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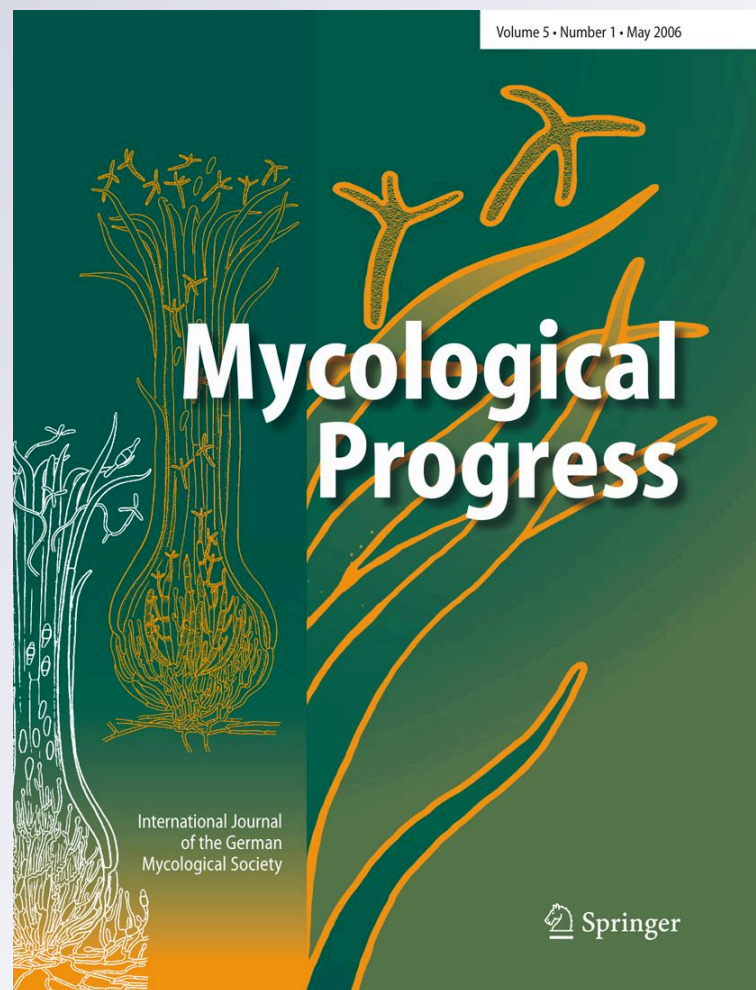
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Obba and *Sebipora*, new polypore genera related to *Cinereomyces* and *Gelatoporia* (Polyporales, Basidiomycota)

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Abstract *Cinereomyces* clade is a newly proposed monophyletic group of polypores containing currently four genera and five species, including two promising biopulping fungi, *Ceriporiopsis rivulosa* and *C. subvermispota*. The *Cinereomyces* clade is well-delimited in nrDNA-based phylogenetic analysis, but its position in Polyporales remains unclear. Its closest relative may be found in the core polyporoid clade. Only a few morphological characters are common for all the species in the clade, e.g. CB– and CRB+ hyphae, white fruiting bodies, presence of oil, and middle-sized spores. Culturally, the species are unified by producing simple-septate generative hyphae in the margin, which produce simple-clamped hyphae backwards. The genus *Gelatoporia* is the correct place for *Ceriporiopsis subvermispota*. Two new genera are described in the group: *Obba* to incorporate *C. rivulosa* and a new austral species, *Obba valdiviana*, known from southern Argentina and recorded here also from Tasmania, and *Sebipora* to accommodate a new species from tropical Asia, *S. aquosa*. ITS sequences imply that Eurasian *Gelatoporia subvermispota* may belong to a different species from the North American one. *G. subvermispota* is recorded as new to Indonesia.

Keywords *Ceriporiopsis rivulosa* · *Ceriporiopsis subvermispota* · *Diplomitoporus lindbladii* · Taxonomy · Biopulping

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Introduction

The generic position of the polypore *Ceriporiopsis rivulosa* (Gilbertson and Ryvarden 1986) has long been uncertain. Besides *Ceriporiopsis*, it has been placed in *Physisporinus* (Ryvarden 1984) and *Rigidoporus* (David 1971). Morphologically, it does not fit nicely in any of the above-mentioned genera in the strict sense. On the other hand, cultural and enzymatic characters have placed it in the vicinity of *Gelatoporia subvermispota* (= *Ceriporiopsis subvermispota*), another effused polypore species of uncertain generic affinity (David 1971; Hakala et al. 2005; Nakasone 1981; Rajchenberg 1995).

Interestingly, both species have shown promise for use in biopulping, a process where wood chips are treated with white-rot fungi prior to mechanical pulping in the paper industry (Akhtar et al. 2000; Fackler et al. 2007; Maijala et al. 2008). These fungi decompose lignin selectively when wood chips are pre-treated with them, reducing the need of energy in pulping and even improving paper quality. Consequently, their taxonomic positions are of interest to a wider audience than just taxonomists.

When Niemelä (1985) described the genus *Gelatoporia* based on morphological characters, he included two species in the genus: *G. subvermispota* and *G. pannocincta*. However, cultural characters and sexual behaviour do not support close affinity of these two species, and rather indicate affinity of *G. pannocincta* with *Gloeoporus dichrous* (David 1972).

DNA-sequence-based phylogenetic studies have confirmed the conclusions of cultural studies in this case: *Ceriporiopsis rivulosa* and *Gelatoporia subvermispota* are indeed closely related (Tomšovský et al. 2010). Also, *Gelatoporia pannocincta* and *Gloeoporus dichrous* are closely related to each other and belong to the *Byssomerulius*

family, phlebioid clade of Polyporales, but are not related to *Ceriporiopsis rivulosa* (Binder et al. 2005; Larsson 2007; Tomšovský et al. 2010; Wu et al. 2010; Miettinen & Larsson 2010).

Phylogenetic studies have further shown that *Cinereomyces lindbladii* (= *Diplomitoporus lindbladii*) is also related to *Gelatoporia subvermisporea* and *Ceriporiopsis rivulosa*. During our studies in the southern hemisphere, we have encountered two further taxa in this species group. Together, they form a well-supported monophyletic group, called *Cinereomyces* clade hereafter, but the position of this group inside Polyporales is uncertain. In their larger study, Binder et al. (2005) placed *Cinereomyces lindbladii* inside the core polyporoid clade, whereas in a more restricted taxon sampling, Miettinen and Larsson (2010) left it outside.

In this article, we study the generic arrangements inside the *Cinereomyces* clade using nrDNA sequences and morphological methods, and the phylogenetic position of the *Cinereomyces* clade in Polyporales.

Materials and methods

We chose reference taxa for our phylogenetic analysis based on Binder et al. (2005), Dai et al. (2006), Matheny et al. (2007), Larsson (2007), Larsson et al. (2004), Lindner and Banik (2008), Robledo et al. (2009), Sotome et al. (2008), and through searches in GenBank. A total of 25 new nrDNA sequences were produced for this study (Table 1), while reference sequences of 79 specimens were obtained from GenBank (Tables 1 and 2). In addition to herbarium specimens, strains from University of Helsinki affiliated Fungal Biotechnology Culture Collection (FBCC) were utilised. Reference sequences were sampled from Polyporales with the aim of providing representatives from all major clades within the order (sensu Binder et al. 2005; Larsson et al. 2004; Larsson 2007). Certain divergent groups of brown-rot fungi, which often cause problems in nrDNA 28S-based phylogenetic analysis (*Fibroporia*, *Laetiporus*, *Pycnoporellus*, *Sparassis*, *Taiwanofungus*, *Wolfiporia*), were included in the analysis in the initial stages, but excluded later on. Their inclusion in the analysis did not affect the core results of this study, nor are they closely related to the *Cinereomyces* clade.

Specimens used for this study are listed below. DNA of specimens marked with an asterisk (*) has been utilised in this study. Herbarium abbreviations follow Index Herbariorum standard, except for CIEFAP, which stands for the fungal herbarium of Centro de Investigación y Extensión Forestal Andino Patagónico, Argentina.

Specimens studied

Atraporrella neotropica Ryvarden. **Belize**. Cayo, 20. XI.2001 Ryvarden 44447 (O*, holotype).

Ceriporiopsis gilvescens (Bres.) Domański. **Czech Republic**. Central Bohemia, Sázava 21.IX.1991 Niemelä 5516 (H*). **Poland**. Małopolska, Kraków county, 1.IV.2009 Niemelä 8550 (H).

Cinereomyces lindbladii (Berk.) Jülich. **Finland**. Uusimaa, Inkoo, 24.V.2003 Kotiranta 19911 (H*). Pohjois-Karjala, Ilomantsi, 28.8.1996 Oivanen s.n. (FBCC 117*).

Dichomitus squalens (P. Karst.) D.A. Reid. **Russia**. Ryazan, Spassky, 16.VIII.2006 Zmitrovich s.n. (H*).

Gelatoporia subvermisporea (Pilát) Niemelä. **China**. Heilongjiang, Yichun, on *Picea*, 7.VII.1999 Y.C. Dai 3120 (H*). **Indonesia**. Jambi, Kerinci, 900–1,100 m asl, mountain rainforest, on *Pinus merkusii*, 29.VII.2004 Miettinen 9079 (ANDA, H*). **Finland**. Kittilän Lappi, Kittilä, on *Picea*, 24.VIII.2000 Kinnunen 1052 (H*). **Poland**. Podlesie, Hajnówka, Białowieża, on *Carpinus*, 19.V.1996 Niemelä 5978 (H*). **Russia**. Nizhny Novgorod, Sharanga, on *Populus*, Spirin 2156 (H*). Perm, Kvarkush, on *Picea*, 6.VIII.2005 Kotiranta 20823 (H*).

Obba rivulosa (Berk. & M.A. Curtis) Miettinen & Rajchenb. **Argentina**. Salta, Baritú National Park, 1190 m asl, 22°26'10.8"S, 64°43'40.2"W, 9.V.2007 G. Robledo 1473 (CORD). **Cuba** (see type). **Finland**. Uusimaa, Helsinki, 18. IX.1998 Kotiranta 16702 (H*). Etelä-Häme, Lammi, 14. X.1998 T. Hakala s.n. (strain FBCC 938* alias T241i), 14.-16.X.2003 Miettinen 8054 (H*). Etelä-Häme, Tammela, 21. X.2003 Penttilä 15077 (H*). Pohjois-Karjala, Ilomantsi, 7. IX.2003 Penttilä 14441 (H6002108*). Pohjois-Karjala, Lieksa, 3.-4.IX.2003 Penttilä 14135 & Oinonen PTO8 (H*). **USA**. Oregon, Lincoln county, 3.X.1973 Larsen s.n. (H, ex FP133696).

Obba valdiviana (Rajchenb.) Miettinen & Rajchenb. **Argentina**. Chubut, Los Alerces National Park, Lake Menéndez, Alerzal, 15.III.1993 Rajchenberg 10736 (BAFC 33238 holotype, CIEFAP isotype, strain Rajchenberg 159*), Ibid., 3.V.2010 Rajchenberg 12292 (CIEFAP). Río Negro, Nahuel Huapi National Park, Puerto Blest, pathway to Los Cántaros, 9.X.1995 Rajchenberg 11043 (CIEFAP*). **Chile**. Osorno, Puyehue National Park, Las Termas, 450 m asl, 15.IV.1988 Rajchenberg 4157 (BAFC 31280). Los Ríos, Futrono commune, ca. Lake Maihue, forest of *Aetoxicon punctatum*, *Laureliopsis philippiana*, *Nothofagus obliqua*, *Eucryphia cordifolia*, 3.II.2010 P. Sandoval G53 (SGO). **Australia**. Tasmania, Dalco Creek, 43°23'S, 147°01'E, on *Eucalyptus*, 15. III.2009 G. Gates FF503 (HO 557493*). Tasmania, Liffey Falls, 41°42'S, 146°46'E, on *Eucalyptus*, 7. III.2009 G. Gates FF484 (HO 557492, strain CIEFAP 336*).

