UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
INSTITUTO DE BIOCIÊNCIA
PROGRAMA DE PÓS GRADUAÇÃO EM BOTÂNICA

THESIS FOR DEGREE OF DOCTOR IN
JOINT SUPERVISION

Contribution to the Taxonomy and Phylogeny of *Phellinus sensu lato* (Hymenochaetaceae, Basidiomycota) in Southern Brazil

Marisa de Campos Santana

Porto Alegre, 2014

Marisa de Campos Santana

Contribution to the Taxonomy and Phylogeny of *Phellinus sensu lato* (Hymenochaetaceae, Basidiomycota) in Southern Brazil

Thesis submitted to the Graduate Program in the Universidade Federal do Rio Grande do Sul (UFRGS), as a partial fulfillment of the requirements for the degree of **Doctor of Science: Botany**.

Orientadora: Profa. Dra. Rosa Mara Borges da Silveira
Co-orientador: Dr. Gerardo Lucio Robledo
Segundo orientador: Profº. Dr. Stephan Declerck

Porto Alegre, 2014

UNIVERSITÉ CATHOLIQUE DE LOUVAIN
FACULTÉ D'INGÉNIERIE BIOLOGIQUE, AGRONOMIQUE ET ENVIRONNEMENTALE

Contribution to the Taxonomy and Phylogeny of *Phellinus sensu lato* (Hymenochaetaceae, Basidiomycota) in Southern Brazil

Thèse présentée en vue de l'obtention en cotutelle du grade de doctour en sciences agronomiques et ingénierie biologique et de docteur en sciences botaniques.

Par

Marisa DE CAMPOS SANTANA

Soutenance le 29 septembre 2014 devant le juri d´examen:

Promoteurs
Profª. Dra. Rosa Mara Borges da Silveira
Profº. Stephan Declerck

Juri d´examen:
Dr. Cony Decock
Profª. Dra. Patrícia Valente da Silva
Profª. Dra. Tatiana Teixeira Souza Chies
Profº. Gilberto Coelho
Dr. Gabriel Castillo Cabello
Dr. Jérôme Degreef

DEDICATE:

TO MY MOTHER CARMELITA R. DE CAMPOS

AND

IN THE LOVELY MEMORY OF MY BROTHER: ITAMAR DE CAMPOS SANTANA (TITO).

ACKNOWLEDGMENTS

I am very especially grateful to my mother, Carmelita Ribeiro de Campos and my father, Venceslau Santana for unconditional love, understanding and affection, for support received along these years of study, for trusting in me, for being always at my side and for the incentive so I could proceed in this journey.

Prof. Dra. Rosa Mara Borges da Silveira for accepting to advise me in this project and to believe in it, for all infrastructures placed at my disposal;

Dr. Gerardo Lucio Robledo, for spending much of his time to teach me a little of his large knowledge on Hymenochaetaceae, especially during my stay in Córdoba/Argentina. Thank you especially for friendship, the shared "mates", and the discussions about taxonomy and phylogeny of the group and about life.

Prof Stephan Declerck, for accepting me during the year 2012 in his laboratory (Earth and Life Institute - Microbiology –ELIM/UCL), for supporting my work and accepting the *international convention for the joint supervision of thesis.*

I also thank Dr. Cony Decock, for contagious passion for the Fungi Kingdom, for discussions about hymenochaetoid, for the teachings about the fascinating world of fungi, mycology and science in general. For receiving me during the sandwich internship, for providing infrastructure of laboratories and resources, for sharing, in several moments, his office with me, besides the strict supervision of taxonomic and phylogenetic approach. More especially, I am grateful for the privilege of his friendship and for all the shared moments, which helped me a lot on my adaptation period in Louvain-la-Neuve-Belgium. The words are not enough to express my gratefulness…Merci beaucoup mon ami!

Being a lucky person, I had an extra "advisor". All pages in this work would not suffice to thank the help given by Drª. Clarice Loguercio-Leite, my friend and master degree advisor. I do not forget her eternal teachings, precious advices and invaluable trust. In personal terms, I am still grateful for all optimism words, affection and understanding. For all this and much more, thank you!

Drª Tatiana Chies, Drª Patrícia Valente, Dr. Gilberto Coelho, Dr. Gabriel Castillo and Dr. Jérôme Degreef, who, as members of qualification examination board, contributed with important and enriching suggestions;

I would like to thank the staff of the Mycothèque of the UCL (BCCM/MUCL): Stéphanie Huet and Celine Bivort, who teached me molecular biology thecniques, and the other technician, who contributed in some way for this work accomplishment.

I am grateful to Mário Amalfi, who is also co-author of some publications, for all the adives and help in phylogenetic analysis.

I express my gratefulness to all teachers and employees from "Departamento de Botânica da UFRGS", in particular to the team of ICN herbarium from UFRGS, especially Camila Carneiro, Márcia Pinheiro and Mateus de Oliveira, for availability, agility and competence.

The curators and employees of other herbaria, who gently loaned their collections for this study.

The Brazilian people, through research fomentation agencies: CNPq (GD 149756/2010-0), for PhD scholarship, CAPES for sandwich internship scholarship (PDSE, process 8296/11-1) and UFRGS for financial support which enable this project execution.

The colleagues of "Laboratório de Micologia, UFRGS", especially my friends: Paula Santos, Mauro Westphalen, Mateus Arduvino Reck, Alice Gerlach, Natália Tedy, Emerson Luiz Gumboski and Eduardo Soares Rossetto for fellowship in field works, for friendship and acquaintanceship during these years.

I am also grateful to my friends from close and from far away:

"...We recognize true friends in the most difficult moments..."

To all my Brazilian friends, especially Alice Gerlach, my dear friend and sister from the heart, for true friendship, for the several shared moments, for constant availability, for the straight, carrying, affection, Chaplin sections, fellowship in laboratory at Saturdays, for this helpful work revising the text. Be sure that you are very special; I will take you with me always!

Paula Santos, for friendship, affection, for contagious peace, for the prompt and indispensable help translating and revising English, for companionship in several moments. I have no words to express my gratefulness!

Guilherme A. Roesler, for being so present in my life, for understanding, incentive, help, for mild reprimands, stimulus and teachings; but mainly, for believing in my potential, in my dreams and projects... for sharing the joy of my achievements.

To my family LLN: Cinthya I. Becerra, Diana Rh, Pamela, Marychuy, Yurelkys Fernandez, Diogo Buarque Franzosi**,** Ugo Sangiorgi**,** Vivian Genaro Motti**,** Koen Buyens, Prudence, Madia and other Latin-American and European friends: who received me, helped me, and with who I learned so much. Muchas gracias, muito obrigada, merci beaucoup!

To “cordobéses”, friends from Córdoba-Argentina, who gently received me and cheered my stay in Argentina, especially Luciana Hernández (Luli), Laura S. Dominguez and Noelia Cofre.

Muito obrigada, muchas gracias, merci beaucoup, to everyone that directly or no, contributed to this work accomplishment.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

INDEX OF SPECIES IDENTIFIED

PUBLICATIONS

This thesis is based on the work presented in the following papers and manuscripts. The papers are appended to the thesis, and are referred to by capital roman numbers in the text.

I - Manuscript 34

Campos-Santana M, Decock C, Robledo G, Silveira R.M. 2014.

A Synopsis of the poroid Hymenochaetaceae (Agaricomycetes, Basidiomyceta) in Southern Brazil.

Cryptogamie Mycologie: submitted

II - Manuscript 84

Campos-Santana M, Amalfi M, Robledo G, Silveira R.M., Decock C.

Fomitiporia neotropica, a new species from South America evidenced by multilocus phylogenetic analyses.

Mycological Progress: Mycological Progress 13:601-615

III - Manuscript 88

Campos-Santana M, Amalfi M, Silveira R.M., Decock C. 2014.

Multilocus DNA-based phylogenetic analysis reveal two new species lineages in the *P. gabonensis* / *P. caribaeo-quercicolus* species complex, of which *Phellinus amazonicus* sp. nov.

Fungal Diversity: to be submitted

IV - Manuscript 111

Campos-Santana M, Amalfi M, Silveira R.M., Robledo G, Decock C. 2014.

Morphological, DNA sequences, and ecological data evidence four undescribed *Phylloporia* species from Southern Brazil.

Mycologia: to be submitted

GLOSSARY AND ABBREVIATIONS

AIC – Akaike Information Criterion

Amyloid – (of spores, etc.), stained blue by iodine; *cf.* dextrinoid.

Basidiome – (pl.-ata), a basidium-producing organ: basidiocarp; carpophore; fruitbody; hymenophore; sporophore.

BI – Bayesian Inference.

Cyanophilous – (of spores, etc), readily absorbing a blue stain such as cotton blue.

Dextrinoid – of spores, etc.), stained yellowish-brown or reddish brown by Melzer's iodine.

Dimitic – having hyphae of two kinds (generative and skeletalhyphae which are thick-walled, aseptate).

EPS – exopolysaccharides

Hypha – (pl. hyphae), one of the filaments of a mycelium.

INPE – National Institute for Space Research in Brazil

ML – Maximum Likelihood

Monomitic – Having hyphae of one kind (generative hyphae which are branched, septate, with or without clamp connexions, thin to thick-walled, and of unlimited length.

MP – Maximum Parsimony

MEA – Malt Extract Agar

Pileus – The hymenium-supporting part of the basidioma of non-resupinate *Agaricomycetes*.

s.l – From Latin, *sensu lato* (in a broad sense).

s.s. – From Latin, *sensu strito* (in a narrow sense).

UF – Federal unit/ State of Brazil

Xanthochroique – All structures become dark in 2% KOH.

≡ – Basionym

Seta – (pl. -ae) (Lat., a bristle), (1) a stiff hair, generally.

RESUME

Contribution à la Taxonomie et Phylogénie de *Phellinus sensu lato* (Hymenochaetaceae, Basidiomycota) dans le Sud du Brésil

Phellinus s.l. a été créé par Quélet en 1886. Il comprend actuellement 180 espèces, soit près de la moitié du nombre total d'espèces d'Hymenochaetaceae. Les caractères généralement considérés pour la definition du genre incluent des basidiomes à réaction xanthochroique positive permanente, une trame des tubes jaune à brun, un système d'hyphes dimitique pour l'essentiel avec des hyphes génératives à septa simples (i.e absence de boucles), des hyphes squelettiques brunâtres, et des éléments de type sétoïdes au niveau de l'hyménium ou plus rarement de la trame. Au niveau de leur physiologie (ou de leur biologie nutritionnelle), les *Phellinus s.l.* sont lignivores, possédant un système enzymatique capable de dégrader préférentiellement la lignine, et également partiellement la cellulose et l'hémicellulose, des composés de la paroi cellulaire du bois, produisant à terme une pourriture blanche. Ils se développent tant sur bois vivant (et sont des parasites parfois économiquement importants) ou sur bois mort. Les *Phellinus* sont généralement les champignons lignivores les plus divers et les mieux représentés dans les forêts tropicales. Ils participent ainsi activement au maintien des écosystèmes forestiers. Des études récentes, de morphologie fine et le développement d'approches complémentaires, non-morphologiques, de type biochimique d'abord, génomique ensuite, ont toutefois démontré que la conception généralement admise par la majorité des auteurs modernes (Larsen and Cobb-Poulle 1990, Ryvarden, 1991; Fischer, 1996; Góes-Neto *et al*, 2001) est largement hétérogène et polyphylétique. En conséquence, de nombreux groupes morphologiques plus cohérents et monophylétiques ont émergés (ou ré-émergés) et ont été reconnus comme des genres satellites indépendants plus ou moins larges selon les cas. Certains de ces genres avaient été reconnus par des auteurs anciens, et ont pu être exhumés de la litérature; pour d'autre groupes des genres ont dus être crées. Citons par ex. les *Fomitiporia*, *Fomitiporella, Fulvifomes, Fuscoporia*, *Porodaedalea*, …. Afin d'élargir les connaissances de ces champignons dans la Région Sud du Brésil, une étude taxonomique a été réalisée à partir de révisions d'herbier et de l'analyse des spécimens collectés en 2010, 2011 et 2013, dans les trois États du sud du Brésil. Les données de la littérature ont également été rassemblées avec l'objectif de fournir un cadre des connaissances actuelles du groupe dans la région

étudiée. Plus de 600 spécimens d'Hymenochaetaceae poroïdes ont été analysés. Quarante-quatre espèces, distribuées dans neuf genres, ont été identifiées. De ces espèces et d'espèces mentionnées dans la littérature, 26 sont connus pour Paraná, 25 pour Santa Catarina et 35 pour Rio Grande do Sul. *Fomitiporia neotropica*, *Phellinus amazonicus*, *Phylloporia subchrysita, Phylloporia neopectinata*, *Phylloporia turbinata* et *Phylloporia loguerciae* sont décrites comme nouvelle pour la science. Neuf espèces sont cités pour la première fois au Paraná, 10 pour Santa Catarina, 16 pour Rio Grande do Sul, 14 pour la Région Sud du Brésil, neuf sont mentionnés pour la première fois au Brésil et une pour l'Amérique du Sud. En plus, deux nouvelles combinaisons sont proposées, *Fomitiporia bambusarum et Fulvifomes rhytiphloeus*. Les descriptions et illustrations des structures microscopiques et les photos sont fournies pour les nouvelles espèces. Également, les clés sont fournies pour l'identification des genres et des espèces connues pour la région d'étude.

Mots clés: Diversité, taxonomie, relations phylogénétiques, Hymenochaetaceae

RESUMO

Contribuição à Taxonomia e Filogenia de *Phellinus sensu lato* (Hymenochaetaceae, Basidiomycota) na Região Sul do Brasil

Phellinus s.l. foi criado por Quélet em 1886 e compreende atualmente 180 espécies, quase a metade do número total das espécies de Hymenochaetaceae. As características consideradas para definir o gênero incluem basidiomas com reação xantocroica positiva e permanente, superfície dos poros amarela a marrom, sistema hifal dimítico essencialmente com hifas generativas com septo simples (ou seja, sem fíbulas), hifas esqueletais castanhas e elementos do tipo setoides, no himênio ou, raramente, na trama. Em sua fisiologia (ou biologia nutricional), as espécies de *Phellinus s.l.* são lignocelulolíticas ou xilófilas, possuem um sistema enzimático capaz de degradar a lignina da madeira, causando podridão branca. Desenvolvem-se tanto na madeira viva (e, às vezes, são parasitas de grande importância econômica) ou madeira morta, participando assim ativamente na manutenção dos ecossistemas florestais. Estas espécies são geralmente os fungos xilófilos mais diversos e com maior representatividade nas florestas tropicais. Estudos recentes, enfatizando a morfologia do grupo e o desenvolvimento de abordagens complementares, não morfológicas, bioquímicas e genéticas, têm mostrado que este gênero é amplamente heterogêneo e polifilético (Larsen and Cobb-Poulle 1990; Ryvarden, 1991; Fischer, 1996; Góes-Neto *et al*., 2001). Em consequência, muitos grupos morfológicos mais coerentes e monofiléticos emergiram (ou reemergiram), e foram reconhecidos como gêneros satélites independentes. Alguns destes gêneros tinham sido reconhecidos por autores anteriores e foram exumados da literatura para que outros gêneros fossem devidamente criados, como, por exemplo, os gêneros *Fomitiporia*, *Fulvifomes*, *Fuscoporia*, *Fomitiporia*, *Porodaedalea*, … Com objetivo de ampliar o conhecimento sobre esses organismos na Região Sul do Brazil, um estudo taxonômico foi conduzido a partir de revisões de alguns herbários e análises de espécimes coletados entre os anos de 2010 e 2013, nos três Estados da Região Sul do Brazil. Dados da literatura também foram compilados com o objetivo de fornecer um quadro do conhecimento atual sobre o grupo estudado. Foram examinadas mais de 600 coletas de Hymenochaetaceae poroides, onde foram reconhecidas 44 espécies, pertencentes a nove gêneros. Dessas espécies e das espécies citadas na literatura, 26 são conhecidas para o estado do Paraná, 25 para Santa Catarina e 35 para o Rio Grande do Sul.

Fomitiporia neotropica, *Phellinus amazonicus*, *Phylloporia subchrysita, Phylloporia neopectinata*, *Phylloporia turbinata* e *Phylloporia loguerciae* são propostas como espécies novas. Nove espécies são citadas pela primeira vez para o Paraná, dez para Santa Catarina, 16 para o Rio Grande do Sul, 14 para a Região Sul do Brasil, nove são citadas pela primeira vez para o Brasil e uma para a América do Sul. Além disso, são propostas duas novas combinações, *Fomitiporia bambusarum* e *Fulvifomes rhytiphloeus*. Descrições, ilustrações das estruturas microscópicas e fotos são fornecidas para as novas espécies. Além disso, são fornecidas chaves para a identificação dos gêneros e das espécies conhecidos para a área de estudo.

Palavras chave: Diversidade, taxonomia, relações filogenéticas, Hymenochaetaceae

1. INTRODUCTION

1.1. General Introduction

Systematics is at the foundation of all biological knowledge. Since Darwin's Theory of Evolution until ecology and biogeography, all biological studies depend on knowledge and quantification of the object of study. Until the present days, Linnaeus' classic taxonomy, which is dedicated to describe and inventory organisms, so that they can be named and classified in a general reference system (Amorim 2002; Judd *et al.* 2009), is fundamental for Biology studies.

> *"…Taxonomy is often undervalued as a glorified form of filing—with each species in its folder, like a stamp in its prescribed place in an album; but taxonomy is a fundamental and dynamic science, dedicated to exploring the causes of relationships and similarities among organisms. Classifications are theories about the basis of natural order, not dull catalogues compiled only to avoid chaos…"*
>
> Stephen Jay Gould, ***Wonderful Life*** (1989).

Therefore, identification, classification, nomenclature, in other words, systematics, is the science for the knowledge of biological diversity. Biodiversity, many times, is represented as the number of species that live in a particular place. It may also design genetic diversity among and inside populations of one species in particular, or diversity of communities in which these species are living and interacting.

Biodiversity is essential to maintain a dynamic balance of elements and climate on Earth. It is our main source of food, medicines, but also it has an intrinsic value that constitutes nature beauty, source of inspiration and pleasure. We are surrounded by biodiversity and we are part of it; in that sense, it is our ethical responsability to protect it. The current biodiversity on Earth is the result of 3.5 billions of years of evolution. After mass extinctions during various geological times, a significant recovery of biodiversity always took many millions of years to happen, so nothing allows us to think that the event currently ongoing will have a different issue. It is necessary to point out that species rise, prosper and fade naturally; however, we are facing a current extinction rate 100 to 200

times higher than what would be expected without human interference (Convention on Biological Diversity - CDB 2000).

The concept of biodiversity has evolved inside a context of human activities, magnified by population growth; ecosystems experience degradation increasingly fast and generalized. Certain ecosystems, such as forests (for instance, the Atlantic Forest in Brazil – Table 1) and the species once inhabiting them, are disappearing at an accelerated rate.

TABLE 1. Deforestation of the Atlantic Forest from 2011-2013. Source: Fundação SOS Mata Atlântica and INPE (2013).

DEFORESTATION BETWEEN 2012-2013, IN HA									
	UF	AREA UF	LAW ATLANTIC FOREST	% BIOME	FOREST 2012	% FOREST	DEFORESTATION 2011-2012	DEFORESTATION 2012-2013	VARIATION
1º	MG	58.653.439	27.623.397	47%	2.864.487	10,4%	10.752	8.437	-22%
2º	PI	25.158.115	2.662.017	11%	917.289	34,5%	2.658	6.633	150%
3º	BA	56.472.020	17.976.964	32%	2.040.697	11,4%	4.516	4.777	6%
4º	PR	19.932.306	19.639.352	99%	2.310.110	11,8%	2.011	2.126	6%
5º	SC	9.571.782	9.571.782	100%	2.216.131	23,2%	499	672	35%
6º	MS	35.713.264	6.377.963	18%	708.579	11,1%	49	568	1.049%
7º	PE	9.814.204	1.688.988	17%	201.825	12,0%	128	155	21%
8º	RS	26.880.228	13.836.988	51%	1.090.999	7,9%	99	142	43%
9º	SE	2.190.735	1.018.955	47%	72.524	7,1%	839	137	-84%
10º	RN	5.280.748	350.780	7%	16.094	4,6%	-	109	-
11º	SP	24.821.183	17.071.302	69%	2.378.900	13,9%	190	94	-51%
12º	GO	34.007.266	1.189.787	3%	29.976	2,5%	31	50	61%
13º	AL	2.776.873	1.524.163	55%	143.695	9,4%	138	17	-88%
14º	ES	4.607.118	4.607.118	100%	482.714	10,5%	25	14	-43%
15º	RJ	4.371.498	4.371.498	100%	814.562	18,6%	40	11	-72%
16º	CE	14.891.290	865.242	6%	64.249	7,4%	-	4	-
17º	PB	5.644.914	597.979	11%	54.087	9,0%	-	-	-

*In the second column: MG (Minas Gerais); PI (Piauí); BA (Bahia); PR (Paraná); SC (Santa Catarina); MS (Mato Grosso do Sul); PE (Pernambuco); RS (Rio Grande do Sul); SE (Sergipe); RN (Rio Grande do Norte); SP (São Paulo); GO (Goiás); AL (Alagoas); ES (Espírito Santo); RJ (Rio de Janeiro); CE (Ceará); PB (Paraíba).

In Brazil, the Atlantic Rain Forest, once a global biodiversity hotspot (Fundação SOS Mata Atlântica 2013) included originally an area equivalent to 1,315,469 km^2. Today, remants of forest above 100 hectares cover about 8.5% of the original forest areas (Figure 1). Overall, only 12.5% of the original forest remains, consisting mostly of rather small surface, above 3 hectares.

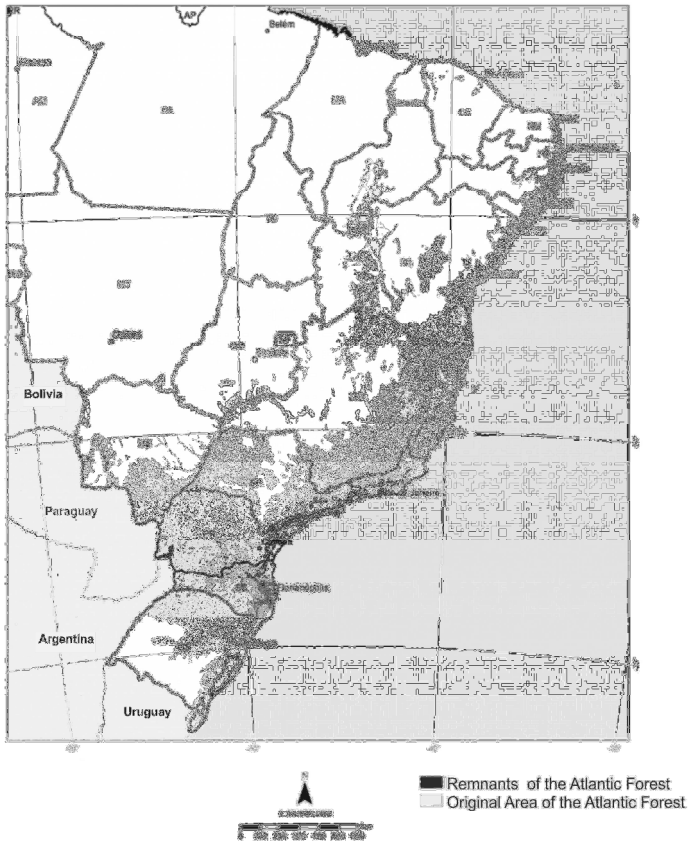


Fig. 1. Atlantic Forest remnants, showing the current situation of the Biome. Source: Fundação SOS Mata Atlântica and INPE (2013).

Facing such data situation, it is urgent to have a broader knowledge about its biodiversity, which needs to be protected. The two sides of Systematics: taxonomy and phylogenetic, provide, in this way, a larger comprehension about biodiversity elements, which is necessary for an effective management, for conservation and sustainable use of biodiversity.

In this context, the present thesis has as main purpose to increase the knowledge of a poorly investigated component of the biological diversity that is the Mycota. More specifically, we will study more deeply the diversity of the wood-decaying *Phellinus sensu lato* (*Hymenochaetaceae*) in Southern Brazil, besides to enlarge its global knowledge, through a systematic study (with a morphological and phylogenetic approach), in order to establish taxa circumscription as well their relationships.

1.2. Mycodiversity - Estimated total fungal numbers

The Kingdom Fungi presents an astonishing diversity (Burfort *et al*. 2003; Schmit and Mueller 2007), holding one of the largest lineage among eukaryotes, since it's ancestral until derivative forms (Blackwell 2011). Despite the increasing number of fungal studies, it is still difficult to estimate the real mycodiversity, which hampers phylogenetic, ecological and biogeographical characterization of the group. Bass and Richards (2011) emphasized that the main difficulties we faced in the attempt of estimate the global fungal richness is the uncertainty regarding the number of described species, the incomplete inventories, the high level of morphological conservatism of species and the lack of knowledge about ecology and geographical distribution of fungal species.

The most "popular" mycodiversity estimates, despite being conservative (Blackwell 2011, Hawksworth 2001), was presented by Hawksworth (1991), who proposed the existence of 1.5 millions of fungal species. This hypothesis is based in a ratio fungi/plants of 6:1 estimated for the temperate regions. The same author in 2004 calculated that about 100,000 fungal species (only 7% of estimated number) have been described in the whole world and that approximately 1,200 additional species are described yearly. Hawksworth (1991) also highlighted that, for a good estimate about mycodiversity, some data such as geographical distribution, endemism rate and host specificity should be considered.

Recent works state that ratio of fungi to plants would be approximately 10.5:1, hence, increasing even more the estimate of unknown species (Blackwell 2011). Hawksworth (2012) considering taxonomic studies in tropical regions and recent phylogenetic studies, revised also his estimate, and proposed a range of 1.5 to 3 millions of fungal species. Many phylogenetic studies have demonstrated the existence of more "cryptic" species than would be expected and as a consequence, have shown that the number of fungal species might be much higher (Bass and Richards 2011).

According to Kirk *et al*. (2008), the difference between the number of described and estimated fungal species (Figure 2) is enormous. The authors also commented that 51% of the 16,013 species registered at Index of Fungi between the years of 1981 and 1999 were not originating from tropical regions. When, fungal surveys are intensive and prolonged, this percentage increase in the tropics, where the percentage of undescribed species would range between 60 to 85%, depending on group and habitats.

Therefore, based on the estimates of the overall fungal species and the current rate of species description, Hawksworth (2001) Mueller and Schmit (2007) and Blackwell (2011) calculated that about 1,000 – 1,200 years of taxonomic studies would be still necessary to achieve the complete knowledge of fungal diversity.

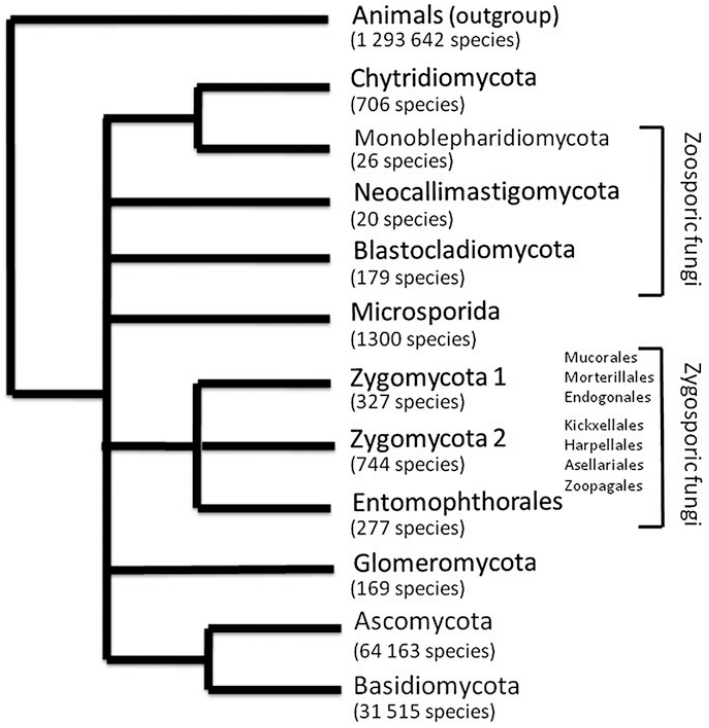


Fig. 2. Phylum of Kingdom Fungi and the approximate number of described species in each group (from Blackwell 2011; Kirk *et al*. 2008).

Reinforcing such statement, Schmit and Mueller (2007) noticed that additional works, especially those with samples originating from tropical regions, as well as rigorous studies in order to establish circumscription and species distribution, are crucial to improve the knowledge about fungal diversity.

1.3. Taxonomy of the Kingdom Fungi: Nomenclature and Classification

> *"…it is probably of great historical significance that Darwin himself expressed the thought that the possibility of arranging organisms in a hierarchic system is explainable only by assuming a phylogenetic relationship among them…"*
>
> Hennig W. (1966). ***Phyllogenetic Systematics***. p.20.

The poor knowledge about fungal diversity reflects on the taxonomic proposal of the kingdom. According to Hibbett *et al.* (2007), R. T. Moore only conducted the validation of the name Fungi according to the International Code of Nomenclature for Algae, Fungi, and Plants, including the Latin diagnosis in 1980. Fifteen years later, Hawksworth et al. (1995) elevated the basidiomycetes to the rank of Division (Basidiomycota). The situation has changed with Kirk *et al.* (2001); the Class Basidiomycetes divided in Subclasses *Tremellomycetidae* Locq. and *Agaricomycetidae* Parmasto, published respectively in 1984 and 1986 (David 2002), were accepted. These names were based on the genera *Tremella* Pers. and *Agaricus* L., in observance to article 7.1 from *International Code of Botanical Nomenclature for Algae, Fungi and Plants* - Melbourne Code (McNeill 2012).

Along with the other groups, Basidiomycetes still present numerous taxonomic problems, position inside the classification system. Recently, the AFTOL project – Assembling the Fungal Tree of Life – (Lutzoni *et al.* 2004), launched an international team by mycologists that has been working on molecular phylogenetic, morphological and reproductive biology studies. These works have changed substantially the classification of the Mycota. In this way, macroscopic basidiomycetes (for example, mushrooms, bracket fungi and polypores), have been placed at Subphylum *Agaricomycotina* Doweld and three classes are accepted to include the different orders (Figure 3): *Auriculariales* J. Schröt, *Corticiales* K. H. Larss, *Gloeophyllales* Thorn, *Polyporales* Gäum., *Thelephorales* Oberw., *Hymenochaetales* Oberw., inside class *Agaricomycetes* (Binder *et al*. 2005; Hibbett *at al*. 2007). Thereby, fungi containing pores (poliporoid) belong to the *Agaricomycetes*, in which they are distributed in several (still) polyphyletic orders, such as *Polyporales* Gäum, Russulales Kreisel ex P.M. Kirk, P.F. Cannon & J.C. David and *Hymenochaetales* Oberw., quantitatively the three most important.

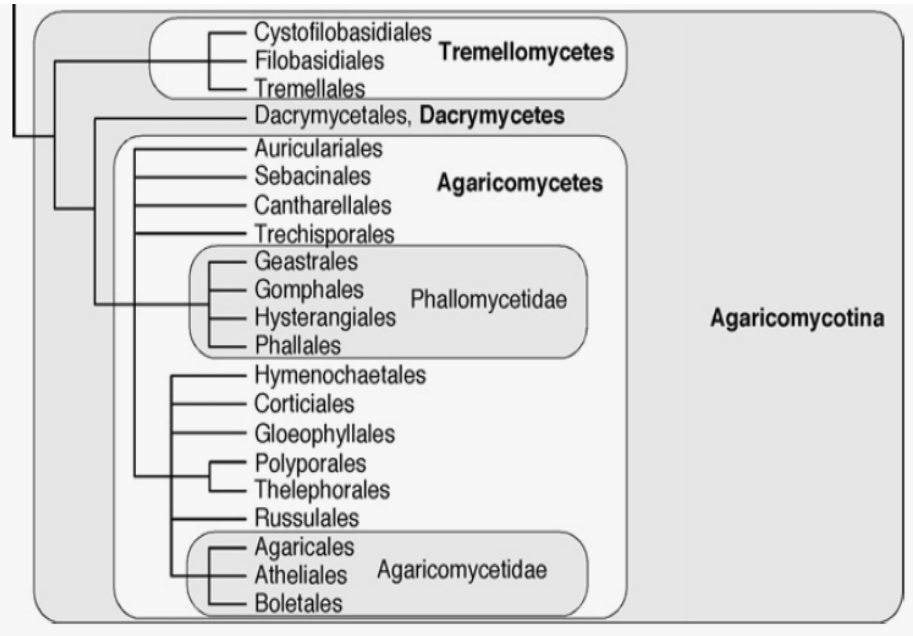


Fig. 3. Phylogeny and classification of Fungi. *Agaricomycotina*. Source: Hibbett *et al.* (2007).

The Hymenochaetales were proposed by Oberwinkler in 1977. Macro- and micromorphological characteristics of this order are exceedingly variable. It includes taxa with different types of hymenophore (corticoid, hydnoid or poroid) and basidiomata (resupinate, pileate or stipitate), all causing wood white rot (though Coltricia / Coltriciella potentially also are symbiotic cf. 1.4), and whose main characters are xantochroic reaction, the simple-septate in generative hyphae and the frequent occurrence of setae. However, Parmasto and Parmasto in 1979 indicated that a xanthochroic reaction is not specific for Hymenochaetales. Hymenochaetales was later extended to include *Schizoporaceae* Jülich (that differs from *Hymenochaetaceae* Donk among other thaits in having basidiomata without xanthocroic reaction, and hyaline, variably clamped hyphae).

Larson *et al*. (2006) performed a molecular phylogeny for the Hymenochaetales supported the idea that the occurrence of dolipores with continuous parenthesomes and the possibility that this structure is a synapomorphy for Hymenochaetales have gained considerable interest.

Currently, the order comprises 48 genera and 610 species (Kirk *et al.* 2008).

Hymenochaetaceae, in the current delimitation (Ryvarden 2004), encompasses a group of white rotting fungi, whose basidiomata present permanent positive xantochromic reaction, yellow to brown tubes trama, generative hyphae with simple septum (absence of clamps), monomitic or dimitic hyphal system, and often occurring setoid structures (setae).

The generic circumscription in *Hymenochaetaceae sensu strito* is under constant change (Corner 1991). For instance, *Phellinus*, which comprises almost half of the total number of species of *Hymenochaetaceae*, as currently understood is more likely polyphyletic. Many "old" *Phellinus* species forming species complexes (Larsen and Cobb-poule 1990; Ryvarden 1991; Fischer 1996; Góes-Neto *et al*. 2001) were transferred to other genera. *Phellinus* is then reducing significatively and will result *in fine* in a morphologically homogeneous and phylogenetically monophyletic entity.

1.4. Ecological and economic importance of the group

Living as saprobes, parasites or symbionts, and being primarily decomposers, the fungi play fundamental roles in all ecosystems (Schmit and Mueller 2007).

Regarding their ability to decompose the wood components, the polyporoid basidiomycetes can be classified into two groups; the first group degrades mainly / primarily cellulose and hemicellulose, leaving much lignin residuals, are called brown rot fungi; the second group has the ability to degrade lignin and some cellulose, hemicellulose, leaving much of the cellulose fibers, and are called white rot fungi. Species of Hymenochaetaceae are mainly lignocellulolytic, able to secrete enzymes that degrade the components of vegetal cellular wall (cellulose, hemicellulose and lignin), obtaining the required nutrients to their development (Akhtar *et al*. 1997; Carlile *et al.* 2001; Jeong *et al*. 2005; Larsson *et al*. 2006).

Because most species of hymenochetoid fungi are wood-decayers, they may be at the origin of economic losses when parasiting tree species of economic value or degrading wood used in constructions and artifacts, (Gilbertson and Ryvaden 1986).

The cellulolytic enzymes produced by wood decaying fungi have been intensively studied, in order to being used *ex-situ* such as for instance in the bioremediation of industrial pollutants. A relevant aspect to be considered, regarding several species of *Hymenochaetaceae*, is their potential use in bioremediation of soils contaminated by toxic

industrial residues (Balan and Monteiro 2001; Novotný *et al*. 2001; Larsson *et al*. 2006). A good example of fungi used in bioremediation is *Phellinus pseudopunctatus* A. David and *Fuscoporia gilva* (Schwein.) T. Wagner & M. Fisch. (Balan and Monteiro 2001; Novotný *et al*. 2001).

On the other hand, being used since antiquity as food or in popular medicine, the fungi have today important role in drugs production. As from their secondary metabolites, they have revealed themselves as promising sources for obtainment of new components with antiviral, antifungic, antibiotic, antioxidant, antidiabetic properties, among others (Wang *et al*. 2004; Wang *et al.* 2013). Several fungal species belonging to *Phellinus s.l*., for example *P. igniarius* (L.) Quél., *P. hartigii* (Allesch. & Schnabl) Pat., *P. pini* (Brot.) A. Ames, *P. linteus* (Berk. & M.A. Curt.) Teng, *P. baumii* Pilát, *Fuscoporia gilva,* among others, produce larger amounts of exopolysaccharides (EPS), pharmacologically important due their remarkable biological activities, such as antitumor activity and elimination of free radicals (Song *et al*. 1995; Han 1999; Jeong *et al*. 2005).

1.5. Defining species in Fungi

> *"... It is really laughable to see what different ideas are prominent in various naturalists' minds when they speak of species; in some, resemblance is everything and descent of little weight in some, resemblance seems to go for nothing, and Creation the reigning idea. In some, descent is the key, in some, sterility an unfailing test, with others it is not worth a farthing. It all comes, I believe, from trying to define the indefinable..."* Darwin (1887), p. 88. ***Letter from Darwin to Hooker***, 24 December 1856.

Species concept, as most biologists understand today, root down to the 17th and 18th centuries, with the publication of Ray [1686, *Historia Plantarum: Species Hactenus Editas Aliasque Insuper Multas Noviter Inventas and Descriptas Complectens*], in which he considered that the adaptations of organisms were evidence of God's benevolence, and later on with work by Buffon [1749, *Histoire Naturelle, Génerale et Particulière, avec la Déscription du Cabinet du Roi*].

Darwin, in the 19th century, believed that the varieties were the first stage of speciation. As for the creationists, he considered the species were real entities created by the Creator, and varieties were local and temporary products of the nature. Thus, Darwin's theory transformed the species in an arbitrary invention of imagination of the taxonomists (Bowler 1989).

> *"...Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such populations..."* Mayr (1942).

According to Mayr (2001), the species is the primary unit of evolution and it is impossible to talk about evolution or about any aspect of biology, without having a clear understanding of the meaning of species.

Accurate species delimitations are important to understand factors driving diversification, and have implications for ecological and conservation studies (de Queiroz 2005). Controversies often occur because of the existence of different views towards the definition of species (Mayr 2001). Biologists, especially systematists, have been debated on species concepts for a very long time. The debate itself has had many nuances. Some systematists have only been interested in discriminating all the discrete, current taxonomic variations without any concern about the processes that might have produced these variations. Although their propensity to describe species has been belittled by some, without their efforts we would know far less about the diversity of the natural world (Cracraft 2000).

Species concepts have been reviewed many times in the past. In a review by Mayden (1997), 22 species concepts were listed from taxonomic literature. According to Hull (1997), Perkins (2000) and Richards (2010) these concepts can be arranged in three broad classes:

- Similarity between organisms (dealing with the phenotypes, morphology or physiology, behavior – e.g. occupation of distinct niches);

- Involving evolutionary processes (biological species – possibility of mating, reproductive isolation – evolutionary species);

- Phylogenetic or lineage based concepts.

All these concepts are usefull to delimit species, but also contain certain limitations in regards to a unified species concept. For example, the traditional concept stating that a species is defined by interbreeding individuals is inapplicable for asexual species.

The application of the species concept of within the Mycota presents several difficulties, because little is known about the magnitude of intrapopulational variability, the life cycles are varied and complex and the reproduction, in addition of being extremely complex, can affect evolutionary patterns in ways we do not yet understand (Petersen and Hughes 1999).

Until the middle of the 20th century, the Morphological Species Concept (MSC) was the basis for fungal classification. According to Wiens and Servedio (2000), although there is currently considerable interest in the use of DNA sequences to infer the limit a certain fungal species, most of them are still defined based on the presence of diagnostic morphological characters, and in comparison with herbarium specimens. Thus, from a strictly morphological point of view, a species in the Mycota is a group of organisms congruent in the macro- and micro-morphological characteristics of their reproductive structures.

Taylor *et al*. (2000) noted that with few exceptions, nearly 100.000 described fungi were diagnosed by morphological or other phenotypic traits (e.g. growth at different temperatures, production of secondary metabolites or the presence of pigments). The main advantage of MSC is that it has been widely used in the Mycota, and comparisons can be made between taxa. However, Hawksworth *et al.* (1995) argued that the disadvantage of MSC is that frequently the species recognized in this way comprise more than one species when diagnosed through other methods.

As far as Fungi are concerned, classical morphological characters were repeatedly shown to be insufficient to separate species; additional parameters have to be considered, including molecular phylogenetics, also known as molecular systematic, or ecological data, to reach in fine a more global species concept. Appropriate taxonomy of a group of organisms should reflect its phylogenetic relationships, based on correct inferences of its evolutionary history.

Quaedvlieg *et al*. (2014) reported that the Biological Species Concept (BSC) emphasizes reproductive isolation (Wright 1940; Mayr 1942); the Morphological Species

Concept (MSC) emphasizes morphological divergence; the Ecological Species Concept (ESC) emphasizes adaptation to a particular ecological niche (van Valen 1976); the Phylogenetic Species Concept (PSC) emphasizes nucleotide (non) divergence (Hennig 1966); the Genealogical Concordance Phylogenetic Species Recognition (GCPSR) (an adaptation of the PSC) uses the phylogenetic concordance of unlinked genes to indicate a lack of genetic exchange and thus, evolutionary independence of lineages (Taylor *et al.* 2000; de Queiroz 2007). Quaedvlieg *et al*. (2014) combined multiple complementary descriptors that would result in a "Consolidated Species Concept" (CSC).

With the introduction of phylogenetic studies, DNA-based the existence of cryptic, morphologically closely related species (Bickford *et al*. 2007) challenged the traditional concept of fungal species. Within the Basidiomycota, Hymenochaetaceae is one of the exemple of such shift in defining species (and generic) concepts (Decock *et al.* 2005; Decock *et al.* 2006; Amalfi *et al*. 2010; Campos-Santana *et al*. 2014). Several cases indicated that the diversity of species has been underestimated with traditional taxonomic characters and several new taxa have been recognized, in correlation with overlooked morphological (Baltazar *et al*. 2009; Baltazar *et al*. 2010; Raymundo *et al*. 2013; Valenzuela *et al*. 2013) or biogeographical (Decock and Stalpers 2006; Decock *et al*. 2007) characters.

