* (10+),**<br>**Tineidae G. sp. (1)** |
| 98 | *Trechispora candidissima* (Schwein.) Bondartsev | 1 | 0/1 | |
| 99 | *Trechispora hymenocystis* (Berk. & Broome) K.-H. Larsson | 1 | 0/1 | |
| 100 | *Trechispora mollusca* (Pers. : Fr.) Liberta | 4 | 0/4 | |
| 101 | *Trichaptum abietinum* (Pers. : Fr.) Ryvarden | 53 | 0/53 | |
| 102 | *Trichaptum fuscoviolaceum* (Ehrenb. : Fr.) Ryvarden | 19 | 1/2 | ***Cis punctulatus* (10+)** |
| 103 | *Trichaptum laricinum* (P. Karst.) Ryvarden NT | 5 | 0/5 | |
| 104 | *Trichaptum pargamenum* (Fr.) G. Cunn. NT | 20 | 6/10 | *Leptusa pulchella* (1),<br>*Acrulia inflata* (1 male),<br>*Rhizophagus dispar* (1),<br>***Cis comptus* (8),**<br>***Cis lineatocribratus* (1),**<br>***Ennearthron cornutum* (2),**<br>***Cis jacquemartii* (2),**<br>***Cis punctulatus* (3)** |
| 105 | *Tyromyces chioneus* (Fr.) P. Karst. | 6 | 0/6 | *Atheta* sp. (1) |

| Fungus species | N | A/B | Insect records |
|---|---|---|---|
| Non-polypore fungi | | | |
| 106 *Amylostereum chailletii* (Pers. : Fr.) Boidin | 1 | 0/1 | |
| 107 *Asterodon ferruginosus* Pat. | 13 | 0/13 | |
| 108 *Basidioradulum radula* (Fr.) Nobles | 5 | 0/5 | |
| 109 *Calocera cornea* (Batsch. : Fr.) Fr. | 1 | | 0/1 |
| 110 *Cantharellus tubaeformis* (Bull. : Fr.) Fr. | 1 | 0/1 | |
| 111 *Chaetoderma luna* (Romell) Parmasto | 8 | 0/1 | |
| 112 *Chondrostereum purpureum* (Pers. : Fr.) Pouzar | 8 | 0/1 | |
| 113 *Columnocystis abietina* (Pers. : Fr.) Pouzar | 14 | 0/14 | |
| 114 *Coniophora olivacea* (Pers. : Fr.) P. Karst. | 13 | 0/13 | |
| 115 *Creolophus cirrhatus* (Pers. : Fr.) P. Karst. | 2 | 0/2 | |
| 116 *Cytidia salicina* (Fr.) Burt | 1 | 0/1 | |
| 117 *Daldinia concentrica* (Bolton : Fr.) Ces. & De Not *s.l.* | 1 | 0/1 | |
| 118 *Gloiodon strigosus* (Schwein. : Fr.) P. Karst. VU | 3 | 0/3 | |
| 119 *Hericium coralloides* (Scop. : Fr.) Pers. | 9 | 0/9 | |
| 120 *Hydnellum aurantiacum* (Batsch : Fr.) P. Karst. | 1 | 0/1 | |
| 121 *Hydnellum ferrugineum* (Fr. : Fr.) P. Karst. | 10 | 0/10 | |
| 122 *Hydnellum gracilipes* (P. Karst.) P. Karst. | 1 | 0/1 | |
| 123 *Hypochnicium multiforme* (Berk. & Broome) Hjortst. | 1 | 0/1 | |
| 124 *Hypsizygus ulmarius* (Bull.) Redhead | 1 | 1/1 | *Rhizophagus dispar* (10+) |
| 125 *Kavinia alboviridis* (Morgan) Gilb. & Budington NT | 1 | 0/1 | |
| 126 *Laeticorticium roseum* (Fr.) Donk | 10 | 0/10 | |
| 127 *Laxitextum bicolor* (Pers. : Fr.) Lentz | 3 | 0/3 | |
| 128 *Lentaria epichnoa* (Fr.) Corner | 2 | 0/2 | |
| 129 *Lentinellus vulpinus* (Sowerby) Kühner & Maire | 3 | 0/3 | |
| 130 *Mycena tintinabulum* Quél. VU | 1 | 0/1 | |
| 131 *Mycoacia fuscoatra* (Fr. : Fr.) Donk | 7 | 0/7 | |
| 132 *Panellus serotinus* (Schrad. : Fr.) Kühner | 1 | 0/1 | |
| 133 *Phanerochaete sanguinea* (Fr.) Pouzar | 2 | 0/2 | |
| 134 *Phellodon niger* (Fr. : Fr.) P. Karst. | 3 | 0/3 | |
| 135 *Phellodon tomentosus* (L. : Fr.) Banker | 1 | 0/1 | |
| 136 *Phellodon secretus* Niemelä & Kinnunen | 2 | 0/2 | |
| 137 *Phlebia centrifuga* P. Karst. VU | 9 | 0/9 | |
| 138 *Phlebia cornea* (Bourd. & Galzin) Parmasto NT | 2 | 0/2 | |
| 139 *Phlebia radiata* Fr. | 3 | 0/3 | |
| 140 *Phlebia tremellosa* (Schrad. : Fr.) Burds. & Nakasone | 18 | 0/18 | |
| 141 *Pholiota heteroclita* (Fr. : Fr.) Quél. | 1 | 0/1 | |
| 142 *Phyllotopsis nidulans* (Pers. : Fr.) Singer | 3 | 0/3 | |
| 143 *Pleurotus dryinus* (Pers. : Fr.) P. Kumm. | 1 | 1/1 | *Rhizophagus dispar* (10+),<br>*Sepedophilus testaceus* (3),<br>*Hapalaraea melanocephala* (1) |
| 144 *Pleurotus pulmonarius* (Fr.) Quél. | 6 | 6/6 | *Rhizophagus dispar* (10+),<br>*R. bipustulatus* (10+),<br>*Mycetophagus multipunctatus* (8),<br>*Triplax aenea* (10+),<br>*Atheta picipes* (10+),<br>*Phloeopora testacea* (3),<br>*Cerylon* sp. (7) |
| 145 *Plicatura nivea* (Sommerf. : Fr.) P. Karst. | 9 | 0/9 | |
| 146 *Pseudohydnum gelatinosum* (Scop. : Fr.) P. Karst. | 2 | | |
| 147 *Pseudomerulius aureus* (Fr.) Jülich | 6 | 0/6 | |
| 148 *Punctularia strigosozonata* (Schw.) Talbot | 1 | 0/1 | |
| 149 *Sarcodon squamosus* (Schaeff.) Quél. | 3 | 0/3 | |
| 150 *Serpula himantioides* (Fr. : Fr.) P. Karst. | 19 | 0/19 | |
| 151 *Sistotrema raduloides* (P. Karst.) Donk | 10 | 0/10 | |
| 152 *Steccherinum ochraceum* (Pers.) Gray | 1 | 0/1 | |
| 153 *Stereopsis vitellina* (Plowr.) D.A. Reid NT | 1 | 0/1 | |

| | Fungus species | N | A/B | Insect records |
|---|---|---|---|---|
| 154 | *Stereum hirsutum* (Willd. : Fr.) Gray | 11 | 0/11 | |
| 155 | *Stereum rugosum* Pers. : Fr. | 8 | 0/8 | |
| 156 | *Stereum sanguinolentum* (Alb. & Schwein. : Fr.) Fr. | 14 | 0/14 | |
| 157 | *Thelephora terrestris* Ehrh. : Fr. | 3 | 0/3 | |
| | Literature data, specimens not studied by us | | | |
| | *Albatrellus confluens* (Alb. & Schwein. : Fr.) Kotl. & Pouzar | | | |
| | *Albatrellus ovinus* (Schaeff. : Fr.) Kotl. & Pouzar | | | |
| | *Albatrellus subrubescens* (Murrill) Pouzar | | | |
| | *Antrodiella romellii* (Donk) Niemelä | | | |
| | *Bjerkandera fumosa* (Pers. : Fr.) P. Karst. | | | |
| | *Ceriporia reticulata* (H. Hoffm. : Fr.) Domański | | | |
| | *Datronia mollis* (Sommerf.) Donk | | | |
| | *Gloeophyllum protractum* (Fr.) Imazeki | | | |
| | *Haploporus odorus* (Sommerf.) Bondartsev & Singer | | | |
| | *Hyphodontia flavipora* (Cooke) Sheng H. Wu | | | |
| | *Hyphodontia paradoxa* (Schrad. : Fr.) E. Langer & Vesterholt | | | |
| | *Junghuhnia collabens* (Fr.) Ryvarden | | | |
| | *Junghuhnia lacera* (P. Karst.) Niemelä & Kinnunen | | | |
| | *Polyporus badius* (Pers.) Schwein. | | | |
| | *Polyporus pseudobetulinus* (Pilát) Thorn, Kotir. & Niemelä | | | |
| | *Rigidoporus populinus* (Schumach. : Fr.) Pouzar | | | |

al. 2004) yielded 125 species; that reserve is often considered to be the richest site in the whole of West and Middle Fennoscandian coniferous forest zone.

We have inventoried several forest reserves during recent years from different parts of North and East Finland (Niemelä & Dai 1998, Niemelä & Dai 1999, Niemelä & Kinnunen 2001, Niemelä & Kinnunen 2002, Niemelä et al. 2002, Niemelä & Kinnunen 2003). All they have been studied in the same way, by making full lists of polypore species from each forest compartment visited. The high number of compartments (593 compartments studied during the listed inventories, Table 4) enables us to make a summary on the commonest polypore species in these old and virgin forests. While most of the high-frequency species (*Fomes fomentarius*, *Trichaptum abietinum*, *Fomitopsis pinicola*, etc.) are able to inhabit many kinds of wooded biotopes, strikingly many are inhabitants of old-growth forests, and have virtually disappeared from areas where forest management has been practiced, for instance, tree stands thinned, dead trees removed, etc. This is a good example on the impoverishing effect of modern forestry on forest biodiversity.

Our research site in the Koitajoki Reserve in eastern Finland lies at the transition between Middle Boreal and Southern Boreal zones (Ahti et al. 1968), in their slightly continental sections. The distributions of many northern species are known to reach further south in these climatically continental parts of East Fennoscandia, and similar results were obtained in our study, too. Among the polypores, *Daedaleopsis septentrionalis* and *Trichaptum laricinum* have typical northern distributions, and for instance in western Finland they are found almost exclusively within the Northern Boreal zone, i.e. in Lapland north of the Arctic Circle. However, they as well as some typically northerly hydnaceous fungi (*Hydnellum gracilipes*, *Phellodon secretus*; see notes below) and Corticiaceae (*Phlebia centrifuga*) were found in our research area, too.

*Trichaptum pargamenum* has a clearly eastern distribution in Europe, and it is lacking from Central and West Finland, as well as from Sweden, Denmark and Norway (Hansen & Knudsen

Table 3. Systematic list of beetles attracted to polypores; North Karelian Biosphere Reserve. Numbers refer to host fungi (Table 2); light face = records of beetle imagines; **bold face** = larvae or rearings.

| Taxon | New for the Reserve | Host fungi |
|---|---|---|
| **Carabidae** Latreille, 1802 | | |
| *Dromius sigma* (Rossi, 1790) | + | 20(?) |
| **Leiodidae** Fleming, 1821 | | |
| *Agathidium arcticum* Thomson, 1862 | | *Reticularia* sp. |
| *Agathidium pisanum* Brisout de Barneville, 1872 | | 83 |
| **Staphylinidae** Latreille, 1802 | | |
| *Acrulia inflata* (Gyllenhal, 1813) | + | 15, 30, 54, 78, 83, 104 |
| *Atheta* (s.str.) *boleticola* J. Sahlberg, 1876 | + | 49 |
| *Atheta (Traumoecia) picipes* (Thomson, 1856) | + | 144 |
| *Atheta* sp. | + | 105 |
| *Atrecus pilicornis* (Paykull, 1790) | + | 78 |
| *Dinaraea aequata* (Erichson, 1837) | + | 43 |
| *Hapalarea linearis* (Zetterstedt, 1828) | + | 1, 70, 73, 74 |
| *Hapalarea melanocephala* (Fabricius, 1787) | + | 143 |
| *Ischnoglossa prolixa* (Gravenhorst, 1802) | + | 75 |
| *Leptusa pulchella* (Mannerheim, 1830) | + | 104 |
| *Lordithon lunulatus* (Linnaeus, 1761) | + | 73 |
| *Quedius xanthopus* Erichson, 1839 | + | 1 |
| *Phloeocharis subtilissima* Mannerheim, 1830 | + | 57 |
| *Phloeopora testacea* (Mannerheim, 1830) | + | 144 |
| *Stenus carbonarius* Gyllenhal, 1827 | + | 10 |
| *Scaphisoma agaricinum* (Linnaeus, 1758) | | 33, 65 |
| *Scaphisoma boreale* Lundblad, 1952 | | 23 |
| *Sepedophilus testaceus* (Fabricius, 1792) | + | 30, 42, 143 |
| **Elateridae** Leach, 1815 | | |
| G. sp. | | 38, 83 |
| **Anobiidae** Fleming, 1821 | | |
| *Dorcatoma dresdensis* Herbst, 1792 | | **38, 40, 53, 55, 58** |
| *Dorcatoma* sp. | | **49, 51, 54** |
| **Trogossitidae** Latreille, 1802 | | |
| *Ostoma ferruginea* (Linnaeus, 1758) | | 1, 4, 27, 28 |
| **Nitidulidae** Latreille, 1802 | | |
| *Epuraea variegata* (Herbst, 1793) | | 40 |
| *Glischrochilus hortensis* (Goeffroy, 1785) | | 64 |
| **Monotomidae** Laporte de Castelnau, 1840 | | |
| *Rhizophagus dispar* (Paykull, 1800) | | 1, 15, 27, 30, 38, 51, 54, 59, 66, 74, 75, 78, 83, 104, 124, 143, 144 |
| *Rhizophagus bipustulatus* (Fabricius, 1792) | | 1, 38, 144 |
| **Cryptophagidae** Latreille, 1802 | | |
| *Atomaria affinis* (F. Sahlberg, 1834) | | 27 |
| **Erotylidae** Latreille, 1802 | | |
| *Triplax aenea* (Schaller, 1783) | | 144 |
| *Triplax russica* (Linnaeus, 1758) | | **38** |
| **Cerylonidae** Billberg, 1820 | | |
| *Cerylon* sp. | | 144 |
| **Corylophidae** LeConte, 1852 | | |
| *Orthoperus atomus* (Gyllenhal, 1808) | + | 54 |
| *Orthoperus corticalis* (Redtenbacher, 1849) | + | 67 |
| **Latridiidae** Erichson, 1842 | | |
| *Corticaria rubripes* Mannerheim, 1844 | | 40 |