Table 1 List of sequenced specimens in *Cinereomyces* clade used in this study, and other newly sequenced specimens

Taxon	Herbarium specimen	Culture	Origin	ITS/5.8S	LSU
<i>Atraporrella neotropica</i>	*Holotype		Belize	HQ659221	HQ659221
<i>Ceriporiopsis gilvescens</i>	*Niemelä 5516		Czech Rep.	HQ659222	HQ659222
<i>Cinereomyces lindbladii</i> FI	Kotiranta 19911		Finland	FN907909	FN907909
<i>C. lindbladii</i> FI 2		*FBCC 117	Finland	HQ659223	
<i>C. lindbladii</i> KEW		KEW 212			AF518615
<i>C. lindbladii</i> NO	KH Larsson 12078		Norway	FN907906	FN907906
<i>Dichomitus squalens</i>	*Zmitrovich s.n.		Russia	HQ659224	HQ659224
<i>Gelatoporia subvermispora</i> CN	*Dai 3120		China	HQ659226	
<i>G. subvermispora</i> CZ	BRNU 592909		Czech Rep.	FJ496694	FJ496706
<i>G. subvermispora</i> FI	*Kinnunen 1052		Finland	HQ659225	
<i>G. subvermispora</i> ID	*Miettinen 9079		Indonesia	HQ659229	
<i>G. subvermispora</i> PL	*Niemelä 5978		Poland	HQ659227	
<i>G. subvermispora</i> RU	Kotiranta 20823		Russia	FN907911	FN907911
<i>G. subvermispora</i> RU 2	*Spirin 2156		Russia	HQ659228	
<i>G. subvermispora</i> US		KCTC 6891 (=CBS 347.63)	USA, CO	FJ496695	FJ496707
<i>G. subvermispora</i> US 2		CBS 347.63 (=KTCT 6891)	USA, CO	FJ349621	
<i>G. subvermispora</i> US 3		ATCC 90467 (=FP 90031)	USA, MD	FJ545252	
<i>G. subvermispora</i> US 4		FP 90031 (=ATCC 90467)	USA, MD	FJ713106	
<i>G. subvermispora</i> WS1		WS1	AY089736		
<i>Obba rivulosa</i> CA		KCTC 6892 (=CBS 434.48)	Canada	FJ496693	FJ496710
<i>O. rivulosa</i> CBS 433.48		CBS 433.48		FJ496692	
<i>O. rivulosa</i> FI	*Miettinen 8054		Finland	HQ659231	HQ659231
<i>O. rivulosa</i> FI 2		*FBCC 938	Finland	HQ659233	
<i>O. rivulosa</i> FI 3	*Kotiranta 16702		Finland	HQ659232	
<i>O. rivulosa</i> FI 4	*Penttilä 14135		Finland	HQ659234	
<i>O. rivulosa</i> FI 5	Penttilä 14441		Finland	FJ496691	
<i>O. rivulosa</i> FI 6	*Penttilä 15077		Finland	HQ659230	
<i>O. rivulosa</i> US		JLL 10602	USA, CA	AY219363	
<i>Obba valdiviana</i> AR 1	isotype	*CIEFAP 159	Argentina	HQ659237	
<i>O. valdiviana</i> AR 2	*Rajchenberg 11043		Argentina	HQ659238	
<i>O. valdiviana</i> AU 1	*Gates FF503		Australia	HQ659235	HQ659235
<i>O. valdiviana</i> AU 2		*CIEFAP 336	Australia	HQ659236	HQ659236
<i>Piloporia sajanensis</i>	*Manninen 2733a		Finland	HQ659239	HQ659239
<i>Sebipora aquosa</i>	*Miettinen 8680.1		Indonesia	HQ659240	HQ659240
<i>S. aquosa</i> 2	*holotype		Indonesia	HQ659242	
<i>S. aquosa</i> 3	*Miettinen 9265.1		Indonesia	HQ659243	
<i>S. aquosa</i> 4	*Miettinen 12032		Indonesia	HQ659241	
<i>Tyromyces chioneus</i>	*Miettinen 7487		Finland	HQ659244	HQ659244

Specimens marked with an asterisk (*) have been sequenced for this study. Two-letter codes after species names denote country of origin (ISO 3166)

Piloporia sajanensis (Parmasto) Niemelä. **Finland.** Inarin Lappi, Inari, 15.VI.2006 Manninen 2733a (H*).

Tyromyces chioneus (Fr.) P. Karst. **Finland.** Etelä-Häme, Lammi, 3.IX.2003 Miettinen 7487 (H*).

Sebipora aquosa Miettinen. **Indonesia.** Riau, Rokan Hilir (see holotype*). Riau, Pekanbaru, open yard on a burned log, 1.XII.2007 Miettinen 12032 (ANDA, H*).

Riau, Indragiri Hulu, Bukit Aluran Babi, 0°50.402'S, 102°14.006'E, secondary half-open rainforest, on a log (60 cm in diameter, decay stage 3/5), 28.VI.2004 Miettinen 8680.1 (ANDA, H*). Papua, Teluk Wondama, Werianggi N, 2°27.168'S, 134°9,100'E, small opening in a primary forest, on a log (25 cm in diameter, decay stage 4/5), 6. IX.2004 Miettinen 9265.1 (MAN, H*).

Table 2 List of taxa and nrDNA sequences retrieved from GenBank with accession numbers

Taxon	ITS/5.8S	LSU
<i>Abundisporus sclerosetosus</i>	FJ411101	FJ393868
<i>Amaurodon viridis</i>	AM490942	AM490942
<i>Amylocystis lapponica</i>	EU118603	EU118603
<i>Antrodia albida</i>	DQ491414	AY515348
<i>Antrodia pallens</i>	FN907921	FN907921
<i>Bjerkandera adusta</i>	DQ060097	AF287848
<i>Boletopsis leucomelaena</i>	DQ484064	DQ154112
<i>Byssomerulius corium</i>	AY463389	AY586640
<i>Ceraceomyces violascens</i>	EU118611	EU118612
<i>Ceriporia viridans</i>	AF347109	AF347109
<i>Ceriporiopsis aneirina</i>	EU340895	EU368503
<i>Cerrena unicolor</i>	FN907915	FN907915
<i>Coriolopsis caperata</i>	AB158316	AB158316
<i>Coriolopsis gallica</i>	AY684172	AY855913
<i>Cryptoporus volvatus</i>		AY858356
<i>Dacryobolus karstenii</i>	EU118624	EU118624
<i>Dentocorticium sulphurellum</i>		AF261539
<i>Diplomitoporus crustulinus</i>	FN907907	FN907907
<i>Diplomitoporus overholtsii</i>		AY333813
<i>Donkioporia expansa</i>	FJ411104	FJ393872
<i>Earliella scabrosa</i>		AY333812
<i>Epithele typhae</i>	DQ486701	DQ457665
<i>Fomes fomentarius</i>		AF311047
<i>Ganoderma adpersum</i>	AM269771	AM269829
<i>Gloeoporus dichrous</i>	EU118627	EU118627
<i>Gloeoporus pannocinctus</i>	AF141612	AF141612
<i>Grammothele fuligo</i>		AJ406506
<i>Grifola frondosa</i>	AY218415	AY218413
<i>Grifola sordulenta</i>	AY854085	AY645050
<i>Hyphoderma definitum</i>	DQ677493	DQ677493
<i>Hyphoderma setigerum</i>	FN907905	FN907905
<i>Hyphoderma transiens</i>	DQ677504	DQ677504
<i>Hyphodermella corrugata</i>	EU118630	EU118630
<i>Hypochnicium polonense</i>	EU118635	EU118635
<i>Ischnoderma benzoinum</i>		AJ406543
<i>Lentinus tigrinus</i>	AY218419	AF518627
<i>Lenzites betulinus</i>	AY463436	AY586683
<i>Lopharia cinerascens</i>	AY463440	AY586687
<i>Megasporoporia cavernulosa</i>		AY351933
<i>Meruliopsis taxicola</i>	EU118648	EU118648
<i>Merulius tremellosus</i>	AF141632	AF141632
<i>Microporellus</i> sp.	FJ411106	FJ393874
<i>Microporus xanthopus</i>		AY333799
<i>Phanerochaete sordida</i>	EU118653	EU118653
<i>Perenniporia fraxinea</i>	FJ411094	FJ393861
<i>Perenniporia medulla-panis</i>	FJ411087	FJ393875
<i>Perenniporia martius</i>	FJ411092	FJ393859
<i>Perenniporia ochroleuca</i>	FJ411097	FJ393864

Table 2 (continued)

Taxon	ITS/5.8S	LSU
<i>Perenniporia subacida</i>	FJ411103	FJ393880
<i>Perenniporiella chaquenia</i>	FJ411085	FJ393857
<i>Polyporus alveolaris</i>	AB070828	AJ487937
<i>Polyporus brumalis</i>	AF347108	AF347108
<i>Polyporus dictyopus</i>	AF516561	AJ487945
<i>Polyporus tuberaster</i>	AF516596	AJ488116
<i>Postia guttulata</i>	EU118650	EU118650
<i>Pycnoporus cinnabarinus</i>	AY463457	AY586703
<i>Pyrofomes demidoffii</i>	FJ411105	FJ393873
<i>Scopuloides hydroides</i>	EU118665	EU118665
<i>Skeletocutis amorphia</i>	FN907913	FN907913
<i>Skeletocutis chrysella</i>	FN907916	FN907916
<i>Skeletocutis jelicii</i>	FJ496690	FJ496727
<i>Steccherinum ochraceum</i>	EU118669	EU118670
<i>Trametes elegans</i>	FJ372692	FJ372714
<i>Trametes hirsuta</i>	AB158313	AB158313
<i>Trametes ochracea</i>	AY684177	AY855908
<i>Vuilleminia comedens</i>	AY463482	AY586725

DNA and phylogenetic methods

DNA was extracted from herbarium specimens or cultures. DNeasy plant mini kit (Qiagen, Hilden) was used for DNA extraction, following the manufacturer's recommendations. For part of the specimens, standard CTAB-chloroform extraction was used. PCR reactions were carried out using Ready-To-Go PCR beads (Amersham Pharmacia Biotech, Uppsala) or Phusion High-Fidelity DNA Polymerase (Finnzymes). Primers used to amplify ITS region were ITS1F, ITS1, ITS4, ITS4B and LR21 (depending on the specimen), and for partial LSU region LR0R and LR7 (Gardes and Bruns 1993; Hopple and Vilgalys 1999; White et al. 1990). Amplified products were purified using Qiaquick spin columns (Qiagen) or GeneClean Turbo kit (Qbiogene). Primers used for ITS sequencing were ITS1, ITS4 and LR22, and for LSU CTB6, LR5, LR3R, and LR7 (White et al. 1990, Hopple and Vilgalys 1999, <http://www.aftol.org>, <http://plantbio.berkeley.edu/bruns>). Sequencing was done by Macrogen (Korea). Sequences were edited and assembled using ChromasPro 1.42 (Technelysium).