In the genera *Fomitiporia, Phellinus*, *Phylloporia*..., the delimitation of species based on morphological characters seems to be relativety well supported by phylogenetic studies (e.g. Decock *et al*. 2006; Amalfi *el al*. 2010; Valenzuela *et al*. 2011).

It is possible that there will be an ideal and unique concept of species. However, the criteria for recognizing species can still be different in different groups. According to Hey (1997), to have significance as "species" does not simplify the process of specimen identification. Instead, this job has proven as difficult as measuring the genetic drift and, then, decide if the data contains evidence of partitions or not.

1.6. Knowledge on *Phellinus* Quélet – a historic summary

Phellinus s.l. is a large, diverse group containing various cryptic generic entities and species. Numerous morphological, anatomical, biological (*e.g*. nuclear behavior), biochemical (pigmentation composition) and ecological characters, pointed to the

heterogeneity of the genus (Dai 1995/ 1999; Fischer 1996; Wagner and Fischer 2002). Since the genus was created by Quélet in 1886, distinct taxonomic arrangements have been proposed in the attempt to solve problems of its delimitation.

According to Larsen and Cobb-Poulle (1990), Quélet (1886) described *Phellinus* to accommodate polyporoid, and pileate wood-inhabiting fungi species with, brown annual and perennial forms basidiomata. In addition Larsen and Cobb-Poulle (1990) included the following characters to describe the genus: resupinate to pileate basidiomata, the pileus sessile to stiptitate, annual to perennial, solitary to gregarious, often imbricate, corky to ligneous; upper surface pubescent to tomentose or finally glabrous, frequently with a thin black cuticle, usually concentrically grooved and radially cracked, rusty to dark brown; margin curved, obtuse to thin, sterile; hymenophore rusty brown to dull brown; 2-11 pores for millimeter; stratified tube layers in perennial forms and occasionally in annual forms; context thin to thick, zoned to no zoned, fibrous to ligneous, rusty brown to dull brown, often with intercalated black lines and generally with a thin upper black cuticle forming a crust; setal hyphae absent or present in trama, context or hymenium; hyphal system dimitic, trimitic or monomitic, clamps absent; skeletal hyphae rarely branched, usually thick walled and without septae, but frequently with adventitious septae; generative hyphae usually septate and thin walled, branched; binding hyphae rare, asseptate, thick walled; basidia hyaline, globose to clavate, bearing 2-4 sterigmata; basidiospores globose, subglobose, ellipsoid, cylindrical or oboclavate, hyaline to pigmented, yellow to brown, thin to thick walled, sometimes dextrinoid to cyanophilous in cotton blue, never amyloid. All structures become dark in 2% KOH.

Fiasson and Niemelä (1984) emphasized the difficulty to define *Phellinus*, because of the numerous characters shared with other genera. Ryvarden and Gilbertson (1994) recognized the genus with perennial basidiomata and a dimitic hyphal system. Wagner and Fischer (2001) questionned much of these features. The differentiation of generative to skeletal hyphae is not always as clear as it is in other polypores and the hyphal system may be clearly monomitic. Besides, several species inside the group are cited as annuals (Wagner and Fischer 2002).

More recently, Ryvarden (2004) presented a more restrictive description of the genus: perennial basidiomata, resupinate to pileate, solitary or imbricate with decurrent pore layers; pileus if present, yellow, rusty brown and gray to black, tomentose, hispid,

glabrous or deeply cracked. Pore surface brownish. Hyphal system dimitic, generative hyphae hyaline and with simple septum, skeletal hyphae yellow to rusty brown, most thick walled and larger than generative; hymenial and tramal setae present or absent; setoid hyphae absent or present in the margin, context or hymenium; basidiospores globose to cylindrical, smooth, hyaline to rusty brown; cosmopolitan genus.

Looking back at the history of *Phellinus*, the importance of Murrill's works (1907) has to be noticed. Murrill (1907) proposed several new genera such as *Fuscoporia*, *Fomitiporia* or *Fomitiporella*, among others, without considering *Phellinus*. Despite of the disagreement of various authors, who considered of weak taxonomic value the generic concepts developped by Murrill, recent works evidenced that some morphologically homogeneous and monophyletic groups of species were worth recognized at generic level, for which some of the genera described by Murrill could be used (Decock *et al*. 2005, 2007; Fiasson and Niemelä 1984; Bondártseva *et al*. 1992; Fischer 1996; Dai 1999; Wagner and Fischer 2001, 2002).

Larsen and Cobb-Poule, in 1990, provided a compilation of morphological data for all taxa described in *Phellinus* sensu Ryvarden and Gilbertson (1987), besides proposing synonyms, host relationships and geographical distribution. This resulted in the recognition of 154 species and 67 forms and varieties.

Another attempt to solve the taxonomic problems of the group was undertaken by Bondártseva *et al*. (1992). These authors combined morphological and biochemical data (chromatographic analysis of stirilpirones) of 35 *Phellinus* species from Cuba and proposed the transfer of 18 of them into various genera including *Fomitiporia*, *Fulvifomes*, *Fuscoporia* and *Phellinidium*. According to the authors (*op. cit*.), the denomination of *Phellinus* must be conserved, not only for those species which present features shared with the type species (*Polyporus igniarius* L.:Fr.), but also as a "temporary" repositary for those species that did not find an appropriate place inside limits of other genera.

Few years later, Fischer (1996) analyzing 23 *Phellinus* species inside well-known species complexes concluded that only *P. robustus* and associated species (*P. robustus* complex) appeared cleared delimited on the basis of nuclear behavior, DNA contents and sexuality. Accordingly, the author proposed that the species of this complex, namely *P. hartigii, P. robustus* and *P. punctatus* should be transferred into *Fomitiporia*. Another important contribution, using classical methods, was made by Dai in 1999, with

67 species of *Phellinus* from East Asia, transferring some of them to other more homogeneous genera, such as *Cyclomyces*, *Fomitiporia*, *Phellinidium* and *Pyrrhoderma.* However, since the remnants species still formed a heterogeneous group, the author suggested also treating some established species complexes already as subgenera instead of genera, waiting to gather more date for the still vast number of poorly known tropical species. In the work performed by Wagner and Fischer (2001), the authors reviewed 42 European species of *Hymenochaetales*; their results allowed recognizing five genera: *Phellinus*, *Fomitiporia*, *Fuscoporia*, *Phellinidium* and *Porodaedalea***.**

Afterwards Wagner and Fischer (2002), in a molecular study containing 99 species of *Hymenochaetales* from Europe, Asia, Oceania, Central and North America, reiterated the polyphyly of *Phellinus*. According to these authors (*op. cit.*), several clades were resolved representing natural groups, which are in accordance with most taxonomic concepts previously showed, based in European species (Fiasson and Niemelä 1984, Wagner and Fischer 2001). More recently, Jeong *et al*. (2005) concluded that more taxa should be studied, in order to create a complete and reliable conclusion about phylogeny of *Hymenochaetales*, and consequently of *Phellinus*.

1.7. Taxonomic diversity of *Phellinus* in Brazil

Brazilian mycology only obtained expression by sporadic works published in other countries, resulting from contribution of Europeans naturalists in their expeditions in South America (Fidalgo 1962). Most of these studies were summerized in the form of checklists based on literature and / or revision of herbarium specimens, such as those published for the Amazon region (Gomes-Silva and Gibertoni 2009a), the Cerrado biome (Gibertoni and Drechsler-Santos 2010), Mangrove (Baltazar *et al*. 2009), Atlantic Rain Forest (Baltazar and Gibertoni 2009) and Semiarid areas (Drechsler-Santos *et al.* 2009). In the Midwest region only three works were published, one with field studies in the Cerrado ecosystem (Sampaio 1916), another with the compilation of material collected in areas of the Amazon and Cerrado domains (M. Fidalgo 1968) and more recently an inventory of species that occur in the Pantanal Rio Negro (Bononi *et al*. 2008). In the northeast, taxonomic studies were developed in several States (Torrend 1940; Batista and Bezerra 1960; Maia 1960; Kimbrough *et al.* 1995; Maia *et al.* 1996, 2002; Góes-Neto 1999) and

both areas in the Atlantic Forest Domain (Cavalcanti 1976; Góes-Neto *et al*. 2000, 2003; Maia and Gibertoni 2002; Gibertoni and Cavalcanti 2003; Gibertoni *et al*. 2003, 2004a, b, c, 2007; Silva and Gibertoni 2006), as in semiarid (Góes-Neto 1996; Góes-Neto and Baseia 2006; Gusmão and Marques 2006; Gusmão *et al*. 2006; Drechsler-Santos *et al*. 2008d, 2010). In the north, all the studies were developed in the Amazonian areas (Capelari and Maziero 1988; Bononi 1992; Jesus 1996; Campos *et al*. 2005; Gomes-Silva and Gibertoni 2009b; Gomes-Silva *et al*. 2009, 2010). In the Southeast Region, most studies were conducted in areas of the Atlantic Forest (Fidalgo and M.Fidalgo 1957; Fidalgo *et al*. 1960; Bononi 1979a, b, c, 1984b; Bononi *et al*. 1981; Almeida Filho *et al.* 1993; Jesus 1993; Gugliotta and Capelari 1995; Capelari *et al*. 1998; Gugliotta and Bononi 1999; Vital *et al.* 2000; Louza and Gugliotta 2007; Leal and Gugliotta 2008; Abraham *et al*. 2009), with some in areas of the Cerrado Domain (Fidalgo *et al*. 1965).

In addition of the above mentioned works, developed by Brazilian researchers, others were developed by foreigners such as Hjortstam (2000, 2007), Hjortstam and Ryvarden (1982, 1993, 2005a, b, 2007), Ryvarden (2004).

According to Fidalgo (1968), in the beginnings of the 20th century, the pioneer works of Johann Rick with polyporoid fungi, of Theissen in 1911, also with polyporoid fungi and ascomycetes, and of Torrend (1915), dedicated to myxomycetes and polyporoid studies, contributed to the advance of knowledge of mycobiota from Rio Grande do Sul State. The taxonomic studies of macrofungi performed by Brazilian scientists started only in 1969, with the works of Profª Maria Henriqueta Homrich, about gasteromycetes diversity (Silveira *et al*. 2006).

Regarding the Santa Catarina State, the study of fungal diversity started in 1815 with Alberto de Chamisso. The field works in the State were carried out in 1883 by Ernest Henrich Ule, and later on, in 1890, expeditions were undertaken by Friederich Alfred Gustav Jobst Möller. The collections resulting from these field works were studied and published by several foreign authors, such as Pazschke in 1892, Hennings in 1897, Bresadola in 1896 and Theissen (1911). Reitz (1949) cited 54 herbarium specimens collected by Rick from Itapiranga. However, there is no other record in literature (Loguercio-Leite 1990).

According to Groposo and Loguercio-Leite (2005), the fungal diversity of Santa Catarina started to be studied for Brazilian mycologist in 1986, with Loguercio-Leite, and

the creation of a research group at “Laboratório de Micologia” from “Universidade Federal de Santa Catarina” - UFSC. Nevertheless, there are records at Herbarium FLOR-UFSC of periodic collections, especially of xylophilous agaricomycetes (polyporoid) since 1983 by members of “Laboratório de Micologia”.

In Paraná State, the fungal studies initiated with field works undertaken by Meijer, in the end of the decade of 70 (Rajchenberg and Meijer 1990).

Several works, dealing with Fungi in Paraná (Rajchenberg and Meijer 1990; Ryvarden and Meijer 2002; Meijer 2006), Santa Catarina (Loguercio-Leite 1990; Willerding and Loguercio-Leite 1994; Loguercio-Leite and Wright 1995; Gerber and Loguercio-Leite 1997/ 2000; Gonçalves and Loguercio-Leite 2001; Groposo 2002; Furlani and Loguercio-Leite 2005; Loguercio-Leite *et al.* 2008; Campos-Santana and Loguercio-Leite 2008; Drechsler-Santos *et al*. 2008 a, b; Trierveiler-Pereira 2008; Baltazar *et al.* 2009; Baltazar *et al*. 2010; Gerlach *et al*. 2013; Borba-Silva *et al*. 2013), and Rio Grande do Sul (Souza 1977; Job 1990; Silveira and Guerrero 1991; Azevedo and Guerrero 1993; Coelho 1994; Coelho and Wright 1996; Groposo and Loguercio-Leite 2002; Reck and Silveira 2008; Coelho *et al*. 2009) present descriptions of *Phellinus* species and other related genera, such as: *Aurificaria*, *Cyclomyces*, *Dichochaete*, *Fuscoporia*, *Fomitiporia*, *Hydnochaete*, *Hymenochaete*, *Inonotus* and *Phylloporia*.

In Brazil, 1.730 species of basidiomycetes are known, and the Hymenochaetaceae family is represented by 22 genera and 136 species (List of Species of Flora of Brazil 2012).

According to the above cited literature and data from Groposo *et al*. (2007), Baltazar and Gibertoni (2009) and the Lista de Espécies da Flora do Brasil (2012), 56 *Phellinus* species are recorded from Brazil of which 48 are cited from Southern Brazil (Table 2). This represents 26.7 % of total diversity of *Phellinus* species, according to data presented by Kirk *et al*. (2008) that point out the existence wordlwide of 180 species. The online catalogue of fungal names, index fungorum (www.indexfungorum.org), cites 468 names given to taxa included in *Phellinus*.

TABLE 2. *Phellinus s.l.* species from Southern Brazil.

SPECIES	RS	SC	PR
P. allardii (Bres.) S. Ahmad		X	
P. apiahynus (Speg.) Rajchenb. & J. E. Wright	X	X	X
P. bambusarum (Rick) M. J. Larsen	X	X	X
P. bambusinus (Pat.) Pat.	X	X	
P. calcitratus (Berk. & M. A. Curtis) Ryvarden	X		
P. callimorphus (Lév.) Ryvarden		X	X
P. caryophylleus (Cooke) Ryvarden [Rick (1960), as *Polyporus caryophylleus* (Cooke) Lloyd]	X		
P. cesatii (Bres.) Ryvarden		X	
P. contiguus (Pers.) Pat. [Rick (1960) for RS, as *Hexagonia dubiosa* Rick]	X	X	
P. dependens (Murrill) Ryvarden [Rick (1960), as *Fomes dependens* (Murrill) Sacc. & Trotter]	X		
P. disciples (Berk.) Ryvarden [Rick (1960), as *Polystictus discipes* Berk.]	X		
P. everhartii (Ellis & Galloway) A. Ames	X		
P. fastuosus (Lév.) S. Ahmad	X		X
P. ferreus (Pers.) Bourdout & Galzin	X	X	
P. ferrugineovelutinus (Henn.) Ryvarden	X		
P. ferruginosus (Schrad.) Pat. [Loguercio-Leite *et al*., 2008b for SC, as *Fuscoporia ferruginosa* (Schrad.) Murrill]	X	X	
P. flavomarginatus (Murrill) Ryvarden		X	X
P. gilvus (Schwein.) Pat.	X	X	X
P. glaucescens (Petch) Ryvarden		X	
P. grenadensis (Murril) Ryvarden	X	X	X
P. linteus (Berk. & M. A. Curtis) Teng.		X	X

P. maxonii (Murril) D. A. Reid			X
P. melonodermus (Pat.) M. Fidalgo		X	
P. merrillii (Murrill) Ryvarden [as *Fomitiporella merrillii* (Murrill) Teixeira]			X
P. nilgheriensis (Mont.) G. Cunn.	X		
P. palmicola (Berk. & M. A. Curtis) Ryvarden [Rick (1960), as *Poria palmicola* (Berk. & M. A. Curtis) Cooke]	X		
P. pectinatus (Klotzsch) Quél. [Theissen (1911) for RS, as *Fomes haskarlii* (Lév.) Bres and for SC, as *Fomes pectinatus* (Klotzsch) Gillet]	X	X	X
P. portoricensis (Overh.) O. Fidalgo	X	X	
P. pseudopunctatus A. David *et al*.	X		
P. pullus (Mont. & Berk.) Ryvarden		X	
P. punctatiformis (Murrill) Ryvarden	X	X	
P. punctatus (Fr.) Pilát	X	X	X
P. rhabarbarinus (Berk.) G. Cunn.	X	X	
P. rickii Teixeira	X		
P. rimosus (Berk.) Pilát	X		
P. robustus (P. Karst.) Bourdot & Galzin	X	X	
P. sancti-georgii (Pat.) Ryvarden			X
P. sarcites (Fr.) Ryvarden		X	
P. senex (Nees & Mont.) Imazeki [Loguercio-Leite *et al*. (1990) as *Fomes senex* (Nees & Mont.) Cooke		X	X
P. spinescens J. E. Wrigth & G. Coelho	X		
P. tabaquilio Urcelay, Robledo & Rajchenb.			X
P. tricolor (Bres.) Kotl.	X		
P. tropicalis M. J. Larsen & Lombard	X		X
P. umbrinellus (Bres.) S. Herrera & Bondartseva	X	X	X
P. undulatus (Murrill) Ryvarden		X	
P. vaninii Ljub.	X		

P. viticola (Schwein.) Donk [Rick (1960) for RS, as *Trametes isabellina* Fr.]	X		
P. wahlbergii (Fr.) D. A. Reid	X	X	X
TOTAL	**33**	**26**	**18**

*RS (State Rio Grande do Sul); SC (State Santa Catarina); PR (State Paraná)

Regarding the knowledge of micodiversity in the neighboring countries, the situation is very variable. In Argentina, the study of polypores has a long tradition starting from the early works of Spegazzini in the last decades of 19th century (Spegazzini 1880; Rajchenberg and Wright 1987, 1998), followed by those from Wright and Deschamps (1972, 1975, 1977), Rajchenberg (1984, 2006), Popoff (2000) and, more recently, Robledo (2009) and Robledo and Urcelay (2009), only to mention a brief resumé of publications. Nevertheless, most of the published work has focused on their morphology, taxonomy and biology. Based on the works of Wright and Blumenfled (1984), Wright and Wright (2005) and Rajchenberg and Robledo (2013) in remnants of Argentina Atlantic Forest, thirty-six species of *Phellinus s.l.* were recorded.

In Uruguay, there are few data on macrofungi. Most of the published works (e.g. Heuhs *et al*. 1994, Sequeira and Tálice 2004, Piaggio 2008) too have focused on their morphology.

2. OBJECTIVES

2.1. General objective

The general objective of this work was to provide a comprehensive, modern taxonomic treatment of *Phellinus s.l.* in the Southern Brazil and neighboring Neotropical zone, through a morphological and molecular approach.

2.2. Specific objectives

- To increase the knowledge on *Phellinus s.l.* diversity in Southern Brazil, implementing a more integrated species concept;
- To provide tools for identification of species occurring in the studied areas such as dichotomic keys, descriptions and illustrations; reference DNA sequences;
- To infer the phylogenetic relationships of several alliances of species of *Phellinus s.s.* and several segregated genera (*Fomitiporia*, *Fuscoporia* and *Phylloporia*) with the congeneric species from other biogeographical domains in South America or other continents;
- To raise questions about the species concepts in some complex groups, as *Phellinus s.s.*, *Fomitiporia*, *Fuscoporia* and *Phylloporia*, confronting the traditional morphological concepts with other such as molecular, DNA-based phylogenetic concepts, and including other data such as ecology;
- To propose broader concepts, including ecological and biogeographical data;
- To the ICN herbarium collection with the deposited of increase the fungal collection the collected specimens;
- To develop the local culture collection by obtaining pure cultures of the different species and storage at UFRGS (Universidade Federal do Rio Grande do Sul, Brazil) and MUCL (Mycothèque de l'Université catholique de Louvain, Belgium).

3. MATERIAL AND METHODS

3.1. Area of Study

The studied area i was the Southern Region of Brazil, that includes the States of Paraná (PR), Santa Catarina (SC) and Rio Grande do Sul (RS) called South Region. The region presents a terrestrial area of about 576.409 km^2. It is limited to the northwest and north by the States of Mato Grosso do Sul and São Paulo and to the south by Uruguay, to the west by Argentina and Paraguay, and and at east by the Atlantic Ocean.

Following the climatic classification of Köppen (Figure 4), according Peel *et al*. (2007), the region has humid subtropical climate with mild summers (Cfa). In that sense, four seasons are well defined although the rains, in general, are evenly distributed through the year. The exception is the Meridional Plateau which has humid subtropical climates with hot summers (Cfb) (local forests are dominated by *Araucaria angustifolia*).

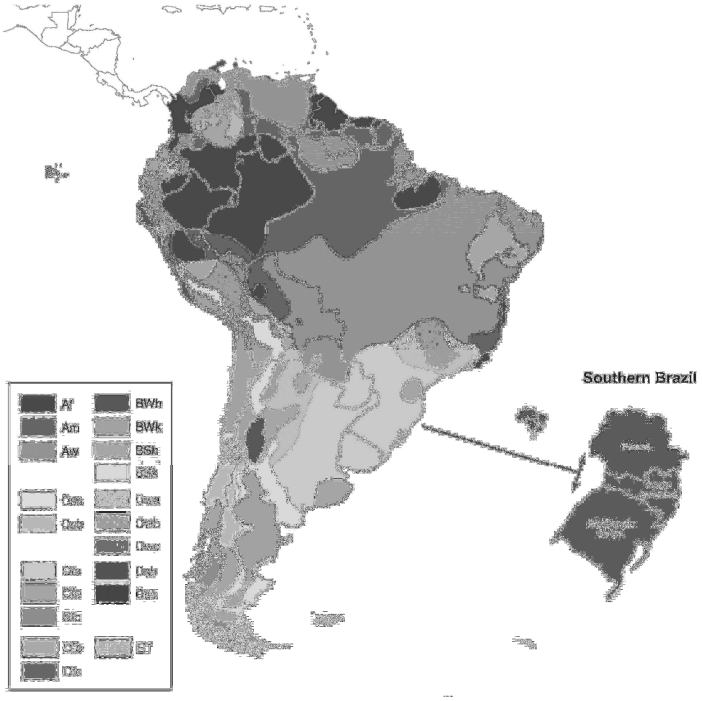


Fig. 4. Koppen-Geiger climate type of South America. Source: Peel *et al*. (2007).

Among the six Brazilian terrestrial biomes, two are predominant in the Southern Region: the Atlantic Forest and Southern Fields or Pampa. According to Leite (2002) and IBGE (2013), among the main phytophysionomies present at the region (Figure 5), the

following ecosystems were surveyed: Tropical Forest, Subtropical Seasonal Forest, Subtropical Mixed Forest and Subtropical Highland Grasslands.

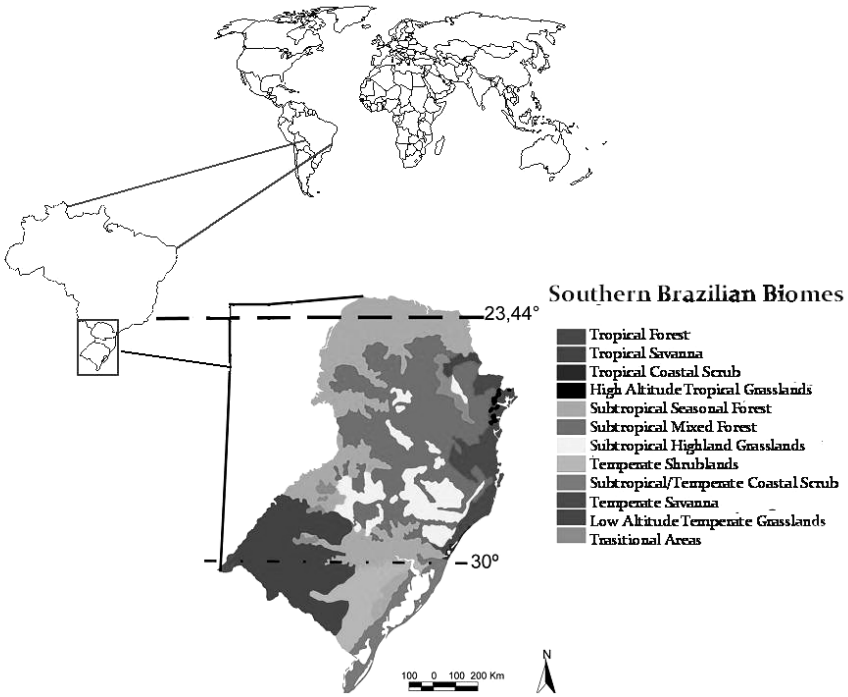


Fig. 5: Vegetal formations from Brazilian South Region. Source: Iganci *et al*. 2011 (modified).

3.2. Field Works

Forty-nine field works were carried out, privileging well preserved areas or Conservation Units. The specimens were collected from March 2010 to April 2013. The visited locations are listed as follows:

TABLE 3.: Localities where collections were performed and number of specimens collected.

State	Locality	Geographical Coordinates Approx.	Nº of Specimens Collected
PR	Antonina	25°25'44" S/48°42'43" W	-
PR	Céu Azul, Parque Nacional do Iguaçu	25°08'38" S/53°48'42" W	011

PR	Foz do Iguaçu, Parque Nacional do Iguaçu	25°22'24" S/54°02'33" W	038
PR	Guaraqueçaba	25°18'25" S/48°19'44" W	002
PR	Matinhos, APA Guaratuba	25°52'58" S/48°34'30" W	026
PR	Morretes, Estrada da Graciosa	25°28'37" S/48°50'02" W	003
PR	Piraquara, Morro do Canal	25°30'55" S/48°58'53" W	018
SC	Florianópolis, Morro da Lagoa	27°33'38" S/48°27'13" W	017
SC	Florianópolis, Unidade de Conservação Ambiental Desterro (UCAD)	27°31'26,4"S/48°30'31,7"W	014
SC	Itapuá, RPPN Volta Velha	26°07'01" S/48°36'58"W	038
SC	Joinville, Morro da Caixa d'água	26°18'14" S / 8°50'45"W	034
SC	Joinville, Vale do Piraí	26°18'13" S / 48°50'44" W	012
SC	Mondaí, Linha Sanga Forte	27°06'10" S / 53°24'07" W	015
SC	Mondaí, Linha Uruguai	27°06'10" S / 53°24'07" W	005
SC	São Francisco do Sul	26°14'36" S / 48°38'17" W	002
RS	Caçapava o Sul, Pedra do Segredo	30°30'43" S / 53°29'27" W	068
RS	Derrubadas, Parque Estadual do Turvo	27°08'44" S / 53°53'10"W	036
RS	Dom Pedro de Alcântara, RPPN from Professor Luis Batista	29°22'08" S / 49°51'00" W	039
RS	Guaíba, Fazenda São Maximiano	30°10'52" S / 51°22'53" W	013
RS	Morrinhos do Sul, Morro da Perdida	29°21'54" S / 49°56'05" W	012
RS	Porto Alegre, Morro Santana	30°03' S / 51°07' W	031
RS	Riozinho	29°38'28" S / 50°27'09" W	015
RS	Santa Maria, Morro da Caturrita	30°00'15" S - 53°47'54" S / 29°41'33" W - 54°07'39" W	012
RS	Santa Maria, Morro do Elefante	30°00'15" S - 53°47'54" S / 29°41'33" W - 54°07'39" W	011
RS	São Francisco de Paula, Centro de Pesquisas e Conservação da Natureza, PRÓ-MATA – PUC	29°27' S - 29°35' S / 50°15'W	012
RS	São Francisco de Paula, Floresta	29°25'22,4" S / 50°23'11,2" W	074

	Nacional de São Francisco de Paula (FLONA-SFP)		
RS	São Francisco de Paula, Hotel Veraneio Hampel	29°26'52" S / 50°35'02" W	013
RS	Viamão, Parque Estadual de Itapuã	30°27'S – 30°20' S/51°03' W – 50°50' W	025
RS	Viamão, Parque Saint' Hilaire	30°5' S / 51°5' W	009
TOTAL			**605**

3.2.1. Sampling and material preservation

The sampling procedures followed conventional techniques utilized for polyporoid fungi. By the picking moment, were noted the following data: place and date, collectors' name, collect number; besides specimens related characters (number of basidiomata, type of insertion) and substrate. Whenever possible, the basidiomata were photographed, still in their substrate, with a digital camera. Then, the materials were detached from substrate with the aid of a pocket knife or a machete.

Each specimen was packed, in an individual envelope or newspaper, in order to avoid basidiospores mixture (Guerrero and Homrich 1999). At the end of each field work, the specimens were placed in paper bags, and transported to Laboratory of Mycology at UFRGS.

In the laboratory, the basidiomata were maintained above the stand for at least 5 days, for drying. When robust, the basidiomata were dried at incubator containing lamp of 45ºC, during 3 to 5 days (Fidalgo and Bononi 1989), or in an electric food dehydrator (Fun Kitchen, Brazil), for 48h, at temperature up to 40ºC. Before inclusion at herbarium, the specimens were maintained in plastic bags and temporarily stored at freezer (about -6ºC). For deposit and incorporation at Herbarium ICN from Departamento de Botânica, Instituto de Biociências, Universidade Federal do Rio Grande do Sul, it was filled a spreadsheet with materials identification data, proceeding to labels and envelops production to specimens packing. Duplicates of some materials were sent to Herbarium MUCL.

3.3. Morphological characterization

3.3.1. Macromorphological analysis

The microscopic analyses were undertaken by naked eye, with the aid of a magnifying glass or a stereoscopic microscope. The specimens were firstly analyzed at the field, being evaluated for the following elements: basidiomata (type of insertion in substrate, pileus form, consistence and dimensions), upper surface (aspect and color), and margin (aspect and color). In laboratory, with the aid of a stereoscopic microscope, it was observed the hymenial surface (form, color, form and number of pores by millimeter, and tubes length) and context (color, thickness and aspect). The measures were obtained with a millimeter ruler. The color of pileus upper and bottom surface, of tubes and context were defined using the color cards of Kornerup and Wanscher (1963) and Munsell (1975) as references. All changes in macroscopic features after material drying were annotated.

3.3.2. Micromorphological analysis

For microscopic observations, were made free hand sections from basidiome parts (context, hymenium), under stereoscopic microscope, with the aid of a steel blade. The sections were mounted between slide and cover slip for observation at optical microscope, with the following solutions:

-Aqueous solution of 1% phloxine (cytoplasmic dye) + 3% KOH (moisturizing), following methods described by Ryvarden (1991).

-Melzer's reagent (IKI), consisting of an iodine base, which is utilized to determine presence of polysaccharides constituents of walls microstructures (especially hyphae, basidiospores and cystidia) from basidiome. The results are designed as negative (absence of reaction) or positive: amyloid reaction (bluish) and/or dextrinoid reaction (reddish brown), according to Singer (1975).

-Cotton Blue (CB), for verification of cyanophilic reaction.

-Aqueous solution of 4% NaOH, to separate hyphae, facilitating the hyphal system analyses. In this analysis, the context and hymenophorous sections were treated for 24h and 72h at 60ºC.

As from these preparations (undertaken preferentially with fresh material), the following structures were analyzed, regarding their morphology, dimensions and coloration: hyphae (types), sterile elements (cystidia, cystidiole, and setae), basidioles, basidia and basidiospores. In each preparation, with the aid of an ocular micrometer, 30

measurements were undertaken for each structure. The statistic data for all measurements were carried out at Microsoft Excel®, and the abbreviations of these data are presented according to Coelho (2005): being, n=x/y (number of measured structures), x (number of measurements) e/y (number of basidiomata), L (length), W (width), Lm (length average), Wm (width average), Q (length/width quotient), Qm (Q average).

The nomenclature of basidiospores shape follows the proposed classifications by Stalpers (1978). The microscopic structures were illustrated with the aid of a light tube, with 1000x and 2000x magnification.

3.4. Mycological terms, scientific names and herbarium acronyms

In this work, the classification proposed by Kirk *et al*. (2008), following that suggested by Hibbett *et al*. (2007), is adopted. Scientific names, independently of their taxonomic category, are italicized. The author names of genera and species were cited following the base data MycoBank (http://www.mycobank.org) and the herbarium acronyms are according to Thiers (http://sweetgum.nybg.org/ih/), continuously updated.

3.5. Revision of herbaria and type studies

In order to enhance the knowledge about occurrence and group distribution, besides comparison and confirmation of identifications, the deposited material at national and international herbaria were analyzed. The herbaria whose collections were loaned are cited bellow:

- ICN: Instituto de Biociências, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil;
- PACA: Instituto Anchietano de Pesquisas, UNISINOS, São Leopoldo, RS, Brazil;
- FLOR: Departamento de Botânica, Universidade Federal de Santa Catarina, SC, Brazil;
- LPS: Instituto de Botânica Carlos Spegazzini, Museo de La Plata, Universidad Nacional de La Plata, Buenos Aires, Argentina;

- BAFC: Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales,Universidad de Buenos Aires, Buenos Aires, Argentina;
- CORD: Facultad de Ciencias Exactas, Físicas y Naturales, Museo Botánico, Universidad Nacional de Córdoba, Córdoba, Argentina;
- NY: New York Botanical Garden, New York;
- MUCL: Mycothèque, Earth and Life Institute, Université catholique de Louvain, Louvain-La-Neuve, Belgium.

3.6. Identification

As from macro and microscopic analysis, all the specimens collected were identified to species, following mainly the works of Ryvarden and Johansen (1980), Gilbertson and Ryvarden (1986/ 1987), Dai (1999), Larssen and Cobb-Poule (1990), Fiasson and Niemelä (1984), Wagner and Fischer (2001/ 2002) and Ryvarden (2004).

3.7. Isolation and culture

Polypores cultures of collected species were obtained in order to get material for molecular studies. In this way, the procedures were followed as bellow.

3.7.1. Culture medium

It was used Malt Extract Agar (MEA), complemented with antibiotic (Cloranfenicol) and antimycotic (Benomyl), previously sterilized in autoclave (120° C, for 20 minutes) with the following composition:

- Distilled water. .....500 ml
- Agar.....10 g
- Malt Extract.....6 g
- Antibiotic (cloranfenicol).....0.025 g
- Antimycotic (benomyl 2ppm) (0.1 g/10ml).....0.1 ml

3.7.2. Obtainment of polisporic cultures

For polisporic cultures obtainment (to achieve polisporic cultures), the basidiome or part of it, were placed in moist chamber, over sterilized slides, with hymenophore facedown, obtaining this way, the spores' deposition. After, the basidiospores were inoculated in Petri dishes with MEA medium. These dishes were incubated at 25 ºC, in complete darkness, for spores' germination. After mycelium development, the cultures were subcultured to test-tubes containing MEA medium, capped with cotton and recovered with aluminum sheets or kitchen film, in order to avoid contaminations, and incubated at 25ºC.

In incubator, under the above referred conditions, the tubes were maintained until mycelium growth. Afterwards, the tubes were stocked in refrigerator at 4 ºC, for posterior use.

For obtaining the cultures, were also used little cubes, of about $1mm^3$ from the most inner part of context or hymenophore of fresh basidiome. These little portions were putted directly on Petri dishes with MEA medium. The procedures were similar to those previously described for polisporic cultures. All procedures were performed in laminar flow cabinet, in order to reduce contamination chances.

3.8. Phylogenetic studies based on molecular data

The molecular studies were performed at Earth and Life Institute (ELI-ELIM) of Université catholique de Louvain (UCL), Belgian. For molecular studies, were used both samples collected in South Brazil, as those available at MUCL.

3.8.1. DNA extraction

DNA was preferentially extracted from polisporic cultures or from those obtained from inner parts of basidiome context, following Lee and Taylor (1990) protocol, modified for Binder and Hibbett (2003). In the impossibility of cultures obtainment, the DNA was extracted from little portions of dry basidiome, preserved in silica gel or directly from herbarium material.

The cultures were inoculated in Erlenmeyer bottles, containing 100 ml of sterile liquid medium (malt extract 2%), and maintained in beater for about 10 days, at 25 ºC.

After the incubation period and with the fungal growth in submerged culture, were used biomass pieces for DNA extraction. When basidiome portions were used, these were macerated with a sterile steel blade, placed in Eppendorf tubes and submerged in *Lysis buffer* for about two weeks, and subsequently submitted to extraction protocol.

The extraction procedure followed the innuPREP Plant DNA kit protocol for DNA extraction (www.analytik-jena.de), that discuss, basically, with homogenization of biologic material, followed by cellular and lysis using proteinase K and buffer solution Sodium Lauryl Sulfate – SLS (detergent), on pre-filtration, RNA digestion through a RNAse treatment, DNA fixation with buffer solution "*Binding solution*" (SBS), DNA membrane fixed washing with buffer solution "*High Salt*" (HS) and "*Washing solution*" (MS) containing ethylic alcohol, and DNA ebullition with biomol water.

3.8.2. DNA concentration in samples

The DNA samples obtained in laboratory were evaluated regarding its concentration in spectrophotometer, being considered 10µm/ml as optimal concentration for amplification performance.

The determination and visualization of DNA amounts present in samples were undertaken in 1% agarose gel electrophoresis.

3.8.3. Amplification

A small amount of purified DNA was used for sample amplifications, through "Polimerase Chain Reaction" (PCR). The amplification procedure consisted basically on adding 5 µL of DNA solution in 20 µL of reagents *mix*. For *mix* preparation were added 0.75 µL of each specific primer, 10 µL of TaqPolimerase and 8.5 µL of ultra pure H_2O. The solution in which the reaction occurred (*mix PCR GOTAQ COLORLESS*) was prepared in ice bath and placed in sterile plastic micro tubes. The PCR reactions were performed in thermocycler, with specific programs to amplification, with the synthesis of new DNA strands. Negative controls (without DNA samples) were included to detect contamination in reagents. Each PCR cycle presented three fundamental stages, which were: denaturation, hybridization and elongation.

The amplified regions and the primers utilized in this work were:

- "*internal transcribed spacer*" ITS (ITS1, 5.8S, ITS2) – non codifying region, containing approximately 560bp.

- "*nuclear ribosomal large subunit rRNA gene*" 28S (LSU) – containing approximately 1300bp.

- *rpb2* – well conserved and codifying region, located in the second larger proteic subunit RNA polymerase II, contains a variable region, between the conserved 6 and 7 domains, which can be useful for fungi phylogeny in lower taxonomic levels (Liu *et al*. 1999). It has approximately 780bp.

- "*translation elongation factor 1α*" *(tef1-a – housekeeping-gene)* – region that codifies the 1 alpha elongation factor. It has approximately 1640bp.

The primers used in this study were: ITS1, ITS2, ITS3, ITS4 (http://biology.duke.edu/fungi/mycolab/primers.htm) for ITS; bRPB2–6F/bRPB2-7 1R (Matheny 2005) for *rpb2*; 2212R, 1953R, 983F and 2218R (Rehner and Buckley 2005; Matheny *et al.* 2007) for *tef1-α* e LR0R, LR3, LR3R, LR5 for nuclear LSU http://biology.duke.edu/fungi/mycolab/primers.htm).

3.8.4. Utilization of agarose gel electrophoresis system for verification of PCR's

The PCR products were verified in 1% agarose gel.Were 5 µL of PCR products were added to 5µL of *loading buffer* and applied in the gel. The voltage and time were established to allow the ideal samples separation. The parameters used for 1% agarose gel were: intensity of 200 mA, tension of 100 V and time of approximately 18 minutes. When the gel was visualized under ultraviolet, the unique and homogeneous bands were identified as positive results (Figura 7).

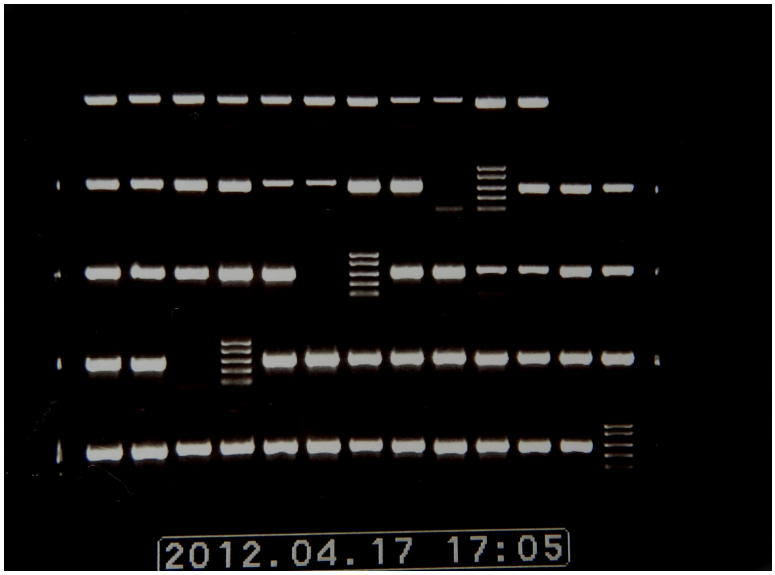


Fig. 6. Visualization of PCR products from regions ITS, LSU, *tef1-α* and *rpb2* in ultraviolet light.

3.8.5. Sequencing

The sequencing reactions were performed at Macrogen Inc., Korea. A specific protocol was followed, using the same primers of PCR reactions. After receiving the obtained sequences, these were corrected by naked eye through Sequencher 5.0 (genecodes.com) program, for exclusion of low resolution portions or ambiguous bases. BLAST searches were undertaken at GenBank (www.ncbi.nlm.nih.gov/blast/) to confront and analyze the sequenced fragments, and to search for additional sequences of interest species, for utilization at phylogenetic trees construction.

3.8.6. Edition and sequence alignment

After checked and edited one by one, the sequences of nucleotides were automatically aligned using Clustal X v2.0.11 (Tompson *et al.* 1997). It was also used alignments deposited at TreeBASE "http://purl.org/phylo/treebase/phylows/study/TB2:S12874" (Amalfi and Decock 2013), as a base for additional sequences alignments. The ambiguous regions and gaps were detected using Gblocks 0.91b program (Castresana 2000; http://molevol.cmima.csic.es/castresana/Gblocks.html). Afterwards, a visual scanning was performed, to verify the presence of

other ambiguous regions. The alignment was also manually adjusted if required, with text editor in PAUP* (versão 4.0b10). All generated alignments and phylogenetic trees were deposited at TreeBASE bank (http://treebase.org/treebase-web/home.html). The access numbers for this information, when available, are provided at manuscripts of this work.

The indels (insertions and deletions) present, mainly at ITS region (Decock *et al*. 2007), were recodified as binaries characters with the simple indel codification method, implemented at SeqState software (Müller 2005). This method aims to maximize the phylogenetic information of aligned sequences or regions in which the main position of gaps in relation to other can be defined safelty, therefore, with an algorithm, the method can be applied to every pattern of insertions and deletions theoretically viable.

3.8.7. Phylogenetic analysis

As from alignment sequences and indels codification, it was possible to carry out the phylogenetic analysis individually for each gene and the combined analysis, with three different methods: Maximum Parsimony (MP) with PAUP* 4.0b10 (Swofford 2003), Bayesian Inference (BI) with MrBayes v3.1.2 and Maximum Likelihood (ML) with RAxML 7.0.4 (Stamatakis 2006). The program ModelTest 3.7 (Posada and Crandall 1998) was used for estimation of the best evolutive models for ITS, LSU, *tef1-α* e *rpb2*, based on Akaike Information Criterion (AIC).