| Taxon | New for the Reserve | Host fungi |
|---|---|---|
| **Ciidae** Leach, 1819 | | |
| *Cis boleti* (Scopoli, 1763) | | **15**, 61, **95–97** |
| *Cis comptus* Gyllenhal, 1827 | | **1, 32, 33, 104** |
| *Cis dentatus* Mellié, 1848 | + | **11, 84** |
| *Cis hispidus* (Paykull, 1798) | | **10, 19, 43, 51, 94–96** |
| *Cis jacquemartii* Mellié, 1848 | | 67, 104 |
| *Cis lineatocribratus* Mellié, 1848 | | **40**, 67, 104 |
| *Cis punctulatus* Gyllenhal, 1827 | | **102**, 104 |
| *Cis bidentatus* (Olivier, 1790) | | **64** |
| *Dolichocis laricinus* (Mellié, 1848) | | **10, 67** |
| *Ennearthron cornutum* (Gyllenhal, 1827) | | **23, 50, 53, 55, 57, 61,** 104 |
| *Octotemnus glabriculus* (Gyllenhal, 1827) | + | **19,** 61, **94, 95, 97** |
| *Sulcacis affinis* (Gyllenhal, 1827) | + | 31, 51, **82** |
| **Mycetophagidae** Leach, 1815 | | |
| *Mycetophagus quadripustulatus* (Linnaeus, 1761) | | 38 |
| *Mycetophagus multipunctatus* Fabricius, 1792 | | 144 |
| **Melandryidae** Leach, 1815 | | |
| *Hallomenus* sp. | | **1, 68, 69, 74, 75, 77, 78** |
| *Hallomenus binotatus* (Quensel, 1790) | | 57, **73, 78** |
| *Abdera affinis* (Paykull, 1799) | + | **38, 39** |
| *Abdera flexuosa* (Paykull, 1799) | | 51 |
| **Tenebrionidae** Latreille, 1802 | | |
| *Diaperis boleti* (Linnaeus, 1758) | | **64** |
| *Bolitophagus reticulatus* (Linnaeus, 1767) | | **26** |

1997). In our research area it was found frequently on birch. *Piloporia sajanensis* seems to have a fairly continental, eastern distribution, too.

Some species of predominantly southern distribution were also found. *Pycnoporellus fulgens* is confined mostly to southern Fennoscandia (Niemelä 1980), but we recorded it once. This species has also been collected in Russian Karelia, not far from the Koitajoki area (Shubin & Krutov 1979), and hence its finding was not unexpected. Among the non-poroid Aphyllophorales with a southern distribution, we found *Punctularia strigosozonata, Steccherinum ochraceum, Stereopsis vitellina*, and among Agaricales *Mycena tintinabulum*, living on fallen trunk of birch.

Our records include a great number of threatened species: 2 endangered (EN), 11 vulnerable (VU), and 16 near-threatened (NT). They are indicated in the species list (Table 2). We made notes on the other wood-inhabiting fungi only in passing, when time allowed. Some threatened species were found: *Mycena tintinabulum* (VU), *Gloiodon strigosus* (VU), *Kavinia alboviridis* (NT), *Phlebia centrifuga* (VU), *Phlebia cornea* (NT), *Punctularia strigosozonata* (CR), *Sistotrema raduloides* (NT) and *Stereopsis vitellina* (NT). These results clearly illustrate the high conservation values of the Koitajoki Natura 2000 site.

## 4.2 Notes on selected fungi

*Antrodia crassa* (Fig. 9) is extremely rare in Finland (Kotiranta & Niemelä 1996), and almost totally confined to the oldest pine forests. However, every now and then the species is found in more mesic, spruce dominated forests, indicating that dry environment *per se* is not obligatory for the species to grow. In our Koitajoki inventory the species was found in the oldest and best-preserved forest patch, the Kelokkoaho forest, which arises like an island in the middle of vast peatlands. Host tree was an exceptionally thick (over 50 cm), long-

Table 4. The commonest polypore species in some protected old-growth forests of North and East Finland. The numbers were compiled from 8 inventories carried out in 1998–2004; their references are given in the text (Repovesi: unpubl.). TOTAL = The total of the inventories in 1998–2004. Luosto = Luosto fells in central Finnish Lapland; Ylläs = Yllästunturi and Aakenustunturi fells and highland in western Finnish Lapland; Koro = Korouoma Forest Reserve in northeastern Finland (Posio commune); Koita = Koitajoki Natura 2000 site; Pisa = Pisavaara Strict Nature Reserve (Rovaniemi commune); Repo = Repovesi National Park, Central Finland (Valkeala commune). n = The number of forestry compartments studied. # = The order of frequency (prevalence) of the species in each inventory. % = In how many of the studied compartments (per cent) the species was found. Name in ***bold face*** = An indicator of old or virgin forest (see Kotiranta & Niemelä 1996).

| | TOTAL 1998–2004 n=593 | | Luosto 1998 n=79 | | Ylläs 1999 n=72 | | Ylläs 2000 n=96 | | Ylläs 2001 n=38 | | Koro 2001 n=65 | | Koita 2002 n=70 | | Pisa 2003 n=124 | | Repo 2004 n=49 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # | % | # | % | # | % | # | % | # | % | # | % | # | % | # | % | # | % |
| *Fomes fomentarius* | **1** | **73.8** | 4 | 65.8 | 2 | 69.4 | 1 | 72.9 | 2 | 81.6 | 1 | 78.5 | 1 | 84.3 | 2 | 76.6 | 1 | 61.2 |
| *Trichaptum abietinum* | **2** | **67.0** | 7 | 57.0 | 3 | 65.3 | 4 | 63.5 | 1 | 86.8 | 5 | 64.6 | 3 | 75.7 | 3 | 70.2 | 3 | 53.1 |
| *Fomitopsis pinicola* | **3** | **66.0** | 5 | 60.8 | 4 | 58.3 | 5 | 56.3 | 6 | 71.1 | 6 | 63.1 | 2 | 81.4 | 1 | 81.5 | 2 | 55.1 |
| *Phellinus igniarius* | **4** | **63.8** | 1 | 70.9 | 1 | 72.2 | 2 | 71.9 | 12 | 65.8 | 2 | 70.8 | 5 | 72.9 | 7 | 49.2 | 7 | 36.7 |
| *Inonotus obliquus* | **5** | **60.6** | 3 | 68.4 | 6 | 55.6 | 3 | 67.7 | 9 | 68.4 | 7 | 58.5 | 6 | 71.4 | 5 | 55.7 | 5 | 38.8 |
| ***Phellinus viticola*** | **6** | **57.3** | 6 | 59.5 | 7 | 54.2 | 6 | 55.2 | 4 | 76.3 | 4 | 64.6 | 8 | 64.3 | 4 | 66.1 | 18 | 18.4 |
| *Antrodia serialis* | **7** | **50.2** | 16 | 34.2 | 8 | 54.2 | 12 | 40.6 | 13 | 63.2 | 3 | 64.6 | 10 | 61.4 | 10 | 46.8 | 6 | 36.7 |
| *Gloeophyllum sepiarium* | **8** | **49.5** | 2 | 69.6 | 9 | 51.4 | 11 | 44.8 | 3 | 79.0 | 8 | 55.4 | 15 | 42.9 | 12 | 40.3 | 27 | 12.2 |
| *Piptoporus betulinus* | **9** | **48.4** | 13 | 40.5 | 15 | 37.5 | 7 | 55.2 | 10 | 68.4 | 12 | 43.1 | 7 | 67.1 | 22 | 28.2 | 4 | 46.9 |
| ***Fomitopsis rosea*** NT | **10** | **44.3** | 8 | 46.8 | 5 | 58.3 | 8 | 52.1 | 8 | 68.4 | 20 | 29.2 | 14 | 47.1 | 11 | 40.3 | 25 | 12.2 |
| *Antrodia xantha* | **11** | **44.2** | 11 | 41.8 | 16 | 33.3 | 15 | 38.5 | 22 | 36.8 | 9 | 52.3 | 4 | 74.3 | 8 | 47.6 | 13 | 28.6 |
| *Trametes ochracea* | **12** | **42.0** | 21 | 26.6 | 14 | 44.4 | 16 | 36.5 | 7 | 71.1 | 18 | 32.3 | 13 | 54.3 | 15 | 36.3 | 9 | 34.7 |
| ***Phellinus chrysoloma*** | **13** | **42.0** | 9 | 46.8 | 10 | 50.0 | 9 | 51.0 | 15 | 60.5 | 10 | 49.2 | 16 | 41.4 | 14 | 37.1 | – | 0 |
| ***Phellinus nigrolimitatus*** | **14** | **37.3** | 15 | 36.7 | 13 | 43.1 | 13 | 40.6 | 5 | 73.7 | 11 | 44.6 | 28 | 24.3 | 17 | 33.1 | 71 | 2.0 |
| *Cerrena unicolor* | **15** | **36.5** | 10 | 45.6 | 11 | 47.2 | 10 | 44.8 | 11 | 65.8 | 23 | 26.2 | 27 | 24.3 | 19 | 29.8 | 36 | 8.2 |
| ***Amylocystis lapponica*** VU | **16** | **36.3** | 12 | 40.5 | 12 | 44.4 | 14 | 38.5 | 14 | 60.5 | 17 | 33.9 | 21 | 32.9 | 13 | 37.9 | 60 | 2.0 |
| *Antrodia sinuosa* | **17** | **35.4** | 17 | 31.7 | 20 | 23.6 | 25 | 19.8 | 27 | 26.3 | 16 | 38.5 | 11 | 60.0 | 6 | 52.4 | 11 | 30.6 |
| *Phellinus tremulae* | **18** | **34.3** | 24 | 21.5 | 23 | 22.2 | 24 | 20.1 | 32 | 23.7 | 14 | 41.5 | 9 | 62.9 | 9 | 47.6 | 8 | 34.7 |
| ***Oligoporus sericeomollis*** | **19** | **31.4** | 20 | 26.6 | 27 | 18.1 | 18 | 31.2 | 19 | 42.1 | 15 | 40.0 | 20 | 35.7 | 16 | 34.7 | 15 | 22.5 |
| ***Phel. ferrugineofuscus*** NT | **20** | **29.9** | 23 | 22.8 | 17 | 33.3 | 17 | 32.3 | 17 | 47.4 | 26 | 21.5 | 18 | 38.6 | 18 | 30.7 | 26 | 12.2 |
| *Trichaptum fuscoviolaceum* | **21** | **26.9** | 18 | 31.7 | 28 | 18.1 | 19 | 29.2 | 26 | 29.0 | 21 | 29.2 | 26 | 27.1 | 23 | 28.2 | 16 | 22.5 |
| *Phellinus laevigatus* | **22** | **25.2** | 29 | 13.9 | 19 | 29.2 | 26 | 19.8 | 24 | 36.8 | 24 | 24.6 | 19 | 38.6 | 21 | 28.2 | 29 | 10.2 |
| ***Antrodia albobrunnea*** NT | **23** | **20.3** | 19 | 27.9 | 30 | 13.9 | 30 | 15.6 | 29 | 23.7 | 13 | 41.5 | 30 | 21.4 | 26 | 16.1 | 63 | 2.0 |
| *Phellinus conchatus* | **24** | **20.0** | 25 | 19.0 | 22 | 23.6 | 27 | 18.8 | 25 | 31.6 | 30 | 13.8 | 35 | 18.6 | 20 | 28.2 | 46 | 6.1 |
| ***Onnia leporina*** | **25** | **18.9** | 14 | 38.0 | 18 | 30.6 | 21 | 26.0 | 20 | 42.1 | 29 | 13.9 | – | 0 | 96 | 0.8 | – | 0 |
| ***Phellinus lundellii*** | **26** | **18.1** | 26 | 19.0 | 40 | 8.3 | 29 | 17.7 | 18 | 44.7 | 33 | 12.3 | 22 | 30.0 | 31 | 12.9 | – | 0 |
| *Postia caesia* | **27** | **17.5** | 72 | 1.3 | 45 | 6.9 | 69 | 2.1 | 16 | 57.9 | 27 | 20.0 | 39 | 15.7 | 44 | 7.3 | 12 | 28.6 |
| *Gloeoporus dichrous* | **28** | **15.9** | 27 | 17.7 | 21 | 23.6 | 34 | 10.4 | 28 | 26.3 | 47 | 4.6 | 31 | 21.4 | 38 | 8.9 | 21 | 14.3 |
| ***Skeletocutis odora*** NT | **29** | **13.6** | 38 | 7.6 | 31 | 13.9 | 22 | 26.0 | 21 | 39.5 | 44 | 6.2 | 57 | 8.6 | 45 | 7.3 | – | 0 |
| *Coltricia perennis* | **30** | **13.5** | 35 | 7.6 | 37 | 8.3 | 20 | 27.1 | 36 | 18.4 | 22 | 27.7 | 83 | 2.9 | 35 | 9.7 | 43 | 6.1 |
| ***Phellinus pini*** | **31** | **13.4** | 33 | 10.1 | 50 | 5.6 | 66 | 2.1 | 74 | 2.6 | 43 | 7.7 | 12 | 57.1 | 27 | 16.1 | 47 | 6.1 |
| ***Skeletocutis lenis*** VU | **32** | **12.0** | 31 | 11.4 | 47 | 6.9 | 31 | 14.6 | 34 | 23.7 | 19 | 30.8 | 99 | 2.9 | 51 | 5.7 | – | 0 |
| *Gloeoporus taxicola* | **33** | **11.9** | 28 | 13.9 | 26 | 18.1 | 38 | 8.3 | 23 | 36.8 | 41 | 7.7 | 67 | 5.7 | 54 | 4.8 | – | 0 |
| *Trametes pubescens* | **34** | **10.8** | 42 | 5.1 | 29 | 16.7 | 23 | 22.9 | 41 | 10.5 | 45 | 6.2 | 44 | 14.3 | 56 | 4.8 | 48 | 6.1 |
| *Climacocystis borealis* | **35** | **10.7** | 32 | 10.1 | 25 | 18.1 | 32 | 11.5 | 31 | 23.7 | 39 | 7.7 | – | 0 | 89 | 14.5 | – | 0 |
| *Rigidoporus corticola* | **36** | **10.7** | 76 | 1.3 | 87 | 1.4 | 93 | 1.0 | – | 0 | 28 | 16.9 | 17 | 40.0 | 30 | 14.5 | 32 | 10.2 |
| ***Junghuhnia luteoalba*** | **37** | **10.7** | 70 | 1.3 | 43 | 6.9 | 47 | 5.2 | 53 | 7.9 | 36 | 10.8 | 34 | 18.6 | 24 | 20.2 | 22 | 14.3 |
| Next species | < | 10.0% | | | | | | | | | | | | | | | | |

ago fallen trunk of pine, on which also *Skeletocutis stellae* was growing. Long continuity of the forest, undisturbed conditions, and a very old, thick, fallen kelo tree (see Niemelä et al. 2002) seem to be needed for *A. crassa* to survive.