The gene regions in the phylogenetic analysis were nrDNA ITS and partial 28S. Limits of ITS1, 5.8S, and ITS2 were determined with ITS extractor (Nilsson et al. 2010). Sequences were aligned using MAFFT 6.708 with strategy G-INS-i (Katoh et al. 2005; Katoh and Toh 2008) and adjusted manually using PhyDE 0.995 (Müller et al. 2008). Out of 78 LSU-sequenced specimens, 5 lacked 5.8S, and another 13 had significantly (>100 bp) shorter

LSU than others. The part of ITS-LSU region used in tree building comprised of about 970 bp of LSU from the start, ca. 80 bp of ITS1 and ca. 70 bp of ITS2. After removing unalignable regions, 1,277 characters remained, of which 436 were variable and 325 parsimony informative. In ITS analysis, the aligned dataset of 30 sequences contained 574 characters, of which 103 were variable and 93 parsimony informative. Genetic distances between ITS sequences were calculated from the manual alignment.

Parsimony analyses were executed in PAUP 4.0b10 (Sinauer Associates, David Swofford) under Windows XP. All transformations were considered unordered and equally weighted. Gaps were treated as missing data. Branches were collapsed if zero length was possible (pset collapse=minbrlen). Heuristic searches used a thousand random taxon addition replicates and tree bisection–reconnection (TBR) branch swapping with other options using the program's default settings. Topology was constrained so that *Amaurodon viridis* (outgroup), *Boletopsis leucomelaena* and *Vuilleminia comedens* were forced together. Relative robustness of clades was estimated through BS analysis using PAUP. Settings used were 1,000 BS replicates with 10 random addition sequences per replicate, TBR branch swapping, and otherwise default settings. For a Bayesian inference of phylogeny, a Bayesian inference run was done with MrBayes 3.1.2 (Ronquist and Huelsenbeck 2003) using eight chains and three runs in parallel, partition to 5.8S and 28S, GTR+I+G substitution model in both partitions, and temp=0.092. Topology was constrained as in parsimony analysis. The analysis was run for 30 million generations, sampling every 3,000 generations. Burnin was set to 2,500 trees. Otherwise default settings were used. ITS analysis used similar settings but without constraints and partitions, was run for 2 million generations sampling every 1,000 generations, and burn-in set to 500 trees. Both analysis were done running eight processors in parallel in CSC—IT Center for Science (<http://csc.fi>).

Morphology

During microscopic studies, the mountant media used were Cotton Blue (CB), Melzer's reagent (IKI), 5% KOH, and Cresyl Blue (CRB, Merck 1280). Measurements and drawings were made in CB. Entry CB+ means cyanophily, CB− acyanophily, and IKI− means neither amyloid nor dextrinoid reaction. Cresyl Blue reaction terms follow Torti c (1976): strong lilac reaction of hyphae, i.e. metachromatic reaction, is marked CRB+; blue reaction (orthochromatic) CRB−. For further references on the use of CB in Aphyllphorales, the reader is referred to Kotlaba and Pouzar (1964), J lich (1974), and Niemel  (2005).

Measurements were done using $\times 1,000$ magnification and phase contrast illumination (see Miettinen et al. 2006

for further detail). Pores were measured by subjectively choosing as straight line of pores as possible and measuring how many fit per mm. Sketches were vectorised in CorelDRAW X3. Terms on nuclear behaviour follow Boidin (1971).

Results

In Bayesian analysis of both the ITS and ITS+LSU datasets, the separate runs converged well (average SD of split frequencies constantly <0.01). In the case of the ITS dataset, parsimony analysis produced identical trees with Bayesian analysis with similar bootstrap support values. Also, the strict consensus parsimony tree of the ITS+LSU dataset supported all the results discussed below, though partly with low bootstrap support, differing from the Bayesian results only in some deeper nodes irrelevant to this paper. Only the results of Bayesian analysis are shown here.

The *Cinereomyces* clade is very well supported both in Bayesian and parsimony analysis, sitting on a long branch in the phylogram (Fig. 1). However, the position of the *Cinereomyces* clade within Polyporales remains unclear: it does not group either with *Tyromyces* clade (as suggested by Miettinen and Larsson 2010), nor with core polyporoid clade (Binder et al. 2005). This is consistent with results of Tomšovsk y et al. (2010). Though results are far from conclusive, a closer relationship with the core polyporoid clade seems more likely.

Within *Cinereomyces* clade, nrDNA analysis (Fig. 1) as well as ITS-based analysis (Fig. 2), show four separate, well-delimited groups (7–12% ITS difference between the groups, 0–4% within). This leaves open two kinds of taxonomic solutions inside the clade: whether to lump everything in one genus (*Cinereomyces*) or place the species in four different genera. Lumping would result in a morphologically very heterogenous genus, since *Cinereomyces lindbladii* is dimittic and the rest monomittic, since spore and basidium shapes show large variation (Figs. 3 and 4), and as sexual characters between the genera vary considerably (Table 3). Such a genus would be in practice unusable since it cannot be properly characterised. Thus, we describe below two new genera: *Obba* to accommodate *Ceriporiopsis rivulosa* and *Ceriporiopsis rivulosa* var. *valdiviana*, and *Sebipora* for an Indonesian, undescribed species. This solution leaves *Cinereomyces* and *Gelatoporia* as monotypic genera for the time being.

ITS sequences of *Gelatoporia subvermisporea* indicate that North American ($n=3$) and Eurasian material ($n=7$) might not belong to the same species. ITS sequence differences between continents are small, occurring in six nucleotide bases only (1.1%). However, within-continent

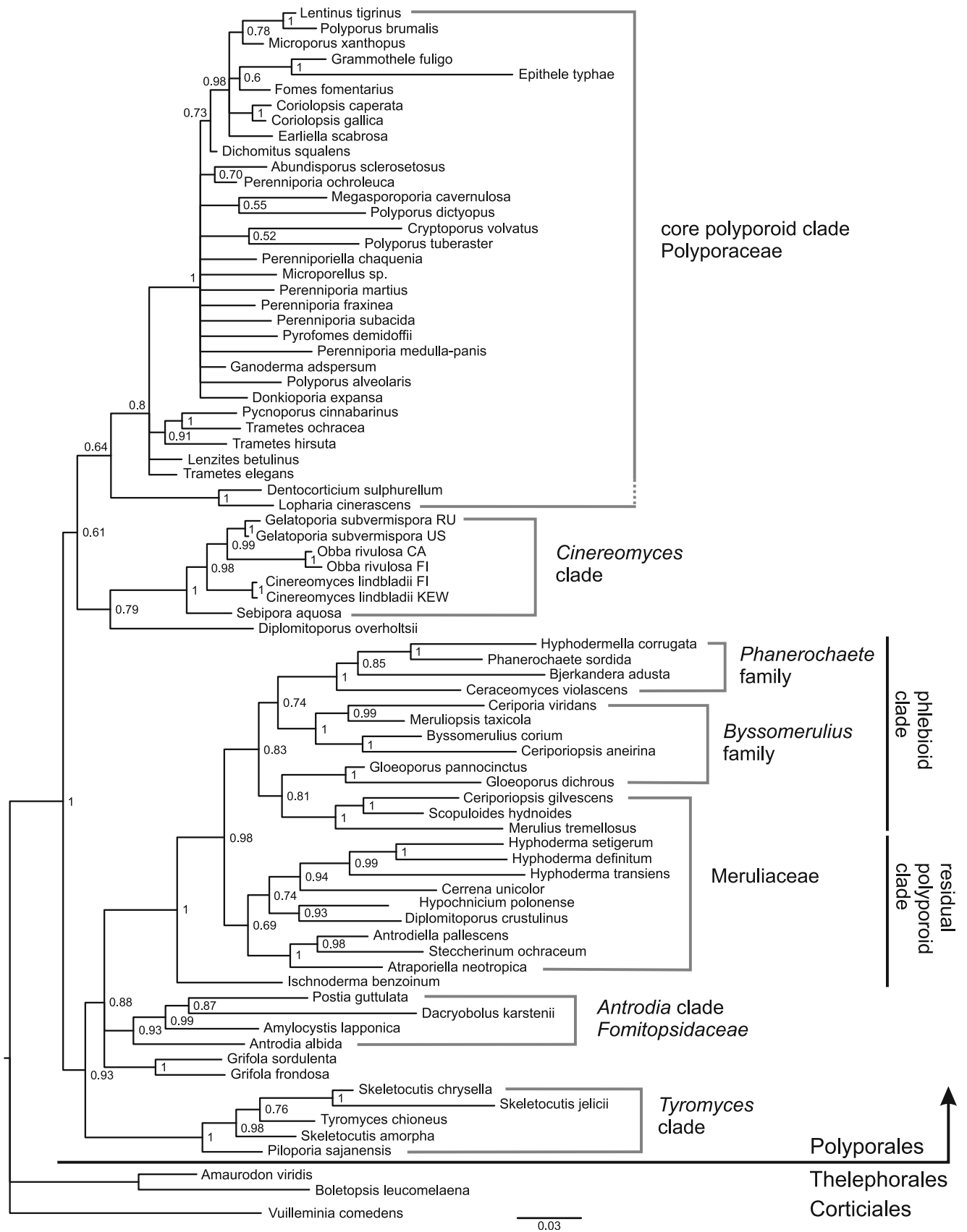
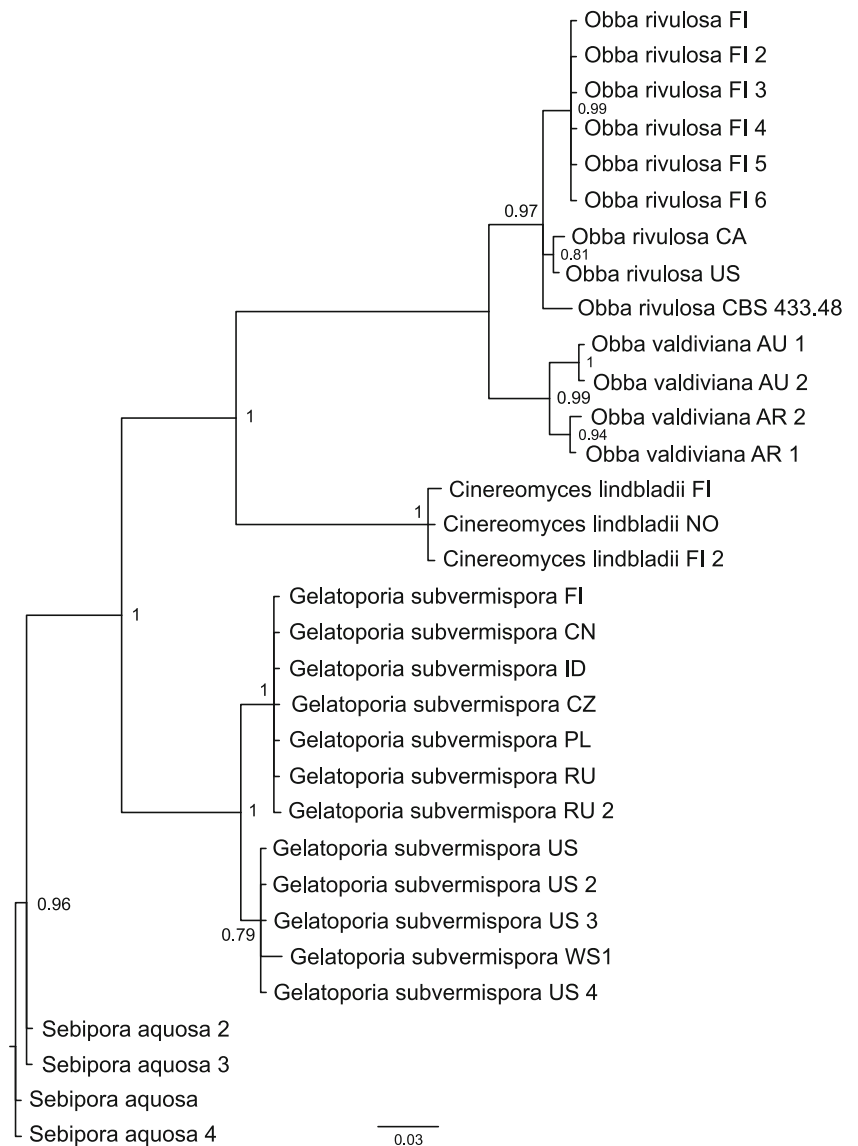


Fig. 1 Consensus phylogram of the 22,503 trees retained in the Bayesian analysis of nrDNA ITS and LSU. Numbers represent Bayesian posterior probabilities. Branch lengths reflect expected changes per site as indicated by the scale. Clade names follow Binder et al. (2005), family names Larsson (2007), and order names Hibbett et al. (2007)

sequences are homogenous in those sites, but consistently different between the two continents. At the very least, it appears that there is a geographic structure within the species, which should be taken into account when strains of *G. subvermispora* are utilised in biotechnological studies. So far, the strains used in biopulping studies derive from North America (e.g. FP-90031, CZ-3, ATCC 90467; Akhtar et al. 1992; Amirta et al. 2006; Atik et al. 2006; Galkin et al. 1998; Harreither et al. 2007). *Gelatoporia subvermispora* has been described from North America, so it is the Eurasian species that would require a new name in case there are two species involved instead of one.