Chapter I

Campos-Santana M., Decock C., Robledo G. and Silveira R.M. 2014.

A Synopsis of the poroid Hymenochaetaceae (Agaricomycetes, Basidiomycetes) in Southern Brazil.

[***Cryptogamie Mycologie***: submitted]

This article provides a commented synopsis of poroid Hymenochaetaceae species in Southern Brazil. Two new combinations (*Fomitiporia bambusarum* and *Fulvifomes rhytiphloeus*) are proposed; *Fomitiporia dryophyla*, *Fulvifomes durissimus* and *Phellinus lopezzi* are recorded for the first time from Brazil. New records from Paraná, Santa Catarina and Rio Grande do Sul are also presented. Keys to genera and species are provided.

A Synopsis of the poroid Hymenochaetaceae (Basidiomycota) in Southern Brazil

Marisa de CAMPOS SANTANA✉, Gerardo ROBLEDO [2], Cony DECOCK [3] & Rosa Mara SILVEIRA[1]

[1]*Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Botânica, Avenida Bento Gonçalves 9500, 91501-970, Porto Alegre, RS, Brazil.Corresponding author✉: marisacampossantana@gmail.com*

[2]*Instituto Multidisciplinario de Biología Vegetal, UniversidadNacional de Córdoba, C.C.495, 5000 Córdoba, Argentina*

[3]*Mycothèque de l'Université catholique de Louvain (MUCL, BCCM™), Earth and Life Institute – Microbiology (ELIM), Université catholique de Louvain, Croix du Sud 2 bte L7.05.06, B-1348 Louvain-la-Neuve, Belgium.*

Abstract – A synopsis of the current knowledge about the poroid Hymenochaetaceae from Southern Brazil (States Paraná, Santa Catarina and Rio Grande do Sul) is presented. Forty-two species belonging to nine genera are reported from the areas surveyed. An annotated, partly illustrated checklist and identification keys are provided. The new combinations *Fomitiporia bambusara* and *Fulvifomes rhytiphloeus* are also proposed.
Key words: Hymenochetales / Taxonomy / Neotropics / Atlantic Forest

INTRODUCTION

Hymenochaetaceae was formally described by Donk in 1948. It includes taxa whose basidiomata present permanent positive xantochroic reaction – dark discoloration in alkali –, yellow to brown tubes trama, simple septate generative hyphae, mono- to dimitic hyphal system, and variable occurrence of setoid structures such as hymenial or extra-hymenial setae or setal hyphae. The family encompasses a group of wood-decomposing causing white rot of wood (Holf *et al*. 2004).

Polypores have been continuously surveyed in Southern Brazil, mainly in the last two decades (Drechsler-Santos *et al*. 2008a, Campos-Santana and Loguercio-Leite 2008a 2010, Silveira *et al*. 2008, Baltazar and Gibertoni 2009, Campacci and Gugliotta 2009, Coelho *et al*. 2009, Meijer 2010, Westphalen *et al*. 2010, Gerlach *et al.* 2013). However, the poroid Hymenochaetaceae have been less addressed than other groups.

In this paper, we present a synopsis of the poroid Hymenochaetaceae species in Southern Brazil based on revision of herbarium material, newly collected material, and literature data.

MATERIALS AND METHODS

Original (INC) Brazilian materials were collected in the States of Paraná (PR), Santa Catarina (SC) and Rio Grande do Sul (RS), between 22º30'and 33º45'S / 48º02'and 57º40'W. The Southern Region of Brazil comprises 576,409.6 km^2 and the climate is tropical to subtropical. Two Biomes types, the Atlantic Forest and the Pampa, were surveyed.

Macro- and microscopical descriptions of the specimens followed Campos-Santana *et al*. (2013). Colors are described according to Kornerup and Wanscher (1981). To study the staining reaction of the basidiospores and hyphae, sections of the basidiomata were examined in Melzer's reagent, lactic acid cotton blue, and KOH 4%. All microscopic measurements were done in Melzer's reagent. In presenting the size range of several microscopic elements, 5% of the measurements at each end of the range are given in parentheses when relevant. The following abbreviations are used: ave = arithmetic mean/average, Q = the ratio of length/width of basidiospores, and ave_q = arithmetic mean of the ratio R. Voucher material was deposited at ICN.

RESULTS (TAXONOMY)

Key to the known genera of poroid Hymenochaetaceae

1'. Basidiomata stipitate, meso / pleuropodal.....***Phylloporia***

1'. Basidiomata sessile, resupinate to pileate 2

2. Basidiomata fully resupinate 3

2'. Basidiomata reflexed to pileate 6

3. Basidiospores dextrinoid ..... ***Fomitiporia***

3'. Basidiospores not dextrinoid 4

4. Basidiospores hyaline, thin- to slightly thick-walled; basidiospores print white; hymenial setae present, straights to lanceolate ..... ***Fuscoporia***

4'. Basidiospores yellow to brownish, thick-walled; basidiospores print cream to pale brown; hymenial setae absent or present then ventricose 5

5. Basidiomata cushion-shaped; setae present, ventricose; basidiospores yellowish; basidiospores print cream-colored ..... ***Phellinus***

5'. Basidiomata effused; setae absent; basidiospores brownish; basidiospores print brown .. .. ***Fomitiporella***

6. Basidiospores dextrinoid ..... ***Fomitiporia***

6'. Basidiospores not dextrinoid 7

7. Basidiospores hyaline to pale yellow in KOH; basidiospores print white to cream 8

7'. Basidiospores distinctly brown coloured (olivaceous, rust to dark brown); basidiospores print brown 10

8. Basidiospores yellowish, distinctly thick-walled; basidiospores print cream colored; setae ventricose ..... ***Phellinus***

8'. Basidiospores hyaline, thin- (to slightly thick-walled); basidiospores print white..... 9

9. Hyphal system dimitic; setae lanceolate..... ***Fuscoporia***

9'. Hyphal system monomitic; setae subulate ..... ***Cyclomyces***

10. Basidiospores olivaceous brown..... ***Aurificaria***

10'Basidiospores rust brown or darker..... 11

11. Setae (hymenial/extra-hymenial) present ..... ***Inonotus s.l.***

11'. Setae (hymenial/extra-hymenial) absent ..... ***Fulvifomes***

Aurificaria D.A. Reid, Kew Bull. 17(2): 278, 1963.

Aurificaria luteoumbrina (Romell) D.A. Reid, Kew Bull. 17: 279, 1963.

≡ *Phaeoporus luteoumbrinus* Romell, Bihang K. Svenska vet. akad. handlingar 26: 27, 1901.

Description: Ryvarden (2004).

Distribution in Southern Brazil: Santa Catarina (Gerber and Loguercio-Leite 2000, Drechsler-Santos *et al*. 2008).

Specimen examined: **BRAZIL**, **SANTA CATARINA**: Joinville, Bairro Paranaguamirim, 11/X/2010, *Campos-Santana 292* (ICN).

Other specimen examined: **ARGENTINA**, **CÓRDOBA**: Jujuy, Dpto. Ledesma, Parque Nacional Calilegua, Sendero Pedemontano, 01/IV/2008, *Robledo 1825* (CORD).

Remark: The species is characterized by pileate basidiomata, with dimidiate to flabelliform pilei, soft when fresh, drying rigid and curved, a monomitic hyphal system, hyaline to pale brown basidiospores, discoloring to olivaceous brown in KOH, and the lack of setae. The pileus surface has a hard cuticle.

Cyclomyces Fr., Linnaea 5: 512, 1830

Cyclomyces iodinus (Mont.) Pat., Essai taxonomique sur les familles et les genres des Hyménomycètes 98, 1900. Figs 1–2

≡ *Polyporus iodinus* Mont., Ann. Sci. Nat., Bot. 16: 108, 1841.

Description: Ryvarden (2004).

Distribution in Southern Brazil: Paraná (Ryvarden and Meijer 2002, Meijer 2006) and Santa Catarina (Loguercio-Leite and Wright 1991, Gerber 1996, Gonçalves and Loguercio-Leite 2001, Groposo and Loguercio-Leite 2005). First record from Rio Grande do Sul.

Specimens examined: **BRAZIL**, **PARANÁ**: Matinhos, APA Guaratuba, 13/XI/2010, *Campos-Santana 411* (ICN); Foz do Iguaçu, Parque Nacional do Iguaçu, Trilha do Poço Preto, 12/XII/2010, *Campos-Santana 467* (ICN); ibid., Trilha da Bananeira, 13/XII/2010, *Campos-Santana 480* (ICN); **SANTA CATARINA**: Itapuá, RPPN Volta Velha, 23/II/2011, *Campos-Santana 512* (ICN); ibid., *Campos-Santana 519* (ICN); **RIO GRANDE DO SUL**: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 26/III/2010, *Campos-Santana 38* (ICN).

Other specimen examined: **ARGENTINA**, **CATAMARCA**: Dpto. Paclín, Arroyo Los laureles, Robledo 1733 (CORD).

Remark: The species is distinguished by its dimidiate to flattened flabeliform pilei, with a tomentose and concentrically sulcate pileal surface and microscopically in having a monomitic hyphal system, abundant, straight hymenial setae and cylindrical to ellipsoid basidiospores, 4.0–4.5 × 2.0–2.5 µm (Ryvarden 2004).

Fomitiporella Murrill, North Am. Flora 9: 12, 1907.

Fomitiporella umbrinella (Bres.) Murrill, North Am. Flora 9(1): 13, 1907. Fig. 3

≡ *Poria umbrinella* Bres., Hedwigia 35: 282, 1896.

Description: Núñez and Ryvarden (2000), Ryvarden (2004).

Distribution in Southern Brazil: Paraná (Rajchenberg and Meijer 1990, Ryvarden and Meijer 2002, Meijer 2006); Santa Catarina (Loguercio-Leite 1990, as *Poria umbrinella*, Loguercio-Leite and Wright 1991a, 1995, Groposo and Loguercio-Leite 2005) and Rio Grande do Sul (Rick 1960, as *Poria umbrinella* Bres.).

Specimens examined: **BRAZIL**, **SANTA CATARINA**: Florianópolis, Morro da Lagoa da Conceição, 07/VIII/1987, *Loguercio-Leite & Jimena Furlani 12* (FLOR 10495); ibid., 06/X/2010, *Campos-Santana 259* (ICN); ibid., *Campos-Santana 263* (ICN); **RIO GRANDE DO SUL**: Dom Pedro de Alcântara, RPPN do professor Luis Baptista, *Campos-Santana 19* (ICN); ibid., *Campos-Santana 20* (ICN); São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 26/III/2010, *Campos-Santana 49* (ICN); ibid., 07/VI/2010, *Campos-Santana 186* (ICN); ibid., 22/05/2011, *Campos-Santana 571* (ICN); São Francisco de Paula, Hotel Veraneio Hampel, 27/III/2010, *Campos-Santana 56* (ICN); ibid., Santa Maria, Itaara, Parque Pinhal, 02/VIII/1991, *G. Coelho 3-1* (ICN 97803); São Leopoldo, 1940, *J. Rick 18720* (PACA 8674).

Remark: The species is characterized by a resupinate, effused and adnate basidiomata, with 8–9 pores / mm, and small, ellipsoid (with a flattened side), thick-walled, ochre brown to dark reddish brown basidiospores, 4.0–4.5(–5.0) × 3.0–3.5(–4.0) µm, and absence of setae.

Phylogenetic analysis (Wagner and Fischer 2002, Larsson *et al.* 2006) showed that *F. umbrinellus* clustered with other species with similar characters in an independent *Fomitiporella* clade, distant from the *Phellinus s.s.* clade and related to the genera

Phylloporia, *Inocutis and Fulvifomes*. *Fomitiporella*, *Fulvifomes* and *Phylloporia* have yellow to brown, ellipsoid basidiospores, with a flattened side and lack setae.

Fomitiporia Murrill, North Am. Flora 9: 7, 1907.

Key to *Fomitiporia* species

1. Basidiomata pileate 2
1'. Basidiomata resupinate, effused, cushion-shaped, or pseudopileate 3
   2. Pores 5–6/mm; pileus rimose with age; basidiospores 6.0–7.5 × 6.0–6.5 µm; basidiomata applanate to ungulate ..... ***Fomitiporia* sp**. (*F. robusta* complex)
   2'. Pores 7–10/mm; pileus not rimose; basidiospores 5.0–6.0 × 4.0–5.0 µm; basidiomata triquetrous ..... ***F. apiahyna s.l.***
3. Hymenial setae present 4
3'. Hymenial setae absent 5
   4. Hymenial setae slightly ventricose, apex acute; basidiospores 4.0–5.0 × 3.5–4.5µm; on bamboo ..... ***F. bambusarum***
   4'. Hymenial setae fusiform, slightly ventricose or lageniform, apex pointed to rounded; basidiospores 5.0–7.0(–7.5) × 4.5–7.0 µm; on other hosts .... ***F. neotropica***
5. Basidiomata cushion-shaped, pseudopileate; basidiospores (5.5–) 6.0–8.0(–8.5) × (5.0–5.7–7.3 (–7.5) µm ..... ***F. dryophila***
5'. Basidiomata resupinate, effused; basidiospores 5–7(–7.5) × 4.5–7 µm..... ***F. neotropica***

Fomitiporia apiahyna (Spegazzini) Robledo, Decock & Rajchenberg ***s.l.***, Mycologia 102(6): 1315, 2010. Fig. 4

≡ *Fomes apiahynus* Speg., Bol. Acad. Nac. Cien., Córdoba 11(4): 438, 1889.

Description: Loguercio-Leite and Wright (1995), Ryvarden (2004).

Distribution in Southern Brazil: Paraná (Rajchenberg and Meijer 1990, Meijer 2006) Santa Catarina (Loguercio-Leite and Wright 1991, 1995, Gerber 1996, Groposo and Loguercio-Leite 2002, Drechsler-Santos *et al*. 2008a); Rio Grande do Sul (Groposo and Loguercio-Leite 2002).

Specimens examined: **BRAZIL**, **PARANÁ**: Ponta Grossa, Parque Estadual de Vila Velha, 30/IV/1989, *A.de Méijer 1225* (BAFC 31979); **SANTA CATARINA**: Itapuá, RPPN Volta Velha, Trilha da Casa de Vidro, 24/IV/2013, *Campos-Santana 661* (ICN).

Other specimens examined: **ARGENTINA**, **MISSIONES**: Parque Nacional do Iguaçu, 27/X/1973, *Wright, Dechamps & Del* (BAFC 24382, Cult. 2626, holotype of *Phellinus elegans*); **BRAZIL**, **SÃO PAULO**: Apiaí, V/1888, *J.Puiggari 1438* (BAFC 24922, holotype of *Fomes apiahynus*).

Remark: The species concept used here follows Ryvarden (2004) and should be considered as *sensu lato* (or *sensu* Ryvarden 2004). However, as shown by Amalfi and Decock (2013), *F. apihayna sensu lato* (2004) encompasses more than one species; the *F. apiahyna* lineage comprises at least 4 distinct phylogenetic species in the Neotropics (Amalfi and Decock 2013). *Fomitiporia apiahyna s.l.* is characterized by pileate basidiomata, small triquetrous pileus the surface of which thinly sulcate, 7–10 pores / mm, lack of hymenial setae and globose to subglobose, thick-walled basidiospores 5–6 × 4–5 µm. Wright and Blumenfeld (1984) described this species as *Phellinus elegans*, with thin-walled basidiospores. In our materials, the basidiospores are typically thick-walled and dextrinoid, as previously described (Loguercio-Leite and Wright 1995, Ryvarden 2004).

Fomitiporia bambusarum (Rick) Campos-Santana & Decock **comb**. **nov.**

[Mycobank MB 809550] Figs 5–7

≡ *Poria bambusarum* Rick, Brotéria, Ci. Nat. 6: 146, 1937 (basionym).

≡ *Phellinus rickianus* J.E. Wright & J.R. Deschamps, Mycotaxon 21: 414, 1984.

Description: Larsen and Cobb-Poulle (1990).

Distribution in Southern Brazil: Paraná (Rajchenberg and Meijer 1990, Ryvarden and Meijer 2002, Meijer 2006); Santa Catarina (Gerber and Loguercio-Leite 2000, Drechsler-Santos *et al.* 2008, Loguercio-Leite *et al.* 2008b); Rio Grande do Sul (Coelho *et. al*. 2009).

Specimens examined: **BRAZIL**, **PARANÁ**: Piraquara, Morro do Canal, 12/XI/2010, *Campos-Santana 378* (ICN); ibid., *Campos-Santana 394* (ICN); ibid., *Campos-Santana 395* (ICN); **RIO GRANDE DO SUL**: Dom Pedro de Alcântara, RPPN do professor Luis Baptista, 12/III/2010, *Campos-Santana 2* (ICN); ibid., *Campos-Santana 14* (ICN); ibid., 13/VIII/2011, *Campos-Santana 630* (ICN); ibid., *Campos-Santana 633* (ICN); ibid.,

Campos-Santana 637 (ICN); ibid., Mourinhos do Sul, Lajeadinho, 13/III/2010, *Campos-Santana 26* (ICN); ibid., *Campos-Santana 28* (ICN); ibid., *Campos-Santana 29* (ICN); São Salvador, 1939 (*Fungi Rickiani* 13938, PACA, lectotype of *Poria bambusarum*); ibid., Santa Maria, Distrito de Boca do Monte, EPAGRO, 26/III/2003, leg. *G. Coelho382-7* (ICN 139047); ibid., 01/VI/2006, *G. Coelho*.

Other specimens examined: São Francisco de Paula, Potreiro Velho, Pró-Mata, Três Forquilhas trail, 10/VI/2005, *G. Coelho et al.*, (ICN139044, holotype of *Fomitiporia sanctichampagnatii* G. Coelho, R.M.Silveira & Rajchenb); ibid., 01/VI/2006, *G.Coelho et al*., (ICN 139201, *F. sanctichampagnatii*); ibid., (ICN 139202, *F. sanctichampagnatii*); Ibid., (ICN 139203, *F. sanctichampagnatii*).

Remark: the globose to subglobose, hyaline, and dextrinoid basidiospores clearly point toward *Fomitiporia*, as already noted by Coelho *et al*. (2009). For a more detailed discussion on this taxon see Rajchenberg (1987a), Rajchenberg (1987b), Larsen and Cobb-Poulle (1990), and Coelho *et al*. (2009).

Fomitiporia bambusara belongs to a bamboo-specific species complex, which includes *F. sanctichampagnatii*, *F. spinescens* and *Phellinus garuhapensis*. *Fomitiporia bambusara* and *F. sanctichampagnatii* are differentiated by their pore size, respectively (8–)9–11(–12)/mm and 2–5/mm; *Fomitiporia spinescens* is differentiated in having spinulated setae, whereas *P. garuhapensis* in having undextrinoid basidiospores (Coelho *et al*. 2009). A phylogenetic approach is desirable to solve the relationships within this complex.

Hjortstam and Ryvarden (1990) also revised the holotype of *Lopharia bambusae* and determined it as "cfr. *Phellinus punctatus* (Fr.) Pilát."

Fomitiporia dryophila Murrill, North Am. Flora 9(1): 8, 1907.

≡ *Poria dryophila* (Murrill) Sacc. & Trotter, Sylloge Fungorum 73: 11, 1948.

Description: Decock *et. al*. (2007), Raymundo *et al*. (2012).

Distribution in Southern Brazil: First record from Brazil.

Specimen examined: **BRAZIL**, **RIO GRANDE DO SUL**: São Francisco do Sul, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 07/VI/2010, *Campos-Santana 190* (ICN).

Remark: *Fomitiporia dryophila* is characterized by resupinate to pseudopileate basidiomata, developing a black pseudopileus, becoming rimose in aging, and by the lack of hymenial setae.

The taxonomic status of the species has been for a long time questioned (Lowe 1966). *Fomitiporia dryophila* was considered as a synonym of *Fomes robustus* (Lowe 1957) or of *F. punctata* (Lowe 1966, Fiasson and Niemelä 1984, Fischer 1996, 2002, Ryvarden 1985, 1991, Gilbertson and Ryvarden 1987). However, critical morphological analysis and phylogenetic studies recognized *F. dryophila* as a distinct species (Decock *et al*. 2007). Decock *et al*. (2007) separated this species from *F. punctata* by having a brighter pores surface and by forming a black and rimose pseudopileus. *Fomitiporia robusta* is distinguished by its true pileate basidiomata. *Fomitiporia langloissi* is a related species living sympatrically with *F. dryophyla* in Southeastern United States and Northeastern Mexico. It is distinguished by having effused resupinate basidiomata and smaller basidiospores [6.0–6.5(–7.0) × 5.0–6.5 µm].

Fomitiporia punctata was reported from Southern Brazil as *F. punctata* or *Phellinus punctatus* (Campos-Santana and Loguercio-Leite 2008, Ryvarden & Meijer 2002, Silveira and Guerrero 1991). However, very likely, *F. punctata* is restricted to the temperate areas of the Northern hemisphere and absent from the Neotropics. The voucher specimens of *F. punctata* in Southern Brazil should be revised and compared to *F. dryophila*.

Fomitiporia neotropica Campos-Santana, Amalfi, R.M. Silveira, Robledo & Decock, Mycol. Progr., 2014.

Description: Campos-Santana *et al*. (2013).

Distribution in Southern Brazil: Santa Catarina and Rio Grande do Sul (Campos-Santana *et al*. 2013).

Specimens examined: **BRAZIL**, **SANTA CATARINA**: Florianópolis, Unidade de Conservação Ambiental Desterro - UCAD, 02/X/2010, *Campos-Santana 253/10* (ICN 190599; culture ex-MUCL 54206); **RIO GRANDE DO SUL**: Itapuã, Parque Estadual de Itapuã, 16/X/2010, *Campos-Santana 319/10* (ICN 190600; culture ex-MUCL 54212); ibid., Morrinhos do Sul, Lajeadinho, 13/III/2010, *Campos-Santana 030/10* (ICN 190598;

culture ex-MUCL 54196); ibid., Porto Alegre, Refúgio da Vida Silvestre da UFRGS, approx, 16/VIII/2011, *Campos-Santana 644/11* (ICN 190601; culture ex-MUCL 54246).

Other specimens examined: **ARGENTINA**, **CORDOBA**: San Justo, Miramar, Mar Chiquita, 29/VII/2007, *Robledo 1713* (MUCL 49549; culture ex-MUCL 49549); ibid., Jujuy province, Parque Nacional Calilegua, Sendero La Junta, IV/2008, *M. Amalfi, AR 7508* (holotype, MUCL 51335; isotype NY, culture ex-holotype MUCL 51335, CBS); ibid., *M. Amalfi, AR* 7608 (MUCL 51336, culture ex- MUCL 51336). **FRENCH GUIANA**: Regina, Nouragues Natural Reserve, CNRS "inselberg" research plots, "grand Plateau", 04/VIII/2010, *C. Decock, FG-10-263* (MUCL 53114, culture ex-MUCL 53114); ibid., 21/VII/2013, *C. Decock, FG-13-789* (MUCL 55071, culture ex-MUCL 55071).

Remark: *Fomitiporia neotropica* was described from the Neotropics on the basis of collections originating from Argentina, Brazil and French Guiana (Campos-Santana *et al*. 2014). Hymenial setae are variably present in this taxon; most of the collections examined lack setae, which were only present in two collections from Argentina.

Fomitiporia maxonii Murrill has been reported from Southern Brazil (Ryvarden & Meijer (2002). The voucher specimens at the origin of these citations should be carefully revised; they might represent *F. neotropica*.

Fomitiporia sp. (***F. robusta*** (P. Karst.) Fiasson & Niemelä complex), Karstenia 24: 25, 1984. Fig. 8

≡ *Fomes robustus* P. Karst., Bidrag till Kännedom av Finlands Natur och Folk 48: 467, 1889.

Description: Larsen and Cobb-Poulle (1990), Ryvarden (2004).

Distribution in Southern Brazil: Rio Grande do Sul (Rick 1960, as *Fomes robustus* P. Karst.; Loguercio-Leite *et al*. 2008a); Santa Catarina (Loguercio-Leite *et al*. 2008a).

Specimens examined: **BRAZIL**, **SANTA CATARINA**: Florianópolis, Morro da Lagoa da Conceição, 27/V/2011, *Campos-Santana 596* (ICN); **RIO GRANDE DO SUL**: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 24/V/2010, *Campos-Santana 155* (ICN); ibid., *Campos-Santana 163* (ICN); ibid., 07/VI/2010, *Campos-Santana 172* (ICN); ibid., *Campos-Santana 187* (ICN); Viamão, Parque Estadual de Itapuã, 16/X/2010, *Campos-Santana 311* (ICN); Santa Maria,

Caturrita, Sítio Aldorino, 05/IV/1992, *G. Coelho 16-8* (ICN 97785, *Phellinus robustus*); São Leopoldo, 01/XII/1994, *J. Rick 22977* (PACA 7585).

Remark: Our collections are characterized by pileate, ungulate basidiomata, the pileus surface deeply concentrically furrowed and becoming rimose in aging, with radial cracks forming small cubic blocks, overall grayish to black. The macro- and micromorphological characters of our collections points towards *F. robusta sensu* Ryvarden (2004).

However, the concept of *F. robusta* used by Ryvarden (2004) should be considered as *sensu lato*. Phylogenetic analysis demonstrated that the *F. robusta* concept in North America (Gilbertson and Ryvarden 1987) encompassed several species, as for instance *F. bakeri* or *F. calkinsii* (Vlasák and Kout 2011). *Fomitiporia robusta s.s.* forms a species clade within a holarctic lineage, together with most of the species spanning over the north temperate area (Decock *et al*. 2007, Amalfi and Decock 2013). *Fomitiporia robusta s.s.* is more likely restricted to Eurasia (Amalfi *et al*. 2010, 2012, Amalfi and Decock 2013, Vlasák and Kout 2011), absent from North America and, *a fortiori*, from the Neotropics.

As it was not possible to obtain molecular data, the species was accepted as *Fomitiporia* sp.

Fulvifomes Murrill, Northern Polypores (5): 49, 1914.

Key to *Fulvifomes* species (basidiospores color are noted in KOH)

1. Basidiomata resupinate.....2
1'. Basidiomata pileate 3
2. Pores circular; basidiospores ellipsoid, yellowish brown, 3.0–4.0 × 2.5–3.0 µm .... ***F. membranaceus***
2'. Pores angular; basidiospores ovoid to ellipsoid, yellowish to pale golden brown, 4.0–5.0 × 3.0–3.5 µm..... ***F. melleoporus***
3. Pores 4–5/mm; pileal surface distinctly rimose with age..... ***F. rimosus***
3'. Pores 7–10/mm; pileal surface not rimose with age.....4
4. Context dark fulvous to reddish-brown, up to 6 mm thick..... ***F. merrillii***
4'. Context golden-brown or bright with a silky luster, up to 15 mm thick.....5
5. Basidiospores thin-walled, yellow brown…. ..... ***F. durissimus***
5'. Basidiospores thick-walled, golden to rusty brown 6

6. Context golden-brown to more cinnamon or ferruginous .....***F. fastuosus***

6'. Context golden-brown or bright with a silky luster, up to 15 mm thick .... ***F. rhytiphloeus***

Fulvifomes durissimus (Lloyd) Bondartseva & S. Herrera, Mikol. Fitopatol. 26(1): 13, 1992.

≡ *Fomes durissimus* Lloyd, Mycol. Writings 6(62): 943, 1920.

Description: Roy (1979), Herrera and Bondartseva (1985).

Distribution in Southern Brazil: This is the first record from Brazil.

Specimen examined: **BRAZIL**, **RIO GRANDE DO SUL**: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 08/XI/2010, *Campos-Santana 375* (ICN).

Remark: The species is characterized by applanate to ungulate basidiomata, the pileus surface concentrically furrowed, 7–10 pores/mm, lack of hymenial setae and setal hyphal, and subglobose, thin-walled, dark reddish brown (in KOH) basidiospores (Herrera and Bondartseva 1985).

Fulvifomes fastuosus (Lév.) Bondartseva & S. Herrera, Mikol. Fitopatol. 26(1): 13, 1992. Fig. 9

≡ *Polyporus fastuosus* Lév., Ann. Sci. Nat., Bot. 2: 190, 1844.

Description: Núñes and Ryvarden (2000).

Distribution in Southern Brazil: Paraná (Gerber and Loguercio-Leite 2000, Ryvarden & Meijer 2002, Meijer 2006, as *Fulvifomes fastuosus* (Lév.) Bondartseva & S. Herrera); Rio Grande do Sul (Teixeira 1950, Rick 1960, as *Fomes fastuosus* (Lév.) Cooke).

Specimens examined: **BRAZIL**, **PARANÁ**: Céu Azul, Trilha Manuel Gomes, 14/XII/2010, *Campos-Santana 483* (ICN); **RIO GRANDE DO SUL**: Santa Maria, Barragem Ibucuú-mirim, 12/XI/1991, *G. Coelho 4-2* (ICN 97699).

Remark: In our collection and the ICN – 97699, we noticed that this species have ungulate basidiome, with the pileus surface concentrically furrowed, 7–10 pores/mm, lack of setae,

and subglobose dark reddish brown (in KOH) basidiospores as noted by Núñez and Ryvarden (2000) and Ryvarden (2004).

Fulvifomes melleoporus (Murrill) Baltazar & Gibertoni, Mycotaxon 111: 205, 2010.

≡ *Fomitiporella melleopora* Murrill, North Am. Flora 9(1): 13, 1907.

Description: Larsen and Cobb-Poulle (1990), Ryvarden (2004).

Distribution in Southern Brazil: Rio Grande do Sul (Westphalen *et al*. 2010, as *Phellinus melleoporus*). First record from Paraná and Santa Catarina.

Specimens examined: **BRAZIL**, **RIO GRANDE DO SUL**: Viamão, Parque Estadual de Itapuã, 16/X/2010, *Campos-Santana 309* (ICN); ibid., *Campos-Santana 316* (ICN); Derrubadas, Parque Estadual do Turvo, 26/X/2010, *Campos-Santana 341* (ICN).

Remark: *Fulvifomes melleoporus* is characterized by a resupinate, effused basidiomata. The pore surface is golden brown, discoloring to dark purplish brown in older specimens, and the pores are angular, 5–7/mm. The basidiomata lack setae and the basidiospores are ellipsoid to subglobose, yellow to golden brown basidiospores, 3.0–5.0 × 3.0–4.0 µm. This is the first record for Paraná and Santa Catarina.

We follow here the taxonomic placement in *Fulvifomes* as proposed by Baltazar & Gibertoni (2010). However, the resupinate basidiomata and the yellowish basidiospores might indicate a different alliance of species within the Hymenochaetaceae. Affinities might be searched for in *Fomitiporella*.

DNA-based phylogentic inferences would be desirable to ascertain its affinities and those of other related taxa such as *Fulvifomes membranaceus* for instance.

Fulvifomes membranaceus (J.E. Wright & Blumenf.) Baltazar & Gibertoni, Mycotaxon 111: 206, 2010.

≡ *Phellinus membranaceus* J.E. Wright & Blumenf., Mycotaxon 21: 422, 1984.

Description: Larsen and Cobb-Poulle (1990).

Distribution in Southern Brazil: First record from Southern Brazil.

Specimen examined: **BRAZIL**, **RIO GRANDE DO SUL**: Santa Maria, 14/V/2010, *Campos-Santana 137* (ICN).

Remark: The species is characterized by resupinate basidiomata, with a hard consistency, lack of setae and hyaline to pale yellow, thick-walled basidiospores, 3.0–4.0 × 2.5–3.0 µm. The resupinate habit and yellowish basidiospores might also indicate a different alliance of species (cf. remark under *F. melleoporus*).

Fulvifomes merrillii (Murrill) Baltazar & Gibertoni, Mycotaxon 111: 206, 2010. Fig. 10

≡ *Pyropolyporus merrillii* Murrill, Bull. Torrey Bot. Club 34: 479, 1907.

Description: Núñez and Ryvarden (2000).

Distribution in Southern Brazil: Paraná (Rajchenberg and Meijer 1990, Meijer 2006, as *Fomitiporella merrillii* (Murrill) Teixeira). First record from Rio Grande do Sul.

Specimens examined: **BRASIL**, **RIO GRANDE DO SUL**: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 24/V/2010, *Campos-Santana 153* (ICN); ibid., 22/V/2011, *Campos-Santana 573* (ICN); ibid., *Campos-Santana 580* (ICN).

Other specimen examined: **PHILIPPINE**, **PALAWAN**: Culion, XII/1902, Murrill #3579, BAFC 27760 (Ex. NY 883, type of *Pyropolyporus merrillii* Murrill.).

Remark: The species is distinguished by its ungulate basidiomata, with a concentrically furrowed pileus surface, reddish brown, darkening with age er, not rimose, the poorly developed to absent context, small pores, absence of setae and broadly ellipsoid dark reddish brown basidiospores.

Fulvifomes rhytiphloeus (Mont.) Campos-Santana & Robledo **comb. nov.**

[Mycobank MB 809551] Figs 11–13

≡ *Polyporus rhytiphloeus* Mont., Ann. Sci. Nat., Bot. 5: 369, 1856 (basionym).

Description: Larsen and Cobb-Poulle (1990), Ryvarden (2004).

Distribution in Southern Brazil: Santa Catarina (Campos-Santana and Loguercio-Leite 2010). First record from Paraná.

Specimens examined: **BRAZIL**, **PARANÁ**: Foz do Iguaçu, Parque Nacional do Iguaçu, Trilha do Poço Preto, 12/XII/2010, *Campos-Santana 453*(ICN); ibid., *Campos-Santana*

460 (ICN); ibid., *Campos-Santana 469* (ICN); ibid., Trilha da Bananeira, 13/XII/2010, *Campos-Santana 476* (ICN); *Campos-Santana 477* (ICN); Céu Azul, Trilha Manoel Gomes, 14/XII/2010, *Campos-Santana 484* (ICN); *Campos-Santana 489* (ICN); **SANTA CATARINA**: Itapuá, RPPN Volta Velha, Trilha da Casa de Vidro, 23/02/2011, *Campos-Santana 525* (ICN); Mondaí, Linha Uruguai, *Campos Santana, Santana & Zanella 77*, 15/VI/2006 (FLOR 32218); ibid., *Campos-Santana & Santana 257, 290*, 25/V/07 (FLOR 32219, FLOR 32220).

Remark: *Fulvifomes rhytiphloeus* is distinguished by its flattened basidiome with a yellowish brown context, discoloring to red in KOH, and a thin black line separating an upper thin, ochre brown tomentum.

The thick-walled, brown to dark reddish brown, and ellipsoid to broadly ellipsoid basidiospores and the absence of setae are characteristic of *Fulvifomes* rather *Phellinus s.s*; hence the species is transferred to *Fulvifomes*. Besides, the species is close to *Fulvifomes fastuosus* in having coriaceous consistence and by the presence of a thin black line in context.

Fulvifomes rimosus (Berk.) Fiasson & Niemelä, Karstenia 24(1): 26, 1984. Fig. 14

≡ *Polyporus rimosus* Berk, London J. Botany 4: 54, 1845.

Description: Núñez and Ryvarden (2000).

Distribution in Southern Brazil: Rio Grande do Sul (Theissen 1911, Rick 1960, as *Fomes rimosus* (Berk.) Cooke; Teixeira 1950).

Specimens examined: **BRAZIL**, **RIO GRANDE DO SUL**: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 24/V/2010, *Campos-Santana 158* (ICN); Caçapava do Sul, Pedra do Segredo, 06/VI/2011, *Campos-Santana 612* (ICN).

Other specimen examined: **PORTUGAL**, Curaçao, Savonet (BAFC 29368, ex S, type of *Fomes subendothejus* Bres.).

Remark: *Fulvifomes rimosus* is characterized by having the pileus surface typically blackened and rimose with age, relatively large pores and basidiospores 6.0–7.5 × 5.0–6.0 µm. Macroscopically, it ressembles *Phellinus chaquensis*, but the latter has hymenial setae and yellowish basidiospores (characters that connect *P. chaquensis* to *Phellinus s.s.*).

Fuscoporia Murrill, North Am. Flora 9: 3, 1907.

Key to *Fuscoporia* species

1. Basidiomata resupinate.....2
1'. Basidiomata pileate 4
2. Extra-hymenial setae present.....***F. contigua***
2'. Extra-hymenial setae absent 3
3. Pores large, 2–3/mm.....***F. palmicola***
3'. Pores small, 6–7/mm .....***F. ferrea***
4. Hymenial setae apically hamate, hooked.....***F. wahlbergii s.l.***
4'. Hymenial setae apically straight.....5
5. Pores 5–7/mm; context brown.....***F. gilva s.l.***
5'. Pores 7–(–10)/mm; context yellow .....***F. rhabarbarina***

Fuscoporia contigua (Pers.) G. Cunn, Bull. New Zealand Dept. Sci. Industr. Res. 73: 4, 1948. Figs 15–16

≡ *Boletus contiguus* Pers., Synopsis methodica fungorum 2: 544, 1801.

Description: Ryvarden (1978).

Distribution in Southern Brazil: Santa Catarina (Groposo *et al*. 2007, Loguercio-Leite *et al*. 2008a) and Rio Grande do Sul (Rick 1960, as *Hexagonia dubiosa* Rick, *Poria suberis* (Durieu & Mont.) Cooke, *Poria bicolor* Bres. and *Poria cryptacantha* (Mont.) Cooke; Rajchenberg 1987; Groposo *et al*. 2007; Loguercio-Leite *et al*. 2008a). First record from Paraná.

Specimens examined: **BRAZIL**, **PARANÁ**: Céu Azul, Parque Nacional do Iguaçu, Trilha Manuel Gomes, 14/XII/2010, *Campos-Santana 491* (ICN); **SANTA CATARINA**: Joinville, Bairro Paranaguamirim, 11/X/2010, *Campos-Santana 293* (ICN); Itapuá, RPPN Volta Velha, Trilha do Sambaqui, 24/II/2011, *Campos-Santana 528* (ICN); ibid., *Campos-Santana 534* (ICN); Mondaí, Linha Sanga Forte, 25/IV/2011, *Campos-Santana 538* (ICN); **RIO GRANDE DO SUL**: Riozinho, 10/IV/ 2010, *Campos-Santana 62* (ICN); ibid., *Campos-Santana 63* (ICN); ibid., *Campos-Santa 65* (ICN); ibid., *Campos-Santana 66* (ICN); Santa Maria, Sítio Aldorino, *G. Coelho 20-3* (ICN 97696); ibid., 07/VI/1993, *G.*

Coelho 40-3 (ICN 97697); Viamão, Parque Estadual de Itapuã, 16/X/2010, *Campos-Santana 327* (ICN); ibid., *Campos-Santana 334* (ICN); ibid., *Campos-Santana 335* (ICN); Derrubadas, Parque Estadual do Turvo, 26/X/2010, *Campos-Santana 349* (ICN); ibid., 29/X/2010, *Campos-Santana 369* (ICN); ibid., 26/X/2010, JMB 502 (ICN).

Other specimen examined: **ARGENTINA, BUENOS AIRES**: La Plata, Bosque, VII/1906, *C. Spegazzini* (LPS 21507, type of *Daedalea effusa* Speg.).

Remark: The species is characterized by a resupinate basidiomata, with large and irregular pores, long hymenial setae and presence of extrahymenial setae in marginal areas and in decayed wood, and hyaline thin-walled basidiospores.

Fuscoporia ferrea (Pers.) G. Cunn., Bull. New Zealand Dept. Sci. Industr. Res. 73: 7, 1948. Figs 17–18

≡ *Polyporus ferreus* Pers., Mycol.Eur. 2: 89, 1825.

Description: Ryvarden (1978), Larsen and Cobb-Poulle (1990).

Distribution in Southern Brazil: Santa Catarina (Loguercio-Leite and Wright 1991, 1995, Groposo *et al*. 2007, Loguercio-Leite *et al*. 2008b, as *F. ferrea*; Drechsler-Santos *et al*. 2008) and Rio Grande do Sul (Rick 1960, as *Poria subcanescens* Rick, *Poria vestita* Rick and *Poria cinnamomea* Rick; Rajchenberg 1987, Silveira and Guerrero 1991, Groposo *et al*. 2007, as *Fuscoporia ferrea* (Pers.) G. Cunn.). First record from Paraná.

Specimens examined: **BRAZIL**, **PARANÁ**: Piraquara, Morro do Canal, 12/XI/2010, *Campos-Santana 387* (ICN); **SANTA CATARINA**: Florianópolis, Morro da Lagoa da Conceição, 06/X/2010, *Campos-Santana 258* (ICN); ibid., *Campos-Santana 265* (ICN); ibid., 27/V/2011, *Campos-Santana 597* (ICN); ibid., Costa da Lagoa, 25/V/1985, *Loguercio-Leite & Zanin* (FLOR 10133); Joinville, Bairro Paranaguamirim, 11/X/2010, *Campos-Santana 297* (ICN); São Francisco do Sul, 30/04/2013, *Campos-Santana 673* (ICN); **RIO GRANDE DO SUL**: Caçapava do Sul, Pedra do Segredo, 16/IV/2010, *Campos-Santana 103* (ICN); Derrubadas, Parque Estadual do Turvo, 26/X/2010, *Campos-Santana 342* (ICN); ibid., *Campos-Santana 343* (ICN); ibid., *Campos-Santana 350* (ICN); Cambará do Sul, Itaimbezinho, 09/XII/1989, *Silveira & Guerrero 243* (ICN 80536); Dom Pedro de Alcântara, RPPN do Professor Luis Baptista, 12/III/2010, *Campos-Santana 04* (ICN); ibid., *Campos-Santana 08* (ICN); ibid., 13/VIII/2011, *Campos-Santana 632* (ICN); Guaíba, Fazenda São Maximiano, 22/VIII/2010, *Campos-Santana 240* (ICN); Cambará do

Sul, Itaimbezinho, 09/XII/1989, *Silveira & Guerreiro 243* (ICN80536); São Francisco de Paula, Centro de Pesquisas e Conservação da Natureza, PRÓ-MATA – PUC, 08/XI/2010, *Campos-Santana 374* (ICN); Viamão, Parque Estadual de Itapuã, 16/X/2010, *Campos-Santana 310* (ICN); ibid., *Campos-Santana 314* (ICN); ibid., *Campos-Santana 317* (ICN); ibid., *Campos-Santana 320* (ICN); ibid., *Campos-Santana 365* (ICN); ibid., *Campos-Santana 368* (ICN).

Remark: this species is recognized by its resupinate, widely effused basidiomata, circular pores 6–7/mm, and hymenial setae 30–36 μm long (Ryvarden and Johansen 1980).