*Piloporia sajanensis* (Fig. 10) is a rarity throughout its range. It belongs to the so-called successor species (Niemelä et al. 1995; see below), which mostly inhabit trees that have first been decayed by other fungi. Such successors are fairly specific in terms of their preceding species; *Piloporia sajanensis* lives almost exclusively on trees decayed by *Trichaptum laricinum* or, more seldom, the other *Trichaptum* species. Our sole find of *P. sajanensis* was growing on a fallen trunk of spruce, effectively white-rotted by *T. laricinum*, whose basidiocarps emerged in hundreds along the whole trunk. There are about 10 records of this vulnerable species in Finland, all of them from northern or easternmost parts of the country.

*Hyphodontia latitans* was reported from the same area already by Bondartseva et al. (1998). We recollected the species in another site of the Koitajoki Reserve, from a thin (9 cm diam.), strongly decayed fragment of spruce trunk. These are

Fig. 9. Fruit body of *Antrodia crassa*. Posio, Korouoma Nature Reserve, 2001, *Niemelä 7085*.

Fig. 10. Fruit body of *Piloporia sajanensis*. North Karelian Biosphere Reserve, Tapionaho, 2002, *Niemelä 7496*.

the only records of the species in Finland. The material was kindly identified by Heikki Kotiranta (Helsinki) and Karl-Henrik Larsson (Göteborg).

*Hydnellum gracilipes* is a rare, northern species of hydnaceous fungi. It was thoroughly described, illustrated and discussed by Kõljalg and Renvall (2000); at that time it was known from seven sites in Finland and one from Norway. Recent inventories have revealed a handful of new localities, but anyhow the species is very rare. All the collections were made in old, dry pine woodlands, where the basidiocarps of *H. gracilipes* are found growing in the small space between long-ago fallen kelo trunk and forest soil. The fragile, rhizomorph-like stipe arises from the ground, and the pileus spreads along the wood surface above.

*Phellodon secretus* was described recently (Niemelä et al. 2003), almost exclusively from the materials of our inventories. This slender, pale ash-grey species resembles *Phellodon connatus* (Schultz : Fr.) P. Karst., but its spores are smaller and context hyphae make a soft and loose, interwoven structure, while *P. connatus* has densely packed and parallel contextual hyphae. The holotype of this species is one of our Koitajoki collections. Both this and *H. gracilipes* are surely threatened, but their Red List statuses in Finland have not yet been established.

*Punctularia strigosozonata* is a stereoid fungus, characterized by soft, small, cigar brown pilei and usually an effused-reflexed habit of the basidiocarps. Bondartseva et al. (2000) made a detailed overview on the species in Europe, where its distribution is clearly eastern, continental. Now this rare species has been found also in Finland: one record from our inventory area, plus two others nearby, close to the Mekrijärvi Biological Station of the University of Joensuu in Ilomantsi, and an old collection by TN from the Koli National Park in Lieksa. All these were found growing on *Populus tremula*. First Finnish finds were reported by Niemelä (2003b).

### 4.3 Basidiocarp consistency classes

It is no surprise that in the North Karelian Biosphere Reserve both the species composition of beetles and their spatial distribution inside polypore fruit bodies appeared characteristic for taiga zone in general. Up to 73% of fungivore beetles are known to be polyphagous (Schigel 2002). They often show no preference to certain polypore genera or groups of related genera, but colonize polypores of certain *consistency classes* (Table 5).

This concept of *basidiocarp consistency classes* is here proposed to be used when describing different kinds of fungi as habitats for insects and their larvae. It is not yet fully understood, which particular characteristics of fungal basidiocarps are ecologically decisive to make them suitable for beetles. Critical are, for instance:

- Shape and volume of the fruit body;
- Annuality *vs.* perenniality, and how long the perennial ones persist;
- Presence or absence of certain structures, e.g. crust;
- Water contents of the basidiocarp;
- Toughness of the mycelium, which depends on the hyphal system (monomitic, dimitic, trimitic), thickness of hyphal walls, and how dense the structure is;
- Chemical characteristics of the fruit body.

The division of basidiocarp consistency classes, proposed here, is based on an informal classification long used by mycologists while describing species and genera. Consequently, the names of the consistency classes derive from certain polypore genera, but here taxonomy is omitted and the terms represent patterns of physical characteristics only. Basidiocarp consistency classes are outlined in Table 5.

Although these consistency classes seem to be valid and are repeatedly found in nature, sometimes it is difficult to define sharp borders between them: for instance, *Ischnoderma resinosum* Fr. (P. Karst.), a central European species, is tyromycetoid (= leptoporoid) when young but turns fomitoid when old (Pouzar 1971). Another example of uncertainty is found in the genus *Trichaptum*: *T. abietinum*, *T. fuscoviolaceum* and possibly *T. laricinum* (more data needed), all growing on coniferous trees, have a characteristic set of beetle species, unlike *T. pargamenum* on birch and other deciduous trees, which is usually colonized by specialists of the trametoid consistency class. Beetles of resupinate polypores are much less well known, and these fungi are more difficult to be addressed in certain consistency classes. Anyhow, some of them could well be placed in the same classes as the pileate ones, for instance *Postia placenta* and *Sarcoporia salmonicolor* among the tyromycetoid ones.

Table 5. Basidiocarp consistency classes, and examples of characteristic polypore and beetle genera in European southern taiga.

**Fomitoid**
Hard, perennial, voluminous fruit bodies with thick context and several annual layers in hymenophore; robust when living; basidiocarps may stay attached on substrate for several years after death.
**Examples of fungal genera:** *Fomes, Fomitopsis, Phellinus, Ganoderma, Heterobasidion.*
**Examples of beetles associated:** *Bolitophagus, Ennearthron, Dorcatoma, Oplocephala, Ropalodontus, Cis* (subg. *Eridaulus*).
**NB:** In addition to beetle larvae adapted to develop in the hard context and trama, these fungi sometimes attract untypical imago, visiting sporulating fruit bodies (Latridiidae), or those covered by slime moulds (Leiodidae) or anamorphic fungi (Cryptophagidae). Larvae of beetles occur mostly in dying or dead fruit bodies. The life cycle may take more than one year.

**Trametoid**
Corky or leathery, projecting and fairly thin, shelf-shaped, fairly quickly drying, trimitic fruit bodies, annual.
**Examples of fungal genera:** *Trametes, Daedaleopsis, Funalia, Lenzites, Gloeoporus, Pycnoporus, Cerrena, Bjerkandera.*
**Examples of beetles associated:** *Cis (C. comptus, C. hispidus, C. micans), Sulcacis, Octotemnus, Tritoma, Wagaicis.*
**NB:** The tough context of dead fruit bodies is usually effectively eaten (generally by Ciidae) in dry condition the next season after sporulation. Larvae start to develop in living or dying fruit bodies. Several generations may utilize the cluster of fruit bodies before it is completely eaten.

**Tyromycetoid**
Soft and watery, monomitic, annual fruit bodies.
**Examples of fungal genera:** *Tyromyces, Postia, Amylocystis, Leptoporus, Hapalopilus, Pycnoporellus.*
**Examples of beetles associated:** *Hallomenus.*
**NB:** The high moisture contents of the fruit body and its short persistence limit the number of beetle species. Only two species of *Hallomenus*, pupating in soil, were found. Larvae eat living fruit bodies. Larval development is fast, one generation per year.

**Piptoporoid**
Corky or fleshy, voluminous, di/trimitic fruit bodies with thick and homogeneous context.
**Examples of fungal genera:** *Piptoporus, Polyporus, Laetiporus.*
**Examples of beetles associated:** *Mycetophagus, Diaperis, Dacne, Eledona.*
**NB:** Usually relatively large and thick fruit bodies, hosting both surface- and context-living larvae, which start to develop in either living or dying fruit bodies.

**Xanthochroic**
Brown coloured and monomitic, annual, at first fibrous, but becoming brittle upon dying.
**Examples of fungal genera:** *Inonotus, Onnia.*
**Examples of beetles associated:** *Abdera, Orchesia, Mycetophagus.*
**NB:** Larvae occupy the context of mostly living fruit bodies in somewhat similar way as the trametoid ones. Larvae very seldom pupate inside the fruit bodies, even if those usually stay on trunks for one or more years after their death. Beetles almost never colonise dead fruit bodies.

**Trichaptoid**
Thin, numerous, dimitic fruit bodies with purple coloured hymenophore; pilei merging at bases, annual, or continuing to grow over the next year.
**Examples of fungal genera:** *Trichaptum* (*T. abietinum, T. fuscoviolaceum, ?T. laricinum*).
**Examples of beetles associated:** *Cis (C. punctulatus), Wanachia, Zilora.*
**NB:** Beetle larvae settle at the confluent bases of the fruit bodies, where context thickness is sufficient to host larvae (Schigel 2002).

Several polypore genera like *Climacocystis*, *Gloeophyllum* and *Fistulina* (Nikitsky & Schigel 2004) have characteristic species assemblages and make consistency classes of their own. We see no sense to construct special names for them as far as there are no other genera sharing the same ecological characteristics.

### 4.4 Families of fungivorous beetles

Our study revealed a typical (Schigel 2002, Nikitsky & Schigel 2004) palearctic set of beetle families that are linked to polypores, among which the Ciidae, Anobiidae (*Dorcatoma*), Melandryidae and Tenebrionidae are the most efficient basidiocarp destructors and decomposers. The Staphylinidae, Nitidulidae, Leiodidae, Trogossitidae, Latridiidae (*Corticaria*) and Corylophidae (*Orthoperus*) visit polypores as adult beetles. They feed on various parts of fruit bodies or secondary organisms, such as anamorphic fungi or slime moulds covering dead basidiocarps. The highest number of species were found among imaginal visitors, although the less diverse Ciidae, Anobiidae, Melandryidae and Tenebrionidae tend to be more abundant and were found either as larvae or were reared (Tables 2–3).

Fungivorous beetles of different families utilise fungal basidiocarps in different ways. Slime mould specialists in Leiodidae often visit polypores during the sporulation period together with Corylophidae and Latridiidae. The most diverse family, Staphylinidae, contains just a few proved fungivorous species, although many species recorded as imagines usually visit moist (both living and dead) polypores as well as agarics and boletes. Strongly decomposed and wet fruit bodies attract saprophagous imagines of the Silphidae, Hydrophilidae, Cholevidae, and Scarabaeidae. Anobiidae (Dorcatominae) larvae develop in the hardest polypores of the fomitoid consistency class. Trogossitidae larvae feed on wood-rotting mycelium, but imagines often stay on polypore hymenophore. Cryptophagidae use such anamorphic fungi that cover dead polypores. Erotylidae live on wood-rotting fungi and have rather short life cycles, which allows them to use ephemeral *Pleurotus* species and some short-persisting polypores (*Inonotus obliquus*, *Trametes* spp., *Polyporus* spp., *Piptoporus betulinus*). Ciidae live in various polypores which stay dry at least part of the decomposition time. Mycetophagidae, Tetratomidae and Melandryidae larvae with short cycles occupy annual tyromycetoid and xanthochroic polypores. Each Tenebrionidae species colonizes a narrow set of polypore species, while the family as a whole has a fairly wide ecological amplitude, decomposing polypores of various consistency classes.

### 4.5 The role of beetles as vectors of successor polypore species

Niemelä at al. (1995) dealt with a very special link in which certain rare polypores share the woody substrate with a number of common poroid or hymenochaetoid fungi. In these cases a common and effective decayer inhabits a tree trunk. When its mycelium becomes senescent, another fungus species invades the tree, possibly killing the mycelium of the first species, and often fruiting on its dead basidiocarps. These predecessor–successor links may be fairly common in boreal forests, but little is known on their ecological background and even less on the mechanisms how the trees inhabited by a predecessor become inoculated by the mycelium of a successor.

By the time when these predecessor–successor relations were described, not much was understood about the spore dispersal of successor species, which are usually fairly rare and selective about their predecessors. We found that certain beetle larvae and successor polypores share similar preferences to the conditions of rotten wood they colonize. At the same time beetle imagines visit sporulating basidiocarps of both the predecessor and successor polypores, and hence spores of successors are present on the body of beetle female actively searching for an appropriate log to lay eggs.

*Ostoma ferruginea* is a beetle whose larvae live on wood brown-rotted by *Fomitopsis pinicola* and *F. rosea*, as well as on mycelia of certain successor polypores. Both imagines and larvae are often located in the transition between wood and fungus fruit body, and imagines feed on the hymenophore of *Fomitopsis* but also on secondary fungal species, which may colonize logs primarily decayed by *Fomitopsis*, e.g. *Pycnoporellus fulgens* and *Antrodia albobrunnea*. Basidiocarps of *Pycnoporellus fulgens* are often eaten by insect larvae fairly quickly after their development and beetles involved in the dispersal were expected to be found (J. Siitonen, pers. comm.).

*Ostoma ferruginea* may further be involved in the spore dispersal of *Amylocystis lapponica* often growing together with *Fomitopsis rosea* on the same log. Imagines of *O. ferruginea* visit both of these polypore species. *A. lapponica* and *F. rosea* are known as co-existing species although no predecessor–successor relations were found on the basis of basidiocarp records. *A. lapponica* fruit bodies never arise from the dead basidiocarps of *F. rosea*, and their parallel occurrence may be based on similar substrate preferences.