Fig. 2 *Cinereomyces* clade consensus phylogram of the 4,503 trees retained in the Bayesian analysis of nrDNA ITS region. Numbers represent Bayesian posterior probabilities. Branch lengths reflect expected changes per site as indicated by the scale



Similarly in the available sequences of *Obba rivulosa*, the North American material ($n=3$) differs consistently from Finnish material ($n=6$) in four bases. The sample and difference are too small for taxonomic conclusions, but this is an indication that North American and North European population may have diverged.

Discussion

Position of *Cinereomyces* clade

In their wide sampling of homobasidiomycetes, Binder et al. (2005) used a considerably larger dataset of nuclear rDNA than here, and also utilised mitochondrial rDNA. In that analysis, *Dentocorticium sulphurellum* formed a monophyletic group with the core polyporoid clade, with

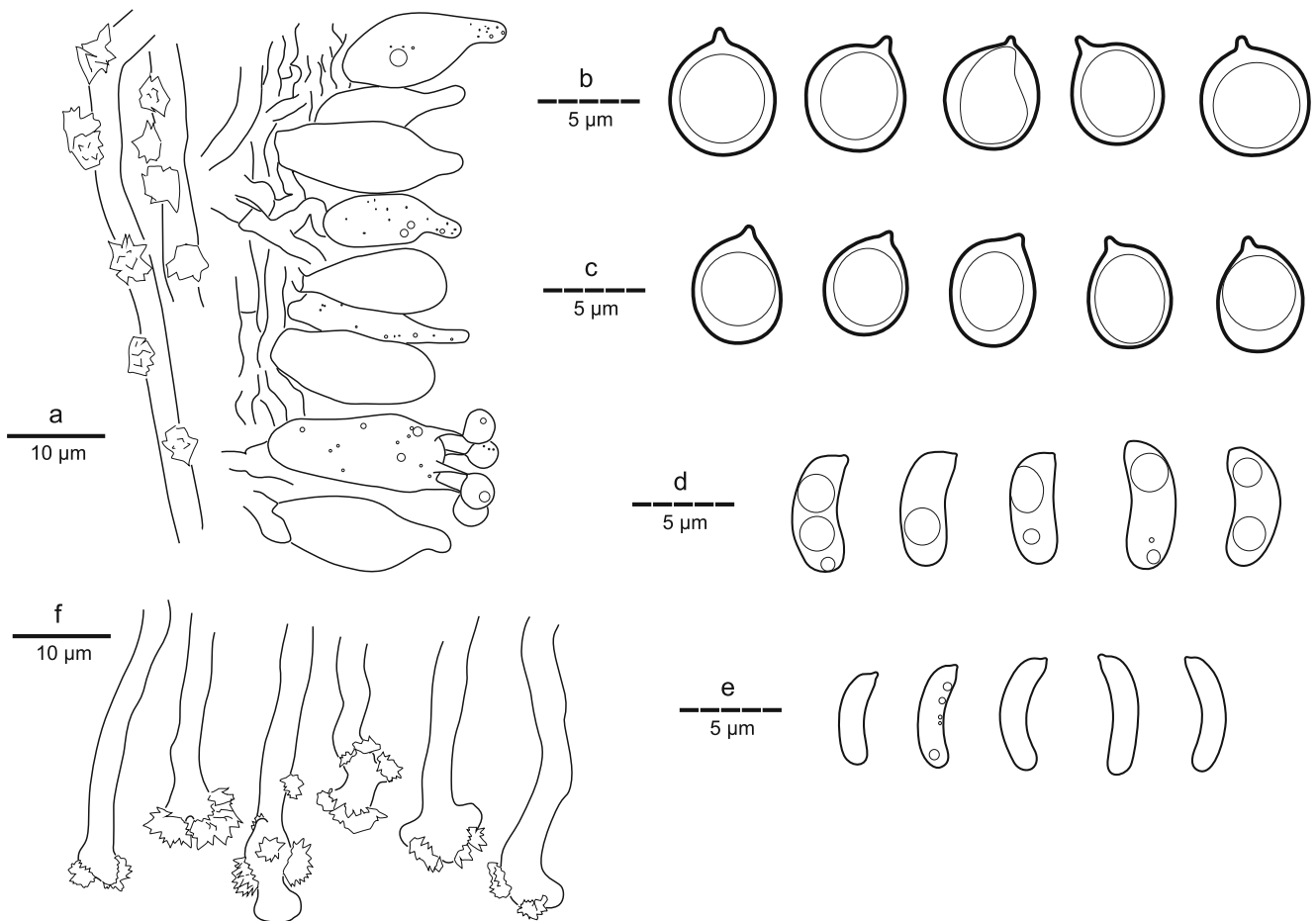


Fig. 3 *Obba valdiviana*, isotype: **a** hymenial cells and tramal crystals, **b** spores. *Obba rivulosa*, Miettinen 8054: **c** spores. *Cinereomyces lindbladii*, Kotiranta 19911: **d** spores. *Gelatoporia subvermispora*, Kotiranta 20823: **e** spores, **f** encrusted hyphal ends in lower trama

a 95% bootstrap support. Their full dataset analysis, where most taxa were represented by sequence data comparable with this study, further grouped *Cinereomyces lindbladii* with *D. sulphurellum* and the core polyporoid clade, albeit with no bootstrap support. The placement of *D. sulphurellum* inside the core polyporoid clade also receives support from Wang et al. (2004), utilising nrDNA and rpb2, and Tomšovský et al. (2010), using nrDNA LSU and mt-rDNA SSU. Wang et al. did not include members of *Cinereomyces* clade in their analysis, but Tomšovský et al. (2010) did, and as in our analysis, *Cinereomyces* clade formed a monophyletic group neither with the core polyporoid clade nor with *D. sulphurellum*.

In all these analyses, *Cinereomyces* clade nests within the same part of the tree with the core polyporoid clade and *Tyromyces* clade, even though their mutual positions are unresolved. It appears that nrDNA ITS and LSU alone are insufficient to solve deep nodes properly in Polyporales. A multi-gene study with wide taxon sampling of Polyporales would be needed to resolve those deeper nodes. For the time being we consider *Cinereomyces* clade as a separate entity from the core polyporoid clade Polyporales.

Characters of *Cinereomyces* clade

Species in the *Cinereomyces* clade share a number of characters: resupinate pale-coloured and poroid fruiting bodies, encrustation in trama or tube mouths, medium-sized spores, hyaline or shiny oily substance in trama, CRB+ but CB– hyphae, and cultural characters. In addition, all species except *Sebipora aquosa* have hyphal walls swelling in KOH, all species except *Cinereomyces lindbladii* have partly agglutinated hyphae, and all species have one or two prominent oil drops inside spores except *Gelatoporia subvermispora*. These morphological characters are shared by many polypores, with the possible exception of cultural characters, and fail to differentiate *Cinereomyces* clade as a group apart from other polypore genera. Table 3 compares the main characters of the genera in this group.

Ecologically, the species in this clade are white-rot causing saprotrophs growing in coarse woody debris. Notably, all the species with the exception of *Obba valdiviana* have frequently been found on burned wood, though none are restricted to it.

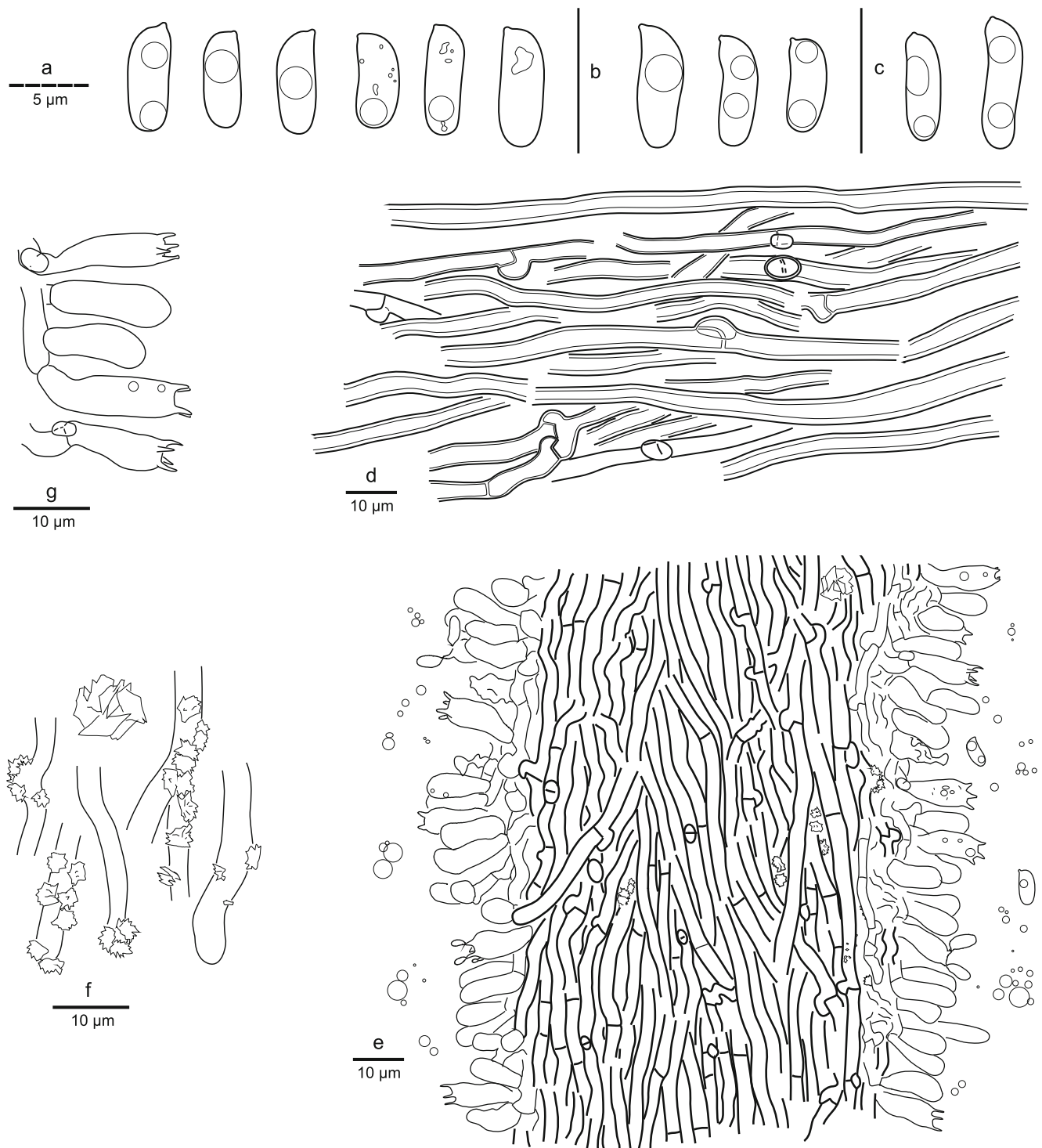


Fig. 4 *Sebipora aquosa*. Spores from **a** holotype, **b** Miettinen 8680.1 and **c** Miettinen 9265.1. Holotype, **d** context, **e** trama, **f** tramal encrustation and **g** hymenial cells