Fuscoporia contigua presents similar basidiomata and basidiospores but differs in having larger pores (2–3/mm), longer hymenial setae (45–75 × 5.0–7.5 μm) and the presence of the (extra-hymenial) tramal setae, 75–190 × 7.0–10 μm. *Fuscoporia ferruginosa* (Schrad.) Murrill is macroscopically similar to *F. ferrea*. According to Gilbertson (1979), the presence of setal hyphae, longer (up to 65 μm) hymenial setae and wider basidiospores (3–3.5 μm) distinguish *F. ferruginosa* from *F. ferrea*.

Fuscoporia gilva (Schwein.) T. Wagner & M. Fisch., Mycologia 94(6): 1013, 2002. Figs 19–21

≡ *Boletus gilvus* Schwein., Schriften Berlin. Ges. Naturf.Freunde 1: 96, 1822.

Fuscoporia gilva is one of the most common species in Southern Brazil. It is a very variable species (Fidalgo and Fidalgo 1968); more likely, molecular and critical morphological studies will show the current species concept to encompass other taxonomic entities.

In this work, we segregated our collections into three distinct varieties on the basis of macro-morphological characters first and subsequently micro-morphological characteristics, following Wright *et al.* (1988).

Table 1 – Comparison of three varieties of *Fuscoporia gilva*

	var. gilva	*var. licnoide*	*var. scruposa*
Basidiospores	2.5–4 × 1.5–2.5 µm	2.5–5 × 1.5–3 µm	2.5–4.5 × 1.5–2.5 µm
Setae	10–27 × 4.5–6 µm	15–32 × 4–7 µm	11–27 × 2–3 µm
Pores per mm	(6–) 8–10	6–8 (–9)	7–8
Context	10–25 mm	1–8 mm	2–7,5 mm
Pileus surface	Glabrous, slightly velutinous when young	Glabrous, concentrically zonate	Radially scrupose

Fuscoporia gilva var. gilva (Schwein.) T. Wagner & M. Fisch.

Distribution in Southern Brazil: Paraná, Santa Catarina and Rio Grande do Sul.

Specimens examined: **BRAZIL**, **PARANÁ**: Piraquara. Morro do Canal, 12/XI/2010, *Campos-Santana 392* (ICN); ibid., Matinhos, 13/XI/2010, *Campos-Santana 409* (ICN); **SANTA CATARINA**: Joinville, Bairro Paranaguamirim, 11/X/2010, *Campos-Santana 300* (ICN); ibid., *Campos-Santana 425* (ICN); Itapuá, RPPN Volta Velha, 21/II/2011, *Campos-Santana 496* (ICN); ibid., 24/II/2011, *Campos-Santana 529* (ICN); **RIO GRANDE DO SUL**: Caçapava do Sul, Pedra do Segredo, 16/IV/2010, *Campos-Santana 119* (ICN); Santa Maria, Morro da Caturrita, 15/V/2010, *Campos-Santana 141* (ICN); Dom Pedro de Alcântara, RPPN do professor Luis Baptista, 11/VI/2010, *Campos-Santana 201* (ICN); Porto Alegre, Refúgio da Vida Silvestre-UFRGS, 21/VI/2010, *Campos-Santana 221* (ICN); ibid., 16/VIII/2011, *Campos-Santana 643* (ICN); São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 22/V/2011, *Campos-Santana 574* (ICN).

Other specimens examined: **ARGENTINA, JUJUY**: Abra de Cañas, 07/XI/1973, *Cordo et al., J29* (LPS 45513); **PARAGUAI**: Guarapí, 1880, *Balansa 3396* (LPS 24978, type of *Polyporus balansae* Seg.).

Remark: *Fuscoporia gilva s.l.* is characterized by an annual, pileate to effused-reflexed, mainly dimidiate basidiomata, abundant subulate hymenial setae, 18–32 × 4.0–8.0 µm, and ovoid to ellipsoid, hyaline and thin-walled basidiospores, 2.5–4.0 × 1.5–2.5 µm. The pilei are applanate and imbricate, frequently sulcate, up to 8 × 9 × 2 cm, with a glabrous to slightly velutinous pileus surface when young (see table 1).

Fuscoporia gilva var. licnoide (Mont.) Lloyd in Corner, Trans. Br. Mycol. Soc., 17(1–2): 1932.

≡ *Polyporus licnoides* Mont., Ann. Sci. Nat., Bot. 13: 204, 1840.

Distribution in Southern Brazil: Paraná, Santa Catarina and Rio Grande do Sul.

Specimens examined: **BRAZIL**, **PARANÁ**: Matinhos, 13/XI/2010, *Campos-Santana 406* (ICN); ibid., *Campos-Santana 413* (ICN); ibid., *Campos-Santana 419* (ICN); ibid., *Campos-Santana 421* (ICN); ibid., Foz do Iguaçu, Parque Nacional do Iguaçu, Trilha do Poço Preto, 12/XII/2010, *Campos-Santana 458* (ICN); 12/XII/2010, ibid., *Campos-Santana 459* (ICN); ibid., Trilha da Bananeira, 13/XII/2019, *Campos-Santana 479* (ICN); ibid., Céu Azul, Trilha Manuel Gomes, 14/XII/2010, *Campos-Santana 486* (ICN); ibid., *Campos-Santana 488* (ICN); **SANTA CATARINA**: Florianópolis, Unidade de Conservação Ambiental Desterro (UCAD), 02/X/2010, *Campos-Santana 245* (ICN); ibid., *Campos-Santana 248* (ICN); Joinville, Bairro Paranaguamirim, 11/X/2010, *Campos-Santana 291* (ICN); ibid., *Campos-Santana 294* (ICN); ibid., *Campos-Santana 296* (ICN); ibid., *Campos-Santana 303* (ICN); ibid., 15/XI/2010, *Campos-Santana 432* (ICN); Mondaí, Linha Sanga Forte, 25/IV/2011, *Campos-Santana 537* (ICN); **RIO GRANDE DO SUL**: Caçapava do Sul, Pedra do Segredo, 16/IV/2010, *Campos-Santana 114* (ICN); Dom Pedro de Alcântara, RPPN do Professor Luis Baptista, 11/06/2010, *Campos-Santana 194* (ICN); ibid., *Campos-Santana 196* (ICN); ibid., *Campos-Santana 205* (ICN); ibid., 13/VII/ 2011, *Campos-Santana 627* (ICN); ibid., *Campos-Santana 631* (ICN); ibid., *Campos-Santana 634* (ICN); ibid., *Campos-Santana 638* (ICN); ibid., *Campos-Santana 639* (ICN); Derrubadas, Parque Estadual do Turvo, 29/10/2010, *Campos-Santana 358* (ICN); ibid., *Campos-Santana* 362 (ICN); Porto Alegre, Refúgio da Vida Silvestre-UFRGS, 21/VI/2010, *Campos-Santana 217* (ICN); ibid., 17/V/2011, *Campos-Santana 551* (ICN); 16/XI/2011 *Campos-Santana 641* (ICN); Santa Maria, 14/V/2010, *Campos-Santana 132* (ICN); ibid., *Campos-Santana 133* (ICN); ibid., *Campos-Santana 134* (ICN); ibid., Morro da Caturrita, 15/V/2010, *Campos-Santana 147* (ICN); ibid., *Campos-Santana 148* (ICN); ibid., *Campos-Santana 149* (ICN); ibid., *Campos-Santana 150* (ICN); São Francisco do de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 24/V/2010, *Campos-Santana 156* (ICN).

Remark: *Fuscoporia gilva* var. *licnoides* differs from *F. gilva* var. *gil*va in having thin basidiome, effused to pileate, the pileus surface concentrically zoned. The basidiospore and hymenial setae are also slightly larger than in var. *gilva* (see table 1).

Fuscoporia gilva var. scruposa (Fr.) Corner, Trans. Br. Mycol. Soc., 17(1-2): 79, 1932.

≡ *Polyporus gilvus var. scruposus* (Fr.) Bres., Hedwigia Ser. Bot. 56(4): 292 (1915).

Distribution in Southern Brazil: Paraná, Santa Catarina and Rio Grande do Sul.

Specimens examined: **BRAZIL**, **PARANÁ**: Matinhos, 13/XI/2010, *Campos-Santana 416* (ICN); **SANTA CATARINA**: Itapuá, RPPN Volta Velha, Trilha Apegatur, 22/II/2011, *Campos-Santana 505* (ICN); **RIO GRANDE DO SUL**: Dom Pedro de Alcântara, RPPN do professor Luis Baptista, 12/III/2010, *Campos-Santana 06* (ICN); ibid.,11/VI/2010, *Campos-Santana 197* (ICN); Porto Alegre, Refúgio da Vida Silvestre-UFRGS,17/V/2011, *Campos-Santana 549* (ICN); ibid., *Campos-Santana 550* (ICN); ibid., 31/V/2011, *Campos-Santana 608* (ICN); Mourinhos do Sul, Morro da Perdida, 13/III/2010, *Campos-Santana 21* (ICN); São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 26/III/2010, *Campos-Santana 38* (ICN); ibid., *Campos-Santana 48* (ICN); ibid., 21/V/2011, *Campos-Santana 556* (ICN); ibid., Hotel Veraneio Hampel 27/03/2010, *Campos-Santana 52* (ICN).

Remark: *Fuscoporia gilva* var. *scruposa* and *F. gilva* var. *gilva* are morphologically very similar, both at macro- and microscopic level; both taxa share thick basidiomes and identical basidiospore and hymenial setae. *Fuscoporia gilva* var. *scruposa* differs mainly by having the pileus surface radially scrupose (see table 1).

Fuscoporia palmicola (Berk. & M.A. Curtis) Bondartseva & S. Herrera, Mikol. Fitopatol. 26(1): 13, 1992. Figs 22–23

≡ *Polyporus palmicola* Berk. & M.A. Curtis, Bot. J. Linn. Soc. 10: 317, 1869.

Description: Raymundo *et al.* (2013), Ryvarden (2004).

Distribution in Southern Brazil: Rio Grande do Sul (Rick 1960, as *Poria palmicola* (Berk. & M.A. Curtis) Cooke). First record from Santa Catarina.

Specimen examined: **BRAZIL**, **SANTA CATARINA**: Itapuá, RPPN Volta Velha, Trilha do Sambaqui, 24/II/2011, *Campos-Santana 535* (ICN).
Other specimens examined: **ARGENTINA**, **MISIONES**: Santa Ana, 14/I/2993, *Ibénez Cristina 135* (LPS 45254).

Remark: *Fuscoporia palmicola* is characterized by effused-reflexed to pileate basidiomata, large pores (1–2 / mm) and long hymenial setae. It is related to *F. contigua*, which is distinguished by having fully resupinate basidiomata, extrahymenial setae, shorter hymenial setae and larger basidiospores.

Fuscoporia rhabarbarina (Berk.) Groposo, Log.-Leite & Góes-Neto, Mycotaxon 101: 61, 2007. Figs 24–25

≡ *Polyporus rhabarbarinus* Berk., Ann. Mag. Nat. Hist. 3: 388, 1839.

Description: Gerber and Loguercio-Leite (1997).
Distribution in Southern Brazil: Santa Catarina (Gerber 1996, Gerber and Loguercio-Leite 1997, Groposo and Loguercio-Leite 2002, Drechsler-Santos *et al*. 2008, as *P. rhabarbarinus*, Groposo *et al*. 2007) and Rio Grande do Sul (Groposo and Loguercio-Leite 2002, as *Phellinus rhabarbarinus* (Berk.) G. Cunn., Groposo *et al*. 2007). First record from Paraná.
Specimens examined: **BRASIL**, **PARANÁ**: Foz do Iguaçu, Parque Nacional do Iguaçú, Trila do Poço Preto, 12/XII/2010, *Campos-Santana 470* (ICN); **SANTA CATARINA**: Florianópolis, Morro da Lagoa da Conceição, 26/XII/1988, *Loguercio-Leite & Furlani 186* (FLOR 10929); **RIO GRANDE DO SUL**: Cachoeirinha, Reserva Biológica Tancredo Neves, 11/VIII/1997, *Groposo 149* (PACA 85544); Riozinho, 10/IV/2010, *Campos-Santana 446* (ICN).
Other specimen examined: **ARGENTINA**, **SALTA**: Santa Victoria, Quadrada El Nogalar, 19/III/1986, *Palau 467* (BAFC 30716).

Remark: *Fuscoporia rhabarbarina* is characterized by the yellow context, glabrous pileus in sulcate zones, distinct black crust and ventricose hymenial setae.

Fuscoporia wahlbergii (Fr.) T. Wagner & M. Fisch., Mycol. Res. 105(7): 780, 2001. Figs 26–27

≡ *Trametes wahlbergii* Fr., Bihang K. Svenska vet. akad. Handlingar 1848: 131, 1849.

Description: Larsen and Cobb-Poulle (1990), Ryvarden and Gilberson (1994), Ryvarden (2004).

Distribution in Southern Brazil: Paraná (Ryvarden and Meijer 2002, Meijer 2006); Santa Catarina (Loguercio-Leite and Wright 1991, 1995, Gerber 1996, Gonçalves and Loguercio-Leite 2001, Groposo and Loguercio-Leite 2005, Groposo *et al*. 2007, as *F. wahlbergii*); Rio Grande do Sul (Silveira and Guerrero 1991, Groposo *et al*. 2007, as *Fuscoporia wahlbergii* (Fr.) T. Wagner & M. Fisch.).

Specimens examined: **BRAZIL**, **PARANÁ**: Céu Azul, Parque Nacional do Iguaçu, Trilha Manuel Gomes, 14/12/2010, *Campos-Santana 487* (ICN); Foz do Iguaçu, Parque Nacional do Iguaçu, Trilha do Poço Preto, 12/12/2010, *Campos-Santana 450* (ICN); Piraquara, Morro do Canal, 12/11/2010, *Campos-Santana 379* (ICN); **SANTA CATARINA**: Florianópolis, Unidade de Conservação Ambiental Desterro (UCAD), 02/10 2010, *Campos-Santana 245* (ICN); Itapuá, RPPN Volta Velha, Sede, 21/II/2011, *Campos-Santana 498* (ICN); ibid., *Campos-Santana 499* (ICN); ibid., Trilha do Apegatur, 22/02/2011, *Campos-Santana 503* (ICN); ibid., *Campos-Santana 508* (ICN); ibid., Trilha da Casa de Vidro, 23/II/2011, *Campos-Santana 520* (ICN); Trilha do Sambaqui, 24/II/2011, *Campos-Santana 530* (ICN); Mondaí, Linha Sanga Forte, 25/IV/2011, *Campos-Santana 540* (ICN); **RIO GRANDE DO SUL**: Derrubadas, Parque Estadual do Turvo, 26/10/2010, *Campos-Santana 356* (ICN); Dom Pedro de Alcântara, RPPN do professor Luis Baptista, 12/III/2010, *Campos-Santana* 09 (ICN); ibid., 16/VI/2010, *Campos-Santana 203* (ICN); ibid., 13/08/2011, *Campos-Santana 626* (ICN); Mourrinhos do Sul, Morro da Perdida, 13/III/2010, *Campos-Santana 25* (ICN); São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 26/III/2010, *Campos-Santana 35* (ICN); ibid., 24/V/2010, *Campos-Santana 152* (ICN); ibid., *Campos-Santana 162* (ICN); ibid., *Campos-Santana 165* (ICN); ibid., *Campos-Santana 168* (ICN); ibid., 07/VI/2010, *Campos-Santana 189* (ICN); ibid., 22/V/2011, *Campos-Santana 564* (ICN); ibid., *Campos-Santana 575* (ICN); ibid., *Campos-Santana 586* (ICN); Viamão, Parque Saint' Hilaire**,** 08/XI/2011, *Campos-Santana 652* (ICN).

Other specimens examined: **AUSTRALIA**, **VICTORIA**: Maite Rain Forest, 2001, *Burdsall, H.H.* (FP 140105); **PHILIPPINE**, **MINDANAO**: Lake Lanao, Camp Keithly, IX/1907, *Mary S. Clemens 58431-2* (NY 00743051, type for *Pyropolyporus subextensus* Murrill); ibid., Davão, 22/IV/1904, E. *B. Copeland* "E" (NY 00743052, *Pyropolyporus subextensus*); **JAMAICA**, Monkey Hill, July 11, 1904, *Miss W.J. Robinson* (NY 00743008, type for *Pylopolyporus robinsoniae* Murrill).

Remark: This species is recognized by a perennial basidiomata, roughly sulcate, a velutinate to tomentose pileus, and microscopically by straight to more commonly apically hooked hymenial setae and hyaline broadly ellipsoide basidiospores.

Inonotus P. Karst. Meddeland. Soc. Fauna Fl. Fenn. 5: 39, 1879.

Key to *Inonotus* species

1. Basidiomata resupinate to effuse-reflexed 2
1'. Basidiomata pileate 4
   2. Pores 4–6/mm; hymenial setae and setal hyphae absent ..... ***Inonotus* sp.**
   2'. Pores > 6/mm; hymenial setae and setal hyphae present or absent 3
3. Setal hyphae in the dissepiments; hymenial setae up to 40 µm long; basidiospores globose / subglobose, yellow pale brown, up to 13 µm; pores 6–7/mm, round ..... ***I. micantissimus***
3'. Setal hyphae absent; hymenial setae up to 25 µm long; basidiospores subglobose, hyaline, up to 5 µm long; pores 7–9/mm ..... ***I. tropicalis***
   4. Setal hyphal present 5
   4'. Setal hyphal absent 7
5. Pores 8–10/mm; basidiospores subglobose, 3.5–5.0 × 3.0–4.0 µm ..... ***I. portoricensis***
5'. Pores < 8/mm; basidiospores ellipsoid, > 5 × 4 µm 6
   6. Pileal surface cracking; pore surface umber to sepia often with a yellowish tint; pores 3–4/mm; basidiospores 6.0–8.0 × 4.0–5.5 µm ..... ***I. patouillardii***
   6'. Pileal surface glabrous, concentrically sulcate, with a black cuticle in section; pore surface rusty brown; pores 4–6/mm, basidiospores 5.0–6.0 × 4.0–4.5 µm .....

.....***I. pseudoglomeratus***

7. Hymenial setae ventricose or subulate, dark brown, 20.0–32.0 × 4.0–7.5 µm; darkening in KOH .....***I. linteus***

7'. Hymenial setae absent; turning red in KOH.....***I. splitgerberii***

Inonotus linteus (Berk. & M.A. Curtis) Teixeira, Rev. Bras. Bot. 15(2): 126, 1992.

≡ *Polyporus linteus* Berk. & M.A. Curtis, Proc. Am. Acad. Arts Sci. 4: 122, 1858.

Description: Ryvarden (2004).

Distribution in Southern Brazil: Paraná (Ryvarden and Meijer 2002, Meijer 2006; Santa Catarina (Drechsler-Santos *et al*. 2008, Campos-Santana and Loguercio-Leite 2008b, as *Phellinus linteus* (Berk. & M.A. Curtis) Teng.). First record from Rio Grande do Sul.

Specimens examined: **BRAZIL**, **PARANÁ**: Foz do Iguaçu, Parque Nacional do Iguaçu, Trilha do Poço Preto, 12/XII/2010, *Campos-Santana 463* (ICN); ibid., *Campos-Santana 472* (ICN); **SANTA CATARINA**: Joinville, Bairro Paranaguamirim, 15/XI/2010, *Campos-Santana 424* (ICN); ibid., Salto Veloso, 24/VIII/1992, *Willerding, Folle, Cantú and Bridi 180* (FLOR 10902); ibid, Major Gercino, 11/VIII/1993, *Willerding and Atanazio 279* (FLOR10906); ibid, 290, 11/VIII/1993 (FLOR 10909); **RIO GRANDE DO SUL**: Derrubadas, Parque Estadual do Turvo, 26/X/2010, *Campos-Santana 338* (ICN); ibid., *Campos-Santana 399* (ICN); Caçapava do Sul, Pedra do Segredo, 07/VI/2010, *Campos-Santana 618* (ICN).

Remark: Diagnostic characteristics of this species are the pale golden brown, ovoid to subglobose basidiospores and variably abundant setae (Ryvarden 2004).

The species concept adopted here follows Ryvarden (2004). However, as demonstrated by Tian *et al*. (2013) and Vlasák *et al*. (2013), *I. linteus sensu* Ryvarden (2004) is a species complex; in addition to *I. linteus s.s.*, three other taxa occur in the Neotropics, viz., *I. cubensis* Y.C. Dai *et al.*, *I. pseudolinteus* Vlasák & Y.C. Dai and *I. sideroxylicola* Vlasák & Y.C. Dai. A phylogenetic approach is desirable to ascertain the species concept in southern Brazil.

Inonotus micantissimus (Rick) Rajchenb., Nord. J. Bot. 7(5): 565, 1987. Figs 28–30

≡ *Poria micantissima* Rick, Iheringia Ser. Bot. 7: 287, 1960.

Description: Ryvarden (2004).

Distribution in Southern Brazil: Paraná (Ryvarden and Meijer 2002, Meijer 2006); Rio Grande do Sul (Rick 1960, as *Poria micantissima* Rick; Rajchenberg 1987). This is the first record from Santa Catarina.

Specimens examined: **BRAZIL**, **SANTA CATARINA**: São Francisco do Sul, 30/IV/2013, *Campos-Santana 672* (ICN); **RIO GRANDE DO SUL**: Santa Maria, Caturrita, Sítio Aldorindo, 1992, *G. Coelho 20-6* (ICN 97676); Itaara, Parque Pinhal, 07/VI/1992, *G. Coelho 24-13* (ICN 97677).

Other specimen examined: **ARGENTINA**, **CÓRDOBA**: Córdoba, Jujuy, Dpto. Ledesma, Parque Nacional Calilegua, Sendero Momota, 07/III/2005, *Robledo 400* (CORD).

Remark: the species is easily identified by a remarkable combination of characters including abundant setal hyphae and large (10.0–13.0 × 8.0–12.0 µm, fide Ryvarden 2004), subglobose to ovoid and yellowish basidiospores. There is no other Neotropical *Inonotus* species with such large basidiospores.

Inonotus patouillardii (Rick) Imazeki, Bull. Natl. Sci. Mus. 6: 105, 1943. Figs 31–33

≡ *Polystictus patouillardii* Rick, Brotéria, Sér. Bot. 6: 89, 1907.

Description: Núñez and Ryvarden (2000), Gottlieb *et al.* (2002).

Distribution in Southern Brazil: Paraná (Ryvarden and Meijer 2002, Meijer 2006); Santa Catarina (Rick 1960, as *Phellinus patouillardii*; Loguercio-Leite and Wright 1991, Drechsler-Santos *et al*. 2008, Campos-Santana and Loguercio-Leite 2008b) and Rio Grande do Sul (Rajchenberg 1987).

Specimens examined: **BRAZIL**, **PARANÁ**: Foz do Iguaçu, Parque Nacional do Iguaçu, Trilha da Bananeira, 13/XII/2010, *Campos-Santana 474* (ICN); ibis., Céu Azul, Trilha Manoel Gomes, 14/XII/2010, *Campos-Santana 493* (ICN); **SANTA CATARINA**: Florianópolis, Ratones, 27/I/1989, *Loguercio-Leite & Furlani 394* (FLOR 10700); ibid., Rio Tavares, 18/IX/1985, *M.A.Da Ré & P. Ivo* (FLOR 10192); Mondaí, Linha Sanga Forte, 15/IV/06, *Campos-Santana & Santana 66* (FLOR 32208); ibid., Linha Uruguai, 27/XII/06, *Campos-Santana, Santana & Rodrigues-Souza 198* (FLOR 32240).

Remark: *Inonotus patouillardii* is characterized by a zonate pileus with alternate brown and black zones, a hard, lustrous context, large setal hyphae and yellow, ovoid to ellipsoid, thick-walled basidiospores.

In its present circumpscription, the species has a pantropical distribution, also reported from Africa and Asia. According to Gottlieb *et al*. (2002), the current species concept could correspond to a species complex.

Inonotus portoricensis (Overh.) Baltazar & Gibertoni, Mycotaxon 111: 206, 2010.
Figs 34–35

≡ *Fomes portoricensis* Overh., Scientific Survey of Porto Rico and the Virgin Islands 8(1): 158, 1926.

Description: Fidalgo (1968).
Distribution in Southern Brazil: This is the first record from Southern Brazil.
Specimens examined: **BRAZIL**, **RIO GRANDE DO SUL**: Dom Pedro de Alcântara, RPPN do professor Luis Baptista, 12/III/2010, *Campos-Santana 17* (ICN); **SANTA CATARINA**: Florianópolis, Unidade de Conservação Ambiental Desterro (UCAD), 02/X/2010, *Campos-Santana 247* (ICN).

Remark: *Inonotus portoricensis* is recognized by a pileate basidiomata, presence of setal hyphae and hymenial setae and globose to ellipsoid, thin-walled, basidiospores first yellowish then pale rusty brown at maturity, 4.0–6.0 × 4.0–5.5 µm.

The taxonomic placement of this species has been debated; it has been considered as belonging either to *Inonotus* (Baltazar & Gibertoni 2010) or *Phellinus* (Borba-Silva *et al*. 2013, Ryvarden 2004).

We follow here the taxonomic placement in *Inonotus*. The presence of setal hyphae in the hymenophoral trama and hymenial setae, and the brown basidiospores would point better toward *Inonotus sensu* Wagner and Fischer (2002) than to *Phellinus s.s*. Molecular data are desirable to ascertain the affinities of this species.

Inonotus pseudoglomeratus Ryvarden, Synopsis Fung. 15: 78, 2002.

Description: Ryvarden (2004, 2005).

Distribution in Southern Brazil: This is its first record from Southern Brazil.

Specimen examined: **BRAZIL**, **SANTA CATARINA**: Florianópolis, Unidade de Conservação Ambiental Desterro (UCAD), 02/X/2010, *Campos-Santana 244* (ICN).

Remark: *Inonotus pseudoglomeratus* is characterized by a pileate basidiomata. The pileus is dimidiate pileus with a (strongly) contracted base, and concentrically sulcate. The pore surface is olivaceous yellow pore surface. Both setal hyphae and hymenial setae are present.

Inonotus pseudoglomeratus is comparable to *I. patouillardii* Ryvarden (2004). They mainly differ by the size of the pores and basidiospores, respectively 4–6 pores / mm and 5.0–6.0 × 4.0–4.5 μm and 3–4 pores / mm and 6.0–8.0 × 4.0–5.5 μm.

Inonotus splitgerberi (Mont.) Ryvarden, Norw. J. Bot. 19: 232, 1972. Fig. 36

≡ *Polyporus splitgerberi* Mont., Ann. Sci. Nat., Bot. 16: 109,1841.

Description: Ryvarden (2004).

Distribution in Southern Brazil: Paraná (Rajchenberg and Meijer 1990, Ryvarden and Meijer 2002, Meijer 2006); Santa Catarina and Rio Grande do Sul. (Theissen 1911, as *Polyporus shulfuratus* (Fr.) Trotter, Baltazar and Gibertoni 2009, Westphalen *et al*. 2010).

Specimens examined: **BRAZIL**, **RIO GRANDE DO SUL**: Guaíba, Fazenda São Maximiano, 21/VIII/2010, *Campos-Santana 231* (ICN); Viamão, Parque Saint-Hilaire, 1992, *R. T. Guerrero & R. M. Silveira* (ICN 97684); Santa Maria, Camobí, Cidade dos Meninos, 25/V/1993, *G. Coelho 39-1* (ICN 97 683).

Remark: the species is characterized by hyaline to pale golden yellow basidiospores and absence of setae. According to Ryvarden (2004), another remarkable character of *I. splitgerberi* is the cherry red discoloration of the basidiomata in KOH, a feature also known in *Inonotus dentatus* Decock & Ryvarden (Ryvarden 2004). All other *Inonotus* species turn dark brown to black in KOH.

Inonotus tropicalis (M.J. Larsen & Lombard) T. Wagner & M. Fisch., Mycologia 94: 1009, 2002. Figs 37–38

≡ *Poria rickii* Bres., Ann. Mycol. 18(1-3): 37, 1920.

Description: Larsen and Lombard (1988).

Distribution in Southern Brazil: Paraná (Meijer 2006); Rio Grande do Sul [Rick (1960), as *Poria rickii* Bres.].

Specimens examined: **BRAZIL**, **PARANÁ**, Morro do Canal, 12/XI/2010, *Campos-Santana* 383 (ICN); **RIO GRANDE DO SUL**: Dom Pedro de Alcântara, RPPN do professor Luis Baptista, 12/III/2010, *Campos-Santana 15* (ICN); ibid.,16/XI/2010, *Campos-Santana 199* (ICN), ibid., 11/VI/2010, *Campos-Santana 206* (ICN); São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA- SFP), 21/V/2011, *Campos-Santana 560* (ICN); ibid., Centro de Pesquisas e Conservação da Natureza, PRÓ-MATA – PUC/RS, 25/VI/2010, *Campos-Santana 222* (ICN); Santa Maria, Parque Pinhal, I/1992, *G. Coelho 8-5* (ICN 97791).

Remark: *Inonotus tropicalis* has a resupinate basidiomata. Microscopically, it is charaterized by a dimitic hyphal system, small pores (7–9/mm), small and abundant hymenial setae (15.0–25.0 × 5.0–9.0 μm), and hyaline, subglobose basidiospores, 4.0–5.0 × 2.5–3.5(–4.0) μm.

The taxonomic position of *I. tropicalis* is still subject to debate. Larsen & Lombard (1988) described this species (as *Phellinus tropicalis*) with annual basidiomata and two kinds of contextual hyphae, generative hyphae, and thick-walled, infrequently simple-septate skeletal hyphae. Previously, Lowe (1966) pointed out that *P. tropicalis* (as *Poria rickii*) has an annual to biennial basidiomata with a monomitic hyphal system with simple-septate.

Wagner and Fischer (2002) transfered this taxon to *Inonotus sensu* Wagner and Fischer (2002) after phylogenetic analysis based on rDNA nLSU sequence data.

***Inonotus* sp.**

Description: none.

Distribution in Southern Brazil: Santa Catarina and Paraná.

Specimens examined: **BRAZIL**, **PARANÁ**: Céu Azul, Parque Estadual do Iguaçu, 14/XII/2010, *Campos-Santana 492* (ICN); **SANTA CATARINA**: Alfredo Wagner,

Reserva Rio das Furnas, *Gerlach et al. 14*, 01/IX/2007 (FLOR 32325); ibid., *Gerlach & Giovanka 76*, 07/VII/2008, (FLOR 32324), ibid., ipse 109, 07/VII/2008 (FLOR 32326).

Remark: *Inonotus sp.* is characterized by a dense, heterogeneous context, a black line present between several layers and by the absence of setae. This species could be compared to *I. venezuelicus* Ryvarden (Robledo *et al*. 2006, Ryvarden 2004), from which it differs in having multilayered context and smaller pores (4–6/mm *versus* 3–4/mm).

Phellinus Quél. Enchiridion Fungorum in Europa media et praesertim in Gallia Vigentium: 172, 1886.

Key to *Phellinus* species

1. Basidiomata pileate 2
1'. Basidiomata resupinate to effused 3
    2. Pores 8–10/mm; hymenial setae acuminate, 16.0–25.0 × 6.5–7.5 µm ..... ***P. calcitratus***
    2'. Pores 6–7/mm; hymenial setae ventricose, 20.0–28.0 × 7.0–10.0 µm ..... ***P. caryophylleus***
3. Pores ≥ 7/mm (7–11/mm) 4
3'. Pores 5–8/mm 6
    4. Hymenial setae straight ..... ***P. detonsus***
    4'. Hymenial setae hooked 5
5. Pore surface deep tobacco brown; basidiospores globose to subglobose (3.0–)3.5–4.5 × 2.5–3.5(–4.0) µm ..... ***P. lopezii***
5'. Pore surface light to dark brown; basidiospores broadly ellipsoid 4.5–5.5 × 3.5–4.0 µm. ..... ***Phellinus* sp.** (***P. gabonensis*** complex)
    6. Setal hyphal present; hymenial setae conical to ventricose; pore surface light brown; basidiospores (hyaline) to pale yellowish 3.5–4.5 × 3.0–4.0 µm..... ***P. anchietanus***
    6'. Setal hyphal absent; hymenial setae subventricose to acuminate; pore surface reddish-brown; basidiospores pale yellow, 3.5–4.5 × 3.0–4.0 µm..... ***P. shaferi***

Phellinus anchietanus Decock & Ryvarden, Cryptogam. Mycol. 18: 222, 1997.

Description: Decock and Ryvarden (1997), Ryvarden (2004).

Distribution in Southern Brazil: Rio Grande do Sul (Decock and Ryvarden 1997).

Specimen examined: **BRAZIL**, **RIO GRANDE DO SUL**: São Salvador, 1942, [*Fungi Rickiani 13938, PACA,* leg, J.Rick as *Poria chromatica* Berkeley & Cooke (Rick 1960)].

Remark: This species is easily recognized by the combination of the following characteristics: resupinate basidiomata; presence of setal hyphae and hymenial setae, the latter straight to commonly apically curved to distinctly hamate; small, subglobose, (hyaline) to pale yellowish basidiospores. According to Decock and Ryvarden (1997), these characteristics are unique within the genus and make the species distinct. *Phellinus lopezii* and *Phellinus undulatus* also have curved to hooked hymenial setae but both lack setal hyphae.

The taxonomic placement of this species might be reconsidered, however. The presence of both setal hyphae and hymenial setae would indicate better affinities with several species of *Inonotus sensu* Wagner and Fischer (2002).

Phellinus calcitratus (Berk. & M.A. Curtis) Ryvarden, Norw. J. Bot. 19: 234, 1972. Figs 39–40

≡ *Polyporus calcitratus* Berk. & M.A. Curtis, Bot. J. Linn. Soc. 10: 314, 1869.

Description: Lowe (1957), Ryvarden and Johansen (1980).

Distribution in Southern Brazil: Rio Grande do Sul (Rick 1960, as *Fomes calcitratus* (Berk. & M.A. Curtis) Cooke).

Specimens examined: **BRAZIL**, **RIO GRANDE DO SUL**: Caçapava do Sul, Pedra do Segredo, 16/IV/2010, *Campos-Santana 85* (ICN); ibid., *Campos-Santana 92* (ICN); Santa Maria, Morro da Caturrita, 15/V/2010, *Campos-Santana 151* (ICN); Santa Maria, Itaara, Parque Pinhal, 1992, *G. Coelho 14-5* (ICN 97693); ibid., 08/III/1993, *G. Coelho 37-4* (ICN 97694).

Remark: *Phellinus calcitratus* is an interesting poroid Hymenochaetaceae. As observed by Góis-Neto *et al*. (2000) and Ryvarden (2004), *P. calcitratus* can be easily distinguished from the other species of the genus by its sharply zoned pileus, the slightly translucent and

cartilaginous tubes and a black line below the tomentum. Our specimens has 8–10 pores/mm, hymenial setae, 16.0–25.0 × 6.5–7.5 µm, and basidiospores measuring 4.5–6.0 × 4.5–6.5 µm, as previously reported by Ryvarden (2004).

Phellinus caryophylleus (Cooke) Ryvarden, Norw. J. Bot. 19: 234, 1972.

Figs 41–42

≡ *Fomes caryophylleus* Cooke, Grevillea 15(73): 21, 1886.

Description: Ryvarden (2004), Ryvarden and Johansen (1980).

Distribution in Southern Brazil: Rio Grande do Sul (Rick 1960, as *Polyporus caryophylleus* (Cooke) Lloyd). First record from Paraná and Santa Catarina.

Specimens examined: **BRAZIL**, **PARANÁ**: Foz do Iguaçu, Parque Nacional do Iguaçu, Trilha do Poço Preto, 12/XII/2010, *Campos-Santana 462* (ICN); ibid., *Campos-Santana 464* (ICN); ibid., *Campos-Santana 468* (ICN); **SANTA CATARINA**: Mondaí, Linha Uruguai, 10/XII/2010, *Campos-Santana 436* (ICN).

Remark: The examined material is show the typical features of this species, incuding a perennial, pileate, broadly attached basidiomata, a velutinous to tomentose pileus and small pores (6–7/mm). Microscopically it is characterized by mostly ventricose, dark brown hymenial setae, 20.0–28.0 × 7.0–10.0 µm and yellow to rusty brown, subglobose basidiospores, 5.0–6.0 × 4.0–5.5 µm.

Ryvarden (2004) pointed out that this species is similar to *Inonotus linteus* (under *Phellinus linteus*) mainly because of the dark reddish-brown pore surface, the small pores and subglobose basidiospores. *Inonotus linteus* lacks the black line below a persistent tomentum, besides the setae are slender and not as distinctly ventricose as in *P. caryophyllaceus. Phellinus calcitratus* differs in the slender acuminate setae.

Phellinus detonsus (Fr.) Ryvarden, Synopsis Fung. 19: 173, 2004.

≡ *Polyporus detonsus* Fr., Linnaea 5: 519, 1830.

Description: Ryvarden (2004).

Distribution in Southern Brazil: This is its first record from Southern Brazil.

Specimens examined: **BRAZIL**, **PARANÁ**: Matinhos, 13/XI/2010, *Campos-Santana* 398 (ICN); **RIO GRANDE DO SUL**: Mampituba, Silveirão, 12/I/2008, *M.A. Reck 007/08* (ICN 154008); Porto Alegre, Refúgio da Vida Silvestre – UFRGS, 31/V/2011, *Campos-Santana* 600 (ICN).

Remark: *Phellinus detonsus* is easily recognizable by the resupinate basidiomata, a reddish-brown to brown pore surface, 9–11 pores/mm, round. Microscopically it can be identified by the ventricose, hymenial setae scattered, acuminate, dark brown, 16.0–26.0 × 5.0–7.5 µm and subglobose to ellipsoid, hyaline and with age pale yellow basidiospores, 3.0–4.0(–5.0) × 2.5–3.0 µm, as described by Ryvarden (2004).

Phellinus* sp**. (P. gabonensis*** Decock & Yombiyeni morpho-ecological complex), Mycol. Prog. 10: 351-362, 2011. Figs 43–44

Description of P. gabonensis: Yombiyeni *et al*. (2011).

Distribution in Southern Brazil: This is a first record from South America.

Specimens examined: **BRAZIL, SANTA CATARINA**: Itapuá, RPPN Volta Velha, 23/II/2011, *Campos-Santana 515* (ICN); ibid., *Campos-Santana 516* (ICN); ibid., *Campos-Santana 655* (ICN); **RIO GRANDE DO SUL**: Dom Pedro de Alcântara, RPPN do professor Luis Baptista, 12/III/2010, *Campos-Santana 13* (ICN).

Remark: This species is recognized by the thickly cushion-shaped basidiomata, ventricose, apically curved hymenial setae, and broadly ellipsoid, slightly thick-walled, pale yellowish basidiospores, accumulating in a cream spore print. These morphological characteristics are also found (nearly) identical in *P. caribaeo-quercicolus* (Decock *et al.* 2005), *P. gabonensis* (Yombiyeni *et al.* 2011), *P. ellipsoideus* (Dai and Cui 2011, Cui and Decock 2013), and *P. castanopsidis* (Cui *et al.* 2013). These species form a morphological complex. Our collections from Southern Brazil also share with *P. gabonensis* the same type of habitat; hence they form a morpho-ecological complex.

However, a single sequence (ITS region) from a collection from southern Brazil shows that it is more closely related to *P. caribaeo-quercicolus* than to *P. gabonensis*. *Phelinus caribaeo-quercicolus* is found northerly in the Caribbean area, in Cuba and southern Florida, and grows (presumably) exclusively on *Quercus*. More material and

multilocus sequences data are necessary to ascertain the status of the material from southern Brazil.

Phellinus lopezii M. Mata & Ryvarden, Synopsis Fung. 27: 60, 2010.

Description: Mata and Ryvarden (2010).
Distribution in Southern Brazil: New record for Brazil.
Specimen examined: **BRAZIL**, **RIO GRANDE SUL**: Dom Pedro de Alcântara, RPPN do professor Luis Baptista, 2009, *Reck 232* (ICN).

Remark: *Phellinus lopezii* is characterized by round pores, 8–10/mm and abundant hymenial setae, ventricose to acuminante, mostly hooked, 13.0–27.0 × 6.0–11.0 µm. The basidiospores are small, globose to subglobose, thin walled, pale yellow, (3.0–)3.5–4.5 × 2.5–3.5 µm (Mata and Ryvarden 2010). *Phellinus undulatus* (Murrill) Ryvarden is similar but has angular pores, 4–6/mm and broadly ellipsoid and hyaline basidiospores (Mata and Ryvarden 2010).

Phellinus undulatus belongs to the *Inonotus sensu* Wagner and Fischer (2002) clade (Yombiyeni *et al*. 2011). The morphology of *P. lopezii* also points toward *Inonotus*. Molecular data are desirable to ascertain the affinities of this species.

Phellinus shaferi (Murrill) Ryvarden, Norw. J. Bot. 19: 235, 1972. Figs 45–46
≡ *Fuscoporella shaferi* Murrill, North Am. Fl. 9(1): 7, 1907.

Description: Larsen and Cobb-Poulle (1990), Valenzuela *et al*. (2012).
Distribution in Southern Brazil: First record from Southern Brazil.
Specimens examined: **BRAZIL**, **PARANÁ**: Piraquara, Morro do Canal, 12/XI/2010, *Campos-Santana 385* (ICN); ibid., Foz do Iguaçu, Parque Nacional do Iguaçu, Trilha do Poço Preto, 12/XII/2010, *Campos-Santana 456* (ICN); **SANTA CATARINA**: Itapuá, RPPN Volta Velha, Trilha da Casa de Vidro, 29/IV/2013, *Campos-Santana 658* (ICN); **RIO GRANDE DO SUL**: São Francisco de Paula, Floresta Nacional de São Francisco de Paula (FLONA-SFP), 07/VI/2010, *Campos-Santana 170* (ICN).
Remark: *Phellinus shaferi* is characterized by resupinate basiomata, pores surface cracked with age, yellowish brown to dark brown, subventricose to acuminate hymenial setae

(15.0–23 × 5.5–10.0 µm) and ellipsoid, thin-walled, pale yellow to rusty brown basidiospores, 3.5–4.5 × 3.0–4.0 µm.

Phylloporia Murrill, Torreya 4: 141, 1904

Phylloporia aff. ***spathulata*** (Hook.) Ryvarden (***P. spathulata*** morpho-ecological type), Synopsis Fung. 5: 196, 1991. Fig. 47

≡ *Boletus spathulatus* Hook., Syn. Pl. 1: 9, 1822.

Description: Núñez and Ryvraden (2000), Wagner and Ryvarden (2002), Ryvarden (2004).

Distribution in Southern Brazil: Paraná, Santa Catarina and Rio Grande do Sul (Baltazar *et al.* 2012).

Specimens examined: **BRAZIL**, **RIO GRANDE DO SUL**: Caçapava do Sul, Pedra do Segredo, 16/IV/2010, *Campos-Santana 127*(ICN); Santa Maria, Itaara, Parque Pinhal, 17/VI/1993, *G. Coelho 43-08* (ICN 97845).