We believe that at least in some cases spores of successor polypores are dispersed both by wind and beetles, improving chances of rare successor polypores to maintain viable populations.

### 4.6 Calculations

Fresh basidiocarps attract the highest number of beetle species, collected as imagines (decomposition stage I, Figs. 5, 11). The decline in the number of species (imagines) during the decomposition of the fruit body is interrupted in stage III, when anamorphic fungi start to grow over the fruit body and attract specialized visitors, but structural changes and the decline of basidiocarp volume are not yet drastic. At the same time stages I and III are favoured by the larvae of fungivore beetles: *Hallomenus* and *Abdera* generally in stage I, while *Dorcatoma* and *Ennearthron* in stage III. These two peaks show that larvae of polypore-dwelling beetles use a strategy either of a short life cycle starting in living fruit body, or a more long one in recently dead polypore basidiocarp. *Cis* larvae and imagines were found in all the stages (Figs. 5–8, 11).

### 4.7 Notes on selected beetles

Of the two Leiodidae species found, only *Agathidium pisanum* was observed feeding on the hymenophore surface of the polypore *Rigidoporus corticola*. *A. arcticum* imagines were found on *Reticularia* sp., a slime mould.

Imagines of *Phloeocharis subtilissima* hide inside the tubes or wander on the surface of the hymenophore of *Phellinus pini*. Vibration of substrate makes beetles escape in the tubes, where they possibly consume spores. Similar behaviour was shown for another staphylinoid (Ptiliidae) beetle *Baranowskiella ehnstromi* Sörensson, 1997 in the much more fine tubes of *Phellinus conchatus* (Sörensson 1997).

Fig. 11. Numbers of beetle species during the decomposition of fungal basidiocarps. The study was made with polypores of the North Karelian Biosphere Reserve, Finland. For the decomposition stages (I–IV) see Table 1.

Imagines of *Atheta boleticola* were found on the hymenophore of *Phaeolus schweinitzii* together with numerous unidentified staphylinoid larvae living inside the spongy context. Rearings failed, but it is possible that larvae of *A. boleticola* feed on this polypore. Most of Staphylinidae were found on the hymenophore of various polypores, usually moistened by wet soil, dew, or atmospheric precipitation. However, the larval host preferences of the Staphylinidae would deserve further study.

Two related *Cis* species are known to develop in basidiocarp context and on the transition layer between hymenophore and context (Schigel 2002), which was supported in our study with other substrates: *Cis comptus* in *Amylocystis lapponica* and *Gloeophyllum sepiarium*, and *Cis hispidus* in *Antrodia pulvinascens*, *Ceriporiopsis resinascens* and *Lenzites betulinus*. In *Trametes* it was found that species composition of the Ciidae includes three size classes of beetle larvae (and emerging adults) interlacing their burrows of different diameters simultaneously, as it was found in European Russia (Schigel 2002). These three classes in the North Karelian Nature Reserve are represented by *Cis boleti* (largest burrows), *C. hispidus* (medium-sized) and *Octotemnus glabriculus* (narrowest), respectively. Burrows of the larvae merge in the late stages of the fruit body decomposition. Fruit body size limits the spatial distribution of larvae inside the basidiocarp: large larvae of *Cis boleti* are located in fruit bodies of *Trametes ochracea*, *T. pubescens* and *T. velutina* at their thick base (umbo), while larvae of *Cis hispidus* and, in particular, *Octotemnus glabriculus* tend to graze inside the inner parts of the basidiocarp margin.

Imagines and larvae of *Cis dentatus* burrow the resupinate but fairly thick fruit bodies of *Sarcoporia salmonicolor* and aggregate in their dryer and thicker parts. *C. punctulatus* larvae develop usually in *Trichaptum fuscoviolaceum* and *T. abietinum* (Kompantsev 1982, Schigel 2002) but we reared a few individuals also from *T. pargamenum*, which is typically colonized by other ciids.

*Dolichocis laricinus* larvae develop in the strongly decomposed fruit bodies of *Antrodia pulvinascens* and *Polyporus leptocephalus* (*P. varius*).

Imagines of *Rhizophagus dispar, Acrulia inflata* and *Orthoperus atomus* were found on the surface of *Phellinus laevigatus* around excrements of unidentified Tineidae larvae. Imagines of *R. dispar* on the fruit bodies of *Gelatoporia pannocincta* were usually found on excrements of Diptera and Lepidoptera larvae. Processed fungal substrate is more attractive to certain beetle generalists than the hard hyphae of an intact hymenophore. In particular imagines of *Rhizophagus* tend to occur on sporulating polypores (*Inonotus obliquus* and *Fomitopsis pinicola*) but decompose also other fungal substrates, especially euagarics (Moncalvo et al. 2002) such as *Pleurotus* species and *Hypsizygus ulmarius*. *Rhizophagus* was found both on basidiocarps on standing trees and on fruit bodies fallen on the ground. Generally, unlike polypores, euagarics attract less beetles from families other than Stapylinidae, although in Europe the beetle fauna of these two large groups of fungi partly overlap.

Colonization of the fruit bodies of *Phellinus (P. pini, P. populicola, P. igniarius* complex) usually starts when the area of living hymenophore starts to shrink. From this moment the upper part of a fruit body begins to die off. This stage of decomposition (III) is preferred by *Dorcatoma* larvae, for instance *Dorcatoma dresdensis* in *Phellinus lundellii*. Fruit bodies of *P. laevigatus* are sometimes quite thin, less than 1 cm, and in this case the sickle-shaped larvae of *Dorcatoma* change their typical vertical position to horizontal, but still avoid the hymenophore. In dead fruit bodies larvae can consume also the hymenophore. During the whole development cycle the larvae of *Dorcatoma* tend to avoid the outer 1-cm zone of the fruit body. This avoided distance is greater still in the fruit bodies of *P. populicola* because of the deep cracks of the upper side of the fungus. On the one hand, avoiding outer layers of the substrate is characteristic for nearly all the substrate dwellers because of the lower risk of parasite attack and more stable substrate conditions deeper in, but on the other hand imagines emerging from pupae and leaving the fungus face certain difficulties to come out. However, Anobiidae are adapted to live in hard and dry substrates, and Doracatominae occupy the niche of decomposers of robust polypores. They can also appear at the early stages of fruit body decomposition, thus avoiding competition with Ciidae and other Coleoptera.

Imagines and larvae of *Ennearthron cornutum* are located between the living hymenophore of *Phellinus pini* and the half-dead context of this long-persisting fungus, or in senescent inner layers of the hymenophore. Similar distribution was found in *P. conchatus* and *P. chrysoloma*, where larvae are using mostly the marginal parts of the fruit body. *P. viticola* is softer in its consistency, and harbours larvae close to the context. On the contrary, *Dichomitus squalens* is a soft polypore, and *Ennearthron cornutum* larvae are restricted to the context. *E. cornutum* is a generalist beetle, but the preferred parts of fruit bodies vary according to fungus species.

The more firm and structured the polypore fruit body is, the more complex the structure of spatial distribution of larvae inside the fungal substrate tends to be. Soft and homogeneous context will lead in an even distribution of larvae: *Ennearthron cornutum* in *Dichomitus squalens*; larvae of *Sulcacis affinis* in the context of *Pyconoporus cinnabarinus*; *Hallomenus* sp. larvae in *Postia alni, P. fragilis, P. lateritia, P. leucomallella, P. placenta, P. stiptica, P. tephroleuca* and *Amylocystis lapponica*.

*Dromius sigma*, a small, common carabid species, is an inhabitant of lake- and riversides, living under leaves of *Alnus* and *Salix*. Sometimes occasional individuals move far from water in untypical habitats, like the polypore *Cerrena unicolor*.

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# Hebeloma alvarense, a new species from Estonia

JAN VESTERHOLT and JUKKA VAURAS

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*Hebeloma alvarense* Vesterh. & Vauras (Basidiomycota, Agaricales) is described as a new species from open alvar pine forest of Western Estonia. It belongs to the section Denudata (Fr.) Sacc., and it is characterized macroscopically by a cinnamon-coloured pileus and a very fragile, floccose stipe.

Key words: *Agaricales, Estonia, Hebeloma, taxonomy*

*Jan Vesterholt, Botanical Museum, Gothersgade 130, DK-1123 Copenhagen K, Denmark*

*Jukka Vauras, Biological Collections of Åbo Akademi University, Herbarium, FI-20014 University of Turku, Finland*

## Introduction

A special habitat type known as alvar has developed on limestone areas, especially on the coast and islands of Estonia, as well as on the islands Öland and Gotland of Sweden. Different types of alvar habitats include alvar forests, alvar shrublands, alvar grasslands and alvar heaths. They are characterized by a thin mineral soil layer upon limestone or calcareous gravel. The productivity is relatively low, mainly because of the lack of moisture. The fungus flora of the alvars is very interesting. In these areas several fungi are found, which have never been found in Finland, e.g. *Cortinarius terpsichores* Melot, *Entoloma bloxamii* (Berk. & Broome) Sacc., *E. incanum* (Fr. : Fr.) Hesler, *E. roseum* (Longyear) Hesler and *Hygrocybe calciphila* Arnolds.

During the stay of the second author in Hiiumaa island, participating in the Estonian–Finnish Workshop on Fungal Taxonomy on 12–18 Sept. 2001, the fungus season in the area was excellent. A very distinctive *Hebeloma* was found in an open pine forest in the southern part of Hiiumaa, Estonia. Even in the field the species was eye-catching being cinnamon, distinctly zoned, and having broad lamellae and a very fragile stipe. Later, it was found to have a combination of characters, which do not match any of the known species of the genus.

Microscopical characters were measured and drawn in 5% KOH. The quantitative values D1, D4, O3, P2 used for spore characters in this paper refer to Vesterholt (1995). The colour code refers to Kornerup and Wanscher (1978) and Heilmann-Clausen et al. (1998).

**Hebeloma alvarense** Vesterh. & Vauras, species nova Figs. 1–2

*Pileus 1.3–3.8 cm latus, convexus, deinde expansus, cinnamomeus, zonatus. Lamellae usque ad 7 mm latae, ventricosae, emarginatae, satis distantes, pallide brunneae, guttis aqueis siccae maculatae. Stipes 3.0–3.8 cm longus, 3–6 mm* *crassus, cylindraceus, floccosus, albidus, fragilissimus. Cortina nulla. Velum non observum. Odore raphanino. Sporae 11.0–14.0 × 5.5–7.5 µm, ex maxima parte anguste amygdaliformes vel fusiformes. In solo calcareo.*

*Holotypus:* **Estonia**. Hiiumaa. Käina commune, Kassari, Sääre, camping place, open alvar forest with *Pinus sylvestris* and *Juniperus communis*, on calcareous soil, alt. ca. 5 m, 17.IX.2001 *J. Vauras 17955F* (C; isotypes in H, TAA, TUR).

*Pileus* 13–38 mm broad, convex to expanded, not umbonate, margin even or slightly crenulate, surface smooth, nearly dry, almost unicoloured cinnamon (6C5–6), very pale brown at the extreme margin, with innate greyish brown fibrils and a narrow, greyish brown ring-zone at half the radius. *Lamellae* deeply emarginate, fairly distant, ventricose, broad to very broad, up to 7 mm, lamellulae abundant, clay-buff, edge uneven, whitish, with small droplets, later spotted from these. *Stipe* 30–38 × 3–6 mm, cylindrical, not distinctly widened at base, not rooting, floccose in the entire length, whitish to greyish white, tinged pinkish buff at base, very fragile. *Cortina* absent. *Universal veil* not seen. *Smell* raphanoid. *Exsiccatae* not blackened.

*Spores* 11.0–14.0 × 5.5–7.5 µm, on average 12.4–13.3 × 6.1–6.7 µm (four fruitbodies, each 25 spores), narrowly amygdaliform to amygdaliform or fusiform, a large majority narrowing towards the apiculus, often with apical papilla, Q = 1.70–2.15, on average 1.88–2.06; ornamentation very distinct (O3), perispore loosening in many spores (P2), dextrinoid reaction weak (D1). *Basidia* 25–32 × 8.5–10 µm, cylindrical to clavate, 4-spored. *Cheilocystidia* 28–65 µm long, 6–9(–10) µm wide at apex, 4–5 µm wide in the median part, 4–11 µm wide near the base, clavate, often also widened in the lower part, a minority ventricose with a cylindrical apical part, apex on average 7.2 µm wide (n = 25), hyaline, thin-walled or somewhat thick-walled in the apical part. *Pleurocystidia* not observed. *Gill trama* hyaline to very pale brownish. *Pileipellis* an ixocutis; epicutis about 20–30 µm thick, enclosed hyphae 2–5 µm broad, encrusted, hyaline to brownish; cutis of dark reddish brown elements with encrusting pigment.

Fig. 1. *Hebeloma alvarense* Vesterh. & Vauras, *in situ*. Type, × approx. 1.2, photograph Jukka Vauras.

## Ecology

*Hebeloma alvarense* is only known from the type collection, which was found in open alvar forest with *Pinus sylvestris* and *Juniperus communis*. The type locality has been used as a natural camping area, but not too intensively. The site is characterized by a low vegetation of lichens and vascular plants, e.g. *Filipendula vulgaris, Thymus serpyllum, Helianthemum nummularium, Plantago lanceolata,* and *Antennaria dioica*. Agarics found in the type locality include *Inocybe inodora* Velen., *I. oblectabilis* (Britzelm) Sacc., *Hebeloma senescens* (Batsch) Berk. & Broome and *Russula sanguinea* (Bull.) Fr., all mycorrhizal species with *Pinus sylvestris*, and species characteristic of *Juniperus* alvars, viz. *Entoloma catalaunicum* (Singer) Noordel., *E. excentricum* Bres., *Lepiota alba* (Bres.) Sacc., and *L. oreadiformis* Velen. *Volvariella pusilla* (Pers. : Fr.) Quél. was also collected.