Cultures of *Cinereomyces lindbladii*, *Gelatoporia subvermispora*, *Obba rivulosa* and *O. valdiviana* pertain to group 54 of Nobles' (1958) classification. Group 54 is characterised by taxa that produce in culture broad, simple-septate marginal hyphae, which give rise to narrower,

simple-clamped hyphae that dominate backwards and throughout the mature mycelium. Cultures also give positive extracellular oxidases reactions, grow rapidly (i.e. dishes covered in 1–2 weeks), their simple-septate hyphae become thickened and appear gelatinous, and the mycelium

Table 3 Comparison of genera in *Cinereomyces* clade

	<i>Cinereomyces</i>	<i>Gelatoporia</i>	<i>Obba</i>	<i>Sebipora</i>
Mating system	Tetrapolar	Bipolar	Bipolar (and tetrapolar?)	NA
Nuclear behaviour	Astatocoenocytic	NA	Astatocoenocytic	NA
Annual/perennial	Short-lived perennial	Annual	Annual to biennial	Annual
Hyphal system	Dimitic	Monomitic	Monomitic	Monomitic
Spore shape	Broad allantoid	Allantoid	Subglobose - broadly ellipsoid	Cylindrical
Spore wall	Thin	Thin	Slightly thick-walled	Thin
Cystidioles	Poorly differentiated	Poorly differentiated	Characteristic	Absent
Tramal crystals	Irregular, if present mostly large plates	Fine encrustation, large plates	Rosettes, plates	Fine encrustation, large plates
KOH reaction	Skeletal hyphae swell and slowly dissolve	Hyphal walls swell inwards and gelatinise	Hyphal walls swell inwards and gelatinise	KOH- though walls slightly thicker than in CB, IKI
Distribution	Temperate-boreal, northern hemisphere	Temperate-boreal, northern hemisphere	Temperate-subtropical, northern and southern hemisphere	Tropical Asia

NA Not available

forms chlamydospores and/or conidia. Nobles' group 54 also included other corticioid and poroid species from the unrelated genera *Aurantiporus*, *Byssomerulius*, *Hapalopilus*, *Ischnoderma*, and *Phlebia*. All taxa that Nobles studied had a bipolar mating system and astatocoenocytic nuclear behaviour with the exception of *Hapalopilus salmonicolor*, which is tetrapolar and heterocytic.

Nakasone (1981) pointed out that cultures of *Obba rivulosa*, *Cinereomyces lindbladii* and *Gelatoporia subvermisporea* are nearly indistinguishable. For instance, they all produce unique, slender "binding hyphae" in the aerial mat. The species differ in their optimum growth temperature, growth at 40°C, and ability to grow on cabbage extract agar.

Considerable interest has been shown on the biopulping abilities of *Gelatoporia subvermisporea* and *Obba rivulosa*. We suggest that other species in the clade might show potential for that purpose, since besides being closely related they also share very similar cultural characters and are aggressive white-rotters in the nature.

TAXONOMY

Cinereomyces Jülich

Bibliotheca Mycologica 85: 400, 1981

Type species: *Cinereomyces lindbladii* (Berk.) Jülich

The type species has formerly been included in *Diplomitoporus*. Spirin (2005) included *Skeletocutis lenis* and *S. vulgaris* in *Cinereomyces*, but Miettinen and Larsson (2010) showed them to belong to a new genus in Hymenochaetales, *Sidera*, and concluded that *Ciner-*

omyces should be considered monotypic, i.e. containing only *C. lindbladii*. They also provided a comparison of *Cinereomyces* to *Diplomitoporus*, accompanied with drawings of skeletal hyphae and spores. For cultural characters, Nobles (1958, 1965), Stalpers (1978), Nakasone (1981), and David (1982) provide further detail.

Cinereomyces has acyanophilous (CB-) and metachromatic (strongly lilac, CRB+) hyphae. In *Diplomitoporus flavescens*, the type species of *Diplomitoporus*, hyphae are orthochromatic (dark blue, CRB-) and cyanophilous (CB+). *Sidera lenis*, in turn, has less strongly but clearly lilac hyphae in CRB; the hyphae are also acyanophilous.

Gelatoporia Niemelä

Karstenia 25: 22, 1985

Type species: *Gelatoporia subvermisporea* (Pilát) Niemelä

Niemelä (1985) gives a detailed description of the type species accompanied with a drawing. For cultural characters, see Nobles (1958, 1965), Nakasone (1981), and Stalpers (1978). We consider this genus currently monotypic. *Gloeoporus pannocinctus* (Romell) J. Erikss., which had been included in *Gelatoporia*, differs from the type species *G. subvermisporea* by presenting tetrapolar sexuality and heterocytic nuclear behaviour (David 1972) as opposed to bipolar sexuality (nuclear behaviour unknown). Phylogenetic analysis place it close to *Gloeoporus dichrous* (Fr.) Bres. in the *Byssomerulius* family, phlebioid clade (Binder et al. 2005; Miettinen and Larsson 2010; Tomšovský et al. 2010; Wu et al. 2010). Morphologically, *Gloeoporus* species differ from *Gelatoporia* in their layered fruiting bodies with partly fluffy subiculum

contrasting to dense trama, and a cyanophilous reaction of hyphae.

Gelatoporia subvermisporea seems to have an exceptionally wide distribution, and the current concept as previously discussed may actually contain two species. The Indonesian record, the first from that country, comes from a log of introduced *Pinus merkusii* in a forest plantation about 1 km above sea level.

Obba Miettinen & Rajchenb. gen. nov.

MB 519509

Type species *Obba valdiviana* (Rajchenb.) Miettinen & Rajchenb.

Etymology *Obba* (Lat.), a type of household container for liquids used in Rome; refers to the broad bottle-shaped cystidioles characteristic of the genus.

Description Basidioma lignicola, resupinatum, pallidum, hymenophorum poroideum. Systema hypharum monomiticum, basidia magna (plus quam $15 \times 6 \mu\text{m}$). Cystidiola frequentia, mammiformia vel subulata. Sporae globosae vel subglobosae, gutta olei magna. Putrificatio ligni alba.

Basidiocarp resupinate, annual to biennial, white when fresh, cream to ochraceous when dry, a few millimetres up to 13 cm long, up to 3 mm thick. Consistency soft when fresh, drying hard to brittle. Subiculum thin, cartilaginous line when dry.

Hyphal system monomitic, clamps present, CB–, IKI–, CRB+. Hyphae mostly thin-walled to slightly thick-walled, mostly 2–3 μm in diameter. Coarse crystal rosettes in trama and tube mouths, (2)4–7(9) μm in diameter, also rhomboidal plates. Subicular hyphae often agglutinated. Tramal hyphae interwoven to subparallel, tissue rather dense, upper trama may be agglutinated. In KOH part of hyphal walls swell inwards and gelatinise, resulting in a capillary, distinct lumen. Free oil droplets present in microscopic slides.

Cystidia none.

Hymenium. Cells large (about $15\text{--}20 \times 6\text{--}9 \mu\text{m}$), with oily contents. Basidia mostly clavate, with 4 sterigmata. Cystidioles subulate to mammiform, common.

Basidiospores subglobose to globose, CB(+), plasma stained in CB, with a large hyaline oil droplet, thin- to slightly thick-walled, smooth.

Distribution Eurasia, Australia (Tasmania), the Americas, from subtropics to boreal zone.

Ecology Associated with white-rot on trunks of gymnosperms and angiosperms.

Sexuality Bipolar, possibly also tetrapolar (David 1971; see *O. rivulosa*).

Nuclear behaviour Astatocoenocytic.

Remarks Morphologically, the species of *Obba* are similar to *Physisporinus* species with subglobose spores, large hymenial cells and monomitic hyphal structure. For instance, Ryvarden and Gilbertson (1994) and Niemelä (2005) have placed *O. rivulosa* there. Species of *Physisporinus* differ from *Obba* species in having simple septa and showing quite different cultural characters, such as the formation of plectenchymatous areas and/or cuticular cells (Stalpers 1978). Most *Physisporinus* species seem to belong to the *Meripilus* clade and are not related to the *Cinereomyces* clade (Fig. 1).

Obba shares a monomitic, clamped hyphal structure with several other polypore genera including *Atraporrella*, *Ceriporiopsis*, *Erastia*, *Hapalopilus* and *Raduliporus*. Type species of these genera never show quite the same combination of characters as species of *Obba*: white, thin, resupinate fruiting bodies, large hymenial cells, abundant cystidioles and subglobose, (very) slightly thick-walled spores. DNA data, when available, shows that those genera are not related to the *Cinereomyces* clade (Fig. 1). Microscopically somewhat similar *Aurantiporus* and *Hapalopilus* species are characterised by strongly pigmented and fleshy fruiting bodies, which are pileate in the case of the type species. Species of *Spongipellis* have pileate, large and fleshy fruiting bodies, and clearly more thick-walled and cyanophilous large spores.

Differences and similarities between genera in *Cinereomyces* clade are summarised in Table 3. *Gelatoporia* and *Obba* share a monomitic hyphal structure, which is often partly agglutinated and partly embedded in a gelatinous matrix; rather fine encrustation in trama and particularly on hyphal ends; CB– but CRB+ hyphae, similar KOH reaction, and somewhat similar-looking fruiting bodies. Both have a bipolar mating system and similar cultural features (i.e. formation of simple septate hyphae in the growing margin; David 1971; Nakasone 1981; Rajchenberg 1995).

Could *Ceriporiopsis rivulosa* be included in *Gelatoporia* instead of creating a new genus for it? Analysis based on nrDNA does not support that conclusion (Fig. 2). Certain key characters also argue against such an arrangement: narrow allantoid, thin-walled spores (*Gelatoporia*) versus subglobose, slightly thick-walled spores (*Obba*), and size and shape of basidia and cystidioles, which are small in *Gelatoporia* and large in *Obba*. *Gelatoporia subvermisporea* possesses slightly but clearly thick-walled hyphae whereas *Obba* species mostly thin-walled. Based on spore characters, Niemelä (1985) refrained from combining *O. rivulosa* in *Gelatoporia*.

Obba rivulosa (Berk. & M.A. Curtis) Miettinen & Rajchenb. comb. nov.

MB 519510

Fig. 3c

Basionym *Polyporus rivulosus* Berk. & M.A. Curtis, J Linn Soc Bot 10:318, 1869. Type: Cuba, Wright 154 (lectotype in S! selected here, no F5556, syntypes at least in K, NY!).