Remark: This species was for a long time accepted in *Coltricia* Gray because of its stipitate basidiomata. However, its small coloured spores, a duplex context with a thin black line below a pileal tomentum indicate *Phylloporia* Murrill (Baltazar *et al*. 2010a, Wagner and Ryvarden 2002). Its generic position is also supported by molecular data (Wagner and Ryvarden 2002).

Phylloporia veraecrucis (Sacc.) Ryvarden, another species with stipitate basidiomata, differs mainly by its slightly larger basidiospores (4.0–4.5 × 3.0–3.5 µm versus 3.0–4.0 × 2.0–3.0 µm in *P. spathulata*) (Wagner and Ryvarden 2002).

CONCLUSIONS

Hymenochaetaceae from Southern Brazil had been previously studied by Baltazar *et al*. (2009a), Baltazar *et al*. (2009b) and Gerlach *et al*. (2013). In the present study, ten species are added for the areas. Furthermore, the distributions of several species are extended.

Two new combinations are also proposed, *Fomitiporia bambusarum* and *Fulvifomes rhytiphloeus*. Nevertheless, the generic placement of numerous species is still uncertain or debated. The generic entities, as presently circumscribed, are still large, morphologically heterogenous, and more likely phylogenitically polyphyletic. Critical morphological studies complemented by DNA-based phylogenetic studies are higly necessary to better circumscribed the different genera in Hymenochataceae.

Acknowledgements – The first author would like to thank all colleagues that helped during the field work. We also acknowledge the direction of the surveyed areas for granting permits to collect. This study is a partial result of the first author's Ph.D. thesis, with a scholarship provided by the Brazilian government CNPq and CAPES (process 8296/11-1). Cony Decock gratefully acknowledges the financial support received from the Belgian State – Belgian Federal Science Policy through the BCCM research program and the FNRS / FRFC (convention FRFC 2.4544.10).

Figure captions

Figs 1–2. *Cyclomyces iodinus*. **1.** Hymenial setae. **2.** Basidiospores (1 and 2 scale bar = 10 µm).

Figs 3–4. *Fomitiporella umbrinella*. **3.** Basidiospores; *Fomitiporia apiahyna*. **4.** Basidiospores (3 and 4, scale bar = 10 µm).

Figs 5–7. *Fomitiporia bambusarum*. **5.** Basidiomata *in situ* (scale bar = 3 cm). **6.** Hymenial setae. **7.** Basidiospores (6 and 7, scale bar = 10 µm).

Figs 8–9. *Fomitiporia sp.* (*F. robusta* complex). **8.** Basidiospores; *Fulvifomes fastuosus*. **9.** Basidiospores (8 and 9, scale bar = 10 µm).

Fig. 10. *Fulvifomes merrillii*. **10.** Basidiospores (scale bar = 10 µm).

Figs 11–13. *Fulvifomes rhytiphloeus*. **11.** Pileus surface. **12.** Pore surface [Source: Campos-Santana and Loguercio Leite 2008; 11 and 12, scale bar = 6 cm (modified)]. **13.** Basidiospores (scale bar = 10 µm).

Fig. 14. *Fulvifomes rimosus*. **14.** Basidiospores (scale bar = 10 µm).

Figs 15–16. *Fuscoporia contigua*. **15.** Extra-hymenial setae. **16.** Basidiospores (15 and 16, scale bar = 10 µm).

Figs 17–18. *Fuscoporia ferrea*. **17.** Hymenial setae. **18.** Basidiospores (17 and 18, scale bar = 10 µm).

Figs 19–21. *Fuscoporia gilva*. **19.** Hymenial setae. **20.** Basidiospores. **21.** Hymenium (19, 20 and 21, scale bar = 10 µm).

Fig. 22–23. *Fuscoporia palmicola*. **22.** Hymenial setae. **23.** Basidispores (22 and 23, scale bar = 10 µm).

Figs 24–25. *Fuscoporia rhabarbarina.* **24.** Hymenial setae. **25.** Basidiospores (24 and 25, scale bar = 10 µm).

Figs 26–27. *Fuscoporia wahlbergii.* **26.** Hymenial setae. **27.** Basidiospores (26 and 27, scale bar = 10 µm).

Figs 28–30. *Inonotus micantissimus*. **28.** Basidiospores. **29.** Hymenial setae. **30.** Setal hyphae (28, 29 and 30, scale bar = 10 µm).

Fig. 31–33. *Inonotus patouillardii.* **31.** Hymenial setae. **32.** Basidiospores. **33.** Setal hyphae (31, 32 and 33, scale bar = 10 µm).

Figs 34–35. *Inonotus portoricensis*. **34.** Basidiospores. **35.** Setal hyphae (34 and 35, scale bar = 10 µm).

Fig. 36. *Inonotus splitgerberi*. **36.** Basidiospores (scale bar = 10 µm).

Figs 37–38. *Inonotus tropicalis*. **37.** Hymenial setae. **38.** Basidispores (37 and 38, scale bar = 10 µm).

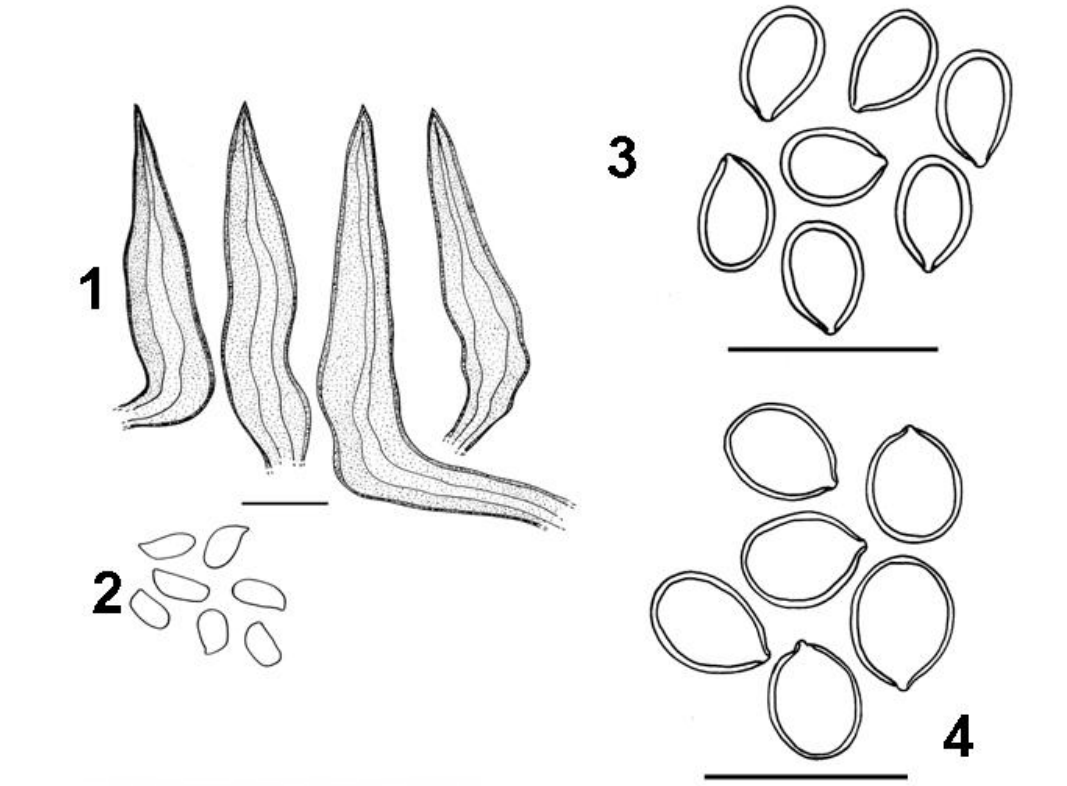
Figs 39–40. *Phellinus calcitratus*. **39.** Hymenial setae. **40.** Basidiospores (39 and 40, scale bar = 10 µm).

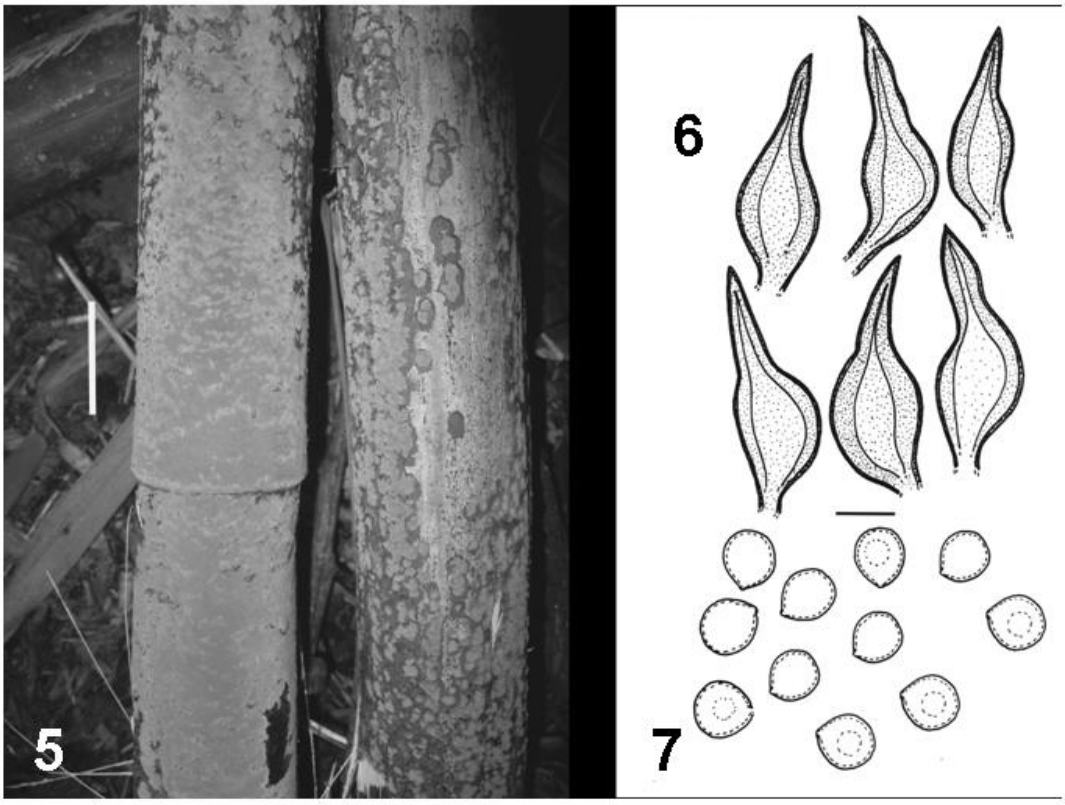
Figs 41–42. *Phellinus caryophylleus*. **41.** Hymenial setae. **42.** Basidiospores (41 and 42, scale bar = 10 µm).

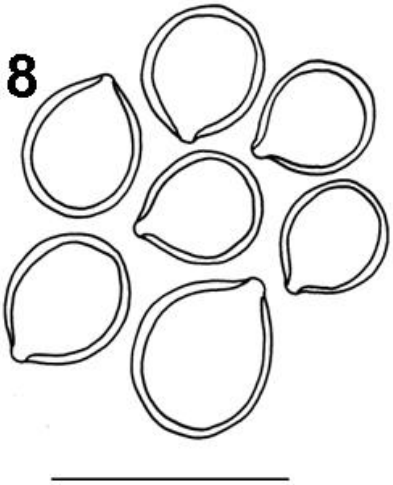
Figs 43–44. *Phellinus* sp. (*P. gabonensis* morpho-ecological complex). **43.** Hymenial setae. **44.** Basidiospores (43 and 44, scale bar = 10 µm).

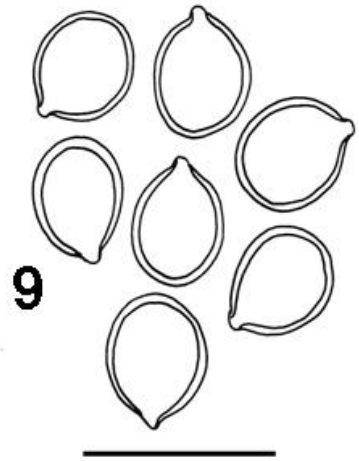
Fig. 45–46. *Phellinus shaferi*. **45.** Hymenial setae. **46.** Basidiospores (45 and 46, scale bar = 10 µm).

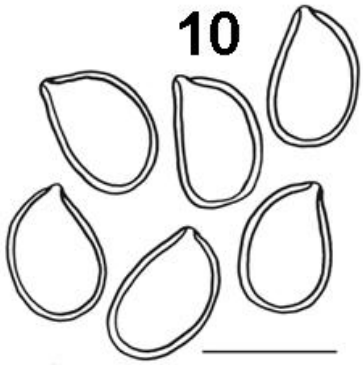
Fig. 47. *Phylloporia spathulata*. Basidiospores (scale bar = 5 µm).

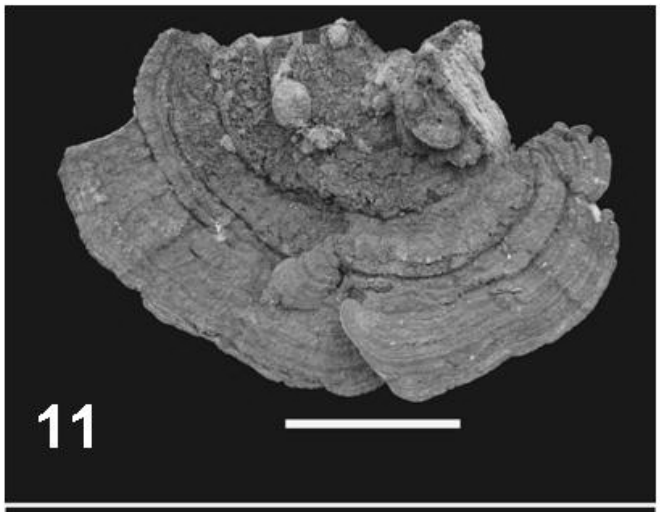

1
2
3
4


5
6
7

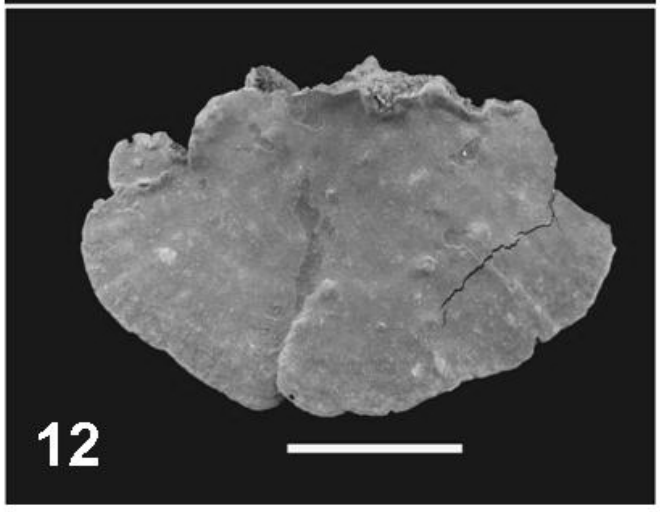

8

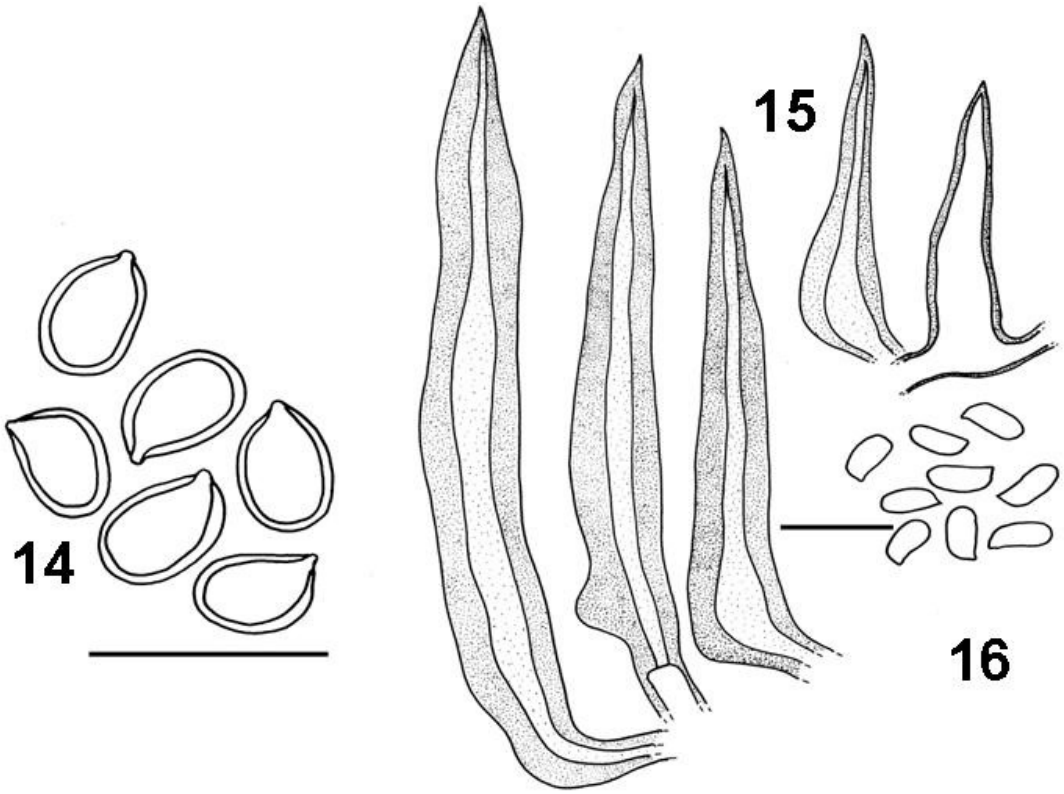

9

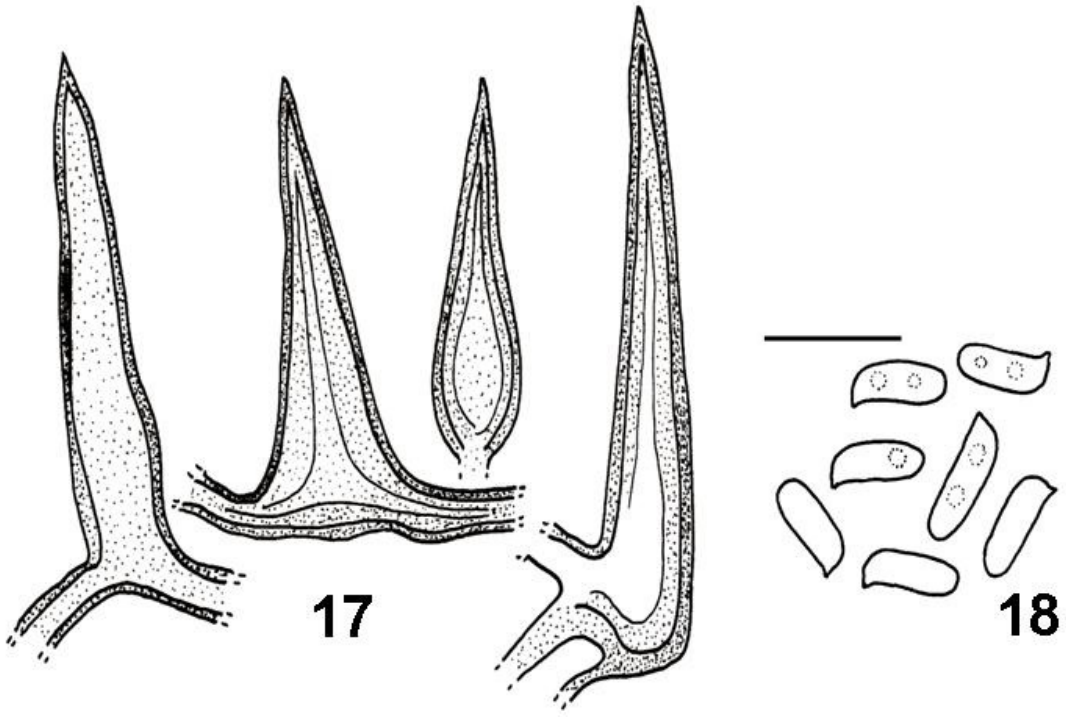

10

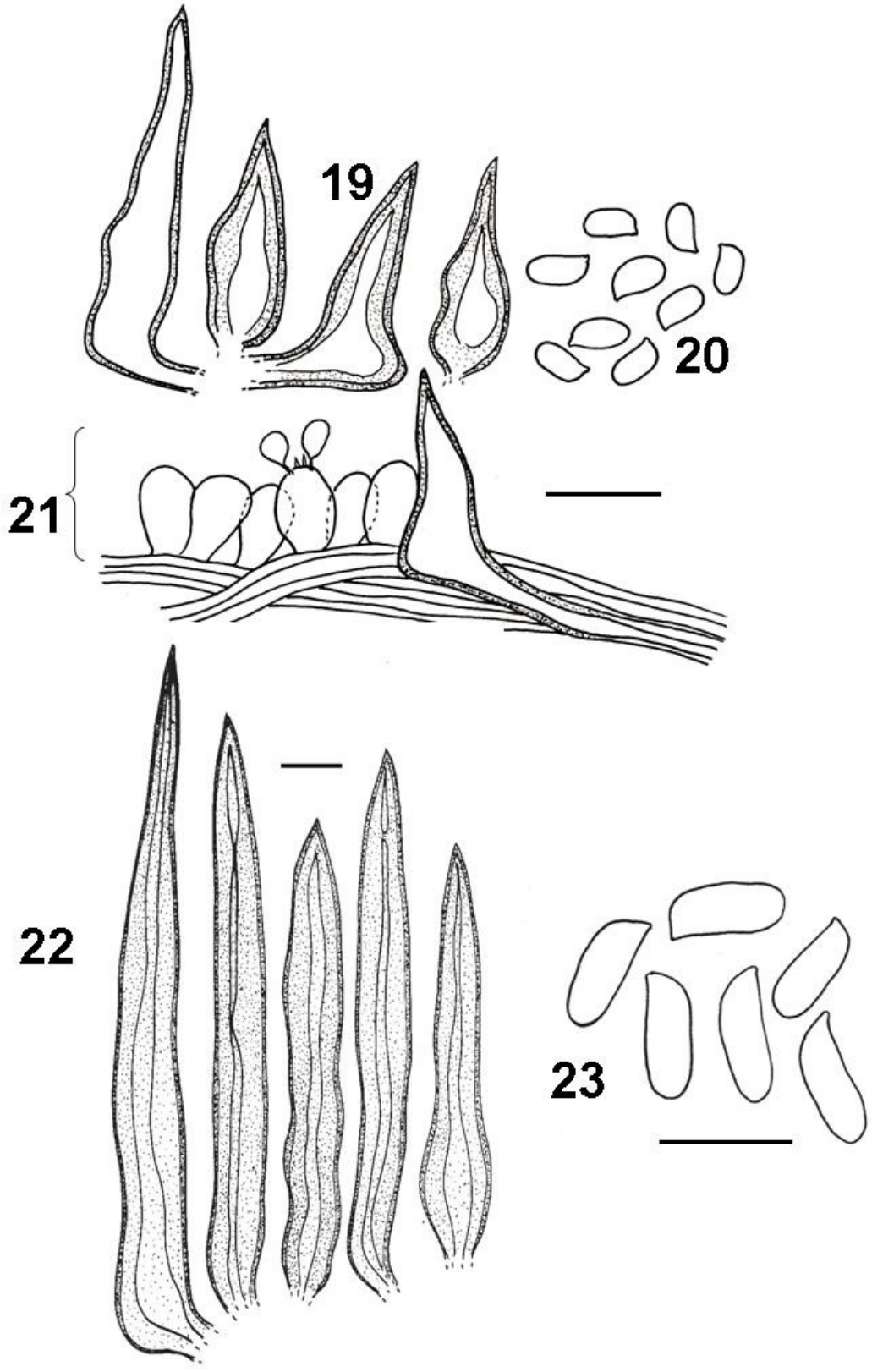

11

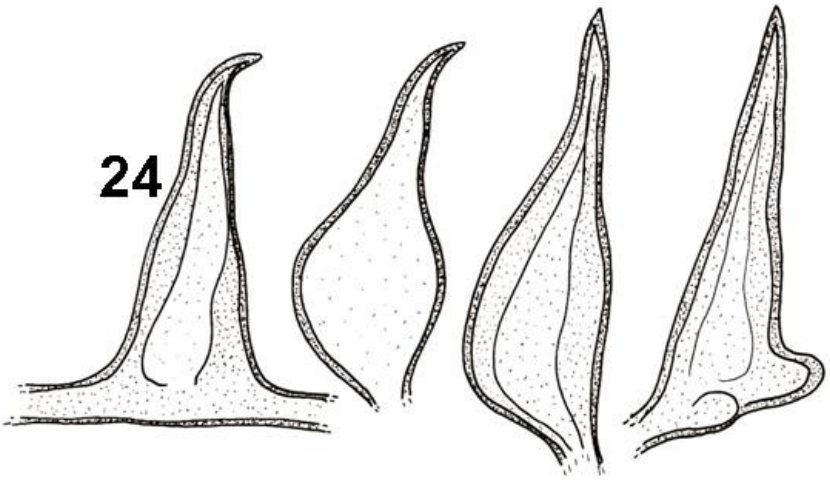

13


12

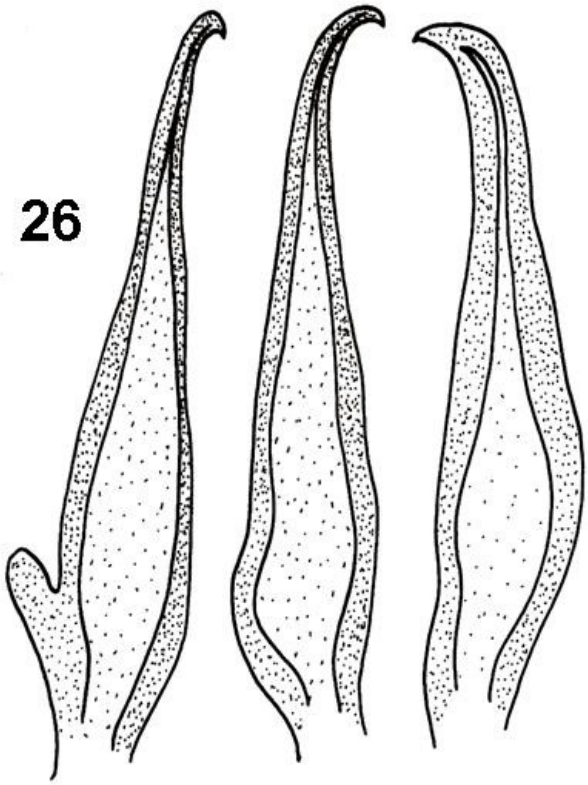

14
15
16

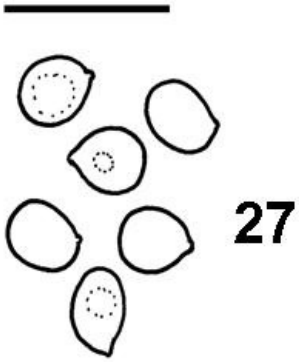

17
18

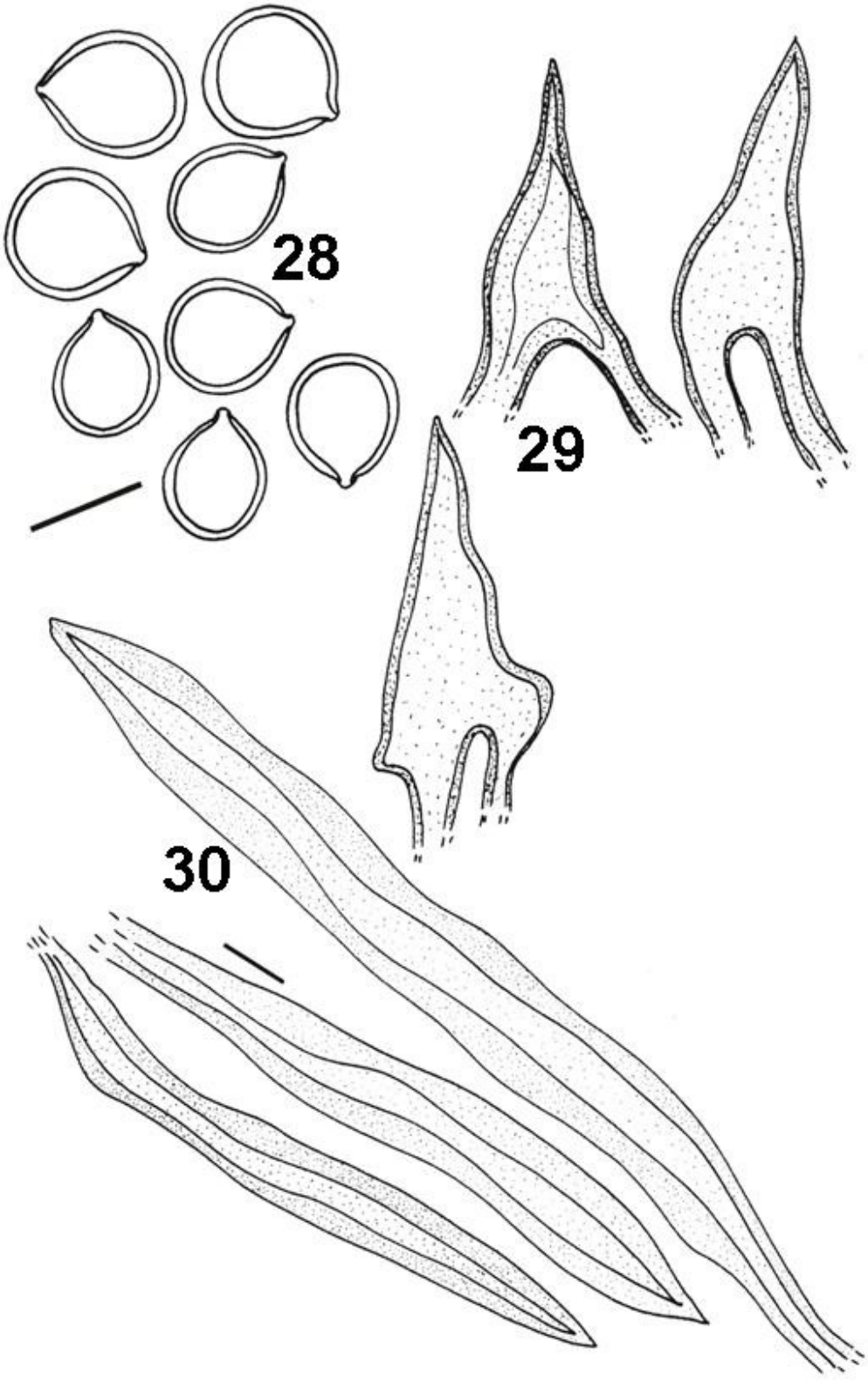

19
20
21
22
23

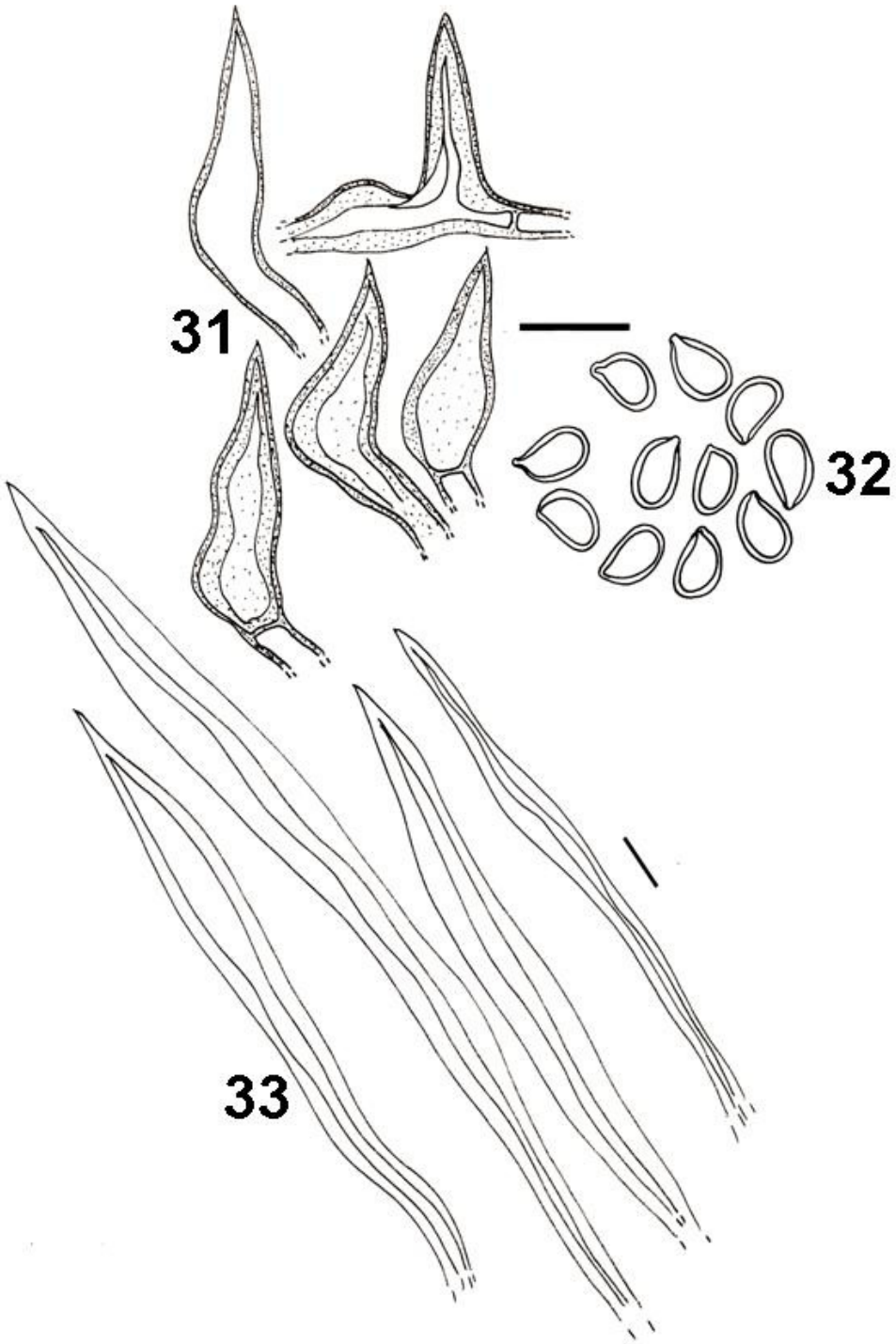

24

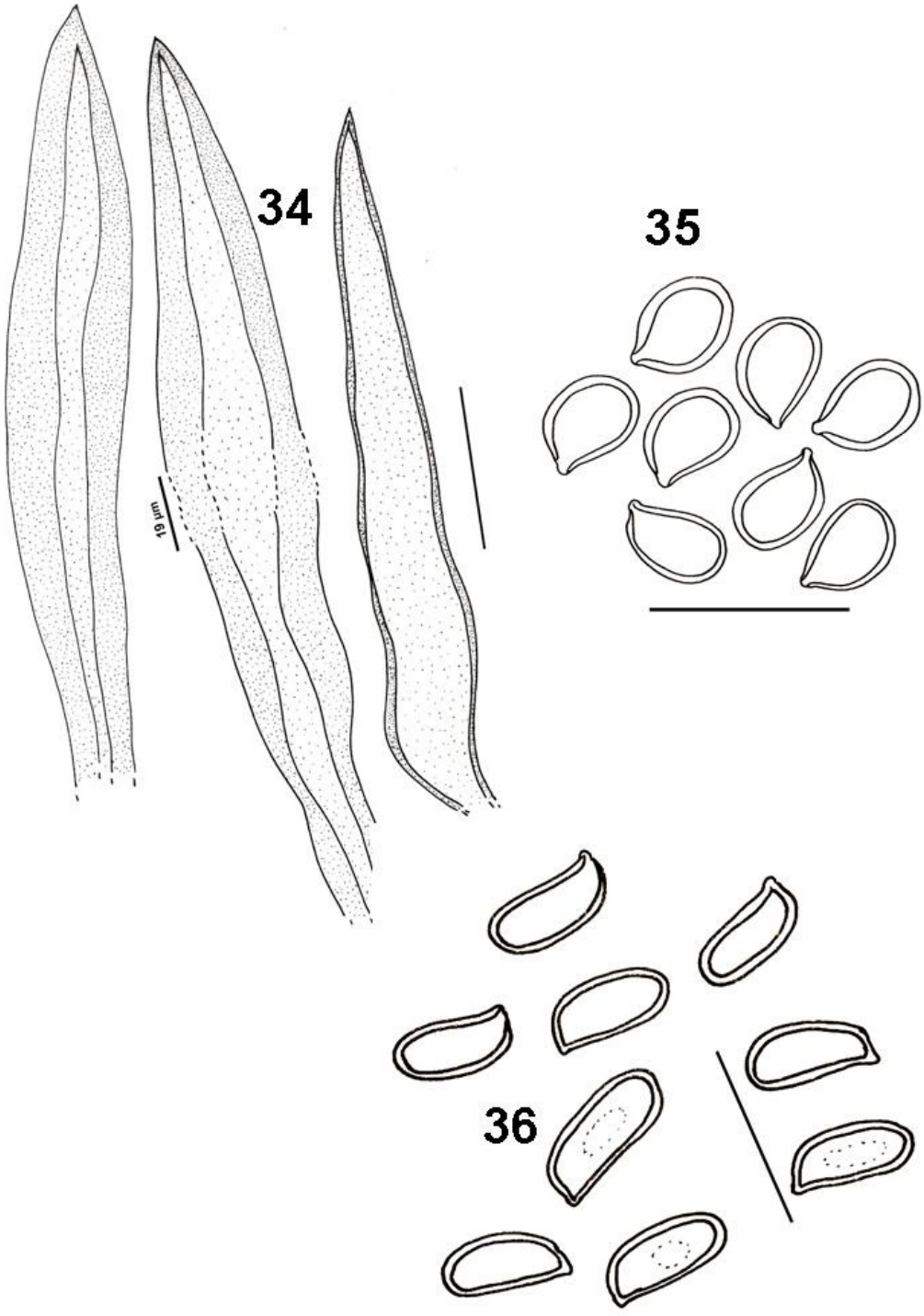

25

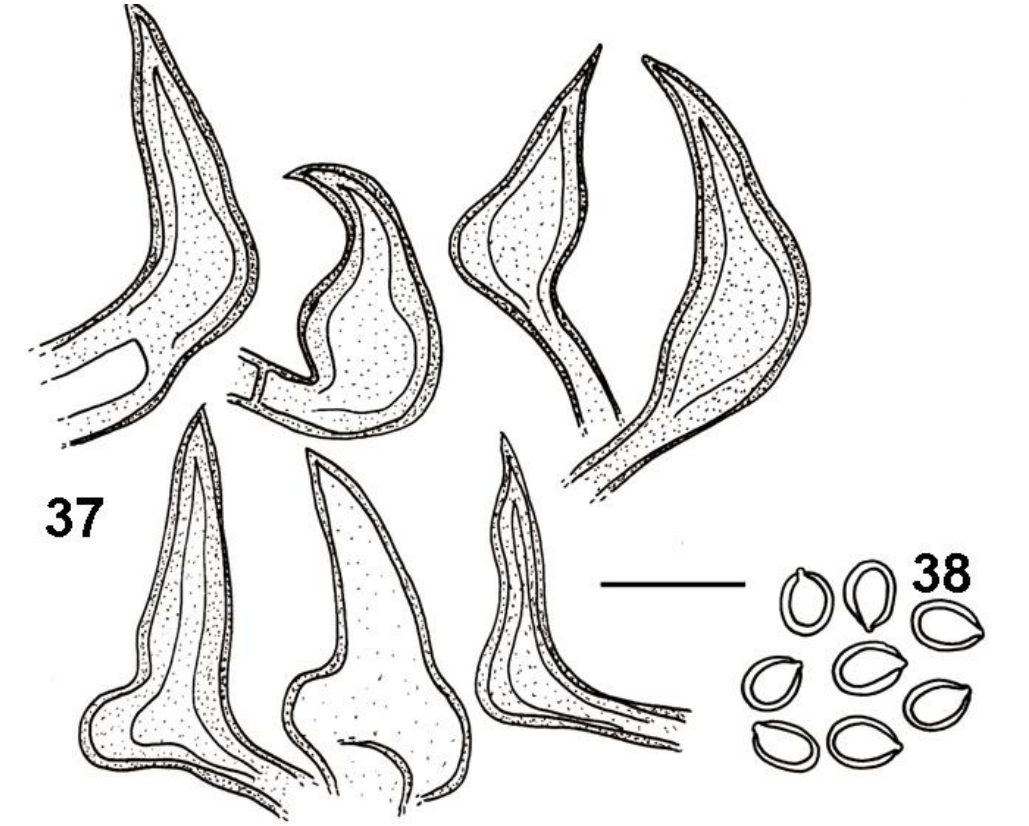

26

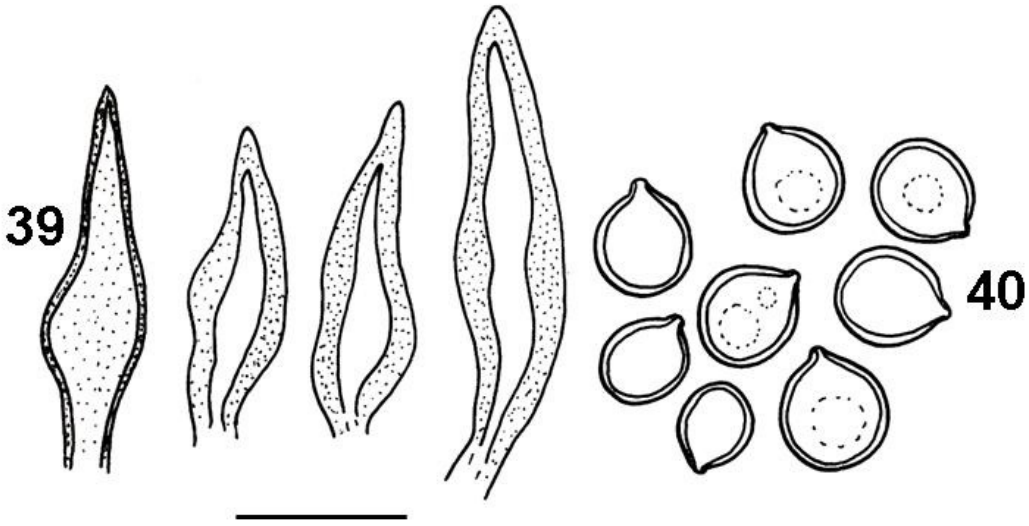

27

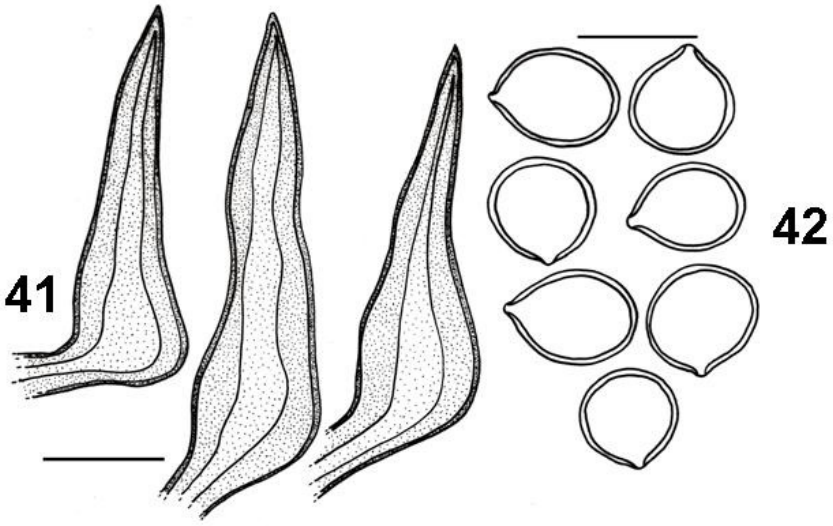

28
29
30

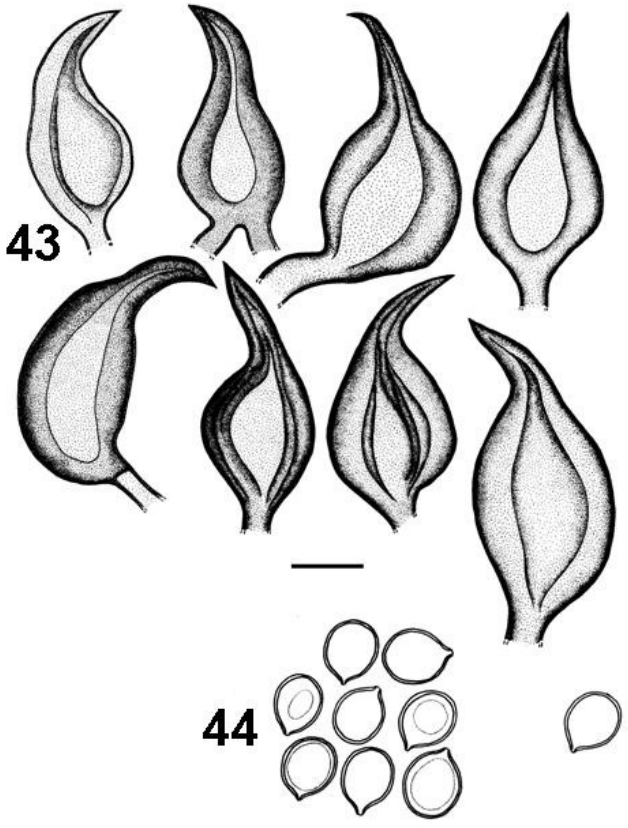

31
32
33

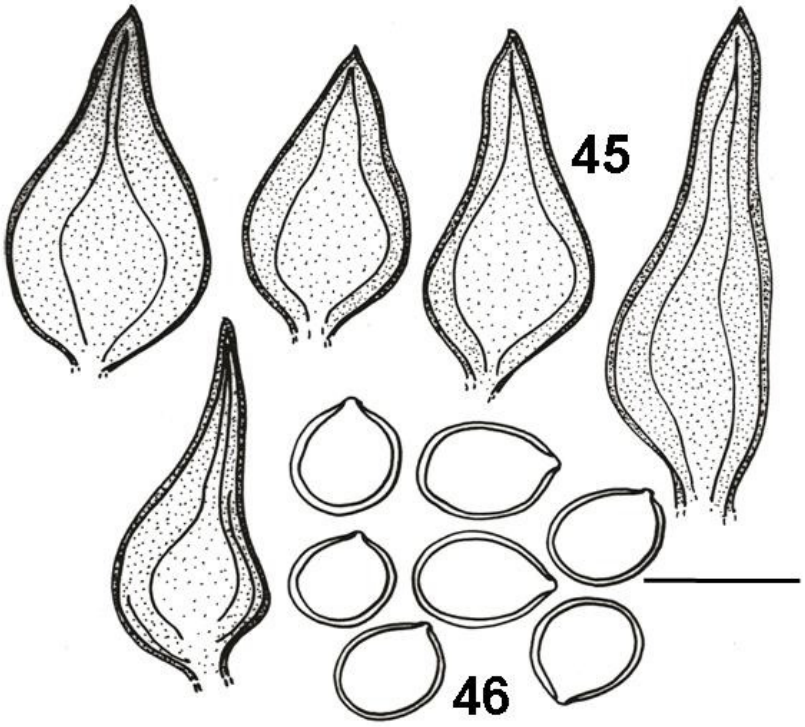

34
19 µm
35
36

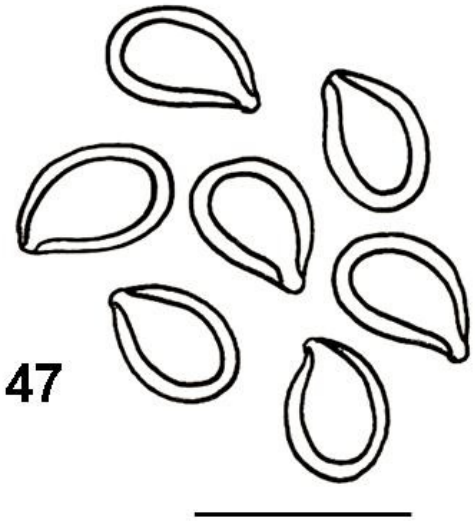

37
38


39
40


41
42


43
44


45
46


47

Chapter II

Campos-Santana M., Amalfi, R.M. Silveira, Robledo G. and Decock C. 2014.