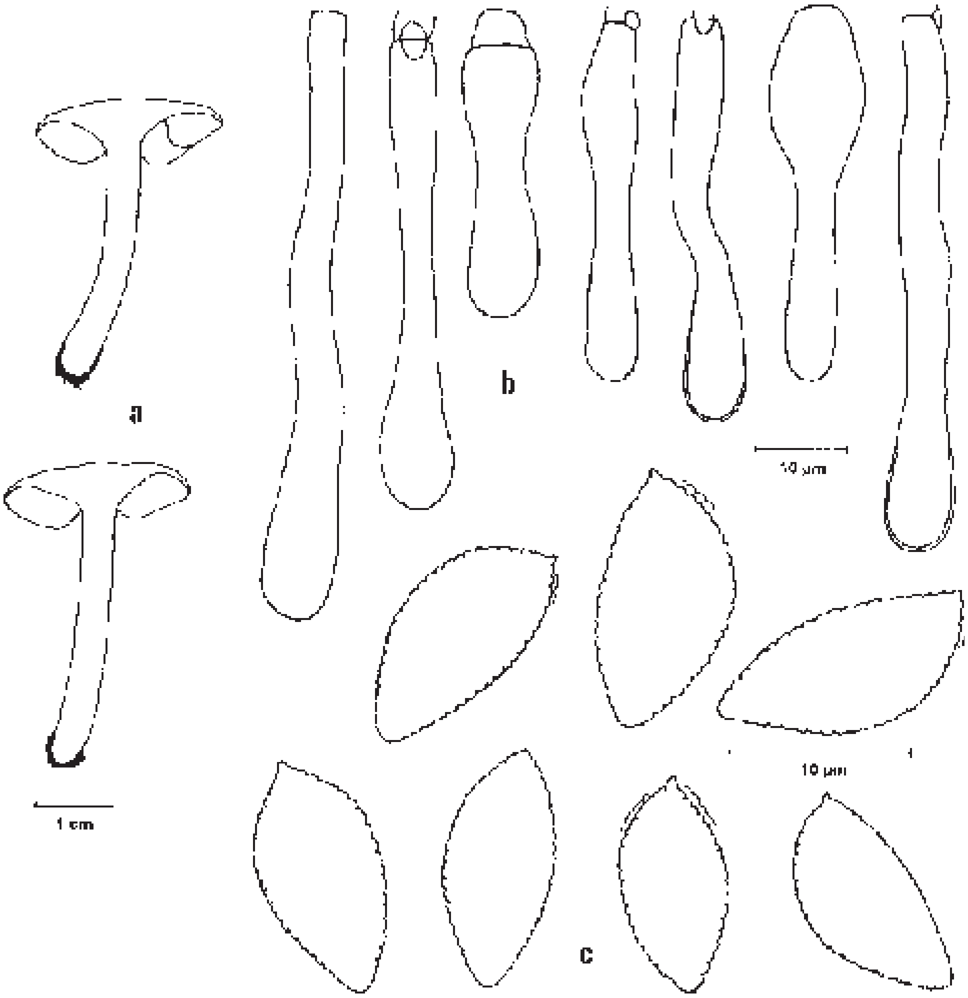

Fig. 2. *Hebeloma alvarense* Vesterh. & Vauras (type). a) fruit bodies, b) cheilocystidia, c) spores.

## Discussion

With the droplets formed on the gills, the raphanoid smell, the non-rooting stipe, the strongly ornamented spores and the clavate cheilocystidia, *Hebeloma alvarense* is a member of section Denudata, which is typified with *H. crustuliniforme* (Bull.) Quél. The outstanding characters of *H. alvarense* are the cinnamon coloured pileus, the broad and fairly distant lamellae, the fragile stipe, the very thin epicutis and the more or less fusiform spores with a loosening perispore. The zonation of the pileus may also prove to be a useful character to delimit the species, but until more material has been studied it is impossible say whether this character is constant.

The fragile stem and the slightly dextrinoid spores with a loosening perispore are also found in *Hebeloma fragilipes* Romagn., but that species has a much paler cap, and a much thicker epicutis, generally around 100 µm. For a description of *H. fragilipes*, see Romagnesi (1965) and Vesterholt (1995, 2000). In the type material of *H. fragilipes* the cystidia often have thickened walls in the median part. This feature has not been observed in *H. alvarense*. It should be noted that *H. fragilipes* and *H. hiemale* Bres. belong to a species complex that is not yet fully understood, and which probably includes several species varying in a number of characters such as colour, size and spore features. For a description of original material of *H. hiemale*, see Grilli (1997).

The only known species from Europe combining ± fusiform spores and a very thin epicutis is *Hebeloma cremeopallidum* (Esteve-Rav. & Heykoop) Esteve-Rav. & Heykoop (Esteve-Raventós & Heykoop 1990, Heykoop & Esteve-Raventós 1997). Until now it is only known from Spain, and it differs from *H. alvarense* in having a pale cap and longer spores, 12.5–15(–17) × 6–7 µm, on average 14.3 × 6.6 µm (n = 20, own observations), with a strong dextrinoid reaction (D4).

Due to the cinnamon colour, *Hebeloma alvarense* may superficially resemble *H. theobrominum* Quadr. or *H. birrus* (Fr.) Gillet. The former has smaller spores with a non-loosening perispore and a strong dextrinoid reaction, while the latter has a fruity smell, short, ± cylindrical cheilocystidia and spores with a strong dextrinoid reaction. In addition, both of these species have a thicker epicutis than *H. alvarense*, and none of the aforementioned species has broad lamellae or droplets on the lamellae.

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# Notes on Polish polypores 4. Polyporus alveolaris

MARCIN PIĄTEK

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Abundant recent collections of *Polyporus alveolaris* (DC. : Fr.) Bondartsev & Singer (Basidiomycota) help to outline the morphology, ecology and distribution of this rare, predominantly submediterranean polypore. The Polish localities are actually the northernmost ones in Europe, notably expanding the range of *P. alveolaris*. Eleven species of *Polyporus* are known in Poland.

Key words: *ecology, Poland, Polyporus, taxonomy, wood-rotting fungi*

*Marcin Pitek, Department of Mycology, W. Szafer Institute of Botany, Polish Academy of Sciences, Lubicz 46, PL-31-512 Cracow, Poland; e-mail: mpiatek@ib-pan.krakow.pl*

## Introduction

*Polyporus alveolaris* (DC. : Fr.) Bondartsev & Singer is a species of warm-temperate climate, widely distributed throughout southern Europe, Asia and North America (Gilbertson & Ryvarden 1987, Ryvarden & Gilbertson 1994, Núñez & Ryvarden 1995, 2001). In the monograph of Polish polypores, Domański et al. (1967) mentioned *P. alveolaris* among the species whose finding in Poland is hardly probable. However, some southern species have been found in Poland in subsequent years, for instance *P. rhizophilus* (Pat.) Sacc. and *Oligoporus obductus* (Berk.) Gilb. & Ryvarden, as well as *P. alveolaris*. The map in Ryvarden and Gilbertson (1994) showed the species to exist in Poland, but this record was not accompanied with the reference of citation or herbarium specimen. It seems that the first published record of *P. alveolaris* in Poland, deriving from year 2000, was given by Friedrich and Orzechowska (2002). However, this is not the sole collection of the fungus in the country since there are numerous unpublished findings of this species from 1995 onwards, collected in Tarnów town in southern Poland. My paper provides information on these collections. The morphology, ecology and distribution of *P. alveolaris* are here outlined based on specimens and observations from Poland.

## Taxonomy

***Polyporus alveolaris*** (DC. : Fr.) Bondartsev & Singer Fig. 1
Ann. Mycol. 39: 58. 1941. – For synonyms, see Núñez and Ryvarden (1995).

*Basidiome* annual, sessile or short stipitate. *Pileus* circular or flabelliform, up to 5 cm in diam. *Upper surface* smooth, glabrous, but with flattened, concentric squamules, orange-yellow, with age becoming cream-coloured to ivory and pale buff and resembling many other species. *Edge* concolorous, uneven, acute. *Pore surface* cream-coloured, pores large, hexagonal or pentagonal, 1–2 per mm. *Context* ivory coloured, azonate, corky, tubes concolorous with context. Stipe short, central or lateral, cream-coloured or ivory, up to 1 cm long. Hyphal system dimitic, generative hyphae thin-walled, hyaline, with clamps, moderately

Fig. 1. Microscopical structures of *Polyporus alveolaris* (DC. : Fr.) Bondartsev & Singer (drawn from KRAM F-39490). – a) hymenium, b) generative hyphae, c) skeleto-binding hyphae, d–h) basidia, i) basidiospores. Use the scale 1 for a–h and scale 2 for i.

branched, up to 4 µm wide, skeleto-binding hyphae thick-walled, nonseptate, richly branched, up to 7 µm wide. Cystidia or other similar sterile elements absent. Basidia clavate, with basal clamp and 4 sterigmata, 20–30 × 7–9 µm. Basidiospores cylindrical, hyaline, smooth, non amyloid, 10–13(–14) × 3.5–5 µm.

*Specimens examined:* **Poland**. Małopolska Prov. Tarnów Distr., Tarnów: Park Kwiatkowskiego, fallen branch of deciduous tree (4 cm), 6.IX.1996 *Piątek* (KRAM F-39230); at Akacjowa St., dead still attached branch of *Syringa vulgaris*, 12.IX.1996 *Piątek* (KRAM F-39213); Lasy Krzyskie (complex I, at Wiśniowa St.), *Tilio cordatae-Carpinetum betuli*, fallen branches of *Acer platanoides* (0.5 and 1.5 cm), 21.IX.1999 *Piątek* (KRAM F-39541), fallen branch of *Fraxinus excelsior* (2 cm), 8.IX.2000 *Piątek* (KRAM F-52161); Lasy Krzyskie (complex IC, at Wiśniowa St.), *Tilio cordatae-Carpinetum betuli*, fallen branch of *Quercus rubra* (6 cm), 10.V.1999 *Piątek* observation; Lasy Krzyskie (complex IIA, at Ścieżki St.), with *F. excelsior* and *Q. rubra*, fallen branches of *F. excelsior* (3 and 5 cm), 10.V.1999 *Piątek* (KRAM F-39508, F-39509); Lasy Krzyskie (complex IIB, at Ścieżki St.), with *F. excelsior* and *Q. rubra*, fallen branch of *F. excelsior* (1cm), 26.VIII.1999 *Pitek* (KRAM F-39838); Lasy Krzyskie (complex III, at Kalinowa St.), with *F. excelsior* and *Q. rubra*, dead still attached branch of *Q. rubra* (2 cm), 10.V.1999 *Piątek* (KRAM F-39510); south of the Krzyskie Stawy ponds, humid alder forest, fallen branch of *F. excelsior* (5 cm), 20.IX.1999 *Piątek* (KRAM F-39737); Park Sanguszków, manor park, fallen branch of deciduous tree (1 cm), 12.IX.1995 *Piątek* (KRAM F-39214); near ruins of the Tarnowskich Castle, tree stand, fallen branch of *F. excelsior* (2 cm), 6.IX.1997 *Piątek* observation; Góra Świętego Marcina, *Tilio cordatae-Carpinetum betuli*, fallen branch of *A. platanoides* (1 cm), 13.VIII.1997 *Piątek* (KRAM F-39229), fallen branch of *A. platanoides* (4 cm), 2.VII.1998 *Piątek* (KRAM F-39228), fallen branch of *A. platanoides* (1 cm), 6.IX.2002 *Piątek* (KRAM F-52814), fallen branch of *F. excelsior* ( 2cm), 17.V.1999 *Piątek* observation, fallen branch of *F. excelsior* (3 cm), 17.V.1999 *Piątek* (KRAM F-39507); Pogórze Wiśnickie: Panieńska Góra Reserve, *ca.* 16 km SW of Tarnów, *Tilio cordatae-Carpinetum betuli*, fallen branch of *A. platanoides* (5 cm), 10.VIII.1998 *Piątek* (KRAM F-39348).

## Discussion

*Polyporus alveolaris* is a lignicolous species, restricted to deciduous wood. In Poland it was most often recorded on small branches 1 to 6 cm thick. Usually the basidiomes were growing on the upper side of branches lying on the ground, but sometimes the basidiomes emerged from dry branches still attached to the tree. The main host in the Polish populations of the fungus was *Fraxinus excelsior* followed by *Acer platanoides*, *Quercus rubra* and *Syringa vulgaris* (Fig. 2). Similar hosts were found for the fungus, e.g. in Switzerland (Breitenbach & Kränzlin 1986), Italy (Bernicchia 1990) and the Czech Republic and Slovakia (Kotlaba 1984). However, in the latter area the most common hosts were maple trees *Acer campestre* and *A. pseudoplatanus*, but a few

Fig. 2. Host spectrum for *Polyporus alveolaris* (DC. : Fr.) Bondartsev & Singer in Poland. – 1) *Fraxinus excelsior*, 2) *Acer platanoides*, 3) *Quercus rubra*, 4) *Syringa vulgaris*, 5) unidentified deciduous tree.

further specimens were collected, e.g., on ash (*Fraxinus* sp. and *F. angustifolia* ssp. *danubialis*) and lilac (*Syringa vulgaris*).

*Polyporus alveolaris* grew both in synanthropic, natural and semi-natural habitats. The sites affected by humans were parks and green belts. In such environments the fungus has been found four times, once in Szczecin (Friedrich & Orzechowska 2002) and three times in Tarnów. Natural forests were mostly classified as the Tilio cordatae-Carpinetum betuli association, and rarely mesic herb-rich alder forests with the dominance of *Fraxinus excelsior* or semi-natural forest with the dominance of *F. excelsior* and *Quercus rubra*. In natural and semi-natural habitats *P. alveolaris* favoured fairly humid and sunny places.

*Polyporus alveolaris* started to form basidiomes already in May: from this month the number of collections is relatively high. However, the main fruiting period was in September. In other months the number of specimens is smaller, and for instance in June no collections were made.

In Europe *Polyporus alveolaris* shows a submediterranean type of distribution with maximal occurrence in the Mediterranean region, extending to the southern parts of Germany (Krieglsteiner 1991), the Czech Republic and Slovakia (Kotlaba 1984). In the light of the present study the occurrence of P. alveolaris in Tarnów at the northern border of the Carpathians (Fig. 3) is an isolated outlier, including one locality in the Panieńska Góra Reserve, 16 km south-west of Tarnów. The

Fig. 3. Distribution of *Polyporus alveolaris* (DC. : Fr.) Bondartsev & Singer in Poland.

localities in Tarnów are mostly in northern and southern parts of the city in natural and semi-natural forest complexes, while only two localities are in the parks and green belt in central part of the city (Fig. 4). The closest locality to these lays about 80 km south in eastern Slovakia on the southern slopes of the Carpathian chain. *P. alveolaris* has in southern Poland a limited occurrence; the species has not been found in Cracow, 80 km west from Tarnów, despite this city is well explored mycologically (Wojewoda 1991, 1996).