Description **Basidiocarp** annual, resupinate, white when fresh, drying cream to light ochraceous, occasionally with brown stains (type specimen), usually forming small elongated patches a few millimeters to centimeters in width, up to 13×5 cm, up to 2 mm thick, according to Lowe (1966) up to 3 mm thick. Consistency soft when fresh, fragile when dry but thick subiculum resinous hard when dry; old fruiting bodies often detaching easily from substrate, young ones firmly attached. Pores rather regular, thin-walled, (rounded) angular, mouths smooth, white when fresh and dry, tubes cream to ochraceous to brownish resinous when dry, American material 3–5/mm (Gilbertson and Ryvarden 1986; Lowe 1966), Finnish material 5–7/mm, tubes 0.4–2.5 mm long. Subiculum a thin line, watery white when fresh, often turns brownish resinous upon drying, 0.1–0.3 mm thick, according to Gilbertson and Ryvarden (1986) up to 1 mm thick. Margin usually distinct, thinning out, without a sterile margin or with a thin (<1 mm) sterile margin, which is watery when fresh.

Hyphal system monomitic, CB–, IKI–, CBR+, hyphal walls swell inwards in KOH. Hyphae thin- to slightly thick-walled, rather similar throughout the fruiting body, (1.5) 2.2–3.0(4.2) μm in diameter in subiculum, (1.3)2.2–2.9 (3.4) μm in diameter, in KOH up to 4 μm in trama, clamps present, simple septa rare. Crystals always present, common in trama and tube mouths as rather small rhomboidal plates and irregular rosettes. Subiculum usually at least partly agglutinated, hyphae horizontally arranged and parallel to subparallel, sinuous, thin- to slightly thick-walled. Tramal hyphae interwoven to subparallel, in lower trama thin-walled, in upper trama thin- to slightly thick-walled, often partly agglutinated. Subhymenium dense. Free-floating oil drops usually common in microscopic slides.

Cystidia none.

Hymenium cells commonly with oily contents, detach easily in KOH. Basidia broad clavate to cylindrical to slightly constricted, 16–27×6–9.5 μm , with 4 sterigmata up to 4 μm long, with basal clamp. Cystidioles fusiform to mammiform, numerous, 12–27×4.8–8.8 μm .

Basidiospores subglobose to broad ellipsoid, hyaline, CB(+), IKI–, thin- to slightly thick-walled, smooth, (4.4) 4.6–5.2(5.5)×(3.6)3.7–4.3(4.7) μm . L=4.89 μm , W=4.00 μm , Q'=1.1–1.3(1.4), Q=1.22, n=120/4.

Distribution North America, Caribbean, and Eurasia, from subtropical to boreal vegetation zone. The species is evidently more common in North America than in Europe. Robledo (2009) reported it from the subtropical Yungas forest that lies in the eastern slope of the Andes (NW Argentina).

Ecology Associated with white-rot on fairly decayed conifer trunks: *Abies*, *Pinus*, *Pseudotsuga*, *Sequoia*, *Thuja* and *Tsuga*, and, rarely, angiosperms such as *Alnus*, *Castanea*, *Populus* and *Quercus*. Host of the lectotype is angiosperm (studied by Tuuli Timonen and Pirkko Harju, H). A relatively high proportion of the collections of this species have been made on charred wood, both in America and Europe (Bernicchia 2005; Kotiranta 1985; Niemelä 2005). In Finland, this otherwise rare species is sometimes common on old forest fire areas (Penttilä and Kotiranta 1996). However, the species is certainly not restricted to charred wood or burned forest. Gilbertson and Ryvarden (1986) report it from living conifers as well.

Cultural characters See David (1971), Nakasone (1981), Nobles (1965), and Stalpers (1978). The species is characterised by its ability to grow on cabbage extract agar as opposed to *Cinereomyces lindbladii* and *Gelatoporia subvermispora* (Nakasone 1981).

Sexuality Repeatedly recorded as bipolar for North American specimens (Nobles et al. 1957; Nakasone 1981) but tetrapolar for two European materials (David 1971).

Nuclear behaviour Astatocoenocytic (David 1971).

Remarks Along with our own data, we have utilised Bernicchia (2005), Dai (1998), Gilbertson and Ryvarden (1986), Kotiranta (1985), Lowe (1966), Melo and Tellería (1992), Niemelä (2005), and Ryvarden and Gilbertson (1994) in writing the macroscopic, distribution and ecology descriptions. Kotiranta (1985) provides a microscopic drawing of *O. rivulosa*.

David (1971) reports that her European cultures differ in their sexuality from North American material (tetrapolar vs bipolar). She also reports considerably larger pore size (2–3/mm) than in Finnish (5–7/mm) or American material (3–5/mm). Difference in sexuality may indicate different species as has been shown for, e.g., several *Antrodia* taxa that, despite being morphologically very similar, represent different biological, non-compatible taxa (David and Déquatre 1984, 1985). On the other hand, David (1971) recorded formation of dikaryons between North American cultures and monosporic European cultures.

ITS and pore size differences indicate that *O. rivulosa* may be a species complex even after the separation of *O. valdiviana* from it. It should be noted that the type specimen

Table 4 Spore measurements of *Obba rivulosa*, *O. valdiviana* and *Sebipora aquosa*. Composite statistics of *O. valdiviana* exclude Tasmanian specimen, Gates FF503

Species/specimen	Length	L	Width	W	Q'	Q	n
<i>Obba rivulosa</i>	(4.4)4.6–5.2(–5.5)	4.89	(3.6)3.7–4.3(–4.7)	4.00	1.1–1.3(–1.4)	1.22	120/4
Lectotype	(4.5)4.6–5.1(–5.2)	4.86	(3.7)3.8–4.1(–4.4)	3.94	1.1–1.3(–1.4)	1.23	30
Larsen 3.X.1973	4.5–5.2(–5.5)	4.84	(3.6)3.7–4.4(–4.5)	3.97	1.1–1.3(–1.4)	1.22	30
Miettinen 8054	4.6–5.2	4.89	(3.7)3.8–4.6(–4.7)	4.11	1.1–1.3	1.19	30
Penttilä 15077	(4.4)4.5–5.5	4.96	3.7–4.3	3.99	1.1–1.4	1.24	30
<i>Obba valdiviana</i>	(4.5)4.6–5.3(–5.6)	4.99	4.2–5.0(–5.2)	4.63	1.0–1.2	1.08	90/3
Isotype	(4.6)4.7–5.2(–5.5)	5.00	(4.3)4.4–5.1(–5.2)	4.72	1.0–1.1	1.06	30
Gates FF503	4.5–5.4	4.79	4.2–5.0(–5.1)	4.48	1.0–1.1	1.07	32
Rajchenberg 4157	4.6–5.2	4.94	(4.2)4.3–5.0	4.66	1.0–1.1	1.06	30
Rajchenberg 11403	(4.5)4.6–5.5(–5.6)	5.02	4.2–4.9(–5.2)	4.52	1.0–1.2	1.11	30
<i>Sebipora aquosa</i>	(5.2)5.7–7.6(–8.0)	6.44	(2.0)2.1–2.7(–2.8)	2.39	(2.2)2.3–3.3(–3.6)	2.70	96/3
Holotype	5.6–7.2(–8.0)	6.29	(2.2)2.3–2.8	2.50	2.2–2.9(–3.0)	2.52	32
Miettinen 9265.1	(5.2)5.8–7.6(–8.0)	6.68	2.0–2.6(–2.7)	2.29	(2.2)2.5–3.6	2.91	32
Miettinen 8680.1	(5.6)5.7–7.6	6.34	2.2–2.8	2.37	2.4–3.0	2.67	32

was collected in subtropical Cuba, whereas the current species concept is based mainly on temperate North American collections. Morphologically, the holotype is fairly similar to northern specimens, and spore size is nearly identical nearly identical (Table 4). Fresh collections from subtropical North America or Caribbean would be needed to clarify species range and limits of the type species.

Obba valdiviana (Rajchenb.) Miettinen & Rajchenb. stat. et comb. nov.

MB 519511

Fig. 3a–b

Basionym Ceriporiopsis rivulosa (Berk. & M.A. Curtis) Gilb. & Ryvarden var. *valdiviana* Rajchenb., Bol Soc Argent Bot 30:153, 1995. Holotype: Argentina, Chubut, Futaleufú, Los Alerces National Park, 15.III.1993 Rajchenberg 10736 (BAFC 33238, isotype CIEFAP!).

Description Basidiocarp annual to biennial, resupinate, snow-white, initially forming small, circular to elongated bodies up to 13×9 cm, but fusing and often covering large surfaces. Consistency hygrophanous and fleshy when fresh, hard and waxy to bony and detaching from substrate upon drying, yet easy to cut with a razor blade. Pore mouths felty and white, often resinous in cross section, 6–8/mm, tubes 0.5–5 mm long, up to 11 mm in Tasmanian material. Subiculum white when fresh and brown cartilaginous line when dry, 0.1–0.3(0.5) mm. Sterile margin distinct or not, up to 1 mm wide, felty, slightly separated from substrate but always well attached to it.

Hyphal system monomitic, CB–, IKI–, CRB+, hyphal walls swell inwards in KOH. Hyphae thin- to slightly thick-walled, (1.5)2.0–3.7(4.2) µm in diameter in subiculum, (1.5)2.0–2.7(3.7) µm in trama, clamps present. Irregular crystal rosettes common in trama and tube mouths, typically 5–7 µm in diameter, in upper trama also some rhomboidal plate-present, up to 20 µm long. Subiculum partly to fully agglutinated, hyphae mostly horizontally arranged and subparallel, in agglutinated parts sinuous and difficult to tell and break apart, partly covered with slime: tissue rather dense, hyphae interwoven to subparallel, thin-walled at least in lower trama. Subhymenium tightly arranged, hyphae interwoven. Small oil droplets floating around in microscopic slides.

Cystidia none.

Hymenium. Cells commonly with oil droplets. Basidia broad clavate to rarely constricted cylindrical, 16.5–22×6.5–9 µm, with 4 sterigmata. Cystidioles fusiform to mammiform, common, 13–20×6–8.2 µm.

Basidiospores globose to subglobose, hyaline, CB(+), IKI–, with thin to slightly thickened walls, smooth, (4.5)4.6–5.3(5.6)×4.2–5.0(5.2) µm, L=4.99 µm, W=4.63 µm, Q'=1.0–1.2, Q=1.08, n=90/3 based on the Argentinian material, with a prominent hyaline, oily-like guttule in the otherwise cyanophilous cytoplasm.

Distribution Temperate southern Argentina and Chile. Two recent finds have been made in Tasmania.

Ecology Associated with white pocket rot on strongly decayed trunks of *Nothofagus dombeyi* and undetermined broad-leaved tree species. In Tasmania, it has been collected from *Eucalyptus* sp. logs over 90 cm in diameter.