***Fomitiporia neotropica*, a new species from South America evidenced by multilocus phylogenetic analyses**

[***Mycological Progress*** 13: 601-615. DOI 10.1007/s11557-013-0943-1]

This paper results from an in-deep revision of Neotropical species of *Fomitiporia* presenting resupinate, effused basidiomata. Based on molecular phylogenetic analysis, morphology and biogeographical distribution, *Fomitiporia neotropica* Campos-Santana et al. was proposed as a new species. The species has an ample distribution in South American in distinct ecosystems with variable humidity regime. *Fomitiporia neotropica* is morphologically variable regarding the presence/absence of hymenial setae. The range of divergent positions in the DNA sequences used in this study (ITS, 28S, partial *tef1-α*, and *rpb2*), between specimens from distant origins, is of the same magnitude as that between specimens of other related species, such as *F. langloisii*, *F. dryophila*, *F. maxonii* or *F. mediterranea*. A key to the species from the *F. langloisii* lineage is given.

Mycol Progress (2014) 13:601–615
DOI 10.1007/s11557-013-0943-1

ORIGINAL ARTICLE

Fomitiporia neotropica, a new species from South America evidenced by multilocus phylogenetic analyses

Marisa de Campos Santana · Mario Amalfi · Gerardo Robledo · Rosa Mara Borges da Silveira · Cony Decock

Received: 13 March 2013 / Revised: 23 October 2013 / Accepted: 28 October 2013 / Published online: 20 November 2013

Abstract During the revision of the Neotropical *Fomitiporia* species with resupinate basidiomata, several collections from southern Brazil, central Argentina, and French Guiana were found to represent an undescribed species, on the basis of molecular (DNA sequence) and additional morphological and distributional data. This taxon is described and illustrated as *Fomitiporia neotropica* sp. nov. The species belongs to the *Fomitiporia langloisii* lineage, the lineage type within *Fomitiporia* that so far contains only species with resupinate basidiomata spanning exclusively over the Neotropics. *Fomitiporia neotropica* is morphologically variable regarding the presence/absence of hymenial setae, and secondarily, regarding the pore size. It also inhabits distinct ecosystems characterized by variable moisture regimes. The range of divergent positions in the DNA sequences used in this study (ITS, 28S, partial *tef1-α*, and *rpb2*), between specimens from distant origins, are of the same magnitude as those between specimens of other related species, such as *F. langloisii*, *F. dryophila*, *F. maxonii*, or *F. mediterranea*. A key to the species from the *F. langloisii* lineage is given.

Keywords Hymenochaetaceae · Neotropics · Phylogeny · Taxonomy

Marisa de Campos Santana and Mario Amalfi contributed equally to the research and should be considered co-first authors.

M. de Campos Santana · R. M. Borges da Silveira
Programa de Pós-Graduação em Botânica, Universidade Federal do Rio Grande do Sul, Avenida Bento Gonçalves 9500, 91501-970 Porto Alegre, RS, Brazil

M. Amalfi · C. Decock (✉)
Mycothèque de l'Université catholique de Louvain (MUCL, BCCM™), Earth and Life Institute - Microbiology (ELIM), Université catholique de Louvain, Croix du Sud 2 bte L7.05.06, B-1348 Louvain-la-Neuve, Belgium
e-mail: cony.decock@uclouvain.be

G. Robledo
Instituto Multidisciplinario de Biología Vegetal, Universidad Nacional de Córdoba, C.C.495, 5000 Córdoba, Argentina

Present Address:
M. Amalfi
Jardin Botanique National de Belgique, Domaine de Bouchout, Meise, Belgium

Introduction

Fomitiporia (Hymenochaetales), typified by *F. langloisii* (Decock et al. 2007; Murrill 1907), is above all characterized by globose to subglobose, thick-walled, cyanophilous, and dextrinoid basidiospores, in addition to a dimitic (pseudodimitic) hyphal system. Its basidiomata are resupinate to pileate. Cystidioles and hymenial setae are variably present (Fischer 1996). The genus has been segregated into two morphological complexes based on the basidiomata habit: species with pileate basidiomata have been referred to as the *F. robusta* complex (e.g., *F. robusta*, *F. erecta*, *F. hippophaeicola*); species sharing resupinate basidiomata have been commonly referred to as the *F. punctata* complex (e.g., *F. langloisii*, *F. punctata*, *F. pseudopunctata*).

The genus has received much attention in the last 10 years, and an understanding of the phylogenetic structure of both morphological complexes has improved considerably. It is now evident that these two complexes have no phylogenetic grounds (Amalfi and Decock 2013; Amalfi et al. 2010, 2012), and that the resupinate and pileate habits are spread throughout the genus. Our understanding of the taxonomic diversity and species distribution range, in all biogeographical areas, has also greatly improved (Amalfi and Decock 2013; Amalfi et al. 2010, 2012; Dai et al. 2008; Decock et al. 2005, 2007; Fischer and Binder 2004; Fischer et al. 2005; Raymundo et al. 2012; Vlasák and Kout 2011; Zhou and Xue 2012). As far as

Chapter III

Campos-Santana, Amalfi, R.M. Silveira and Decock. 2014.

Multilocus, DNA- based phylogenetic analysis reveal two new species lineages in the *P.gabonensis / P. caribaeo-quercicolus* species complex, including *Phellinus amazonicus* sp. nov.

[***Fungal Diversity***: to be submitted]

Phellinus amazonicus nom. prov. is described based in morphological, molecular and ecological data, from several collections from Ecuador and French Guiana tropical forests. *Phellinus amazonicus* is morphologically similar from *P. gabonensis*, which is distributed along the occidental border of Equatorial Guinea – Congolian forest. *Phellinus amazonicus* and *Ph. gabonensis* also occupy an ecological niche in their respective habitat. However, in an evolutionary perspective, phylogenetic inferences based in three DNA loci (ITS, partial LSU, TEF1 - α) demonstrate that *P. amazonicus* is closer from *P. caribaeo - quercicolus* than from *P. gabonensis.* Several collections originating in Southern Brazil and morphological closely similar to *P. amazonicus*, represent also a undescribed species. However, to few molecuar data are presently available to infer its relationships with *P. amazonicus*.

Short Title: *Phellinus amazonicus* sp. nov.

Multilocus, DNA-based phylogenetic analysis reveal three new species lineages in the *P. gabonensis / P. caribaeo-quercicolus* species complex, including *Phellinus amazonicus* sp. nov.

Marisa de Campos Santana
Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Botânica, Avenida Bento Gonçalves 9500, 91501-970, Porto Alegre, RS, Brazil.

Mario Amalfi
Mycothèque de l'Université catholique de Louvain (MUCL, BCCM™), Earth and Life Institute – Microbiology (ELIM), Université catholique de Louvain, Croix du Sud 2 bte L7.05.06,
B-1348, Louvain-la-Neuve, Belgium.

Rosa Mara Borges da Silveira
Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Botânica, Avenida Bento Gonçalves 9500, 91501-970, Porto Alegre, RS, Brazil.

Cony Decock✉
Mycothèque de l'Université catholique de Louvain (MUCL, BCCM™), Earth and Life Institute – Microbiology (ELIM), Université catholique de Louvain, Croix du Sud 2 bte L7.05.06,
B-1348, Louvain-la-Neuve, Belgium.

Abstract: Species complexes in poroid Hymenochaetaceae are well documented in the temperate areas. Potential species complexes are less known in tropical areas, however. In the last ten years, four phylogenetically closely related *Phellinus* species were described from tropical /subtropical areas, which are characterized by cushion-shaped basidiomata, ventricose, apically curved hymenial setae, and broadly ellipsoid, slightly thick-walled basidiospores. They are *P. caribaeo-quercicolus*, *P. gabonensis*, *P. ellipsoideus,* and *P. castanopsidis*. During the studies of South American *Phellinus s.l.*, a phylogenetic

approach based on DNA multilocus (ITS, partial LSU, *tef1-α*) revealed two new Neotropical lineages or phylogenetic species in the vicinity of these four species clade: *Phellinus amazonicus* sp. nov. and *Phellinus* PS 1. *Phellinus amazonicus* sp. nov. is described on the basis of multiple collections originating from the rainforests of Ecuador and French Guiana. *Phellinus amazonicus* is a morphological sibling of *P. gabonensis*. Furthermore, both species occupy the same ecological niche in analogous rainforest ecosystem in their respective distribution range. This impedes to define unequivocally a morpho- or an ecological species concept. *Phellinus* PS 1 is known from two DNA data sets from two collections originating from northeastern Argentina and Southeastern Brazil. These two collections slightly differ from *P. amazonicus* but we refrain describing for the time because of the paucity of the specimens available. In an evolutionary perspective, the three Neotropical species, *P. amazonicus*, *P. caribaeo-quercicolus*, and *Phellinus* PS 1 form a clade, sharing a closely related genetic background indicating a common origin. A scenario of dispersion and allopatric speciation might be plausible in the Neotropics. A third lineage (*Phellinus* PS 2) is shown in the vicinity of the Asian *P. ellipsoideus* and *P. castanopsidis*. It is suspected to represent *P. setulosus*. Species delineation in this complex by the sole morphology proved challenging, as it is for other species complexes in *Phellinus*. There is a need to implement other species concept within Hymenochaetaceae involving more descriptors (ecological / biogeographical / molecular / biological) to develop a more integrate concept (or implementing a Consolidated Species Concept).
Key words: *Phellinus sensu lato*, Hymenochaetaceae, polypores, North America, Biogeography.

Introduction

Phellinus is one of the major genera in the Hymenochaetaceae (Basidiomycota). It was once the largest genus in the family in term of species number (Corner 1991, Larsen and Cobb-Poulle 1990; Ryvarden 2004). In the last two decades, the commonly accepted *Phellinus* concept (Corner 1991, Gilbertson and Ryvarden 1987, Larsen and Cobb-Poulle 1990, Ryvarden and Gilbertson 1994) was shown to encompass multiple morphologically homogeneous and phylogenetically monophyletic entities, which were worth recognized at generic level. Many species were consequently redistributed into these different multiple generic entities. Nevertheless, in 2008 (Kirk 2008), *Phellinus sensu lato* (*s.l.*) still contained about 180 species.

Phellinus s.l. (and more globally the poroid Hymenochaetaceae) is also well known for containing so-called morphological species complexes. For historical reasons, these complexes are mainly documented in north temperate areas. It includes for instance the *Phellinus ignarius*, the *Fomitiporia robusta*, or the *Porodaedalea pini* complexes (Amalfi *et al.* 2012, Tomšovský 2010a, b, Vlasák and Kout 2010). These complexes would encompass a number of taxonomic "entities" for which divergences (genetic, biological, ecological) occurred without clear indications of morphological changes (e.g. Fischer and Binder 2004, Tomšovský 2010a, b). The delimitation of these entities using classical macro- and/or microscopic features only proved therefore challenging; additional descriptors were considered as critical to circumscribe taxa. It included mostly autecological requirements, such as the host relationships (preference / specificity). However, the importance of ecological features for characterizing taxonomic entities has been variously interpreted (e.g. Rizzo *et al* 2003, Tomšovský 2010a, b). Validation is almost case by case. For instance, presumed host specificities within *P. ignarius* or the *P.* (*Porodaedalea*) *pini* complexes (Fischer 1994, 1995, Fischer and Binder 1995, Niemelä 1975) were only partially confirmed by molecular data (Tomšovský 2010a, b). Pieri and Rivoire (2000) also questioned the status and, as a consequence, the host specialization of *F. erecta* (David *et al* 1982) and *P. juniperinus* (Bernicchia 1990), two *Fomitiporia* (or *Phellinus* of the *Fomitiporia* alliance) species from Mediterranean areas, presumably having different hosts (*Quercus* versus *Juniperus*).

Application of the Phylogenetic Species (PS) concept using the principle of multiple gene genealogy concordance (GC, Taylor *et al* 2000, 2006) helps to evidence diversity within Hymenochaetoid complexes (e.g. Amalfi *et al.* 2010, Decock *et al.* 2007, Vlasák and Kout 2011). *A posteriori*, it may validate the pertinence of questionable ecological descriptors and do more to circumscribe the (bio) geographical distribution range of the various entities (Tomšovský 2010a, b). Finally, as suggested by Amalfi *et al.* (2012), integrating morphological, ecological, biogeographical, and DNA sequence data would yield a more complete (holistic) concept of the species. Such holistic concept has been recently highlighted within the Ascomycota; Quaedvlieg *et al.* (2014) proposed a "consolidated species concept" on a similar basis.

Species complex are less documented in the tropical areas, more likely because these areas remain still poorly explored (Yombiyeni *et al.* 2011). Nonetheless, as far as the New World is concerned, Decock *et al.* (2007), Amalfi *et al.* (2012) and Amalfi & Decock

(2013) showed the existence of multiple clades within the presumed Neotropical *Fomitiporia punctata* or *F. apiahyna* morphospecies. Decock *et al.* (2013) also evidenced multiple lineages within *Phylloporia*, composed of collections that would have entered the *Phylloporia spathulata* morphospecies. Tian *et al*. (2013) and Vlasák *et al.* (2013) also demonstrated that the *I. linteus* species concept encompassed several species in the Neotropics, recognized by combination of both morphological and molecular data.

In the last decade, four phylogenetically closely related *Phellinus* species were described from tropical/subtropical areas. These species are all characterized by cushion-shaped basidiomata, ventricose, apically curved hymenial setae, and broadly ellipsoid, slightly thick-walled basidiospores; they are *P. caribaeo-quercicolus* (Decock *et al.* 2005), *P. gabonensis* (Yombiyeni *et al.* 2011), *P. ellipsoideus* (originally described as *Fomitiporia ellipsoidea*, Cui *et al.* 2011), and *P. castanopsidis.* These species are morphologically very similar, hence forming a morphological complex. They have different ecologies and/or habitat and distribution ranges. In a phylogenetic perspective, they form a well defined lineage within *Phellinus* (Yombiyeni *et al.* 2011, Cui and Decock 2013). They have suggested affinities with *Phellinus setulosus* (Decock *et al.* 2005, Yombiyeni *et al.* 2011).

Pursuing the revision of the Neotropical poroid Hymenochaetaceae, the taxonomic status of several collections from Southern Brazil firstly identified to *P. gabonensis*, based on gross morphological resemblance (Campos-Santana and Silveira 2011) was brought into question by molecular data. These collections were also compared to other specimens originating from Argentina, Ecuador and French Guiana. Phylogenetic inferences based on three DNA loci (partial LSU, ITS, and *tef1-α*) show firstly the South American collections to be distributed over two lineages, and secondly these two clades proved to be distant from the *P. gabonensis* lineage. They are therefore interpreted as belonging to two distinct, phylogenetic species. One species for which numerous collections are available is proposed below as *Phellinus amazonicus*. The second species, for which a single DNA data set is known, needs more material to be adequately described.

Materials and methods

Collection localities of the new taxa.— MUCL materials of the new taxon were collected in French Guiana and in Ecuador. In French Guiana, specimens originated from

the Nouragues, CNRS "Inselberg" research plots, in the homonymous Nouragues Natural Reserve (NNR) (approximately 04°05.5’ N, 52°40.6’ W), along the bank' hills of the Marouini river (approximately 04°05.5’ N, 52°40.6’ W), and in the littoral forest. In Ecuador, they originated from the Yasuni Biological Station (including the CTFS research plot) within the homonymous Biosphere Reserve (YBR) (approximately 76°24’1.8”W, 0°40’16.7”S). These forests belong to the Guiana shield very humid forest (average precipitation is about 3000 mm/year in the Nouragues) and the western Amazonian at the Yasuni rainforest, respectively. White sand forests in French Guiana are Littoral forests. Specimens from Brazil were collected in state Rio Grande do Sul, Dom Pedro de Alcântara, RPPN do Professor Luis Baptista and state Santa Catarina, Itapuá, RPPN Volta Velha in the Atlantic Forest. The Atlantic rain forest is in the Neotropical region. The climate in the region is warm and humid, of the Cfa type, according to the Köppen Climate Classification, with distributed rainfall along the year and hot summer.

Material.— Herbarium specimens are preserved at MUCL with a duplicate at CAY (specimens from French Guiana), PUCE (specimens from Ecuador), NY (herbarium acronyms are from Thiers B. [continuously updated]). Types are deposited at MUCL, CAY (ISOTYPES) and NY (HOLOTYPE). Specimens from Brazil are hosted at ICN with a duplicate at MUCL. MUCL original strains were all isolated from basidiome tissues during field works, on malt extract agar with 2 ppm benomyl (benlate) and 50 ppm chloramphenicol, and later, when necessary, purified from bacteria in the laboratory. Living cultures (strains) are preserved at MUCL, with ex-holotype strains deposited at the CBS.

Morphology and anatomy.— Basidiomata colors are described according to Kornerup and Wanscher (1981). Specimens were examined in Melzer's reagent, lactic acid Cotton blue (Kirk *et al.* 2001), and KOH 4 %. All microscopic measurements were done in Melzer's reagent. In presenting the size range of the microscopic elements, 5% of the measurements were excluded from each end and are given in parentheses, when relevant. Ave = arithmetical mean, Q = ratio of length/width of basidiospores, and ave_Q = arithmetical mean of the ratio Q. Thirty elements per specimen were measured for each microscopic character.

Sequencing.— DNA extraction, amplification and sequencing of the nuclear ribosomal 5’ end of the LSU, ITS regions (including 5.8S) and partial *tef1*-α gene were

described in Amalfi and Decock (2013) and Yombiyeni *et al.* (2011). Sequencing reactions were performed at Macrogen Ltd, Korea with the primers LROR, LR3, LR3R, LR5 for the LSU; ITS1, ITS2, ITS3, ITS4 for the ITS (http://biology.duke.edu/fungi/mycolab/primers.htm, White *et al.* 1990); and 2212R, 1953R, 983F, 2218R for the *tef1-α* (Rehner and Buckley 2005, Matheny *et al.* 2007).

Phylogenetic analysis.— 41 collections representing 8 species / potential species were included in the phylogenetic analysis (TABLE I). Nucleotide sequences were automatically aligned with Clustal X (version 2.0.11) (Thompson *et al*. 1997) then manually adjusted when necessary with the text editor in PAUP* (version 4.0b10). *Phellinus* sp. MUCL 52000 was designated as outgroup. The dataset used in the present study to infer phylogenetic inferences is the same as used previously by Yombiyeni *et al*. (2011), implemented with collections from South America and Asia (Table I). Alignments will be deposited at TreeBASE (http://www.treebase.org/treebase/index.html). The methodologies and parameters for running phylogenetic analyses are described in details in Yombiyeni *et al.* (2011) and not repeated here in details.

Phylogenetic analyzes were performed separately for each gene region using maximum parsimony (MP) as implemented in PAUP* version 4.0b10 (Swofford 2003) and Bayesian inference (BI) as implemented in MrBayes v3.1.2 (Ronquist and Huelsenbeck 2003).

TABLE I. List of species, collections, and sequences used in the phylogenetic analyses.

Genus / Species names number Voucher specimens / cultures reference	GenBank accession nLSU	 ITS	 *tef1-a*
Phellinus amazonicus nom. prov.			
MUCL 53128	–	–	–
MUCL 53141	–	–	–
MUCL 53685	–	–	–
MUCL 55076	–	–	–
MUCL 53056	–	–	–
MUCL 55050	–	–	–
MUCL 53117	–	–	–
MUCL 53036	–	–	–
MUCL 53084	–	–	–
MUCL 55075	–	–	–
MUCL 51478	–	–	–
MUCL 51476	–	–	–
MUCL 53095	–	–	–
MUCL 51487	–	–	–
MUCL 51483	–	–	–
***Phellinus caribaeo- quercicolus* Decock & S. Herrera**			
MUCL 46003	DQ127279	HM635697	HM635725
MUCL 46004 (T)	DQ127280	HM635698	HM635726
MUCL 46005	DQ127281	HM635699	HM635727
***Phellinus castanopsidis* Cui & Decock**			
CUI 10153	JQ837944	JQ837956	–
CUI 10157	JQ837945	JQ837957	–
***Phellinus gabonensis* Decock & Yombiyeni**			
MUCL 47562	HM635682	HM635721	HM635734
MUCL 51275	HM635683	HM635720	HM635735
MUCL 51277	HM635684	HM635719	HM635736
MUCL 52007	HM635685	HM635718	HM635729
MUCL 52012	HM635687	HM635717	HM635730
MUCL 52014	HM635688	HM635716	HM635728
MUCL 52023 Clone A	ND	HM635700	ND
MUCL 52023 Clone H	ND	HM635707	ND
MUCL 52025 Clone A	ND	HM635708	ND
MUCL 52025 Clone H	ND	HM635715	ND
MUCL 52070	HM635686	HM635722	HM635733
Phellinus PS 1			
MUCL 54977	–	–	–
MUCL	–	–	–
Phellinus cf. setulosus			
MUCL 53634	–	–	–
Phellinus sp.			
MUCL 52000	HM635695	HM635723	HM635737
MUCL 52001	HM635696	HM635724	HM635738

T, PT = type, paratype ; ND = no GenBank accession

For MP analyses, gaps were treated as missing. The most parsimonious trees (MPT) for each data set were identified using heuristic searches with 1000 random addition sequences, further evaluated by bootstrap analysis, retaining clades compatible with the 50% majority-rule in the bootstrap consensus tree. Analysis conditions were: tree bisection addition branch swapping (TBR), starting tree obtained via stepwise addition, steepest descent not in effect, MULTREES effective. A bootstrap support value (BS) above 75% was considered significant.

Evolution models for Bayesian inference were estimated using the HLRT (hierarchical Likelihood Ratio Test) as implemented in Modeltest 3.7 (Posada and Crandall 1998). Bayesian analyses were implemented in two independent runs, each with four simultaneous independent chains for three million generations for each dataset, starting from random trees, and keeping one tree every 1000th generation. All trees sampled after

convergence (ave. standard deviation of split frequencies <0.01 and confirmed using Tracer v1.4 (Rambaut and Drummond 2007) were used to reconstruct a 50% majority-rule consensus tree (BC) and to estimate posterior probabilities. The Bayesian posterior probability (BPP) of each node was estimated based on the frequency at which the node was resolved among the sampled trees with the consensus option of 50% majority-rule (Simmons *et al.* 2004). A BPP above 0.95 was considered a significant value.

Results

Phylogenetic analysis.— All the French Guiana, Ecuador, Brazil and Argentina collections have an almost identical 5' end of the nuc LSU. The ITS dataset is composed of 652 total characters, gaps included. The overall length of the *tef1* region located between exons 4 and 8 ranged from 1151 to 1159 bps. Variations were observed between collections, ranging from 0–4 positions. The best-fit model to the ITS dataset was HKY+G with unequal base frequencies (A= 0.2321, C= 0.2043, G= 0.2564, T= 0.3071) and a gamma distribution shape parameter of 0.5440. A heuristic search with 100 random additions produced numerous equally parsimonious trees but one main topology mostly identical to the BC tree (FIG. 1).

Morphological analysis.— Morphologically, the collections examined from Ecuador (6) and French Guiana (18) are very homogeneous as far as their basidiomata, hyphal system, vegetative hyphae differentiation, hymenial setae size and shape, and basidiospores are concerned. The vegetative hyphae are short, skeletal hyphae of limited growth as described in other taxa, including *P. setulosus* (Corner 1991) or *P. gabonensis* (Yombiyeni *et al.* 2011). The collections from Brazil and Argentina share most of these morphological features.

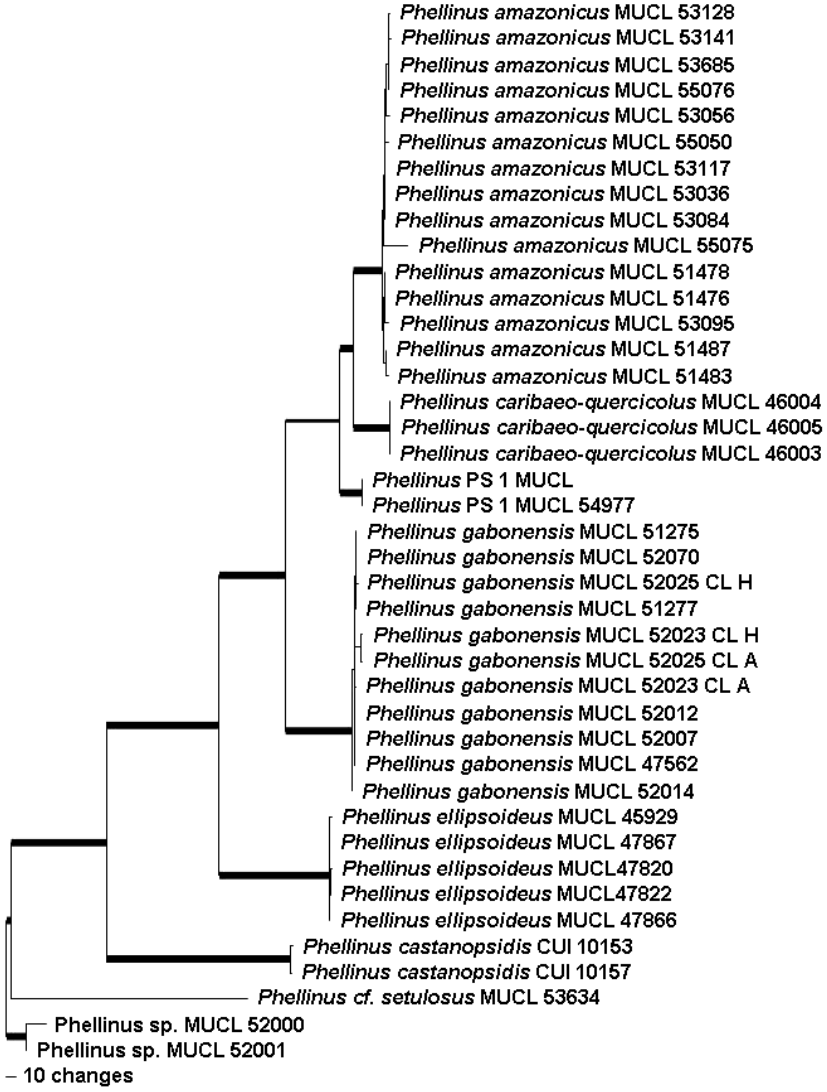


FIG. 1. The 50% majority-rule consensus tree from Bayesian inference of the combined nuclear ITS, *LSU* and *tef1* sequences. Thickened branches in bold indicate bootstrap support greater than 70% and Bayesian posterior probability greater than 0.95.For selected nodes parsimony bootstrap support value and Bayesian posterior probabilities are respectively indicated to the left and right of slashes (/).

Taxonomic conclusions.— As shown in FIG. 1, the phylogenetic inferences resolved the collections from French Guiana and Ecuador as a distinct, well-supported clade. This clade is closely related to and sister clade to the *Phellinus caribaeo-quercicolus* clade. It is interpreted as a distinct species. The collections from Brazil and Argentina form a second well-supported clade, basal to the two species clade French Guiana / Ecuador and *P. caribaeo-quercicolus*).

Although locally common and sometimes with conspicuous basidiomata, no name could be found for the French Guiana / Ecuador species (Larsen and Cobb-Poulle 1990, Ryvarden 2004). It is described below as *Phellinus amazonicus*. The two collections from Brazil and Argentina represent another phylogenetic species. However due to the paucity of material currently available, we refrain to describe it for the time being.

Taxonomy

***Phellinus amazonicus* nom. prov.** Campos-Santana and Decock **sp. nov.** FIGS. 2 -12

MycoBank: MB XXXX.

*Etymology: "*amazonicus"*, from the Amazonian rainforest.*

Basidiomata perennial, resupinate to effused when young, following the substrate, soon cushion-shaped to thickly cushion-shaped, up to nodulose; individual cushion extending up to 600m m in the longest dimension (cushions growing side by side may fuse resulting in large compound basidiomata extending over longer surface, > 1 m, 50–200 mm wide, from 3 mm thick in young specimens up to 100 mm thick in the thickest part of multilayered specimens, strongly adnate and very difficult to cut off from the substrate; consistency very hard, woody; *margin* 0.5–4 mm wide, densely and very minutely velutinous when young, up to pruinose, indurating in old, pulvinate, multilayered specimens, gradually mimetic with the surrounding wood, (whitish) to yellowish brown (5E[7–8]) at the very margin, turning light brown to rusty (6E[7–8]); *pore surface* light to dark brown (6F[4–7]), (chocolate brown 6E[4–8], leather, cocoa brown), glancing with light, then appearing paler, light to golden brown (6D[3–4], camel to cafè au lait); *pores* regular, round to ellipsoid when growing on standing trunk, 7–10/mm, (75–) 90–130 (–140) µm diam (ave = 102 µm); dissepiments entire, thin to thick, (20–) 25–75µm (ave = 39 µm); *subiculum* very thin to almost absent, negligible compared to the thickness of the tube layers, concolorous with the older tube layer; tube layer single to multiple, with numerous individual, weakly distinct layers in old specimens, each 2–35 mm thick, and totaling up to 100 mm thick, in some specimens; *tube layers* brown to dark brown (6[E–F]6–7, cocoa brown to burnt amber), the older layers light brown (6D[5–6], sunburn to camel, 7F[4–5). *Hyphal system* dimitic (of the fifth degree, Corner 1991) identical in the context and hymenophoral trama; generative hyphae hyaline to yellowish, thin-walled, slightly branched, 1.5–3 µm wide; generative hyphae as skeletal hyphae of limited growth, (30–) 47–100 (–125) µm long (ave

= 56.8 µm), 2.0– 2.5 µm diam at the basal septum to 2.5–3.0 (–4 µm) diam (ave = 2.6 µm) in the main part, densely packed, with sub-parallel orientation, straight or occasionally geniculated, especially near the base, then with small, lateral aborted process pale brown, ending rounded, thick-walled but with the lumen open.

Hymenium: *basidia* barrel-shaped, 6.5–8.5 × 4.0–6.0 µm, with four small sterigmata; *basidioles* subglobose to barrel-shaped; *basidiospores* (ellipsoid to) broadly ellipsoid, thin-walled hyaline first, soon distinctly thick-walled, faintly yellowish when mature, pale creamy in dense basidiospores print, 0–1 guttate, negative in Melzer's reagent, 4.5–5.5 (–6.0) × (3.5–) 4.0–5.0 (–5.5) µm (ave = 5.0 × 4.3 µm) R = 1.0– 1.45 (ave_R = 1.2); *hymenial setae* always present, rare to commonly abundant, mono-, bi-, or occasionally three-rooted, occasionally with a small hyphal-like base, acuminate to symmetrically or unilaterally ventricose, straight to curved, occasionally slightly sinuous, the apex acute, straight to commonly curved, or slightly (to strongly) hamate, hooked, (13.0–) 15.0 –23.0 (–25.0) × (4.5–) 5.0–9.5 (–10.0) µm (ave = 17.2 × 6.6 µm); *chlamydospores* not observed in the basidiomata.

Chlamydospores produces in in vitro culture (Fig.12), numerous, subglobose to globose, thick-walled, hyaline to brownish, 8.0–15.0 × 8.0–11.0 µm (ave = 10.9 × 9.5 µm), R = 1.0– 1.50 (ave_R = 1.15).

Type of rot: white pockets rot (Fig.9).

Ecology (substrate, host, habitat): known from dead, standing or fallen trunks, usually large (commonly ≥ 50 cm diam), once on at the base of a living tree, the basidiomata developing on the side, underneath, or covering internal walls of hollowed trunks, of various angiosperms including *Dimorphandra polyandra* (Caesalpiniaceae) and *Minguartia guianensis* (Olacaceae), in humid Neotropical rainforest.

Distribution: known from the Northeastern rainforest of the Guiana shield, French Guiana, Trinidad, and the western edge of the Amazonian rainforest in Ecuador.

Specimens examined: ECUADOR, PROV. ORELLANA: Yasuni Biosphere reserve / Yasuni National Park, in the vicinity of the Biological Station, approx. 0°41' S – 76°24' W, sendero Mirador, on a dead fallen trunk, approx. 50 cm diam, unidentified angiosperm, 01 Jul. 2008, C. Decock, EC-08-49 (MUCL 51476; culture ex-MUCL 51476); ibid., on a dead fallen trunk, approx. 80 cm diam, unidentified angiosperm, C. Decock, EC-08-50;

ibid., on a dead fallen trunk, unidentified angiosperm, C. Decock, EC-08-51 (MUCL 51478; culture ex-MUCL51478); ibid., C. Decock, EC-08-52; ibid. on a dead fallen trunk, approx. 80 cm diam, unidentified angiosperm, 03 Jul. 2008, C. Decock, EC-08-62 (MUCL 51483; culture ex-MUCL 51483); ibid., CTFS-STRI Forest Dynamics Plot, on a dead fallen trunk, unidentified angiosperm, approx. 80 cm diam, 04 Jul. 2008, C. Decock, EC-08-70 (MUCL 51487; culture ex-MUCL 51487). FRENCH GUIANA, MUNICIPALITY OF REGINA: Nouragues Natural Reserve, CNRS "inselberg" research station, approx. 4°05' N - 52°41'W, Grand Plateau, dead fallen trunk, hollowed, basidiomata covering the internal wall, 28 Jul. 2010, C. Decock, FG-10-136 (MUCL 53036, culture ex. MUCL 53036); ibid., Petit Plateau, on a dead standing trunk, broken at about 4 m high, unidentified angiosperm, from the base up to approx. 1 m high, 30 Jul. 2010, C. Decock FG-10-172 (MUCL 53056, culture ex. MUCL 53056); ibid., Petit Plateau, on a dead standing trunk, approx. 50 cm diam, unidentified angiosperm, 01 Aug. 2010, C. Decock, FG-10-217 (MUCL 53084, culture ex. MUCL 53084); ibid., Petit Plateau, fallen trunk, underneath, unidentified angiosperm, 02 Aug. 2010, C. Decock, FG-10-222; ibid., Petit Plateau, on a dead stump, unidentified angiosperm, 02 Aug. 2010, C. Decock, FG-10-234 (MUCL 53095, culture ex. MUCL 53095); ibid., Grand Plateau, dead fallen trunk, approx. 80-90 cm diam, unidentified angiosperm, 04 Aug. 2010, C. Decock, FG-10-269 (MUCL 53117, culture ex. MUCL 53117); ibid., Petit Plateau, on a dead stump, approx. 90 cm diam, 06 Aug. 2010, C. Decock, FG-10-282; ibid., Petit Plateau, on a dead fallen trunk, unidentified angiosperm, approx. 60-70 cm diam, 06 Aug. 2010, C. Decock, FG-10-288 (MUCL 53128, culture ex. MUCL 53128); ibid., on the way to the so-called terrasses, at the Nouragues inselberg, on a dead fallen trunk, 10 Aug. 2010, C. Decock, FG-10-326 (MUCL 53141, culture ex. MUCL 53141); ibid., Petit Plateau, approx. intersection of tracks (layons) 21 & G, at the base of a living trunk, Minquartia guianensis (Olacaceae), 28 Jun. 2011, C. Decock, FG-11-378; ibid., on the way to the so-called terrasses, Nouragues inselberg, on a dead piece of wood, approx. 40 cm diam, 29 Jun. 2011, C. Decock, FG-11-422 (MUCL 53686; culture ex-MUCL 53686); ibid., Grand Plateau, K-L × 15-16, on a dead fallen branch, approx. 30 cm diam, unidentified angiosperm, 03 Jul. 2011, C. Decock, FG-11-501 (MUCL 53722, culture ex. MUCL 53722); on a dead standing trunk, at the base, 16 Jul. 2013, C. Decock, FG-13-751 (MUCL 55075, culture ex. MUCL 55075); MUNICIPALITY OF MARIPASOULA: Marouini river, approx. 02.72854°N – 054.00389° W, elev. approx. 135 masl, forest, on a dead fallen trunk, approx. 50-60 cm

diam, 11 Jul. 2013, C. Decock, FG-13-720 (MUCL 55050, culture ex. MUCL 55050); ibid, dead fallen trunk, underneath, C. Decock, FG-13-729 (MUCL 55053, culture ex. MUCL 55053); MUNICIPALITY OF REGINA: along the track to the Inselberg Savane Roche Virginie, on a dead fallen trunk with mosses, 07 Apr. 2014, C. Decock, FG-14-818 (MUCL 55283, culture ex-MUCL 55283); MUNICIPALITY OF AWALA YALIMAPO: Réserve Naturelle Amana, on a dead fallen trunk, unidentified angiosperm, 15 Apr. 2014, C. Decock, FG-14-860 (MUCL 55321, culture ex-MUCL 55321); dead fallen trunk and roots, possibly Dimorphandra polyandra (Caesalpiniaceae), 17 Apr. 2014, C. Decock, FG-14-893 (MUCL 55326, culture ex-MUCL 55326). TRINIDAD [plants of Trinidad, British Indies]: Brazil, forest, 06 Mar 1921, F.J. Seaver, 3065 (NYBG); Mora forest, east of Sangre Grande, 10 Apr 1921, F.J. Seaver, without number (NYBG).

Remarks. — *Phellinus amazonicus* is well characterized by commonly thickly cushion-shaped basidiomata, short skeletal hyphae, ventricose, apically curved to hamate hymenial setae, and broadly ellipsoid, pale yellowish, slightly thick-walled basidiospores. The basidiomata are found mostly on dead, standing or fallen trunk, commonly ≥ 50 cm diam.