In Szczecin (Fig. 3) *Polyporus alveolaris* was found only once (Friedrich & Orzechowska 2002). This locality is very isolated from the others in southern Germany and Poland, and hence it is very interesting. A similar isolated locality is known in northern Germany far from the main range of the species (Krieglsteiner 1991).

The number of basidiomes of *Polyporus alveolaris* varied greatly between the localities. Most abundant it was in Góra Świętego Marcina, where it formed numerous basidiomes from May to September. It was less frequent in other natural or semi-natural places, for instance in the Lasy Krzyskie in northern Tarnów or in the PanieDska Góra Reserve. In man-influenced places only single basidiomes were seen. However, it is hard to evaluate the red-list status of this fungus accord-

Fig. 4. Distribution of *Polyporus alveolaris* (DC. : Fr.) Bondartsev & Singer in Tarnów town. – a) forests and parks, b) built-up area, c) rivers, d) railway, e) roads, f) town border.

ing to the criteria of IUCN (2001) before long-term observations on the populations are available.

Eleven species of *Polyporus* are known in Poland. Of these, common or rather common are *P. brumalis* (Pers.) Fr., *P. ciliatus* Fr. : Fr., *P. squamosus* (Huds.) Fr., and *P. varius* (Pers.) Fr., while others are rarely reported: *P. arcularius* (Batsch) Fr., *P. badius* (Pers.) Schwein., *P. melanopus* (Pers.) Fr., and *P. umbellatus* (Pers.) Fr. The remaining ones are very rare: *P. alveolaris*, *P. rhizophilus* (Pat.) Sacc. and *P. tuberaster* (Jacq.) Fr.

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*Karstenia 44: 67–77, 2004*

# New and in North Europe rare polypore species (Basidiomycota) with annual, monomitic basidiocarps

TUOMO NIEMELÄ, YU-CHENG DAI, JUHA KINNUNEN and DMITRY S. SCHIGEL

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Two new species of polypores are described: *Postia balsamina* Niemelä & Y.C. Dai and *P. persicina* Niemelä & Y.C. Dai. They were collected on *Picea abies* in Northern boreal zone. *Postia balsamina* is white, fleshy and almost resupinate, monomitic, and bears rather thin-walled, acute cystidia with minute apical encrustation; cystidia are usually found in hymenium close to tube orifices and their amount increases by age. The species is reported from northern Finland and Sweden. It resembles *P. balsamea* (Peck) Jülich, which is pileate, more tough, with smaller spores and pores; *P. balsamea* occurs as rare in South Finland, and its distribution in Europe is southerly. *P. persicina* is beautifully orange-red, pileate, and its white pore surface turns yellow when drying. Externally it resembles *Tyromyces kmetii* (Bres.) Bondartsev & Singer, which grows on angiosperm trees and whose spores are much thicker. In addition to Finland, it was found once in Russian Karelia, growing on spruce. *P. luteocaesia* (A. David) Jülich is reported from Finland. It is compared to the closest related species, *P. caesia* (Fr.) P. Karst., *P. subcaesia* (A. David) Jülich, *P. alni* Niemelä & Vampola and its brief description is included.

Key words: Basidiomycota, *Postia balsamea, Postia balsamina, Postia luteocaesia, Postia persicina,* polypore, taxonomy

*Tuomo Niemelä, Juha Kinnunen and Dmitry S. Schigel, Finnish Museum of Natural History, Botanical Museum, P.O. Box 7, FI–00014 University of Helsinki, Finland*

*Yu-Cheng Dai, Institute of Applied Ecology, Chinese Academy of Sciences, Wenhua Road 72, Shenyang 110016, China*

## Introduction

In 1999 the governmental Metsähallitus (Finnish Forest and Park Service) set up a four-year project *Conservation of the Ylläs–Aakenus Western Taiga Forest Area in Lapland* with the support from the European Union financed LIFE Nature Fund. Forests and wetlands of the Ylläs–Aakenus area in northern Finland were studied in order to get information on species diversity there. Vascular plants, mosses, polypores, lichens, birds, fishes and insects were inventoried. The results offered basic information for management planning of the area. The work was organized by the Natural Heritage Services, and its first results were reported in Koivisto (2003).

Polypores and other wood-inhabiting fungi of the area were studied during three subsequent years. The work was started in 1999 by the authors YCD and TN, and completed in 2000 and 2001 by the latter together with JK and DSS. Some other biologists took part in the fieldwork, and in most of the inventory days a person from the Natural Heritage Services accompanied us.

The basic reason for making the inventories was that the 386.5 square kilometre Ylläs–Aakenus region, including protected forests and peatlands, was intended to become a future national park. The decision has now been made to merge the Ylläs–Aakenus region with the Ounas–Pallastunturi National Park further north. Altogether this will make the third largest continuous nature reserve in Finland, totalling ca. 1000 square kilometres, and extending ca. 100 kilometres in the north–south direction. The new entity will be named the Ylläs–Pallas National Park, after its two well-known peaks.

The Ylläs–Aakenus area comprises spruce and pine dominated forests of Northern boreal zone, not far from northern timberline. Montane forest line is reached in the area at the altitude of 420–480 metres (Pyhätunturi and Äkäskero), but this is not necessarily climatic limit because the hilltops are barren, stony outcrops. The highest peaks are 613 (Lainiotunturi) and 718 (Ylläs) metres a.s.l. This is an area of ancient, low-stature mountains (fells) and lower hills of granitic bedrock rich in quarzite, mostly being exposed as a result of repeated glaciations during the Ice Ages of the Quaternary. In the area there are barren stony hilltops, forested lower slopes, gorges with herb-rich vegetation, peatlands, and several lakes and watercourses. Human population has always been very sparse, and traditionally reindeer-herding.

About 80% of the forests in the area exceed 160 years' age. Most of these forests have never been cut down, although selective loggings (mostly of old pine, in particular *kelo;* see Niemelä et al. 2002) have been performed extensively. Because of the high age of the forests, we had expectations of finding a great deal of species characterizing old-growth forests there. In addition to several rarities, also species new to science were found, for instance one hydnaceous stipitate fungus (Niemelä et al. 2003) and two polypores dealt with here.

The other area of our study, Repovesi National Park, is situated in Valkeala and Mäntyharju communes of Central Finland, Etelä-Savo province. Mostly this is state-owned land but it includes the Aarnikotka Reserve owned and protected by the UPM-Kymmene paper company. Botanically it belongs to the Southern Boreal zone which is characterized by dense spruce- and pine-dominated forests. It totals an area of ca. 30 square kilometres, including (or touching) over 90 lakes of various sizes (mostly small), and hilly terrain with pine-wooded rock outcrops, steep slopes, spruce-dominated valleys and gorges, and a few small peatlands. Water-level is elevated by beavers in many of the smaller lakes, resulting in an abundance of dead trees along lakesides. Most forests are fairly young in this recently (in 2003) established national park. Three of us (TN, JK, DSS) inventoried the polypores of the area in 2004. One of the species reported in this paper was found in the Repovesi National Park.

## Materials and methods

Specimens were mostly collected by the authors with co-workers. They were photographed in the field, and fresh character and ecology notes were made. Specimens were dried soon after field trips in a mushroom dryer with ventilated 30–40°C temperature.

In addition to the new species, selected voucher materials of related species were studied for comparison. All the specimens listed are deposited in the Botanical Museum of the University of Helsinki (H), unless otherwise indicated. Herbarium names are abbreviated according to Holmgren et al. (1990).

*Postia balsamea* (Peck) Jülich and *P. luteocaesia* (A. David) Jülich have been well described in many manuals (e.g. Ryvarden & Gilbertson 1993–1994), and we make here just brief descriptions on the basis of new collections.

Microscopic studies were done and spores were measured from sections mounted in Cotton Blue (abbreviated CB): 0.1 mg aniline blue (Merck 1275) dissolved in 60 g pure lactic acid; CB+ means cyanophily, CB(+) weak but distinct cyanophilous reaction, CB– acyanophily. Amyloid and dextrinoid reactions were tested in Melzer's reagent (IKI): 1.5 g KI (potassium iodide), 0.5 g I (crystalline iodine), 22 g chloral hydrate, aq. dest. 20 ml; IKI– means neither amyloid nor dextrinoid reaction. Occasionally also 5% KOH was used as mountant or reagent.

As a rule 30 spores were measured from each specimen selected for closer scrutiny. Measurements were done using × 1250 magnification, phase contrast and oil immersion; eyepiece scale bar showed a 1-µm-grid, and dimensions were estimated subjectively with an accuracy of 0.1 µm. In presenting the variation of spore size, 5% of the measurements out of each end of the range are given in parentheses. L= mean length (arithmetical mean of all spores), W= mean width, Q= extreme values of the length/width ratios among the studied specimens, and n= the number of spores measured from given number of specimens.

The main reference books used were: Bondartsev (1953), Gilbertson & Ryvarden (1986–1987), Ryvarden & Gilbertson (1993–1994), Núñez & Ryvarden (2001), and Hansen & Knudsen (1997). Special colour terms are from Anonymous (1969), Rayner (1970) and Petersen (1996).

## ***Postia balsamina*** Niemelä & Y.C. Dai, species nova Figs. 1, 2

*Carpophorum annuum, resupinatum vel effuso-reflexum, molle, colore album vel in statu sicco brunneo-cremeum; systema hypharum monom-*

*iticum, hyphae fibulatae; cystidiae lanceolatae vel fusiformae; sporae angusto-ellipsoideae, 4.3–5.6 × 2.3–2.9 µm.*

Holotype: **Finland**. Kittilän Lappi. Kolari, Äkäslompolo, north of Kesänkijärvi, *Picea abies*, fallen trunk, 31.VIII.1999 *Tuomo Niemelä 6601 & Yu-Cheng Dai* (H).

Etymology: *balsamina* (Lat., adj.), referring to microscopic similarity with *Postia balsamea*.

Basidiocarp annual, resupinate or effused-reflexed with minute pilei (1–2 cm wide, projecting 0.5–1 cm) bordering a wide resupinate part, up to 20 × 7 cm, when young fleshy and juicy, soft to touch but flexible and cartilaginous if torn apart, when dry soft corky and easy to cut. Upper surface soft matt or somewhat floccose, uniformly white and azonate; in old and dry specimens cream coloured. Pore surface white when fresh and young, older parts attaining a faint ochraceous or salmon tint, when dry sordid brownish cream (buff, pale olivaceous buff); craters of guttation droplets sometimes frequent; pores angular, (1–)3–4(–5) per mm; sterile margin bordering resupinate areas usually wide (1–5 mm), fibrous, when fresh white, when dry cream coloured. Section: subiculum thick (1–2 mm), cartilaginous and translucent when fresh, opaque white and tough corky when dry; fresh tubes white, dry cream-coloured or brownish, concolorous with pore surface. No specific smell or faint fungoid smell; taste mild.

Monomitic, hyphae hyaline, with clamp connections, amyloid (IKI grey to pink; amyloidy most distinct in subiculum close to tube bottoms), CB–, almost unchanged in KOH. Subiculum hyphae (3–)3.7–5.3(–5.5) µm in diam., thick-walled to sclerified (wall up to 1.5 µm), interwoven with radial orientation, in a fairly tight texture but not glued together. Tube trama with faintly amyloid hyphae, 2.9–4(–4.2) µm, fairly thin-walled at orifices but thick-walled and glued-together higher up, subparallel; subhymenium thin and indistinct. Hymenium with clavate basidia 15–17(–23) × 5.3–6 µm, short clavate basidioles 10–16 × 4.5–5.8 µm; cystidioles with short finger-like apex, becoming commoner towards the end of the season; cystidia common or abundant but in young basidiocarps found only locally close to tube orifices, (13–)15–25(–28) × (4–)4.8–6.5(–8) µm, L=20.36 µm, W=5.50

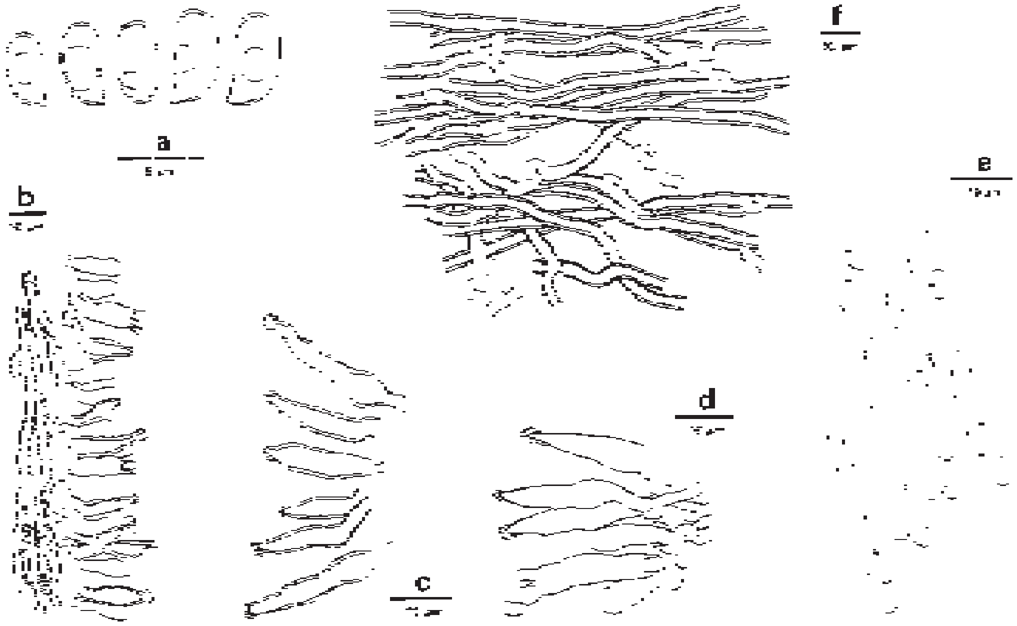

Fig. 1. *Postia balsamina* Niemelä & Y.C. Dai. – a) Spores, b) vertical section through hymenium showing basidia, basidioles and cystidia, c) mature cystidia, d) hymenial cells with juvenile cystidia, e) hyphae from dissepiment edge, f) subicular hyphae. Drawn in CB from *Niemelä 6769* (b, c) and holotype (the others).