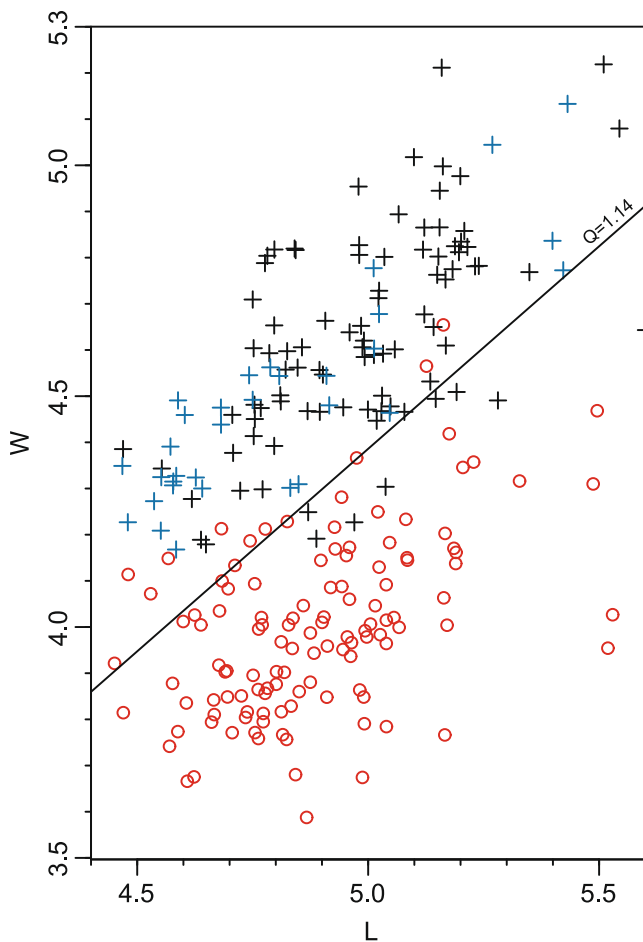


Fig. 5 Size of individual spores of *O. rivulosa* (○) and *Obba valdiviana* (+; black Argentinian, blue/grey Tasmanian). The points have been jittered, i.e., moved randomly within 0.05 μm around the original value along both axes

Cultural features See Rajchenberg (1995) for a complete description. In brief, the mycelium is characterised by a rapid growth, with generative hyphae being simple-septate in the margin but becoming clamped backwards. Microscopically, they form thick-walled generative hyphae, narrow, capilliform, much branched hyphae forming a net-like cluster and chlamydospores, described as "binding hyphae" by Nakasone (1981).

Sexuality Unknown.

Nuclear behaviour Astatocoenocytic.

Remarks *Obba rivulosa* differs from *O. valdiviana* by larger pores and narrower, broadly ellipsoid basidiospores (Figs. 3 and 5, Table 4). Known distributions of the species do not overlap.

Preliminary di \times mono compatibility tests (Hallenberg 1984) performed between the polyspermic culture obtained from *O. valdiviana* holotype (CIEFAP culture collection

159) and 4 monosporous cultures of *O. rivulosa* from USA (FP 133035) gave negative results (Rajchenberg 1995). Nakasone (1981) described the strain derived from FP 133035 (USA, Oregon, Mary's Peak, on *Tsuga*, 8. XI.1971 MJ Larsen) in her culture study of *O. rivulosa*, and we have studied fruiting bodies collected from the same area for this study.

The Tasmanian material differs from the Argentinian material genetically (ITS distance 1.3%). No clear morphological character separate the two (Fig. 5). Further sampling and closer study are needed to determine whether the two are separate species.

***Sebipora* Miettinen gen. nov.**

MB 519512

Type species: ***Sebipora aquosa* Miettinen sp. nov.**

MB 519513

Figs. 4 and 6

Holotype Indonesia, Sumatra, Riau, Rokan Hilir, Desa Sungai Maju, 2°0.790'N, 100°40.546'E, under 40 m above sea level, slash and burn site in a peat swamp forest area, on a partially buried piece of wood (15 cm in diameter, decay stage 2/5), 8.VII.2004 Miettinen 8868 (ANDA, isotype H).

Etymology *Sebum* (Lat.), refers to the tallow look of pore surface of the type species, *aquosus* (Lat.), watery, refers to fresh fruiting bodies of the species.

Description Basidioma lignicola, resupinatum vel pileatum, dilute ochraceum vel pallidum, hymenophorum poroideum, porae 4–6 per mm. Systema hypharum monomiticum,



Fig. 6 Fresh fruiting body of *Sebipora aquosa*, Miettinen 12032

hyphae tenuitunicatae vel leviter crassitunicatae, CB–, KOH–, IKI –, CRB+, 2.6–4.6 μm in diametro. Trama inferiore crusta arenoidea vel fasciculis spinosis crystallorum parvis tectum. Sporae cylindricae, leviter curvata, 1–2 guttis olei magnis, 5.7–7.6 \times 2.1–2.7 μmVB .

Basidiocarp resupinate to pileate, annual, pure white when fresh, upper surface hairless, azonate, in dry specimens shiny cream with greyish, yellowish and brownish hues, pore surface turning greyish, sometimes with yellow or brown hues, 2–10 \times 1–5 cm wide, caps projecting up to 3 cm, 1–9 mm thick, always broadly attached. Consistency rubber-like but easy to tear apart when fresh, often watery, hard when dry. Pores rather regular, rounded angular, rather thin-walled, tubes white to cream in cross section when dry, 4–6/mm, 1–4 mm long. Subiculum white, homogenous, subiculum of the resupinate part 0.1–0.4 mm, cap context 1–6 mm thick. Cap margin sharp, resupinate margin thinning out but well delineated. Mycelial cords absent.

Hyphal system monomitic, CB–, IKI–, KOH–, CRB+. Hyphae rather homogenous throughout the fruiting body, (2.0)2.7–3.9(4.8) μm in diameter in subiculum, (2.2)2.6–3.7(5.0) μm in trama, clamps always present. Crystals present as sandy encrustation in tube mouths and trama or small thorny crystal clusters attached to tramal hyphae, scanty to abundant; sometimes also large rhomboidal plates and irregular crystal clusters in subiculum and upper trama. Subicular hyphae interwoven, slightly thick-walled to thick-walled, lumen very distinct and usually at least half of the total width, walls 0.3–1.7 μm thick. Contextual hyphae subparallel, horizontal, slightly thick-walled to thick-walled, relatively loose, (2.7)3.2–4.6(5.8) μm in diameter. Upper surface consists of partly agglutinated layer of interwoven hyphae. Tramal hyphae subparallel, slightly thick-walled, tissue dense, partly agglutinated. Subhymenial hyphae thin-to slightly thick-walled. Free-floating, hyaline oil in microscopic slides present, scanty to abundant.

Cystidia absent.

Hymenium. Basidia clavate, 11–20.5 \times 4.8–6.5 μm , with 4 sterigmata, 2.2–3 μm long. Cystidioles absent.

Basidiospores cylindrical, often slightly curved, thin-walled, smooth, (5.2)5.7–7.6(8.0) \times (2.0)2.1–2.7(2.8) μm , L=6.44 μm , W=2.39 μm , Q'=(2.2)2.3–3.3(3.6), Q=2.7, n=96/3, with 1–2 oil drops, apiculus inconspicuous.

Distribution Low altitudes in Sumatra and New Guinea. Probably not rare.

Ecology Found in half-open secondary rainforest as well as open yard on a burned tree trunk. Substrate was in all cases a fallen angiosperm tree trunk over 15 cm in diameter.

Remarks Table 3 compares *Sebipora* with the other genera in *Cinereomyces* clade.

In the traditional genus system of polypores, pileate specimens of *Sebipora aquosa* would have been placed in *Tyromyces*, a dumping place for monomitic white-rot species with thin-walled spores. All legitimate names of *Ceriporiopsis* and *Tyromyces* registered in MycoBank as of August 1, 2010 were checked against *S. aquosa*, as well as all species described by E.J.H. Corner, following the interpretation of Hattori (2001a, b, 2002, 2003a, b) when available. No match was found.

In the key of monomitic *Tyromyces* species in Malesia by Corner (1992), *T. pinguis* comes closest. According to the protologue, the species has a "fatty vitreous appearance" and similar-sized spores. Hattori (2003a) studied the type of the species, which is in poor condition, and referred it to *Ceriporia* as it has simple septa. *Tyromyces levis* Corner from the Solomon Islands has rather similar spores and is half-resupinate, but its spores are larger, caps have a tomentose surface, and basidia are 2-sterigmate (Hattori 2003a).

The genus *Tyromyces* sensu stricto, typified by *T. chioneus*, is somewhat similar microscopically: occasional encrustation on hyphae that are CB– and CRB+, cylindrical spores, and oily substance. However, fruiting bodies of *T. chioneus* turn clearly dimitic when aging, and even when young its subicular hyphae have characteristic thick-walled, finger-like projections also present for instance in related *T. canadensis* (Niemelä 1985), but which are lacking in *Sebipora*. Phylogenetically *Tyromyces* s. str. is not closely related to the *Cinereomyces* clade (Fig. 1).

Other monomitic white-rot genera with resupinate fruiting bodies include *Atraporrella*, *Ceriporiopsis*, *Raduliporus*, *Pouzaroporia* and *Sidera*. In the strict sense, none of them are closely related to the *Cinereomyces* clade (Fig. 1; Miettinen and Larsson 2010; Tomšovský et al. 2010). All the above mentioned genera in the strict sense include only the type species or a few monomitic species, so comparison of the genera is essentially a comparison of the type species. Considering spore shape and hyphal structure, morphologically the closest generic type is *Ceriporiopsis gilvescens* with a monomitic, dense hyphal structure with oily substance and cylindrical spores. Its spores are curved, smaller and aguttulate, no encrustation is present, and its fruiting bodies are strictly effused and bright coloured.