The species might be locally common. It has been repeatedly observed in the two research plots (*Grand* and *Petit plateaux*, covering an area of approx. 120 ha) at the Inselbergs camp, Nouragues Research Station, French Guiana, and in the 50 ha parcels of the CTFS-STRI Forest Dynamics Plot, Yasuni Biosphere Reserve, Ecuador. It has been also repeatedly observed in all other surveyed plots in French Guiana, in humid dense forest and in costal, drier forest on white sandy soils. In the white sand forest, it has been found on dead and once at the base of a living, large (> 1 m diam at the base) trunk of *Dimorphandra polyandra* (Caesalpiniaceae).

In a biogeographical perspective, the species is known to date from the northeastern (French Guiana) and western (Ecuador) edges of the Amazonian rainforest ecosystem. It occurs more likely also in Trinidad, insular South America (although the identity of the unique specimen should be confirmed by molecular data). Its distribution between these two locations and its northern and southern limits of distribution are unknown, preventing to define the distribution pattern (for instance pan-Amazonian or peri-Amazonian distribution).

In phylogenetic and biogeographical perspectives, *P. amazonicus* should be compared to *Phellinus* PS 1 and to *P. caribaeo-quercicolus*. *Phellinus* PS 1 is known from

southern locations in Northeastern Argentina and neighboring areas of Southeastern Brazil. *Phellinus caribaeo-quercicolus* is known from northern locations in the Caribbean and southern Florida (USA). *Phellinus caribaeo-quercicolus* is also the *P. amazonicus* closest relative. The main morphological and ecological features of *P. amazonicus* also call to mind *P. gabonensis*, a species spanning over the western edge of the Guineo-congolian rainforest.

The morphological distinctions between *P. amazonicus* and from PS 1 are uncertain, and might reveal subtle. *Phellinus* PS 1 could differ in having extended pulvinate sheets at the lower face of fallen trunks, in a way similar to the basidiomata of *P. ellipsoideus*, contrasting with the well-delimited, cushion-shaped basidiomata of *P. amazonicus*. Microscopically, we could not find any unequivocal character that could be used to separate the two species.

Phellinus amazonicus and *P. caribaeo-quercicolus* differ in slight morphological features, such as the gross habit of the basidiomata. The upper or lateral margins of the basidiomata become rimose with age in *P. caribaeo-quercicolus*, while it remains entire in *P. amazonicus*. More obviously, both species differ in their ecological requirements in term of host specificity / preference, habitat, and distribution range. *Phellinus caribaeo-quercicolus* is known primarily from living trunks or branches of *Quercus spp.* (Fagaceae) in monospecific *Quercus cubana* or mixed *Q. cubana -Pinus* stands in western Cuba (Decock *et al.* 2005). It is also recorded from Southern Florida (USA) on *Quercus*, (Vlasák, http://mykoweb.prf.jcu.cz/polypores/list_phellinus.html). In Cuba, *Quercus* forests are open with the trees distant from each other. The local climate is characterized by marked rain seasonality, with a six month long, dry period. This habitat and this precipitation regime are very different from the hyper humid, dense forests of French Guiana and Ecuador.

Phellinus amazonicus and *Phellinus gabonensis* are very comparable, both in their morphology and ecology (substrate and habitat type). They are also hardly distinguishable on the sole basis of their morphology. They develop both identical dense, well-delimited pulvinate basidiomata, the margins of which indurate in older specimens but without becoming rimose (Yombiyeni *et al*. 2011). Their microscopic characteristics are also very comparable (Yombiyeni *et al*. 2011). They are vicariant species occupying identical ecological niches in rainforest ecosystems of similar physiognomy (Yombiyeni *et al*.

2011). They form a morpho-ecological complex, and are distinguished by their geographical distribution and genetics.

Phellinus amazonicus could be compared also to the East Asian *P. castanopsidis* and *P. ellipsoideus* (Cui and Decock 2013). *Phellinus ellipsoideus* differs from *P. amazonicus* in forming extended pulvinate sheets underneath large dead fallen trunks, differing from the compact, dense, restricted cushion-like basidiomata of *P. amazonicus.* *Phellinus castanopsidis* form pulvinate basidiomata on living trunks of *Castanopsis*, a subtropical Asian Fagaceae (Cui and Decock 2013).

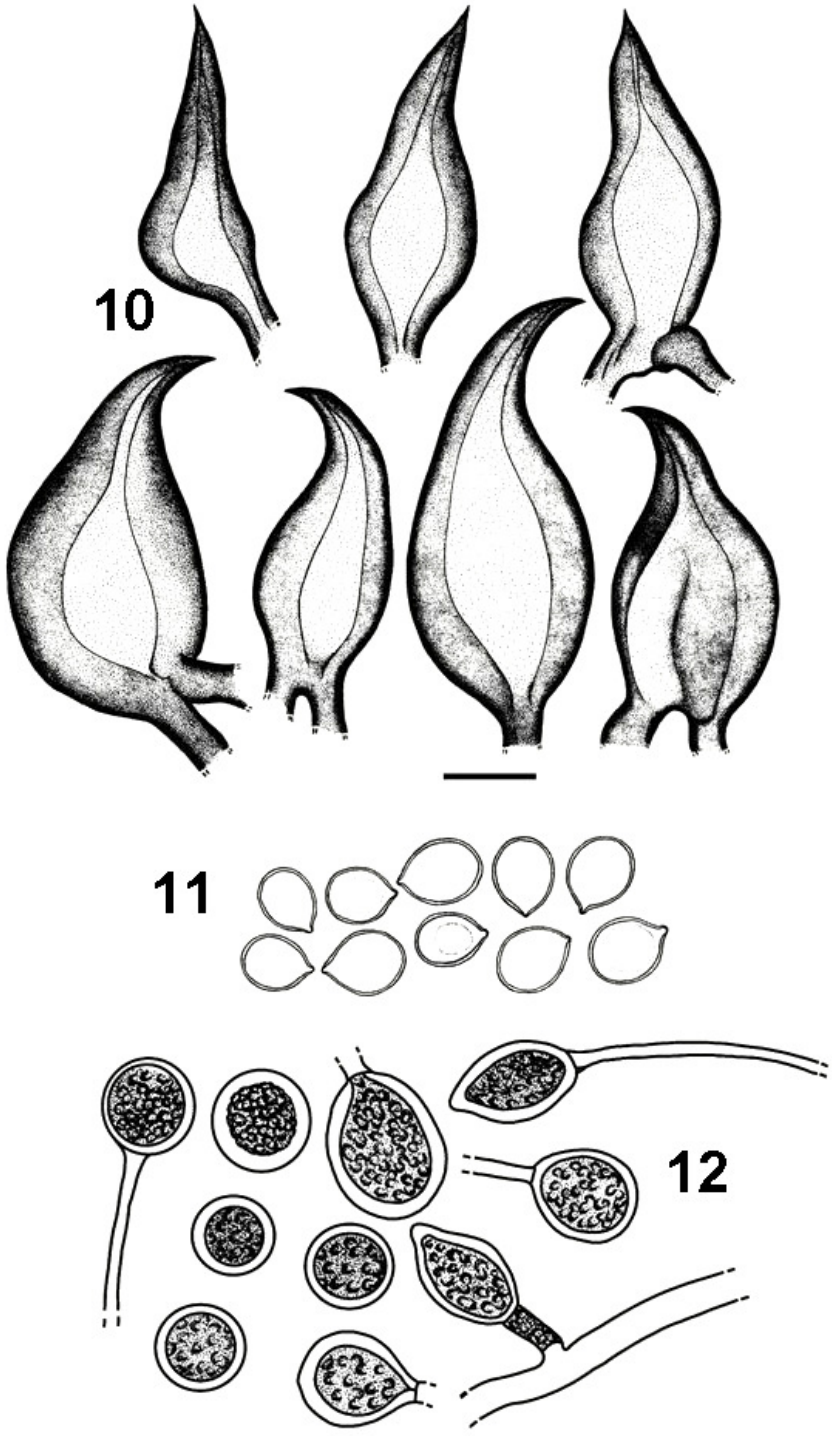
Despite being locally frequent, and sometimes with very conspicuous basidiomata, we could not find a name within *Phellinus s.l.* (Larsen and Cobb-Poulle 1990) that would have applied to this species. Nevertheless, during a revision of the concept of *Fuscoporia wahlbergii* (Fr.) T. Wagner & M. Fisch. over the Neo- and Paleotropics, two specimens both originating from Trinidad and identified to *Pyropolyporus robinsoniae* Murrill in NY (see list of specimens) were found to represent *P. amazonicus*.

Pyropolyporus robinsoniae is currently accepted as a synonym of *F. wahlbergii* (Larsen and Cobb-Poulle 1990, Ryvarden 1990). The specimen (NY) 3065 was annotated "abnormally developed" (anonymous) and as "*P. robinsoniae*" by Lowe (1957). The revision of the type specimen of *P. robinsoniae* confirmed the main features, *viz*. pileate basidiomata with concentrically sulcate pileus, and subulate, apically hamate setae. These features indeed point toward *F. wahlbergii*.

Phellinus setulosus could be compared too, as already noted by Decock *et al*. (2007) and Yombiyeni *et al*. (2011). *Phellinus setulosus* has typically pileate basidiomata. It is, taken *sensu stricto* (e.g. Corner 1991), more likely, a Southeast Asian endemic. Its occurrence in the Neotropics might be re-evaluated. Misidentifications with *P. amazonicus* are not to be excluded. During the revision of the *F. wahlbergii* concept (cf. above), a pure culture held at USDA, Madison, USA under *Phellinus wahlbergii*, is here shown to be affine to *Phellinus ellipsoideus* and *P. castanopsidis* (*Phellinus* PS2, Fig. 1). This culture is of uncertain origin. It should originate from CSIRO (*Commonwealth Scientific and Industrial Research Organisation*, Australia) and there is no data about the locality of the voucher specimen at the origin of this strain).

This strain might represent *Phellinus setulosus*, what should be ascertained by examination of the voucher specimen or gathering of other DNA sequence data from other confirmed *P. setulosus* specimens.

FIGS. 2 - 9. *Phellinus amazonicus*; basidiomata *in situ*. 2: General view of a young basidiomata (MUCL 52487); 3. Mature basidiomata on a standing tree (MUCLMX09-125). 4. Basidiomata on a fallen tree (MUCLMX-09-125). 5. Obclavate basidiomata developping on a standing tree (MUCL52486). 6. General view of the habitat. 7. Small cushion-shaped basidiomata (MUCL 52535). 8. Thick, old basidiomata inside a decayed fallen tree. 9. White pockets rot.



FIGS. 10-12. *Phellinus amazonicus*, MUCL 51487. 10. Hymenial setae. 11. Basidiospores. 12. Chlamydospores. Scale bar=5 μm

***Phellinus* PS 1**.

Specimens examined: ARGENTINA, PROV. MISIONES: Parque Nacional Iguazú, approx 25°41'43" S, 54°26'12" W, on a dead fallen standing trunk, Ocotea sp. (Lauraceae), M. Amalfi (MUCL; culture ex- MUCL); BRASIL, RIO GRANDE DO SUL: Dom Pedro de Alcântara, approx 29°22'10"S, 49°50'59"W, on a dicotyledonous dead wood, unidentified angiosperm, 12 Mar. 2010, Campos Santana 013/10, (ICN); SANTA CATARINA: Itapuá, Reserva Particular do Patrimônio Natural (RPPN) de Volta Velha, approx 26°04'05"S, 48°37'30"W, on a dicotyledonous dead wood, unidentified angiosperm, 23 Feb. 2011, Campos Santana 515 and 516/11 (ICN); 29 Apr 2013, Campos Santana 655/13 (ICN);

Phellinus PS 1 is known from two collections originating from eastern Argentina and southeastern Brazil. It forms extended sheets under fallen trunks. It was observed in the Subtropical Rain Forest phytogeographical area belonging to the Paranaense Region and Tropical Forest (Iganci *et al* 2011). Additional collections from southern Brazil are morphologically similar. More sequence data set are desirable to describe this species.

Diversity within the tropical / subtropical Phellinus species with pulvinate basidiomata and hooked setae.– Previous works demonstrated the occurrence of so-called "cryptic species" in the poroid Hymenochaetales, with no or few "indication of perceptible morphological change" (Fischer and Binder 2004). These species are best evidenced by molecular data, considered alone [phylogenetic species concept / recognition], or linked to ecological or bio-geographical aspects (see for instance Amalfi and Decock 2013, Amalfi *et al.* 2010, Campos-Santana *et al.* 2014, Decock *et al.* 2007, Fischer *et al*. 2005, Fischer and Binder 2004, Fischer 2002). In our case, the collections from French Guiana and Ecuador are identical (sibling) to specimens of *P. gabonensis* (Yombiyeni *et al*. 2011), and likely identical to the collections from Brazil and Argentina. Nonetheless, given their genetic and distribution specificities, a specific taxonomic status is proposed for collections from French Guiana and Ecuador. Specimens from southern locations, in northeastern Argentina and southeastern Brazil belong to a second distinct entity that would be worth recognized at specific status.

The apparent homogeneity of morphological characters, with overlaps of form or size range or the occurrence of subtle differences renders phenotypical identification difficult in this complex. This prevents to define unequivocal morphospecies. Furthermore,

both species occupies similar ecological niche in analogous ecosystems, therefore preventing to define an ecological species concept. They form a morpho-ecological complex. *Phellinus caribaeo-quercicolus* and *Ph. amazonicus* are very closely related but well distinct in their autecologies; they represent vicariant taxa.

Gilbertson and Ryvarden (1987) noted that within the *F. robusta* complex, speciation could have resulted from "[physiological] adaptation to different substrates and vastly different environmental factors". It might be the case for *P. caribaeo-quercicolus*, *P. amazonicus* and *Phellinus* sp. 1. The multiplicity of phylogenetic species evidenced using multiple loci and having potentially differential ecological requirements support this hypothesis.

Amalfi *et al.* (2010) indicated the need to consider other descriptors for species description in Hymenochaetaceae. These descriptors should include, as a rule, combination of descriptors, in addition to morphological data, genomic (multilocus), ecological and biogeographical data, and in the best case, biological data, to define a more "holistic" or "Integrate" species concept. (Puillandre *et al.* 2012). A similar approach was developed in a complex of Ascomycota (Quaedvlieg *et al.* 2014). Quaedvlieg *et al.* (2014) combining multiple complementary descriptors resulted in a "Consolidated Species Concept" (CSC). This should certainly be extended to poroid Hymenochaetaceae. However, still few ecological parameters are systematically collected to add to the species concept.

The *Phellinus caribaeo-quercicolus* complex could be tentatively distributed into two morphological / ecological groups: *P. gabonensis* and *P. amazonicus* form thick, cushion shaped basidiomata underneath or on the side of dead fallen or standing trunks. They occur in very humid rainforest. *Phellinus caribaeo-quercicolus* and *P. castanopsidis* form cushion-shaped basidiomata on living trees (both on Fagaceae) and subtropical, warm Fagaceous forests. *Phellinus ellipsoideus* form very large, convex sheets underneath fallen trunk (Cui and Dai 2008) as it might be the case for *Phellinus* sp. 1. Both occur in subtropical rainforests.

Acknowledgements.

Marisa de Campos Santana acknowledges the financial support received from CAPES (process 8296/11-1) that enabled one year research stay at MUCL, Université catholique de Louvain, Belgium and CNPq (Brazil). Cony Decock gratefully acknowledges the financial support received from the Belgian State – Belgian Federal Science Policy through

the BCCM research program, the FNRS / FRFC (convention FRFC 2.4544.10), and the CIUF/CUD through a PIC program *"reinforcement of the fungal expertise in Ecuador via case studies of fungal plants interactions in selected ecosystems and the development of biotechnology-oriented fungal resource centers",* that allowed fungal diversity studies in Ecuador. The authors also thank warmly Stéphanie Huret for their help with the sequencing program.

Chapter IV

Campos-Santana M., Amalfi M., Silveira R.M., Robledo G. and Decock C. 2014.

Morphological, DNA sequences, and ecological data evidence four **undescribed *Phylloporia* species from Southern Brazil**.

[***Mycological Progress*** to be submitted]

This paper proposed four new species of *Phylloporia* from Southern Brazil. *Phylloporia loguerciae*, *P. neopectinata, P. turbinata* and *P. subchrysita* are described on the basis of morphological and molecular data, during taxonomical and phylogenic studies of poroid Hymenochaetaceae from Atlantic Rainforest and Southern Fields (Pampa) ecosystem. They represent four phylogenetic species (PS). Morphologically, they belong to two distinct morpho-ecological complexes, *viz*. the *P. pectinata* (Klotzsch) Ryvarden and the *P. chrysita* (Berk.) Ryvarden morpho-ecological.

Short Title: Four undescribed *Phylloporia* species from Southern Brazil

Four undescribed *Phylloporia* species from the Brazilian Atlantic Rain Forest and Southern Fields based on morphological, DNA sequences, and ecological data.

Marisa de Campos Santana
Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Botânica, Avenida Bento Gonçalves 9500, 91501-970, Porto Alegre, RS, Brazil.

Mario Amalfi
Mycothèque de l'Université catholique de Louvain (MUCL, BCCM™), Earth and Life Institute – Microbiology (ELIM), Université catholique de Louvain, Croix du Sud 2 bte L7.05.06, B-1348, Louvain-la-Neuve, Belgium.

Rosa Mara Borges da Silveira
Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Botânica, Avenida Bento Gonçalves 9500, 91501-970, Porto Alegre, RS, Brazil.

Gerardo Robledo
Instituto Multidisciplinario de Biología Vegetal, Universidad Nacional de Córdoba, C.C.495, 5000, Córdoba, Argentina

Cony Decock✉
Mycothèque de l'Université catholique de Louvain (MUCL, BCCM™), Earth and Life Institute – Microbiology (ELIM), Université catholique de Louvain, Croix du Sud 2 bte L7.05.06, B-1348, Louvain-la-Neuve, Belgium.

Abstract.— During taxonomical and phylogenetic studies of poroid Hymenochaetaceae from the Atlantic Rainforest and Southern Fields (Pampa) ecosystem, in southern Brazil, several collections of *Phylloporia* were found to represent undescribed species.

Phylogenetic inferences carried out from DNA sequence data of the 5' end of the LSU and the most exhaustive data set available to date distributed these collections into four terminal clades / branches, distinct from all other species clade shown to date. They represent four phylogenetic species (PS). Morphologically, they belong to two distinct morpho-ecological types, *viz*. the *P. pectinata* (Klotzsch) Ryvarden and the *P. chrysita* (Berk.) Ryvarden morpho-ecological type. They are described and illustrated as *Phylloporia subchrysita* that forms soft basidiomata with a thick tomentum, embracing small stem of liana; *P. neopectinata*, *P. loguerciae*, and *P. turbinata* with multiple, gregarious, small basidiomata emerging from on small trunks.
Key words: Hymenochaetaceae, molecular phylogeny, taxonomy, Neotropical mycobiota

Introduction

Phylloporia Murrill (Hymenochaetaceae, Basidiomycota) has received much attention since Wagner and Ryvarden (2002) redefined the generic concept with 12 accepted species. Nowadays 24 species are accepted in the genus (Cui *et al*. 2010, Decock *et al*. 2013, Ipulet and Ryvarden 2005, Valenzuela *et al*. 2011, Zhou 2013, Zhou and Dai 2012). With the exception of *P. resupinata* Douanla-Meli & Ryvarden, that belongs to the *Fomitiporella* clade (Decock *et al*. 2013), all other *Phylloporia* species for which DNA sequence data are available were shown to be closely related, and *Phylloporia sensu* Wagner and Ryvarden (2002) is a monophyletic entity (Decock *et al*. 2013). It is worth noting that DNA sequence data of *P. parasitica* Murrill, the type species of *Phylloporia*, are still missing (Decock *et al*. 2013).

Yombiyeni *et al*. (2014) discussed the possibility of aggregating *Phylloporia* species into several morphotypes, to which would correspond a rather specific ecology, thereby defining morpho-ecological types. It includes for instance the *P. pectinata* or the *P. spathulata* (Hook.) Ryvarden morpho-ecological types (MET). The *P. spathulata* MET correspond to species with stipitate basidiomata that emerge from soil, the mycelial phase likely connected to buried roots, and a variably mono- to dimitic hyphal system. The *P. pectinata* MET encompasses species with small pileate basidiomata, mostly turbinate, gregarious, emerging simultaneously in large number from small stemmed trunk, and a dimitic hyphal system. Nevertheless, in a phylogenetic perspective, the data currently

available does not support a close genetic background of the various species pertaining to these MET (Yombiyeni *et al*. 2014).

The knowledge about the diversity of Neotropical *Phylloporia* has been summarized by Ryvarden (2004). Six species were then reported from this vast area. They are *P. chrysita*, *P. frutica* (Berk. & M.A. Curtis) Ryvarden, *P. parasitica*, *P. pectinata*, *P. spathulata*, and *P. verae-crucis* (Berk.) Ryvarden. Valenzuela *et al*. (2011) added two species, *P. ulloai* R. Valenzuela, T. Raymundo and *P. rzedowskii* R. Valenzuela & Decock, on the basis of collections originating from eastern Mexico, whereas Decock *et al*. (2013) added *P. nouraguensis* Decock & Castillo, found growing at apices of twigs of a bushy Myrtaceae in a peculiar forest covering upper slope of a granitic inselberg in French Guiana. As far as Brazil is concerned, Baltazar and Gibertoni (2009) and Gibertoni and Drechsler-Santos (2010) noted locally five *Phylloporia* species: *Phylloporia chrysita*, *P. frutica, P. pectinata*, *P. ribis* (Schumach.) Ryvarden and *P. spathulata*.

During extensive fieldworks in the Atlantic Rainforest and Southern Fields (Pampa) from Southern Brazil (States of Santa Catarina and Rio Grande do Sul), between 2010 to 2013, about 600 specimens of poroid Hymenochaetaceae were collected. As a continuation of the studies of this material (de Campos Santana *et al*., 2013), several collections of *Phylloporia* were revised. These collections could be sorted into two morpho-ecological types, *viz*. the *P. pectinata* and the *P. chrysita* MET. Phylogenetic inferences based on the 5' end of the nuclear LSU resolved these collections into 4 distinct lineages, hence defining 4 phylogenetic species. They are described and illustrated here below.

Materials and methods

Collection localities.— Specimens from Brazil were collected in Rio Grande do Sul: Caçapava do Sul, Pedra do Segredo (approx. 30º30'44" S, 53º29'29" W); Porto Alegre, Refúgio da Vida Silvestre, UFRGS (approx. 30º21' - 30º26'S, 50º54' - 50º03' W), Dom Pedro de Alcântara (29º22'10" S, 49º50'59" W), Derrubadas, Parque Estadual do Turvo (approx. 27º08'44" S, 53º53'10" W) and Santa Catarina, Mondaí, Linha Uruguai (approx. 27º06'16'S and 53º24'07'W). Two vegetation types are predominant in this region: the Atlantic Forest and the Southern Fields, also known as Pampa. According to Pell *et al*. (2007), following the climatic classification of Köppen, the region has humid

subtropical climate with four well defined seasons and mild summers (Cfa). The rains, in general, are evenly distributed through the year.

Specimens.— The type specimens of the new species are deposited at ICN (Holotype) with isotypes at MUCL and NY (Herbarium acronyms are according Thiers, continuously updated). Living cultures are preserved at the MUCL with a duplicate at ICN and the type strains of the new species deposited at the CBS. The strains used in this work were isolated from basidiospores (obtained from spore prints) on malt extract agar with 50 ppm chloramphenicol.

Specimen description. — Colors are described according to Kornerup and Wanscher (1981). Sections of the basidiomata were incubated for one hour at 40°C in NaOH 3% solution, then carefully dissected under a stereomicroscope and examined in NaOH 3% solution at room temperature (Decock *et al*., 2010, 2013). To study the staining reaction of the basidiospores and hyphae, sections of the basidiomata were examined in Melzer's reagent, lactic acid cotton blue, and KOH 4%. All microscopic measurements were done in Melzer's reagent. In presenting the size range of several microscopic elements, 5% of the measurements at each end of the range are given in parentheses when relevant. The following abbreviations are used: ave = arithmetic mean, Q = the ratio of length/width of basidiospores, and ave_q = arithmetic mean of the ratio R. As a rule, 30 microscopic elements of the basidiomata (pores / basidiospores / chlamydospores / hyphae) were measured from each specimen.

Sequencing.— DNA extraction, amplification and sequencing of the 5' end of the nuclear ribosomal LSU rRNA gene were as described in Decock *et al*. (2013) and Yombiyeni *et al*. (2014).

Phylogenetic analysis.— 101 specimens and cultures representing 56 taxa or potential species clades were included in the phylogenetic analysis. Materials and sequences used in this study are listed in TABLE I. Nucleotide sequences were automatically aligned with Clustal X (version 2.0.11) (Thompson *et al*., 1997). The alignment was then manually adjusted as necessary with the text editor in PAUP* (version 4.0b10). *Inonotus micantissimus*, MUCL52413, a species of the *Inonotus sensu* Wagner and Fischer (2002) clade, was designated as outgroup (Larsson *et al*., 2006).

Phylogenetic analyses were performed using maximum parsimony (MP) as implemented in PAUP* 4.0b10 (Swofford, 2003), Bayesian inference (BI) as implemented

in MrBayes v3.1.2 (Huelsenbeck and Ronquist, 2001), and Maximum likelihood (ML) searches were conducted with RAxML 7.0.4 (Stamatakis, 2006). The general time reversible model (GTR), using proportion of invariant sites and distribution of rates at variable sites modeled on a discrete gamma distribution with four rate classes, was estimated as the best-fit likelihood model of evolution for Bayesian inference and Maximum likelihood analyses. The Akaike Information Criterion (AIC) as implemented in Modeltest 3.7 was used (Posada and Crandall, 1998).

Bayesian analyses were implemented with two independent runs, each with four simultaneous independent chains for ten million generations, and keeping one tree every 1000^{th} generation. The tree with the best likelihood value served as the starting tree for the Bayesian analyses. All trees sampled after convergence [average standard deviation of split frequencies < 0.01, confirmed using Tracer v1.4 (Rambaut and Drummond, 2007)] were used to reconstruct a 50% majority-rule consensus tree (BC) and to estimate posterior probabilities. The posterior probability (BPP) of each node was estimated based on the frequency at which the node was resolved among the sampled trees with the consensus option of 50% majority-rule (Simmons *et al*., 2004). Clades with BPP above 0.95 were considered strongly supported by the data.

Maximum likelihood (ML) searches conducted with RAxML involved 1000 replicates under the GTRGAMMAI model, with all model parameters estimated by the program. In addition 1000 rapid bootstrap (ML BS) replicates were run with the same GTRGAMMAI model. Clades with maximum likelihood bootstrap values of 85% or greater were considered to be significantly supported.

For MP analyses, Gaps were treated as fifth bases. The most parsimonious trees (MPT) were identified using heuristic searches with 100 random addition sequences, further evaluated by bootstrap analysis, retaining clades compatible with the 50% majority-rule in the bootstrap consensus tree. Analysis conditions were tree bisection addition branch swapping, starting tree obtained via stepwise addition, steepest descent not in effect, MulTrees effective. Clades with bootstrap support value (BS) above 90% were considered strongly supported by the data.

TABLE I. List of species / specimens (country of origin, collection reference, substrate / host) and their accession numbers of sequences used in the phylogenetic analyses.

Genera / Species	Country of origin	Collection reference	Substrate / host	LSU GenBank Accession
Aurificaria				
A. luteoumbrina (Romell) D.A. Reid	Puerto Rico	LF 39116	*Pinus sylvestris*	AY059033
Coltricia				
C. cf. stuckertiana (Speg.) Rajchenb. & J.E. Wright	Argentina	MUCL 47643, Robledo 728	Root, unidentified angiosperm	HM635663
	Argentina	CORD, Robledo 219	Root, unidentified angiosperm	KC136219
	Argentina	CORD, Robledo 218	Root, unidentified angiosperm	KC136220
	Argentina	CORD, Robledo 281	Root, unidentified angiosperm	KC136221
	Argentina	CORD, Robledo 351	Root, unidentified angiosperm	KC136226
Fomitiporella				
F. caryophylli (Racib.) T. Wagner & M. Fisch.	India	BBS 448.76	*Shorea robusta*	AY059021
F. cavicola (Kotl. & Pouzar) T. Wagner & M. Fisch.	UK	N 153	*Fagus sylvatica*	AY059052
Fulvifomes				
F. kawakamii (M.J. Larsen et al.) T. Wagner & M. Fisch.	USA	CBS 428.86	*Casuarina equisetifolia*	AY059028
F. robiniae (Murrill) Murrill	USA	CBS 211.36	*Robinia pseudoacacia*	AY411825
Inocutis				
I. jamaicensis (Murrill) A.M. Gottlieb *et al*.	USA	Gilb. 14740	*Quercus virginia*	AY059048

I. rheades (Pers.) Fiasson & Niemelä	Germany	TW 385	*Populus tremula*	AF311019
Inonotus				
I. micantissimus Rick) Rajchenb.	Mexico	MUCL 52413	wood, Unidentified angiosperm	HM635663
Phylloporia				
P. afrospathulata Yombiyeni *et al.*	Gabon	MUCL 54511/ NY (T)	Root, unidentified angiosperm	KJ743248
	Gabon	MUCL 53983 (PT)	Root, unidentified angiosperm	KJ743249
P. bibulosa (Lloyd) Ryvarden	Pakistan	Ahmad 27088	*Peristropha bicalyculata*	AF411824
P. cf. capucina (Mont.) Ryvarden	Argentina	CORD, Robledo 1610	Stem, unidentified angiosperm	KJ651919
P. chrysita (Berk.) Ryvarden	Puerto Rico	N.W. Legon	Unidentified angiosperm	AF411821
	Mexico	MUCL 52763	Unidentified angiosperm	HM635665
	Mexico	MUCL 52764	Unidentified angiosperm	HM635666
	Mexico	MUCL 52862	*Neopringle sp.*	HM635667
P. crataegi L.W. Zhou & Y.C. Dai	China	IFP, Dai 11014 (T)	Root, *Crataegus sp.*	JF712922
	China	IFP, Dai 11016 (PT)	Root, *Crataegus sp.*	JF712923
P. ephedrae (Woron.) Parmasto	Turkmenistan	TAA 72-2	*Ephedra sp.*	AF411826
P. fontanesiae L.W. Zhou & Y.C.	China	IFP, Li 199 (T)	Living *Fontanesia sp.*	JF712925
Dai	China	IFP, Li 194 (PT)	Living *Fontanesia sp.*	JF712924
P. cf. frutica (Berk. & M.A.	Mexico	MUCL 52762	Unidentified angiosperm	HM635668
Curtis) Ryvarden	Mexico	ENCB TR&RV858	Unidentified angiosperm	HM635669
	Mexico	MUCL 52863	Unidentified angiosperm	HM635670
P. fulva Yombiyeni & Decock	Gabon	MUCL 54472 / NY (T)	Trunk, unidentified angiosperm	KJ743247
P. gutta L.W. Zhou & Y.C. Dai	China	IFP, Dai 4103 (PT)	Unidentified angiosperm	JF712926
	China	IFP, Dai 4197 (T)	*Abelia sp.*	JF712927
P. hainaniana Y.C. Dai & B.K. Cui	China	IFP, Dai 9640 (T)	Twig, unidentified angiosperm	JF712928
P. inonotoides Yombiyeni &	Gabon	MUCL 54468 / NY (T)	Trunk, *Crotonogyne manniana*	KJ743250
Decock	Gabon	MUCL 54469 (PT)	Trunk, *Crotonogyne manniana*	KJ743251
	Gabon	MUCL 54470 (PT)	Trunk, *Crotonogyne manniana*	KJ743252
Phylloporia loguerciae nom. prov.	Argentina	CORD, Robledo 1624	Stem, *Magfadyena unguis-cati*	KJ651920
	Argentina	CORD, Robledo 1134	Stem, unidentified liana	KJ651917

	Argentina	CORD, Robledo 429	Dead stem, *Magfadyena unguis-cati*	KJ651913
	Brazil	Isa 437 (T) / MUCL 54226	Unidentified angiosperm	KJ743270
P. minutispora Ipulet & Ryvarden	RDC	MUCL 52865	Root, unidentified angiosperm	HM635671
	Uganda	O, Ipulet 706 (IT)	Root, unidentified angiosperm	JF712929
P. nandinae L.W. Zhou & Y.C. Dai	China	IFP, Dai 10625 (PT)	Living *Nandina domestica*	JF712931
	China	IFP, Dai 10588 (T)	Living *Nandina domestica*	JF712930
Phylloporia neopectinata nom. prov.	Brazil	Isa 352 (T)	Small-stemmed dead standing trunk, unidentified angiosperm	KJ743267
	Brazil	Isa 553	Trunk, unidentified angiosperm	KJ743266
	Brazil	Isa 640 / MUCL 54295	Trunk, unidentified angiosperm	KJ743269
	Brazil	Isa 552 / MUCL 54288	Trunk, unidentified angiosperm	KJ743268
P. nouraguensis Decock & Castillo	French Guiana	MUCL53816 (T)	Living twig, *Myrcia* sp.	KC136222
	French Guiana	MUCL53817 (PT)	Living twig, *Myrcia* sp.	KC136223
	French Guiana	MUCL53818 (PT)	Living twig, *Myrcia* sp.	KC136224
P. oblongospora Y.C. Dai & H.S. Yuan	China	IFP, Zhou 179 (T)	Branch, unidentified angiosperm	JF712932
P. oreophila L.W. Zhou & Y.C. Dai	China	IFP, Cui 2219 (PT)	Bush, unidentified angiosperm	JF712933
	China	IFP, Cui 9503 (T)	Fallen, unidentified angiosperm	JF712934
P. pectinata (Klotzsch) Ryvarden	Australia	R. Coveny 113	Trunk, *Rhodania rubescens*	AF411823
Phylloporia ME pectinata	Gabon	MUCL / GA-12-813	Living trunk, Melastomataceae	KJ743253
	Gabon	MUCL / GA-12-846	Living trunk, Melastomataceae	KJ743254
	Gabon	MUCL / GA-12-816	Living trunk, Melastomataceae	KJ743255
	Gabon	MUCL / GA-12-814	Living trunk, Melastomataceae	KJ743256
	Gabon	MUCL / GA-12-815	Living trunk, Melastomataceae	KJ743257
	Gabon	MUCL / GA-12-812	Living trunk, Melastomataceae	KJ743281

P. resupinata Douanla-Meli & Ryvarden	Cameroon	O, DMC 476 (IT)	Trunk, *Entandrophragma sp.*	JF712935
P. ribis (Schumach.: Fr.) Ryvarden	Germany	MF 82-828	*Ribes uva-crispa*	AF311040
P. rzedowskii R. Valenz. & Decock	Mexico	MUCL 52868 (T)	Branch, *Hybanthus mexicanus*	HM635672
	Mexico	MUCL 52859 (PT)	Branch, *Hybanthus mexicanus*	HM635673
	Mexico	MUCL 52860 (PT)	Branch, *Hybanthus mexicanus*	HM635674
	Mexico	MUCL 52861 (PT)	Branch, *Hybanthus mexicanus*	HM635675
Phylloporia sp.	Argentina	CORD, Robledo 1220	Trunk, unidentified angiosperm	KC136225
	Argentina	CORD, Robledo 526	Living twig, *Allophyllus edulis*	KJ651914
	Argentina	CORD, Robledo 527	Living twig, *Allophyllus edulis*	KJ651915
	Argentina	CORD, Robledo 968	Living twig, *Allophyllus edulis*	KJ651916
Phylloporia sp.	Ecuador	MUCL 52864	Root, unidentified angiosperm	HM635676
	French Guiana	MUCL, FG-11-506	Root, unidentified angiosperm	KC136227
	French Guiana	MUCL, FG-11-462	Root, unidentified angiosperm	KC136228
	French Guiana	MUCL, FG-13-721	Trunk, unidentified angiosperm	KJ743263
	French Guiana	MUCL, FG-13-722	Trunk, unidentified angiosperm	KJ743264
	French Guiana	MUCL, FG-13-670	Trunk, unidentified angiosperm	KJ743262
	French Guiana	MUCL, FG-13-754	Root, unidentified angiosperm	KJ743261
	French Guiana	MUCL, FG-10-321	Trunk, unidentified angiosperm	KJ743277
	French Guiana	MUCL, FG-13-726	Root, unidentified angiosperm	KJ743279
	French Guiana	MUCL, FG-13-749	Root, unidentified angiosperm	KJ743280
	Cuba	MUCL 43733	No data	KJ743278

	Mexico	MUCL 53433	Unidentified angiosperm	KC136231
	Cuba	MUCL, CU-05-249	Branch, unidentified angiosperm	KJ743282
	Cuba	MUCL 45062	Trunk, unidentified angiosperm	KJ743284
	Gabon	MUCL, YOM 5	Unidentified living liana	KJ743283
P. spathulata (Hook.) Ryvarden	Mexico	Chay 456	Root, *Apocynaceae*	AF411822
P. ME spathulata	French Guiana	MUCL, FG-12-522	Root, unidentified angiosperm	KJ743259
	French Guiana	MUCL, FG-12-523	Root, unidentified angiosperm	KJ743260
	French Guiana	MUCL, FG-11-506	Root, unidentified angiosperm	KJ743258
	French Guiana	MUCL, FG-11-462	Root, unidentified angiosperm	KC136228
	Ecuador	MUCL 52684	Root, unidentified angiosperm	KJ743276
	Argentina	CORD, Robledo 1467	Root, unidentified angiosperm	KJ651918
	Argentina	CORD, Robledo 1790	Root, unidentified angiosperm	KJ651921
Phylloporia subchrysita nom. prov.	Brazil	Isa 117	on living stem, unidentified liana	KJ743272
	Brazil	Isa 333	on living stem, unidentified liana	KJ743273
	Brazil	Isa 610 (T)	on living stem, unidentified liana	KJ743274
	Brazil	Isa 555	on living stem, unidentified liana	KJ743271
	Brazil	ICN / ISA G70	on living stem, unidentified liana	KJ743275
Phylloporia turbinata nom. prov.	Brazil	ISA 007 (T)	Trunk, unidentified angiosperm	KJ743265
P. ulloai R. Valenz. et al.	Mexico	MUCL 52866 (PT)	Unidentified living liana	HM635677
	Mexico	MUCL 52867 (T)	Unidentified living liana	HM635678
	Mexico	MUCL 52870 (PT)	Unidentified living liana	HM635679
P. weberiana (Bres. & Henn.: Sacc.) Ryvarden	China	IFP, Dai 9242	Unidentified angiosperm	JF712936

T, PT = type, paratype. ME = Morpho-ecological group

Results

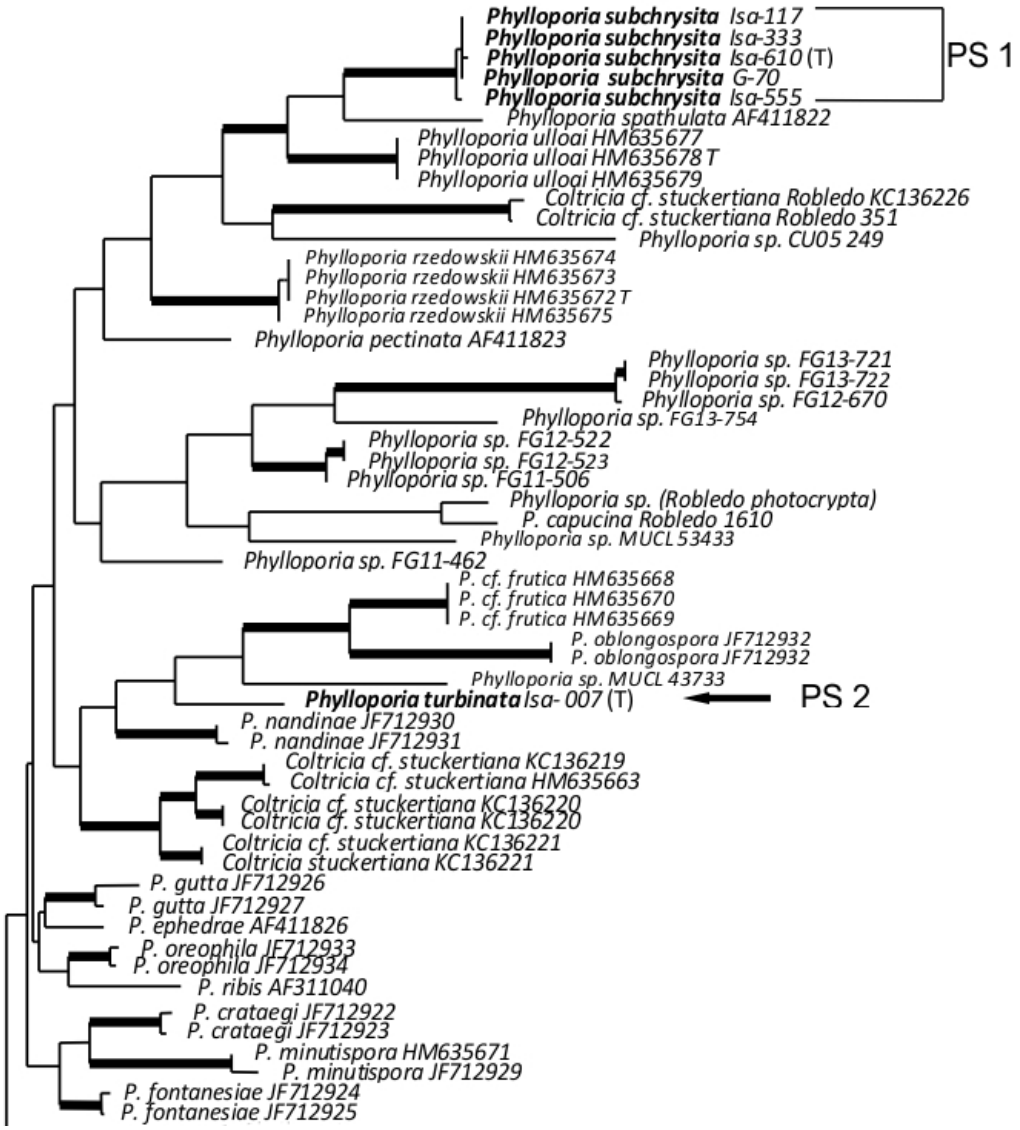
Phylogenetic analysis.— Within *Phylloporia*, the length of the LSU fragment ranged from 866 to 884 bps. The alignment of the 101 sequences resulted in 951 positions of which 20 were excluded, 489 were constant, and 370 were parsimony informative.

Using the Akaike information criterion of MrModeltest 2.3 (Posada and Crandall 1998), the best-fit model for the nucLSU data set was GTR+I+G with unequal base frequencies (A = 0.2468, C = 0.1901, G = 0.3211, T = 0.2419), a gamma distribution shape parameter of 0.5390, and a proportion of invariable sites of 0.3482.