µm, Q=3.25–5.09 (n=58/5), conical, obclavate, lanceolate or fusiform, mostly terminal but also pleural cystidia common, with wall slightly thicker than in basidia and basidioles (young specimens) or strongly thickened (old), and acute tip mostly rough because of minute crystal sand. Hyphal tips normal at dissepiment edge.

Spores ellipsoid or narrow ellipsoid, thin-walled, IKI–, CB–, (4.1–)4.3–5.6(–6.9) × (2.2–)2.3–2.9(–3.1) µm, L=4.87 µm, W=2.62 µm, Q=1.83–1.92 (n=150/5).

*Specimens examined:* **Finland**. Perä-Pohjanmaa. Rovaniemi rural comm., Pisavaara Strict Nat. Res., Kuusilaki, *Picea abies*, 31.VIII.1960 *Kujala & Eriksson 9696* (ex GB 4155); 6.IX.2003 *Kinnunen 2168*. Kittilän Lappi. Kittilä, in valley between Mustakero and Kulkukero, *P. abies*, 24.VIII.2000 *Niemelä 6769 & Kinnunen*. Kolari, Äkäslompolo, Kesänkijärvi N slope, *P. abies*, 20.VIII.1999 *Niemelä 6490 & Dai*, 29.VIII.1999 *Niemelä 6576 & Dai*, 31.VIII.1999 *Niemelä 6601 & Dai* (holotype); Varkaankuru, *P. abies*, 15.VIII.2000 *Niemelä 6679*. Sompion Lappi. Savukoski, Maaselkä 13 km NW of Savukoski church village, *P. abies*, VIII.1994 *Hiltunen 2292*. **Sweden**. Lule Lappmark. Gällivare, Granlandet, *P. abies*, 21.IX.1993 *Bader & Norstedt 32*.

## Notes on Postia balsamina

The species will key out as *Postia balsamea* (*Oligoporus balsameus* (Peck) Gilb. & Ryvarden), if identified with the aid of recent manuals, because in the microscope the two species share a monomitic structure, subulate cystidia, and ellipsoid spores. However, *P. balsamina* has longer spores and larger pores (albeit measurements overlap), and its cystidia seem to be more distinctly projecting, more sharp-pointed and more regularly encrusted. The amyloidy of the hyphae is stronger and more regular than in *P. balsamea*.

Macroscopically the new species bears little resemblance to *P. balsamea;* the white, rubbery flexible, juicy basidiocarp looks more like an exceptionally large and luxuriant specimen of *Postia undosa* (Peck) Jülich. The more distinctly pileate and corky tough *P. balsamea* resembles some *Trametes* species, *Antrodiella semisupina* (Berk. & M.A. Curtis) Ryvarden, or *A. fragrans* (A. David & Tortić) A. David & Tortić).

*Postia balsamina* resembles young, almost resupinate *Climacocystis borealis*: both they grow on coniferous trees, and are monomitic with similar cystidia and spore shape. The latter is finally pileate, tough and strongly fibrous, and its pores are larger and often sinuous; it is a white-rot fungus. *Postia balsamina* may produce pilei, but they develop as small projections bordering the wide resupinate part only, and usually the whole basidiocarp is resupinate. It feels fibrous, too, if torn apart when fresh, but in a softer and more fleshy way. The pores of *P. balsamina* are fairly regularly angular.

Fig. 2. *Postia balsamina* Niemelä & Y.C. Dai. Holotype, photographed *in situ*. Magnification ca. × 1.6.

There was some controversy on the decay type caused by *Postia balsamina*. While most basidiocarps were growing on soft, widespread white-rot, one (*6769*) was collected from brown-rotted wood. There had evidently been other fungi growing on the trunk before, and the decay caused by this species could not be easily seen. In some tree trunks there were remnants of dead *Trichaptum*, and our new species may be its successor. Dr Kari Steffen (pers. comm.) kindly isolated a culture from our collection and confirmed that *P. balsamina* is a brown-rot fungus.

Resupinate, young basidiocarps of *P. balsamina* may be confused with *Oligoporus sericeomollis* (Romell) M. Bondartseva, because the two have monomitic structure with fairly thick-walled and clamped hyphae, spores are fairly similar (strongly cyanophilous in *O. sericeomollis*), and they both have cystidia. However, in *O. sericeomollis* the cystidia are heavily encrusted, and less conical in their shape. Eventually *P. balsamina* is a thicker and more robust species.

*Postia balsamina* was collected on fallen, thick, still corticated trunks of *Picea abies* subsp. *obovata* in virgin spruce swamps or otherwise humid habitats. In most cases the large fruit body was situated on the lower side of the trunk, very close to mossy ground, and it took quite an effort to turn the trunks around. Evidently a tight ground contact of the trunk is needed to keep the substrate moist enough throughout the season. Our collections from Finland and Sweden imply that this is a northern fungus of old-growth spruce forests: the collections derive from Northern Boreal zone and its transition to Middle Boreal (Pisavaara). Some more southern (Middle or South Boreal) old forests in Ilomantsi (Koitajoki Nature Reserve, 2002–2003: Schigel et al. 2004), Valkeala (Repovesi National Park, 2004), Eno (Kolvananuuro and Kirjovaara, 2004) and elsewhere were intensively inventoried with the same field methods, and this species was not found. Obviously this is a rare thing.

In the discussion of *Tyromyces kymatodes* (Rostk.) Bondartsev & Sing. (= *Postia balsamea*) Bondartsev (1953: 218) mentions a collection from Kamenets-Podol'skiy, a resupinate, white basidiocarp which 'we might have described ... as a separate variety'; this may refer to *Postia balsamina*.

Niemelä (2001a, b, 2004) tentatively introduced the species as *Postia balsamina nom. prov.* in Finnish and Russian articles.

### ***Postia balsamea*** (Peck) Jülich Figs.3,4

*Polyporus balsameus* Peck, New York State Mus. Nat. Hist. Ann. Rep. 30: 46, 1878. Holotype: 'Adirondack Mts., on spruce, *C.H. Peck*', NYS (studied). – *Oligoporus balsameus* (Peck) Gilb. & Ry-

Fig. 3. *Postia balsamea* (Peck) Jülich, growing on living *Crataegus douglasii*. Specimen *Niemelä 6876*, × 0.8.

varden, Mycotaxon 22: 364, 1985. *Postia balsamea* (Peck) Jülich, Persoonia 11:423, 1982.

*Polyporus crispellus* Peck, New York State Mus. Ann. Rep. 38: 91, 1885. Holotype: 'Osceola, *Chas. H. Peck*, Aug.', NYS (studied).

*Tyromyces cutifractus* Murrill, Mycologia 4: 94, 1912. Holotype: 'Oregon, *Murrill 1064*', NY (studied).

Basidiocarp pileate or effused-reflexed, pilei 2–5 cm wide, 5–10 mm thick at base, but mostly 4–6 mm, shelf-shaped or flabelliform, with broad or constricted attachment, single or imbricate, fairly tough when fresh, chalky hard when dry. Upper surface matt, at first cream coloured, but soon pale greyish brown and with soft darker zones, finally mouse grey; darkening when drying. Edge sharp, making a fairly regular arc. Pore surface cream coloured, when dry pale greyish brown or tan; pores angular or roundish, (3–)4–6 per mm; sterile margin bordering resupinate base narrow, matt, compact and well demarcated. Section: context cream coloured, leathery; when dry similar in colour but chalky brittle or hard; tubes with a little darker brownish tone, as if oily. Odour farinaceous or reminding non-perfumed soap; tasteless, not at all bitter or sour.

Monomitic, hyphae hyaline, with clamp connections, IKI– (a few specimens faintly amyloid), CB–, almost unchanged in KOH. Context hyphae interwoven or subparallel in a compact and tight fashion, (3.5–)3.9–6(–6.5) µm in diam., thick-walled to sclerified. Tube tramal hyphae (2.9–)3–4(–4.1) µm, subparallel, thick-walled and glued-together; subhymenium indistinct. Hymenium with clavate basidia (14–)17–23 × (4.2–)4.6–5.3 µm, short clavate basidioles 11–16 × 4.4–5 µm; cystidia mostly infrequent, 12–20(–21) × 4.2–5.5(–6) µm, L=19.72 µm, W=5.41 µm, Q=3.38–3.92 (n=11/3), obclavate or bullet-shaped, mostly terminal but also pleural cystidia seen, thick-walled and sometimes with minute apical encrustation; cystidia usually sunken rather deep in hymenium.

Spores short ellipsoid or almost truncate, thin-walled, IKI–, CB–, (3.4–)3.7–4.7(–5.3) × (2.1–)2.2–2.5(–2.8) µm, L=4.03 µm, W=2.34 µm, Q=1.69–1.76 (n=90/3); spores often glued together in tetrads; apiculus almost invisible.

*Specimens examined:* **Finland**. Uusimaa. Helsinki, Kallio, Tokoinranta park, *Crataegus douglasii*, 3.IX.2001 *Manninen*, 4.X.2001 *Manninen 1459;* Koskela Hospital park, *C. douglasii*, 3.X.1999 *Saarenoksa 01099*, 6.X.1999 *Niemelä 6669*, 9.X.1999 *Saarenoksa 01199*,

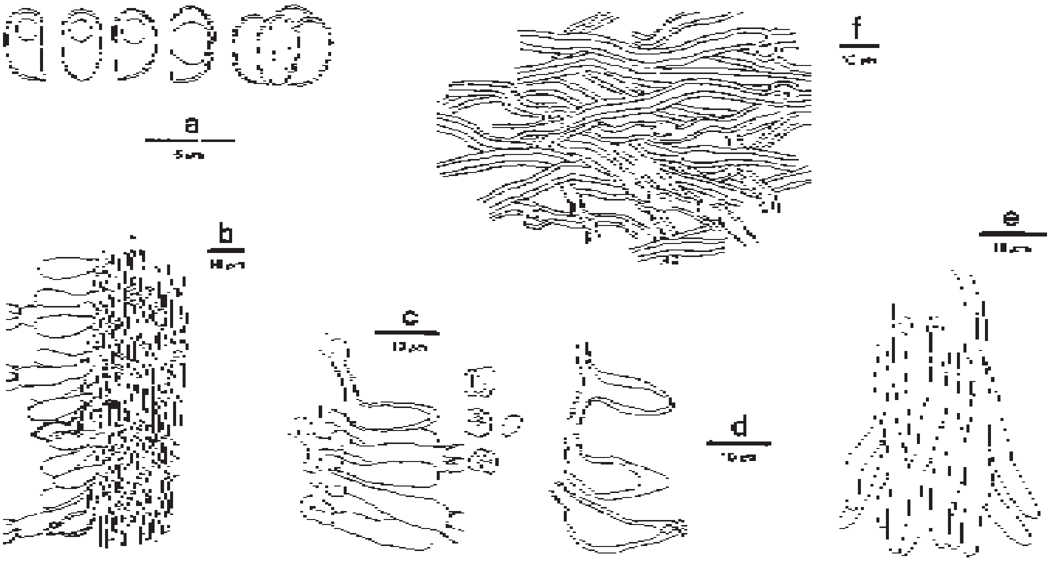

Fig. 4. *Postia balsamea* (Peck) Jülich. – a) Spores, b) hymenium and tube trama in vertical section, c) basidia, basidioles and cystidium, d) different types of cystidia, e) hyphae from dissepiment edge, f) thick-walled and tightly packed hyphae of context. Drawn in CB from 1973 *Lohmeyer* (c–e) and *Saarenoksa 01099* (the others).

7.IX.2000 *Niemelä 6876;* Rajatorppa, *Betula*, 28.VIII.1981 *Erkkilä 231*. **Germany**. Bavaria. Near Tittmonig by river Salzach, gymnosperm tree, 31.VII.1973 *Lohmeyer.* **Switzerland**. Jura Mts. Solothurn, *P. abies*, 30.X.1971 *Schaeren.* **Czech Republic**. Bohemia. Between Lidice and Stredokluky, W of Praha, *Populus*, 13.VIII.1973 *Niemelä, Kotlaba & Pouzar*. **U.S.A.** New York. Adirondack Mts., on spruce *[Abies balsamea]*, VIII.[1877] *Peck* (type of *Polyporus balsameus*, NYS); Lewis Co., Osceola, *[Tsuga canadensis]*, VIII.[1884] *Peck* (type of *Polyporus crispellus*, NYS). Oregon. Newport, *[Abies]*,13.XI.1911 *Murrill 1064* (type of *Tyromyces cutifractus*, NY). **China**. Jilin. Antu, Baihe, *Pinus*, 15.IX.1995 *Dai 2139.*

## Notes on Postia balsamea

Cystidia are often few and indistinct, usually submerged in the hymenium and not too thick-walled, even though they are unmistakable. Sometimes it took several sections to find them in a specimen. However, especially in some American specimens cystidia are numerous indeed, sometimes even dominating among hymenial elements, thick-walled and conspicuous. The type of *Polyporus crispellus* Peck belongs to the cystidiose kind, while in the type of *Tyromyces cutifractus* Murrill cystidia are rare and inconspicuous. The type of *Polyporus balsameus* Peck is intermediary in this respect. Spore sizes of these American type specimens agree completely with the measurements obtained from European materials (Table 1). The microscopy description above was compiled from European specimens only.

The species is very rare in Finland, and southern in its distribution. Erkkilä and Niemelä (1986) reported *Postia balsamea* from Helsinki, growing on *Betula*. However, it mostly lives on park trees, especially on old thick-stemmed *Crataegus douglasii*, which is native of western North America (Hämet-Ahti et al. 1992).

*Postia balsamea* was reported from Finland by Eriksson and Strid (1969) as *Tyromyces kymatodes*. That collection is preserved in GB and its duplicate is now in H; according to our interpretation that northern material represents *P. balsamina*. In his thesis Norokorpi (1979) reported seven finds of *Tyromyces kymatodes* from butt-rot columns of *Picea abies* in his research material from Perä-Pohjanmaa: Rovaniemi (Kivalo) and Kittilän Lappi: Kittilä and Meltaus, all of them in northern Finland. In that work *T. kymatodes* was isolated from older-than-average, living spruce trees with large butt-rot columns. Fungi were determined at least mostly from mycelia, and the identifications cannot be rechecked anymore. According to our results it is evident that *P. balsamina* was in question.