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References

- Akhtar M, Attridge MC, Blanchette RA, Myers GC, Wall MB, Sykes MS, Koning JW Jr, Burgess RR, Wegner TH, Kirk TK (1992) The white-rot fungus *Ceriporiopsis subvermispora* saves electrical energy and improves strength properties during biomechanical pulping of wood. In: Kuwahara M, Shimada M (eds) Biotechnology in pulp and paper industry. UNi, Tokyo, pp 3–8
- Akhtar M, Scott GM, Swaney RE, Shipley DF (2000) Biomechanical pulping: a mill-scale evaluation. *Resour Conserv Recycl* 28:241–252
- Amirta R, Tanabe T, Watanabe T, Honda Y, Kuwahara M, Watanabe T (2006) Methane fermentation of Japanese cedar wood pretreated with a white rot fungus, *Ceriporiopsis subvermispora*. *J Biotech* 123:71–77
- Atik C, Imamoglu S, Bermek H (2006) Impact of xylanase pretreatment on peroxide bleaching stage of biokraft pulp. *Int Biodeter Biodegr* 58:22–26
- Bernicchia A (2005) Polyporaceae s.l. Edizione Candusso, Alassio
- Binder M, Hibbett DS, Larsson KH, Larsson E, Langer E, Langer G (2005) The phylogenetic distribution of resupinate forms across the major clades of homobasidiomycetes. *Syst Biodivers* 3:113–157
- Boidin J (1971) Nuclear behaviour in the mycelium and the evolution of the Basidiomycetes. In: Petersen RH (ed) Evolution in the higher Basidiomycetes. University of Tennessee Press, Knoxville, pp 129–148
- Corner EJJ (1992) Additional resupinate non-xanthochroic polypores from Brazil and Malesia. *Nova Hedwigia* 55:119–152
- Dai YC (1998) Changbai wood-rotting fungi 9. Three new species and other species in *Rigidoporus*, *Skeletocutis* and *Wolfiporia* (Basidiomycota, Aphyllophorales). *Ann Bot Fenn* 35:143–154
- Dai YC, Wang Z, Binder M, Hibbett DS (2006) Phylogeny and a new species of *Sparassis* (Polyporales, Basidiomycota): evidence from mitochondrial atp6, nuclear rDNA and rpb2 genes. *Mycologia* 98:584–592
- David A (1971) Caractères mycéliens de *Rigidoporus rivulosus* (Berk. et Curt.) comb. nov., espèce nouvelle pour l'Europe. *Bull Soc Mycol Fr* 87:415–419
- David A (1972) Comportement nucléaire des représentants du genre *Gloeoporus* Mont.: *G. conchoides* Mont., *G. dichrous* (Fr.) Bres. et *G. pannocinctus* (Rom.) J. Erikss. récolté pour la première fois en France. *Bull Soc Mycol Fr* 88:209–213
- David A (1982) Étude monographique du genre *Skeletocutis* (Polyporaceae). *Naturaliste Can* 109:235–272
- David A, Déquatre B (1984) Deux “ultraespecies”: *Antrodia malicola* (Berk. & Curt.) Donk et *A. ramentacea* (Berk. & Br.) Donk (Basidiomycetes, Aphyllophorales). *Cryptogam Mycol* 5:293–300
- David A, Déquatre B (1985) *Antrodia albidoides* (Polyporaceae) nouvelle ultraspecies meridionale. *Mycol Helv* 6:357–369
- Fackler K, Gradinger C, Schmutzer M, Tavzes C, Burgert I, Schwanninger M, Hinterstoisser B, Watanabe T, Messner K (2007) Biomodification of wood with selective white-rot fungi. *Food Technol Biotechnol* 45:269–276
- Galkin A, Vares T, Kalsi M, Hatakka A (1998) Production of organic acids by different white-rot fungi as detected using capillary zone electrophoresis. *Biotechnol Tech* 12:267–271
- Gardes M, Bruns TD (1993) ITS primers with enhanced specificity for basidiomycetes—application to the identification of mycorrhizae and rusts. *Mol Ecol* 2:113–118
- Gilbertson RL, Ryvarden L (1986) North American polypores 1. *Abortiporus* to *Lindtneria*. *Fungiflora*, Oslo
- Harreither W, Sygmund C, Dünhofen E, Vicuña R, Haltrich D, Ludwig R (2007) Cellobiose dehydrogenase from the ligninolytic basidiomycete *Ceriporiopsis subvermispora*. *Appl Env Microbiol* 75:2750–2757
- Hakala TK, Lundell T, Galkin S, Maijala P, Kalkkinen N, Hatakka A (2005) Manganese peroxidases, laccases and oxalic acid from the selective white-rot fungus *Physisporinus rivulosus* grown on spruce wood chips. *Enz Microb Technol* 36:461–468
- Hallenberg N (1984) Compatibility between species of Corticiaceae s. l. (Basidiomycetes) from Europe and North America. *Mycotaxon* 21:335–388
- Hattori T (2001a) Type studies of the polypores described by E. J. H. Corner from Asia and West Pacific Areas II. Species described in *Gloeophyllum*, *Heteroporus*, *Microporellus*, *Oxyporus*, *Paratrichaptum*, and *Rigidoporus*. *Mycoscience* 42:19–28
- Hattori T (2001b) Type studies of the polypores described by E. J. H. Corner from Asia and West Pacific Areas 3. Species described in *Trichaptum*, *Albatrellus*, *Boletopsis*, *Diacanthodes*, *Elmerina*, *Fomitopsis* and *Gloeoporus*. *Mycoscience* 42:423–431
- Hattori T (2002) Type studies of the polypores described by E.J.H. Corner from Asia and West Pacific Areas 4. Species described in *Tyromyces* (1). *Mycoscience* 43:307–315
- Hattori T (2003a) Type studies of the polypores described by E.J.H. Corner from Asia and West Pacific Areas 5. Species described in *Tyromyces* (2). *Mycoscience* 44:265–276
- Hattori T (2003b) Type studies of the polypores described by E.J.H. Corner from Asia and West Pacific Areas 6. Species described in *Tyromyces* (3), *Cristelloporia*, *Griphola*, *Hapalopilus*, *Heterobasidium*, *Ischnoderma*, *Loweporus*, and *Stecchericum*. *Mycoscience* 44:453–463
- Hibbett DS, Binder M, Bischoff JF, Blackwell M, Cannon PF, Eriksson OE, Huhndorf S, James T, Kirk PM, Lücking R, Lumbsch T, Lutzoni F, Matheny PB, McLaughlin DJ, Powell MJ, Redhead S, Schoch CL, Spatafora JW, Stalpers JA, Vilgalys R, Aime MC, Aptroot A, Bauer R, Begerow D, Benny GL, Castlebury LA, Crous PW, Dai YC, Gams W, Geiser DM, Griffith GW, Gueidan C, Hawksworth DL, Hestmark G, Hosaka K, Humber RA, Hyde K, Ironside JE, Kõljalg U, Kurtzman CP, Larsson KH, Lichtwardt R, Longcore J, Miądlikowska J, Miller A, Moncalvo JM, Mozley-Standridge S, Oberwinkler F, Parmasto E, Reeb V, Rogers JD, Roux C, Ryvarden L, Sampaio JP, Schüßler A, Sugiyama J, Thorn RG, Tibell L, Untereiner WA, Walker C, Wang Z, Weir A, Weiß M, White MM, Winka K, Yao YJ, Zhang N (2007) A higher-level phylogenetic classification of the Fungi. *Mycol Res* 111:509–247
- Hopple JS Jr, Vilgalys R (1999) Phylogenetic relationships in the mushroom genus *Coprinus* and dark-spored allies based on sequence data from the nuclear gene coding for the large ribosomal subunit RNA: divergent domains, outgroups, and monophyly. *Mol Phylogenet Evol* 13:1–19
- Jülich W (1974) Notes on the cyanophily of spores, with discussion of the genus *Leucogyrophana* (Corticiaceae). *Persoonia* 8:51–58
- Katoh K, Kuma K, Toh H, Miyata T (2005) MAFFT version 5: improvement in accuracy of multiple sequence alignment. *Nucleic Acids Res* 33:511–518
- Katoh K, Toh H (2008) Improved accuracy of multiple ncRNA alignment by incorporating structural information into a MAFFT-based framework. *BMC Bioinform* 9:212
- Kotiranta H (1985) *Physisporinus rivulosus*, an interesting polypore species. *Karstenia* 25:66–69

- Kotlaba F, Pouzar Z (1964) Preliminary results on the staining of spores and other structures of Homobasidiomycetes in Cotton Blue and its importance for taxonomy. Feddes Repertorium 69:131–142
- Larsson KH (2007) Re-thinking the classification of corticioid fungi. Mycol Res 111:1040–1063
- Larsson KH, Larsson E, Kõljalg U (2004) High phylogenetic diversity among corticioid homobasidiomycetes. Mycol Res 108:983–1002
- Lindner DL, Banik MT (2008) Molecular phylogeny of *Laetiporus* and other brown rot polypore genera in North America. Mycologia 100:417–430
- Lowe JL (1966) Polyporaceae of North America. The genus *Poria*. State Univ Coll For Syracuse Univ Techn Publ 90:1–183
- Maijala P, Kleen M, Westin C, Poppius-Levlin K, Herranen K, Lehto JH, Reponen P, Mäentausta O, Mettälä A, Hatakka A (2008) Biomechanical pulping of softwood with enzymes and white-rot fungus *Physisporinus rivulosus*. Enz Microb Technol 43:169–177
- Matheny PB, Wang Z, Binder M, Curtis JM, Lim YW, Nilsson RH, Hughes KW, Hofstetter V, Ammirati JF, Schoch CL, Langer E, Langer G, McLaughlin DJ, Wilson AW, Froslev T, Ge ZW, Kerrigan RW, Slot JC, Yang ZL, Baroni TJ, Fischer M, Hosaka K, Matsuura K, Seidl MT, Vauras J, Hibbett DS (2007) Contributions of *rpb2* and *tefl* to the phylogeny of mushrooms and allies (Basidiomycota, Fungi). Mol Phyl Evol 43:430–451
- Melo I, Telleria MT (1992) Novidades para a micoflora portuguesa (Aphyllophorales, Basidiomycotina). Portug Acta Biol Sér B 16:11–50
- Miettinen O, Larsson KH (2010) *Sidera*, a new genus in Hymenochaetales with poroid and hydroid species. Mycol Prog (in press, doi:10.1007/s11557-010-0682-5)
- Miettinen O, Niemelä T, Spirin W (2006) Northern *Antrodiella* species: the identity of *A. semisupina*, and type studies of related taxa. Mycotaxon 96:211–239
- Müller J, Müller K, Quandt D (2008) PhyDE – Phylogenetic Data Editor, version 0.995. <http://phyde.de>
- Nakasone KK (1981) Cultural studies on *Poria cinerascens*, *P. rivulosa* and *P. subvermisporea* (Aphyllophorales, Basidiomycotina). Mycotaxon 13:105–111
- Niemelä T (1985) On Fennoscandian polypores 9. *Gelatoporia* n.gen. and *Tyromyces canadensis*, plus notes on *Skeletocutis* and *Antrodia*. Karstenia 25:21–40
- Niemelä T (2005) Polypores, lignicolous fungi. Norrlinia 13:1–320 (in Finnish, with English summary)
- Nilsson RH, Veldre V, Hartmann M, Unterseher M, Amend A, Bergsten J, Kristiansson E, Ryberg M, Jumpponen A, Abarenkov K (2010) An open source software package for automated extraction of ITS1 and ITS2 from fungal ITS sequences for use in high-throughput community assays and molecular ecology. Fungal Ecol 3:284–287
- Nobles MK (1958) Cultural characters as a guide to the taxonomy and phylogeny of the Polyporaceae. Can J Bot 36:883–926
- Nobles KM (1965) Identification of cultures of wood-inhabiting Hymenomycetes. Can J Bot 43:1097–1139
- Penttilä R, Kotiranta H (1996) Short-term effects of prescribed burning on wood-rotting fungi. Silva Fenn 30:399–419
- Rajchenberg M (1995) Basidiomycetos xilofilos (Aphyllophorales) de los bosques andinopatagónicos, adiciones y correcciones IV. Bol Soc Argent Bot 30:153–161
- Robledo GL (2009) Hongos degradadores de la madera de las Yungas argentinas. Diversidad de Poliporos (Aphyllophorales, Basidiomycota). Doctoral thesis, Universidad Nacional de Córdoba
- Robledo GL, Amalfi M, Castillo G, Rajchenberg M, Decock C (2009) *Perenniporiella chaquenia* sp. nov. and further notes on *Perenniporiella* and its relationships with *Perenniporia* (Poriales, Basidiomycota). Mycologia 101:657–673
- Ronquist F, Huelsenbeck JP (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19:1572–1574
- Ryvarden L (1984) Type studies in the Polyporaceae 16. Species described by J.M. Berkeley, either alone or with other mycologists from 1856 to 1886. Mycotaxon 20:329–363
- Ryvarden L, Gilbertson RL (1994) European polypores. Part 2. *Meripilus* – *Tyromyces*. Fungiflora, Oslo
- Sotome K, Hattori T, Ota Y, To-anun C, Salleh B, Kakishima M (2008) Phylogenetic relationships of *Polyporus* and morphologically allied genera. Mycologia 100:603–615
- Spirin WA (2005) Notes on some rare polypores, found in Russia 2. *Junghuhnia vitellina* sp. nova, plus genera *Cinereomyces* and *Skeletocutis*. Karstenia 45:103–113
- Stalpers JA (1978) Identification of wood-inhabiting fungi in pure culture. Stud Mycol 16:1–248
- Tomšovský M, Menkis A, Vasaitis R (2010) Phylogenetic relationships in European *Ceriporiopsis* species inferred from nuclear and mitochondrial ribosomal DNA sequences. Fungal Biol 114:350–358
- Tortić M (1976) Some experiences with the use of cresyl blue in the determination of polypores. Kew Bull 31:611–616
- Wang, Z, Dai YC, Hibbett DS (2004) Phylogenetic relationships of *Sparassis* inferred from nuclear and mitochondrial ribosomal DNA and RNA polymerase sequences. Mycologia 96:1015–1029
- White TJ, Bruns T, Lee S, Taylor JW (1990) Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis MA, Gelfand DH, Sinisky JJ, White TJ (eds) PCR protocols: a guide to method and application. Academic, San Diego, pp 315–322
- Wu SH, Nilsson HR, Chen CT, Yu SY, Hallenberg N (2010) The white-rotting genus *Phanerochaete* is polyphyletic and distributed throughout the phlebioid clade of the Polyporales (Basidiomycota). Fungal Divers 42:107–118