Kotlaba and Pouzar (1968) reviewed the Czech specimens of *P. balsamea*, and discussed the identity of *Polyporus kymatodes* Rostk., which was in Europe a widely used name for the taxon, until Pilát (1936–1942) showed the correct name to be *Polyporus balsameus*. The description of *P. kymatodes* by Rostkovius (1830) is vague, but many details (burning bitter taste, brown colours) rule out *Postia balsamea*, as pointed out by Kotlaba and Pouzar, who also showed that *Leptoporus alma-atensis* Pilát is a later synonym of *P. balsamea*. We did not restudy materials of these two taxa. *Postia balsamea* is rare in Bohemia, but a very wide range of hosts was listed of both gymnosperm and angiosperm trees.

Gilbertson and Ryvarden (1986–1987) report *Polyporus basilaris* Overh. (in Bailey 1941) to be synonymous with *P. balsamea;* indeed, the de-

Table 1. *Postia balsamina* sp. nova (**bold face**) and *P. balsamea* (light face): spore size in different herbarium materials. L= mean length, W= mean width, Q= length/width quotient, n= number of spores measured and number of specimens.

| | | L | W | Q | n |
|---|---|---|---|---|---|
| ***P. balsamina*** **sp. nova:** | **(4.1–)4.3–5.6(–6.9)×(2.2–)2.3–2.9(–3.1) μm** | **4.87 μm** | **2.62 μm** | **1.83–1.92** | **150/5** |
| *P. balsamea*/Europe: | (3.4–)3.7–4.7(–5.3)×(2.1–)2.2–2.5(–2.8) μm | 4.03 μm | 2.34 μm | 1.69–1.76 | 90/3 |
| *Pol. balsameus* type: | 3.6–4.4(–4.9)×(2.1–)2.2–2.4(–2.5) μm | 4.04 μm | 2.29 μm | 1.76 | 30/1 |
| *Pol. crispellus* type: | (3.8–)3.9–4.4(–4.8)×(2.1–)2.2–2.4(–2.6) μm | 4.09 μm | 2.28 μm | 1.79 | 30/1 |
| *Tyr. cutifractus* type: | (3.6–)3.8–4.3(–4.5)×(2.1–)2.2–2.4(–2.6) μm | 3.99 μm | 2.31 μm | 1.73 | 30/1 |

scription (also in Overholts 1953) is clear and rules out our new species *Postia balsamina*. Still another reported synonym of *P. balsamea*, *Tyromyces carbonarius* Murrill is compatible with that species in mating tests (Gilbertson & Ryvarden 1986–1987).

### ***Postia persicina*** Niemelä & Y.C. Dai, species nova Figs. 5, 6

*Carpophorum annuum, pileatum, firmum, colore pilei albo-persicinum vel pallide rosaceum; facies pororum album, in statu sicco olivaceo-cremeum; systema hypharum monomiticum, hyphae fibulatae; sine cystidiis; sporae cylindricae, 4.1–5 × 1.7–2.1 µm.*

Holotype: **Finland**. Kittilän Lappi. Kolari, Äkäslompolo, Varkaankuru, *Picea abies*, 17.VIII.1999 *Niemelä 6453 & Dai* (H).

Etymology: *persicina* (Lat., adj.), peach-coloured; referring to the pale reddish-orange upper surface.

Basidiocarp annual, pileate with obtuse margin, up to 7 cm wide, up to 1.5 cm thick at base, projecting 1.5 cm from substrate, broadly attached to wood, fleshy but fairly sturdy or somewhat tough when fresh, shrinking a little when drying; actively growing specimens exude milky droplets. Upper surface smooth or uneven but not rough, matt, pale peach coloured (pinkish orange) all over; no colour changes upon touch; the bright colour fades into tan or unevenly cream-and-brown when drying, and small (1–3 mm diam.) craters left from guttation droplets become visible. Edge sharp but not thin, entire, wavy. Pore surface white in fresh condition, even or swollen a little; pores (2–)3–5 per mm, regular, round or somewhat angular, glancing a little when tilted at incident light, tube orifices entire; when drying turning oily-looking olivaceous cream. Section: context soft, uniform, white, when dry chalky or in places resinous hard; tubes white when fresh, olivaceous cream when dry and translucent as if oily; tube layer up to 5 mm. No specific smell, taste mild.

Monomitic, hyphae hyaline, with clamp connections, IKI variable, CB–; in KOH some hyphae unchanged, others (especially in context) with swollen walls and then looking like skeletals, but all hyphae repeatedly clamped. Context hyphae (2.7–)3–5(–6.1) µm in diam. (n=30/1), IKI–, very thin-walled, delicate, subparallel and with prominent clamps; a few hyphae more thick-walled close to the attachment. Tube trama with very regular hyphae, (2.2–)2.9–4(–4.1) µm (n=30/1), faintly grey (amyloid) in IKI, thin-walled, in a subparallel arrangement; dissepiment edge with wavy hyphal tips sometimes sparsely covered with small cubical crystals. Hymenium with clavate

Fig. 5. *Postia persicina* Niemelä & Y.C. Dai. Holotype, growing on fallen and decorticated trunk of spruce. Approximately in natural size.

basidia, 15–20(–22) × (4.4–)4.8–5.9 µm (n=20/1), narrow clavate basidioles, (10–)11–16(–18) × (3.4–) 3.9–5.1 µm (n=20/1), and occasional hyphal pegs; no cystidia.

Spores cylindrical and slightly curved, thin-walled, IKI–, CB–, (3.8–)4.1–5(–5.3) × 1.7–2.1 (–2.2) µm, L=4.47 µm, W=1.91 µm, Q=2.24–2.45 (n= 60/2); often with a large, light-refracting guttule.

*Specimens examined:* **Finland**. Perä-Pohjanmaa. Rovaniemi, Pisavaara Strict Nat. Reserve, E slope of Sorvannulikka, *Populus tremula*, 29.VIII.1960 *Eriksson 9525 & Kujala* (GB, herb. John Eriksson 4161; identification somewhat uncertain). Kittilän Lappi. Kolari, Äkäslompolo, Varkaankuru, *Picea abies*, 17.VIII.1999 *Niemelä 6453 & Dai* (holotype). **Russia**. Karelian Rep. Kostomuksha, 2.5 km WSW of Venehlampi, *P. abies*, 2.IX.1998 *Lindgren 11963 & Siitonen.*

## Notes on Postia persicina

The reddish or orange tints of *Postia persicina* bring in mind *Tyromyces kmetii* (Bres.) Bondartsev & Singer, which is a species of deciduous trees, and whose spores are thicker, up to 3 µm (Kotiranta 1986). Also *Postia guttulata* (Peck) Jülich exudes abundant droplets if growing actively, but it has no reddish hues, it turns more clearly yellow when drying, and its shape is flat, flabelliform or shelf-shaped, with a constricted base.

The new species was found only once in its type locality; the trunk of spruce was checked again during four subsequent years (2000–2002, 2004), but no new basidiocarps emerged. That tree was large, partly decorticated, and it had fallen in a herb-rich slope with seeping water. The Russian find was collected from spruce, 16 cm thick at breast height. The tree trunk was still corticated (98%) but bark was about to detach. The site was a swampy spruce forest, shadowy, about 75 m from a brook, i.e. outside the proximity of running water, evidently an old fire refuge. Host trees were still fairly hard wood both in the type locality and the Russian find. – We have no further notes on the find from Pisavaara, could not confirm the host, and hence its identification remains somewhat uncertain; it was not included in making the description.

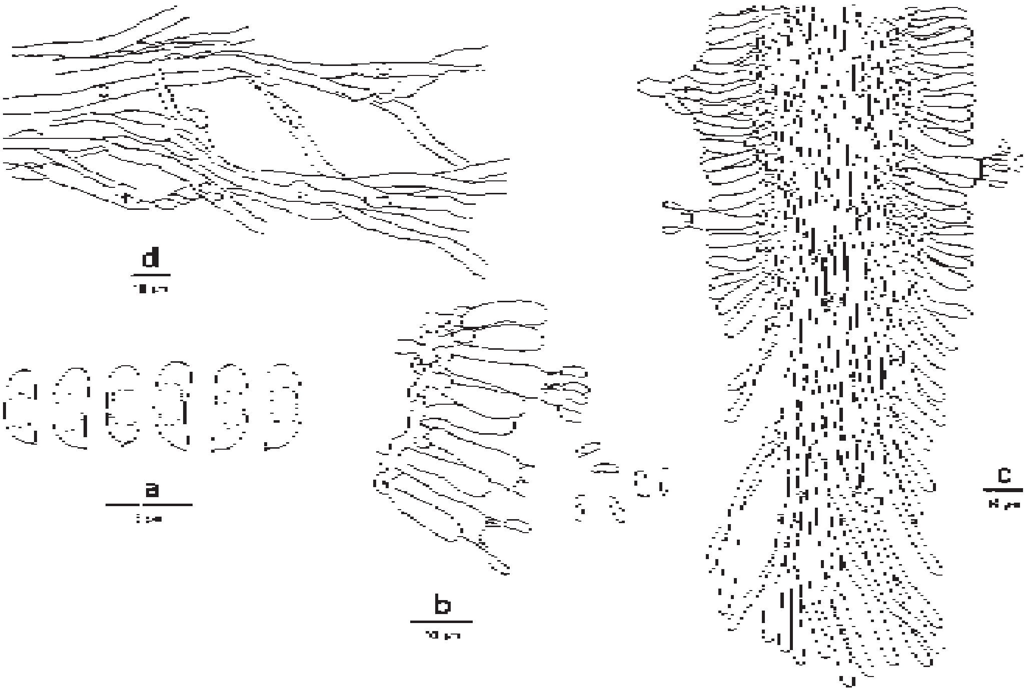

Fig. 6. *Postia persicina* Niemelä & Y.C. Dai, drawn in CB from holotype. a) Spores, b) basidia and basidioles, c) a section through dissepiment showing one hyphal peg arising from hymenium, d) the very thin-walled, often collapsed hyphae of the context, arranged in a spaced subparallel fashion.

### ***Postia luteocaesia*** (A. David) Jülich

*Spongiporus luteocaesius* A. David, Bull. Mens. Soc. Linnéenne Lyon 49:29, 1980.

Basidiocarps annual, pileate, semiorbicular or nodulose, 10–45 mm wide, 4–7 mm thick at base, soft when fresh, brittle when dry. Upper surface matt, a little rough (uneven), when young white with bright yellow outer border, when mature white all over, when old greyish at least at base, when dry sordid cream coloured. Edge entire, rounded and bright yellow in still-growing specimens, when mature sharp and white. Pore surface smooth, bright yellow (citric, vitelline or chrome yellow), bruised parts attaining vivid green tint within 1 hour; old specimens with greenish yellow underside; dried ones yellow, ochraceous yellow or greenish grey; pores round, (3–)4 per mm, in old basidiocarps merged together and then larger (1–2 per mm), pore mouths minutely serrate or lacerate. Section: context soft, white, opaque; tubes greenish at base and yellow close to orifices, when fresh oily- or watery-looking. Odour weak, agreeable; taste faintly sour.

Monomitic, hyphae with clamp connections and somewhat thickened walls, regular, IKI–, CB–; in context (3.1–)3.4–4.8(–5.2) µm in diam., with spaced interwoven texture and often attached in bundles of 5–10 hyphae; in trama (1.6–)2–3.2 (–3.4) µm, yellowish, interwoven (upper parts of tube trama) or subparallel (close to orifices); oil droplets common, small. No cystidia, no cystidioles. Spores cylindric and a little curved (allantoid), with slightly thickened wall which is pale grey in all media, looking like amyloid (in fact the greyish tint is natural of the spores), CB–, (4.5–)4.7–6.3(–6.5) × (1.5–)1.6–1.9(–2) µm, L=5.34 µm, W=1.73 µm, Q=3.03–3.15 (n=60/2).

*Specimens examined:* **Finland**. Etelä-Savo. Valkeala, Repovesi Nat. Park, S lakeside of Valkjärvi, *Pinus sylvestris*, 16.IX.2004 *Niemelä 7887, Kinnunen & Schigel*. **France**. Var. Ile de Port Cros, 10 m a.s.l., *Pinus halepensis*, 12.XII.1992 *Rivoire 733* (ex herb. P. Rivoire, det. A. David 1992).

This species was described from France by David (1980). Its affinity to the *Postia caesia* (Schrad.: Fr.) P. Karst. complex was shown already then, and the identity as a separate species was confirmed with mating tests. Mme David sent a colour photograph of a fresh specimen to the author TN, and our collection is strikingly similar. This species is known at least from France (David 1980, Ryvarden & Gilbertson 1993–1994), Switzerland (Jaquenoud 1984), and Nepal (Hjortstam & Ryvarden 1984). The French specimens were collected from pine (*Pinus halepensis*); the Nepalese one was growing on *Abies*.

The best specific characters are macroscopic. The bright yellow colour is not present in the other species of the *Postia caesia* complex. When the basidiocarps grow older, blue tones develop, characteristic of the complex, but mixing with yellow, they result in vivid moss-green in older tubes. Also bruised parts of young specimens attain green within an hour after collecting.

In the microscope *P. luteocaesia* is very similar to the other species of the *P. caesia* complex. Similarities are the monomitic structure with slightly thick-walled and regular hyphae, and very narrow, bluish-grey spores. Our measurements from French and Finnish specimens imply that David (1980) somewhat overestimated the thickness of the spores (“5–5.5–6 × 2 µm”); her measurements were probably made in KOH. Spore dimensions and ecology of *P. caesia* and *P. alni* Niemelä & Vampola were published by Niemelä et al. (2001). *Postia subcaesia* (A. David) Jülich is a thicker, almost white member of the complex (David 1980, Ryvarden & Gilbertson 1993–1994).

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# New names and combinations appearing in Karstenia 44 (1–2), 2004

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| *Hypocrea cordyceps* (Penz. & Sacc.) H. Chamb., comb. nov. | 5 |
| *Hypocrea daisenensis* (Yoshim. Doi & Uchiy.) H. Chamb., comb. nov. | 14 |
| *Hypocrea eperuae* (Rogerson & Samuels) H. Chamb., comb. nov. | 5 |
| *Hypocrea gigantea* (Imai) H. Chamb., comb. nov. | 6 |
| *Hypocrea leucopus* (P. Karst.) H. Chamb., comb. nov. | 16 |
| *Hypocrea nybergiana* T. Ulvinen & H. Chamb., spec. nov. | 21 |
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