The MP analysis produced 238 most parsimonious trees (1924 steps, consistency index (CI) 0.332, retention index (RI) 0.678. The two Bayesian runs converged to stable likelihood values after 3.898.000 generations and 6102 stationary trees from each analysis were used to compute a 50% majority rule consensus tree in PAUP* and to calculate posterior probabilities. In the ML searches with RAxML, the nuc-LSU alignment had 448 distinct patterns with a proportion of gaps and undetermined characters of 7.75%.

The strict consensus of the 4 most parsimonious trees were mostly identical to the BC tree and to the optimal ML tree (tree score of -lnL = - 8920.620553). One of the equally most parsimonious trees is presented in Fig. 1.

The topologies of the trees regarding the recovery and the relative positions of the different major poroid Hymenochaetales generic entities considered were identical in all the phylogenetic inferences, in accordance with previous results (Decock et al., 2013, Valenzuela et al., 2011, Wagner and Fischer, 2002). The *Phylloporia* clade is very well supported (BS 98% / BPP 1.0 / ML BS 100%) [Fig. 1].


Phylloporia subchrysita Isa-117
Phylloporia subchrysita Isa-333
Phylloporia subchrysita Isa-610 (T)
Phylloporia subchrysita G-70
Phylloporia subchrysita Isa-555
PS 1
Phylloporia spathulata AF411822
Phylloporia ulloai HM635677
Phylloporia ulloai HM635678 T
Phylloporia ulloai HM635679
Coltricia cf. stuckertiana Robledo KC136226
Coltricia cf. stuckertiana Robledo 351
Phylloporia sp. CU05 249
Phylloporia rzedowskii HM635674
Phylloporia rzedowskii HM635673
Phylloporia rzedowskii HM635672 T
Phylloporia rzedowskii HM635675
Phylloporia pectinata AF411823
Phylloporia sp. FG13-721
Phylloporia sp. FG13-722
Phylloporia sp. FG12-670
Phylloporia sp. FG13-754
Phylloporia sp. FG12-522
Phylloporia sp. FG12-523
Phylloporia sp. FG11-506
Phylloporia sp. (Robledo photocrypta)
P. capucina Robledo 1610
Phylloporia sp. MUCL 53433
Phylloporia sp. FG11-462
P. cf. frutica HM635668
P. cf. frutica HM635670
P. cf. frutica HM635669
P. oblongospora JF712932
P. oblongospora JF712932
Phylloporia sp. MUCL 43733
Phylloporia turbinata Isa- 007 (T)
PS 2
P. nandinae JF712930
P. nandinae JF712931
Coltricia cf. stuckertiana KC136219
Coltricia cf. stuckertiana HM635663
Coltricia cf. stuckertiana KC136220
Coltricia cf. stuckertiana KC136220
Coltricia cf. stuckertiana KC136221
Coltricia stuckertiana KC136221
P. gutta JF712926
P. gutta JF712927
P. ephedrae AF411826
P. oreophila JF712933
P. oreophila JF712934
P. ribis AF311040
P. crataegi JF712922
P. crataegi JF712923
P. minutispora HM635671
P. minutispora JF712929
P. fontanesiae JF712924
P. fontanesiae JF712925

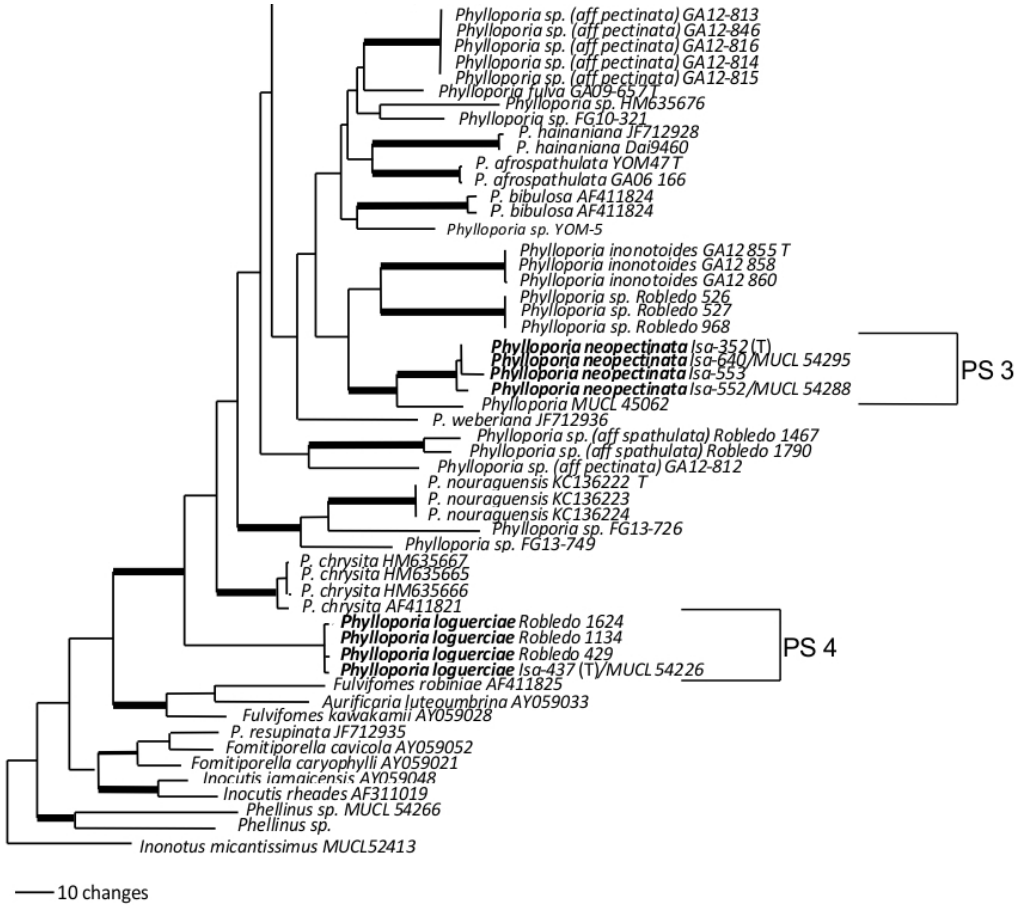


FIG. 1. Phylogenetic relationships of *Phylloporia* species inferred from nucLSU rDNA sequences. The maximum likelihood tree was rooted with *Inonotus micantissimus* MUCL52413. Black dots on branches represent BPP greater than 0.95 and ML/BS greater than 85%; grey dots on branches denote BPP greater than 75% and ML/BS grater than 65%.

In the phylogenetic inferences, our *Phylloporia* collections from Brazil were distributed into 4 terminal clades / branches (Fig. 1, PSs 1–4), within the *Phylloporia* lineage. These four clades / branches are distant from all other species clades / branches shown to date (Decock *et al*., 2013); they represent distinct phylogenetic units, or phylogenetic species.

Subsequent examinations of the various collections pertaining to each of these clades allowed evidencing combinations of morphological features that correspond to two morphotypes / morphospecies as defined by Wagner and Ryvarden (2002). They also correspond to two distinct ecologies, thereby defining morpho-ecological types.

Phylloporia PS 1 belongs to the *P. chrysita* morpho-ecological type, characterized by soft basidiomata with a thick tomentum, a monomitic hyphal system, and broadly ellipsoid to subglobose basidiospores. *Phylloporia* PSs 2–4 are characterized by small, triquetrous to conical basidiomata, gregarious, emerging simultaneously in large number from small stemmed trunks, a dimitic hyphal system, and globose to subglobose basidiospores. They belong to the *P. pectinata* morpho-ecological type.

Taxonomy

Phylloporia subchrysita nom. prov. Campos-Santana, R. M. Silveira & Decock **sp. nov.**

Figs. 2A-D; 4A

MycoBank: MBxxxxx

Etymology: "*subchrysita*", refers to the resemblance with *P. chrysita*.

Basidiomata annual, pileate, sessile; *pileus* solitary or in small number (1–4 specimens), broadly attached, nodulose, semi-ungulate to semicircular to fan-shaped or amplectens (encircling the branch or stem) in pole view, occasionally laterally fused forming compound basidiomata, sometimes projecting from a lateral tomentose base, extending up to 70 mm long, 40 mm wide, 10 mm in the thickest part, light in weight; *pileus surface* dull, spongy, soft, with alternate (wavy) concentric bands of variable height, overall in brown shade, mostly cocoa to rust brown (6E[6–8]) darker toward the basis, dark brown (chestnut brown, 6F7); *margin* obtuse, entire, up to 0.5 mm wide, yellowish white to pale yellow (4A[2–3]), lighter than pore surface and the pileus; *pore surface* plane to slightly concave, yellowish brown (5D[4–6)], yellowish orange (4B[6–8]) becoming brown (4E4) to yellowish brown (4E[5–6]) when mature; *pores* small, (7–) 8–9 (–10) / mm, (80–) 90–130 (–140) µm diam, round to ellipsoid, occasionally in defined rows; *dissepiments* entire, agglutinated when dry, about 30–60 µm thick with many crystals; *context* duplex, with a thin black line (resinous) separating an upper tomentum and a lower context; *upper tomentum a thick trichoderme,* soft, spongious, wavy, in alternate concentric ridges of variable height, from 2–7 mm thick, cinnamon brown (6D6) to brown (6E[4–5)]); *lower context* denser, thin, up to 1 mm, much paler than the tomentum, grayish yellow (4C[6–7]) to dark yellow (4C8) fibrous (with bundle of hyphae under the lens); *tube layer* up to 0.3–1.0 mm deep, concolorous or only slightly darker than the lower context.

Hyphal system monomitic in all parts; *generative hyphae* simple septate, thin- to slightly thick-walled, hyaline to faintly yellowish, scarcely branched, negative in Melzer's reagent; in the *hymenophoral trama hyphae*, hyphae thin- to slightly thick-walled, the lumen widely open, with long aseptate segments, hyaline to pale yellow, darker in KOH, 2.0–4.0 (–5) µm diam (ave = 3.5 µm); in the *context* hyphae tightly packed, slightly interwoven, thick-walled but the lumen widely open, pale golden brown to golden brown, (4.0–) 4.5–5.0 (–5.5) µm diam (ave = 4.1 µm); the upper *tomentum* as a thick trichoderme, with erected to prostrate, thick-walled hyphae, yellowish to brown, mostly unbranched, 6.0–8.0 (–9) µm diam.

Hymenium: *basidia* clavate, hyaline in KOH, up to 9–10 (–11) × 4–5 µm long with four sterigmata; *basidioles* identical in shape but slightly smaller; *cystidia* or other hymenial element absent; *basidiospores* abundant, broadly ellipsoid to subglobose, appearing somewhat angular on drying, thick-walled, pale yellowish in KOH, without reaction in Melzer's reagent, 3.0–4.0 (–5.0) × 2.0–3.0 (–4.0) µm (ave = 3.7 × 2.7 µm), Q = 1.25–1.5 (ave_Q = 1.39).

Substrate and host: on living stem, unidentified liana.

Know distribution: Known from the Brazilian Atlantic rainforest and Brazilian Pampa Biomes, Rio Grande do Sul.

HOLOTYPUS. BRAZIL, RIO GRANDE DO SUL. Refúgio da Vida Silvestre-UFRGS, approx. 30°03' S, 51°07'W, elev. approx. 130 m, on living stem, unidentified liana, 31 May 2011, de Campos-Santana 610/11 (ICN 177689); *isotypus* in herbaria NY and MUCL. Reference nLSU sequence: KJ743274

Additional specimens examined: BRAZIL, RIO GRANDE DO SUL: Caçapava do Sul, approx. 30º30'44"S, 53º29'29"W, elev. approx. 444 masl, on the bark of a small-stemmed dead standing, unidentified liana, 16/IV/2010, *Campos-Santana* 117/10 (ICN 177687); Porto Alegre, Refúgio da Vida Silvestre da UFRGS, approx. 30°03' S, 51°07'W, elev. approx. 130 m, on living stem, unidentified liana, 06/VI/2011, *Campos-Santana* 555/11 (ICN 177688); ibid., Viamão, Parque Estadual de Itapuã, approx. 30°27' S – 30°20' S, 51°03' W – 50°50' W, on living stem, unidentified liana,16/X/2010, *Campos-Santana* 333/10 (ICN 177700).

Remarks: Phylloporia subchrysita has thick, irregular, nodulose to amplectens basidiomata, with a thick tomentum, a monomitic hyphal system, and ellipsoid to

subglobose basidiospores, 3.0–4.0 (–5.0) × 2.0–3.0 (–4.0). The basidiomata are emerging solitary or in small number, from stems of liana.

The overall basidiomata habit, the tick tomentum, the hyphal system, and the ecology point toward *Phylloporia chrysita*. *Phylloporia subchrysita* differs from *P. chrysita* in having smaller pores (8–9 (–10) / mm *versus* 6–8 / mm (fide Ryvarden 2004) and slightly larger, more ellipsoid basidiospores (distinctly subglobose in *P. chrysita*, fide Ryvarden 2004).

Phylloporia subchrysita could be compared also to *P. ulloai*. Both species share amplectens basidiomata, a thick tomentum, a thin tube layer, the monomitic hyphal system, and the basidiospores shape and size. *Phylloporia subchrysita* and *P. ulloai* differ by their pore size, respectively 8–9 (–10) / mm and 6–8 / mm (Valenzuela *et al.* 2011).

Phylloporia subchrysita could be compared also to *P. frutica*, both species have which differs in having much larger pores (2–4 / mm), the darker pore surface (cinnamon to rusty brown) and by the context formed by a dense dark cinnamon to rusty brown layer near the tubes.

Phylloporia turbinata nom. prov. Campos-Santana, R. M. Silveira & Decock **sp. nov**.

Figs. 2E-G; 4

BMycoBank: MBxxxxx

Etymology: "*turbinata*", attached to the substrate by a small vertex and similar to a small inverted cone.

Basidiomata annual, pileate, sessile, gregarious, emerging simultaneously in large number; *pileus* turbinate, attached by a small vertex, pendant, small, up to 1.0–3.0 cm long, 0.5–1.5cm wide and up to 0.7 cm thick in single pilei; and 1–2 mm wide at the attachment point; *pileus surface* dull, narrowly, faintly concentrically sulcate and with hirsute ridges, overall brown, mostly cocoa to rust brown (6E[6–8]), discoloring to dark brown (chestnut brown, 6F[5–7]), eventually blackish toward the basis; *margin* thin, acute, entire, concolorous with the pileus lower half; *pore surface* plane to concave, yellowish brown (5E[5–7]); *pores* very small, (10–) 11–13 / mm, 60–100 µm diam (ave = 70 µm), regular, round, occasionally in well defined rows; *dissepiments* thin, entire, agglutinated when dry, about 30–40 (–45) µm diam (ave = 38 µm); *context* duplex, with a thin (10 µm) black line separating an upper tomentum and a lower context; *upper tomentum* a short trichoderme, shortly velutinous

(under the lens), up to 160 µm thick, from the base light brown, mostly cinnamon, (6D[5–6]), with a soft corky consistency; *lower context* compacter, denser, 0.5–1.0 mm, very thin to the margin, brown, (5D[5–6], ligth brown), shiny, fibrous (with bundle of hyphae under the lens), corky; *tube layer* up to 1 mm deep, concolorous with the pores surface.

Hyphal system dimitic; *generative hyphae* simple septate, thin- to thick-walled, hyaline to pale yellow, sometimes branched, 1.5–3.0 (–4) µm diam (ave= 2.5 µm); *skeletal hyphae* dominantin all parts; in the *context*, the skeletal hyphae descending, parallel to long axis, arising from a generative hyphae, and of limited growth, measured up to 180 µm long, (3.5–) 4.0–5.0 µm diam (ave = 4.4 µm), golden brown, darker (brown) in alkali, thick- to very thick-walled with the lumen wide to narrow, aseptate or with few secondary septa near the apices; *upper trichoderme* with free ending, thick-walled hyphae, 4.0–5.0 µm (ave = 4.6 µm); in the *hymenophoral trama* skeletal hyphae measured from 115 –170 µm long, 2.5–3.0 µm diam at the basal septa to mostly 3.5–4.5 µm diam (ave = 3.9 µm) in the main part, thick-walled to very thick-walled, the lumen mostly straight, or with local constrictions, aseptate throughout but with a few secondary septa near the apices, golden brown, darker (brown).

Hymenium: *basidia* clavate, hyaline in KOH, 4-sterigmata, up to 7.0–8.0 × 4.0–5.0 µm long with four sterigmata; *basidioles* slightly pyriform, hyaline, 6.5–7.0 × 4.0–5.0 µm; *basidiospores* broadly ellipsoid to subglobose, appearing somewhat angular on drying, thick-walled, smooth, pale yellowish in KOH, without reaction in Melzer's reagent, (2.5–) 3.0–4.0 × 2.0–3.0 (–3.5) µm, (ave = 3.2 × 2.2 µm), Q = 1.33–1.5 (ave_Q = 1.48).

Substrate and host: growing on trunk of living, unidentified angiosperm.

Known distribution: known only from the type locality in Brazilian Atlantic rainforest in Rio Grande do Sul.

HOLOTYPUS. BRAZIL, RIO GRANDE DO SUL. Dom Pedro de Alcântara, RPPN do Professor Luis Baptista, approx. 29º22'10"S, 49º50'59"W, elev. approx. 37m, on the bark of a small-stemmed dead standing trunk, unidentified angiosperm, 12 March 2010, Campos-Santana 007/10 (ICN 177690); *isotypus* in herbaria NY et MUCL. Reference nLSU sequence: KJ743265.

Remarks.— Phylloporia turbinata belongs to the *Phylloporia pectinata* morpho-ecological type, characterized by gregarious, small basidiomata, a hard consistency, a dimitic hyphal system. It differs from *P. pectinata* in having smaller basidiomata, not exceeding 3 cm (commonly > 5 cm in *P. pectinata* fide Corner 1991).

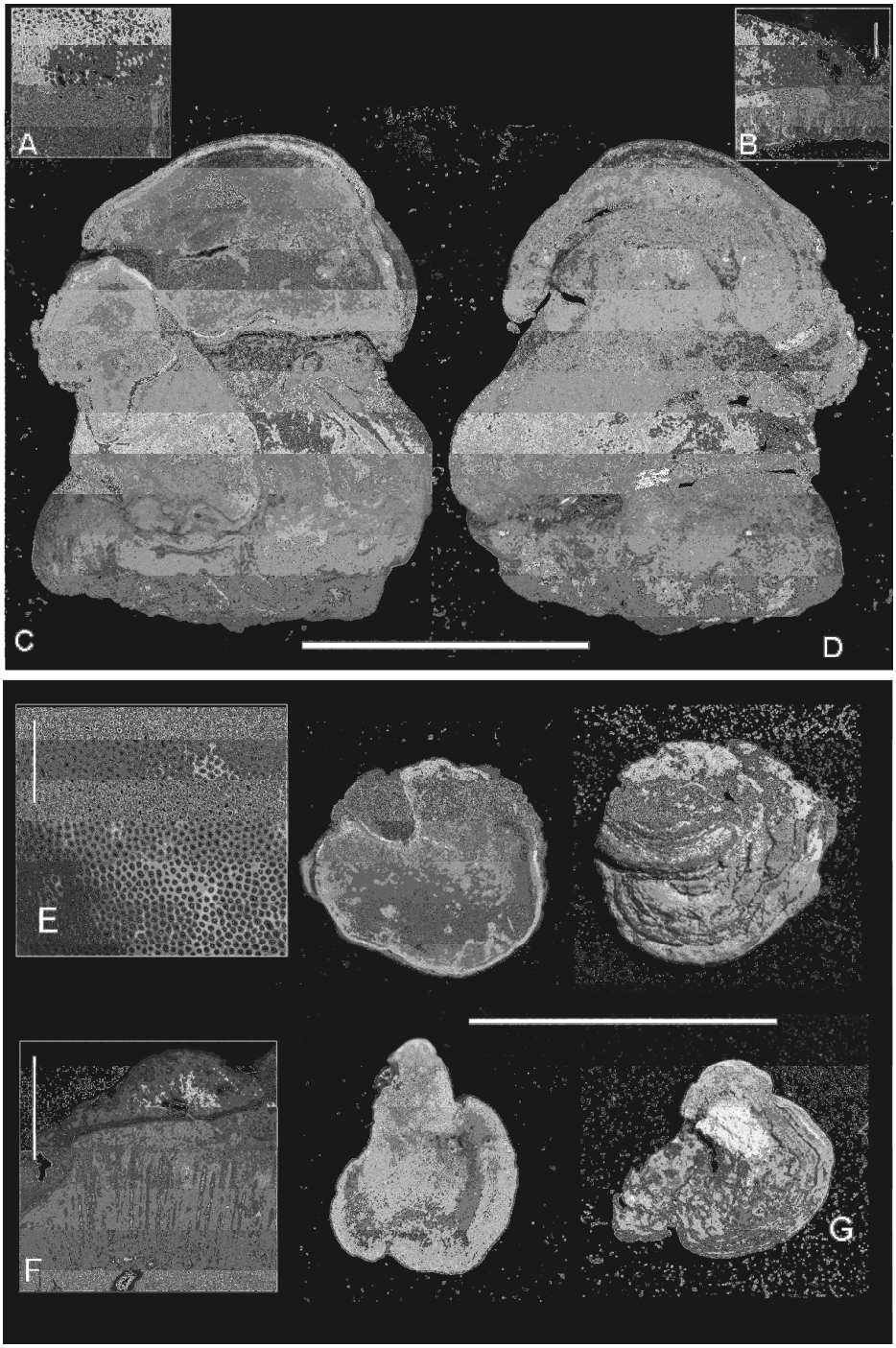


FIG. 2. A, B, C, D: *Phylloporia subchrysita*. A. Pore surface, B. Longitudinal section of the tubes, C. Basidiomata (A, scale bar =.1 mm; B, scale bar =.2 mm; C/D, scale bar =. 3

cm). E, F, G: *Phylloporia turbinata*. E. Pore surface, F. Longitudinal section of the tubes, G.Basidiomata, (E, scale bar =.1 mm; F, scale bar =.1.5 mm; G, =.3 cm).

Phylloporia neopectinata nom. prov. Campos-Santana & Decock **sp. nov.**

Figs. 3A-C; 4C

MycoBank: MBxxxxx

Etymology: "*neopectinata"*, similar *P. pectinata* in the Neotropics.

Basidiomata annual, pileate, sessile, gregarious, emerging in clusters of up to 70 individuals, mostly superposed; *pileus* mostly turbinate, attached by a very small vertex and pendant, 0.5–2 mm wide at the attachment point, small, projecting 1–3 cm long, 0.7–1.2cm wide, up to 0.7 cm thick; *pileus surface* dull, narrowly, faintly concentrically sulcate and hirsute, the lower half mostly cocoa to rust brown (6E[6–8]), the upper half, darker, dark brown (chestnut brown, 6F[5–7]), eventually blackish at the very base; *margin* sterile distinct, thin, entire, soft consistency when fresh, drying corky; concolour with the pileus lower half; *pore surface* plane to concave, yellowish to brownish orange whitish at the very marginal areas margin, soon light brown (5D[5–7]), then yellowish brown (5E[4–5]); *pores* very small, regular, mostly round, (9–)10–13(–14) / mm, (60–) 70–90 mm diam (ave = 76 µm); *dissepiments* smooth, entire, thin, 20–50 µm thick (ave = 35 µm); *upper tomentum* a short velutinous trichoderme, up to ≤ 140 µm thick, from the base light brown, mostly cinnamon, (6D[5–6]), with a soft corky consistency; *context* compacter, dense, mostly homogeneous and without black line (5µm), then with a very thin, soft spongy (watery) when fresh, soft corky consistency, up to 1.5 mm thick; *lower trama* compacter, dense, with squared crystals abundant; *tube layer* single, up to 1.5 mm deep at the base, very thin to the margin.

Hyphal system dimitic, generative hyphae with simple septa, thin- to mostly thick-walled, scarly branched, 1.5–3.0 µm (ave = 2.4 µm), hyaline to mostly pale yellow, forming a network holding the spore mass into the tubes; *context* dominated by skeletal hyphae, parallel to long axis; mensured up to 250 µm long, 2.0–3.0 µm diam at the basal septa, with widening to 3.5–5.0 µm (ave = 4.2 µm), golden brown to darky brown, thick-walled, lumen wide to narrow, mostly aseptate throughout or with secondary septa; *upper trichoderme* with prostrate to erected hyphae, thick-walled, pale golden yellow, 4.5–5.5 µm; *hymenophoral trama* dominated by skeletal hyphae, slightly thick-walled, the lumen widely open, at the basal septa, but with long aseptate segments or with occasional with secondary septa,

sparingly branched, hyaline to pale golden yellow, darker in KOH, 1.5–3.0 µm diam, (ave= 2.20 µm),

Hymenium: *basidioles* subglobose to pediculate; *basidia* not observed; cystidia none; *basidiospores* oblong ellipsoid to subglobose, distinctly thick-walled, smooth-walled, pale yellowish in KOH, without reaction in Melzer's reagent, (2.5–) 3.0–4.0 × 2.0–3.0 µm (ave = 3.1 × 2.1 µm), Q = (1.34–1.5 (ave_Q = 1.47).

Substrate and host: growing on stem of living, undetermined.

Know distribution: Brazilian Atlantic rainforest in the States of Rio Grande do Sul.

HOLOTYPUS. BRAZIL RIO GRANDE DO SUL. Derrubadas, Parque Estadual do Turvo, approx. 27º08'44"S, 53º53'10"W, elev. between 100m and 400m, on the small-stemmed dead standing trunk, unidentified angiosperm, 26 October 2010, Campos-Santana 353/10 (ICN 177691; culture MUCL 54295); *isotypus* in herbaria NY and MUCL. Reference nLSU sequence: KJ743267.

Additional specimens examined: BRAZIL RIO GRANDE DO SUL: Porto Alegre, Refúgio da Vida Silvestre da UFRGS, approx. 30°03' S, 51°07'W, elev. approx. 130 m, on the small-stemmed dead standing trunk, unidentified angiosperm, 18/VIII/2011, *Campos-Santana* 640 (INC 177699); ibid., 17/V/2011, Campos-Santana 553 (ICN 177692); ibid., *Campos-Santana* 552/11 (ICN 177698; culture MUCL 54288).

Remarks. — Phylloporia neopectinata belongs also to the *P. pectinata* morpho-ecological type. The host relationship is unknown for the time being.

Phylloporia turbinata and *P. neopectinata* are sympatric in the southern areas of the Atlantic forest. From a morphological point of view, these species are very similar and the distinction between both species proved challenging. Subtle differences include the yellow to brown orange pore surface, soon light brown and the irregular black line in *F. neopectinata*. The pore surface is yellow brown and there is a regular black line (100 µm thick) in *P. turbinata*. In our phylogenetic analysis based on nLSU sequences these two-species clades appear distinct (FIG. 1).

Phylloporia loguerciae nom. prov. Campos-Santana, Robledo & Decock **sp. nov.**

Figs. 3D-F; 4D

MycoBank: MBxxxxx

Etymology: The species is named in honor of Dr. Clarice Loguercio-Leite, for her valuable contribution to the Mycology, especially in Southern Brazil.

Basidiomata perennial, sessile, gregarious or in small number; *pilei* semicircular to dimidiate, woody-hard, thinly applanate in section, the margin enrolling inward on drying, projecting up 5 cm long, 4 cm wide, up to ≤ 0.7 cm thick, faintly concentrically sulcate, finely velutinate, adpressed velutinate (under the lens), cork-colored, grayish orange to the margin then dull light brown to brown (6[D–E]6, cinnamon to cocoa brown) toward the base, dark brown on aging or weathering (6F6); *margin* corrugated, sterile distinct, yellowish when dry (4B4, grayish yellow); *pore surface* yellow brown to cinnamon; *pores* rounded to ellipsoid entire, (7–) 8 –10/ mm, 80–110 µm diam (ave = 95 µm); *dissepiments* non agglutinated, 15–40 µm thick (ave = 26 µm); *context* duplex, dark brown (6F[6–8]) to (7F[5–6]) with a thin black line separating an upper short tomentum and a lower trama; *upper tomentum* a short trichoderme, shortly velutinous (under the lens), up to ≤ 70 µm thick, brown (6E[6–8]); *lower trama* compacter, denser, corky, 0.5–1.0 mm thick, light brown (6D[5–6]); *tubes* bi- stratified, in some parts with a thin black line separating the layers, to ≤ 5 mm at the deepest, light brown (6D[6–8]).

Hyphal system mono- to incompletely dimitic; *generative hyphae* simple-septate, simple to branched, thin- to moderately thick-walled, hyaline to yellowish; in the *hymenophoral trama* hyphae slightly interwoven, hyaline toward the dissepiments, yellowish to golden yellow deeper in the trama, turning darker, yellowish brown in alkali, little branched, thin- to thick-walled, with the lumen widely open, 3.0–5.5 µm diam; in the *context* hyphae tightly packed, slightly interwoven, yellowish to golden brown, darker brown in alkali, little branched, thick-walled but with the lumen widely open, (3.0–) 3.5–4.5 (–5.0) diam (ave = 4.0 µm); *pileus upper tomentum* a *trichoderme* with erected to prostrate, thick-walled hyphae, yellowish to brown, mostly unbranched, 3.0–4.5 µm diam;

Hymenium: *basidia* not observed; *cystidia* or other sterile hymenial elements absent; *basidiospores* mainly ellipsoid, with the adaxial side occasionally flattened (perhaps on drying), thick-walled, pale yellowish, IKI -, (3.0–) 4.0–5.0 × (2.0–) 3.0–4.0 µm, Q = 1.25–1.5 (ave = 3.9 × 2.9 µm; ave_Q = 1.4).

Substrate and host: growing on stem of living, undetermined.

Know distribution: Brazilian Atlantic rainforest in the States of Santa Catarina and Argentina.

HOLOTYPUS. BRAZIL. SANTA CATARINA, Mondaí, Linha Uruguai, approx. 27º06”16’S and 53º24”07’W, elev. 235m, on the small-stemmed dead standing trunk, unidentified angiosperm, 10.XII.2010, *Campos-Santana* 437/10 (ICN 177693; culture MUCL 54226); *isotypus* in herbaria NY and MUCL. Reference nLSU sequence: KJ743270.

Additional specimens examined: ARGENTINA: stem, Magfadyena unguis-cati, Robledo 429; ibid., stem, unidentified liana Robledo 1134, Dead stem, Magfadyena unguis-cati Robledo 1624.

Remarks. — Phylloporia loguerciae belongs to the *P. pectinata* morpho-ecological type. It is recognized by its sessile basidiomata, emerging in groups, though in low number, semicircular to dimidiate pileus, irregular pores, (7–) 8 –10/ mm, tubes bi-stratified. The hyphal system is uncertain, intermediate between mono- to (incompletely) dimitic. This set of characteristic separates *P. loguerciae* from the other species treated in this work or belonging to the *P. pectinata* morpho-ecological type. *Phylloporia loguerciae* also differs from the *P. turbinata* and *P. neopectina* in having commonly much large pilei, reaching up to 5 cm long, 4 cm wide, up to ≤ 0.7 cm thick. The host relationships are unknown for the time being.

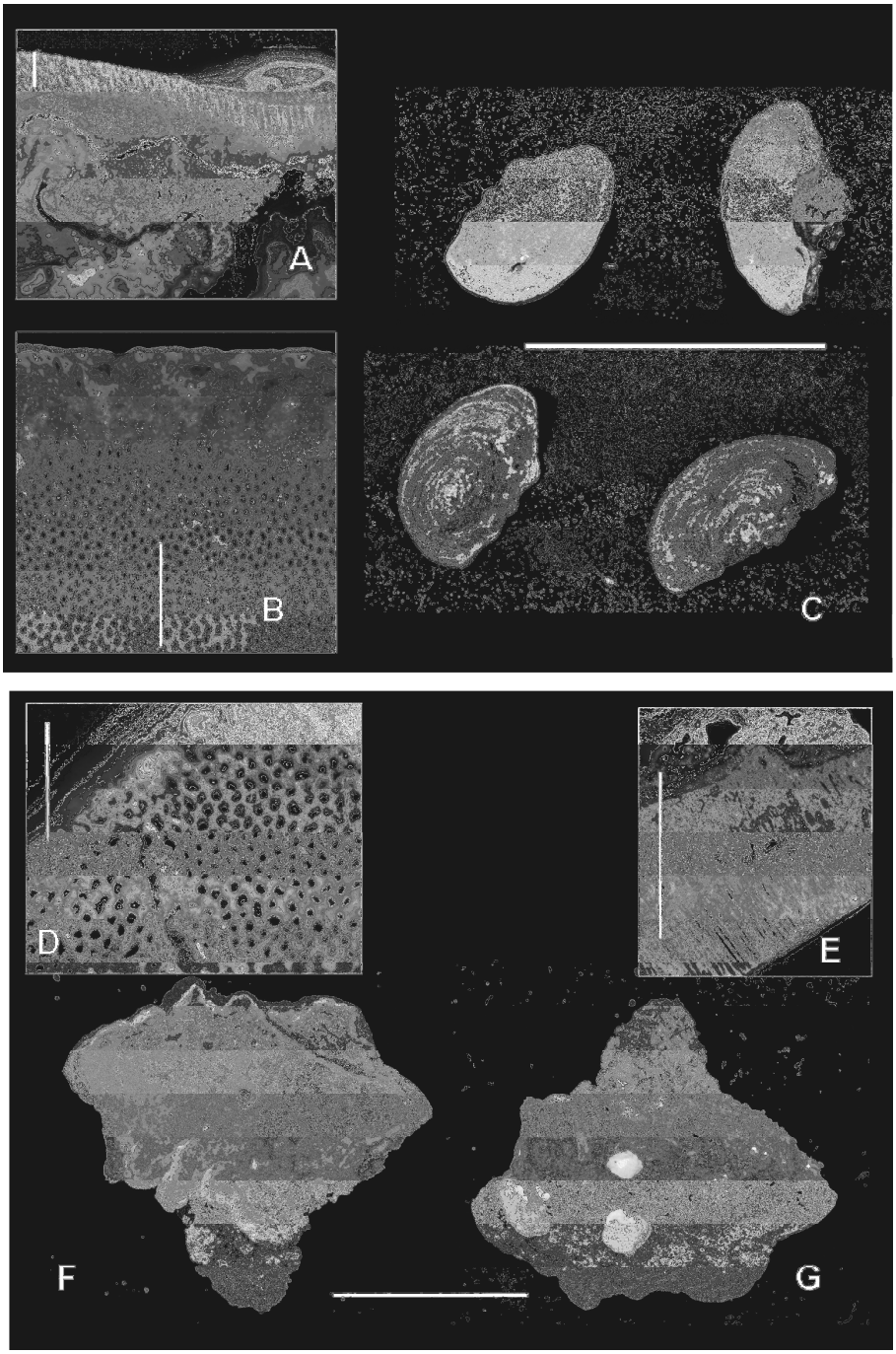
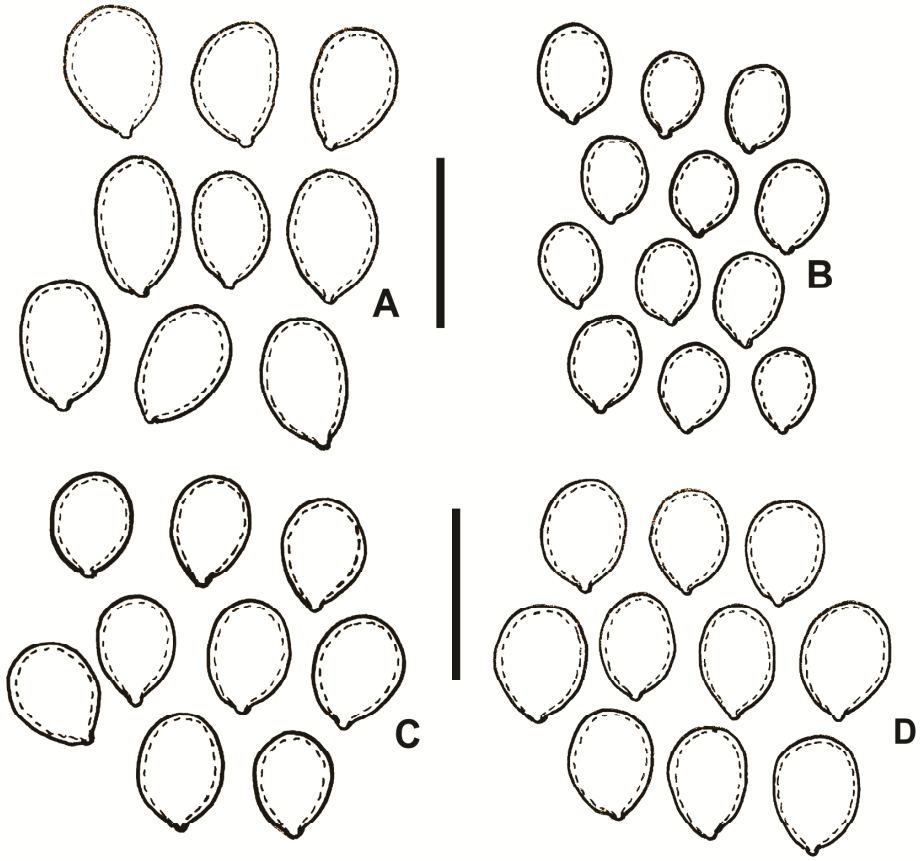


FIG. 3. A, B, C,: *Phylloporia neopectinata*. A. Longitudinal section of the tubes, B. Pore surface, C. Basidiomata (A, scale bar =.1 mm; B, scale bar =.1 mm; C, scale bar =. 3 cm). D, E, F, G: *Phylloporia loguerciae*. D. Pore surface, E. Longitudinal section of the tubes, F and G. Basidiomata, (E, scale bar =.1 mm; F, scale bar =.5 mm; G/H, =.3 cm).



Figs. 4. Basidiospores. A: *Phylloporia subchrysita*; B: *Phylloporia turbinata;* C: *Phylloporia neopectinata*; D: *Phylloporia loguerciae*. Scale bar = 10 µm.

Discussion

Four *Phylloporia* species are added for the Neotropics, all originating from Southern Brazil or in a biogeographical perspective, from the Atlantic Rainforest and Southern Fields (Pampa) ecosystems. These four species nest within the *Phylloporia* lineage as previously defined (Decock *et al*. 2013, Yombiyeni *et al*. 2014).

Three species belong to the *P. pectinata* morpho-ecological type, as defined by Yombiyeni *et al.* (2014). This morpho-ecological type is characterized by dense, usually perennial basidiomata, gregarious and emerging usually simultaneously in large number from small-stemmed, living tree of forest, understorey compartment. The hyphal system is dimitic, with short, limited skeletal hyphae. The basidiospores are globose or subglobose. In its present circumscription, as noted by Yombiyeni *et al.* (2014), *P. pectinata sensu lato* (*sensu* Wagner and Ryvarden 2002) has a wide, pantropical distribution (e.g. Corner 1991, Dai 2010, Ryvarden 2004, Ryvarden and Johansen 1980, Wagner and Ryvarden 2002).

Ryvarden (2004) reported the species from the Neotropics. Rajchenberg and de Meijer (1990), Ryvarden and de Meijer (2002), de Meijer (2006), Theissen (1911), and Sobestiansky (2005) reported also the species from Southern Brazil. Our phylogenetic studies show that our Brazilian collections entering the current concept of *P. pectinata* (e.g. *sensu* Wagner and Ryvarden 2002) to be distributed over 3 terminal lineages (Fig. 1, PS 2-4). These lineages are distant from the reference *P. pectinata* lineage (Wagner and Fischer 2002).

Phylloporia pectinata was originally described from southern India. The current species concept (e.g. Corner 1991, Ryvarden 2004, Ryvarden and Johansen 1980, Wagner and Ryvarden 2002) obviously encompasses multiple cryptic species (see also Yombiyeni *et al.* 2014). This renders any unequivocal circumscription of morphospecies concept very challenging if ever possible. The combination of morphological, molecular, and ecological data (host relationships) are highly desirable to better understand the diversity within this morpho-ecological complex. In the meantime, as suggested by Yombiyeni *et al.* (2014), it is recommend using the current [morphological] concepts of *P. pectinata* with caution and as *sensu lato*.

Phylloporia subchrysita is morphologically related to *P. chrysita* and to *P. ulloai*, a taxon described from eastern Mexico (Valenzuela *et al*. 2011), which is also its closest relative for the time being. Inversely, the *P. chrysita* clade is distantly related to the *P. subchrysita* / *P. ulloai* clade. These three species share a sessile basidiomata, commonly amplectens, a thick, spongy tomentum, a thin tube layer, and a monomitic hyphal system. *Phylloporia subchrysita* and *P. ulloai* share the same ecology, both growing on living stem of liana. They form another morpho-ecological alliance within *Phylloporia*.

Acknowledgements

Marisa de Campos Santana acknowledges financial support received from CAPES (process 8296/11-1) and CNPq (Brazil) that enabled her one-year research stay at MUCL, Université catholique de Louvain, Belgium. Cony Decock gratefully acknowledges the financial support received from the FNRS / FRFC (convention FRFC 2.4544.10) and from the Belgian State–Belgian Federal Science Policy through the BCCMTM research program. Thanks are extended also to Stéphanie Huret for her help with the sequencing program.

4. GENERAL DISCUSSION

The species diagnosis depends on the application of operational concepts (species concept), such as morphological species, biological species or phylogenetic species concepts, as defined by Taylor *et al* (2000).

Taxonomy based on morphological characters only (Morphological Species Concept) for Hymenochaetaceae, hence for *Phellinus s.l.*, is extremely complex, given the high number of described species to the genus, the range of phenotypic plasticity and their wide geographical distribution. The phylogenetic analysis based on ITS, *LSU*, *rpb2* and *tef1-α* regions, considered alone or altogether, have shown suitable for identification and delimitation of species, as in the case of *Fomitiporia neotropica*, *Phellinus amazonicus*, *Phylloporia subchrysita*, *P. turbinata*, *P. neopectinata* and *P. loguerciae* (Chapters II – IV), besides providing a phylogenetic outline which can be used to evaluate morphological characters, biogeographical hypothesis and occurrence of cryptic species.

Studies concerning the occurrence and taxonomy of Hymenochaetaceae, including phylogenetic inference, have being carried out mainly in Europe and North America. However, these analyses are relatively limited due to the paucity of species from other geographical, mainly tropical regions hosting the vast majority of the known species.

Yang (2011) stated that systematic and phylogeny of Fungi based on molecular data evolved quickly in the last two decades. Nevertheless, morphological and ultrastructural characters, ecological features, and biochemical characters such as *e.g.* secondary metabolites are equally important for comprehension of evolution in Fungi Kingdom. For instance, many hypotheses proposed in the last century, based on morphology, ultrastructure, pigment or metabolite structure have corroborated with molecular approaches in the last two decades. Several methodologies, therefore, are required for better comprehending fungal diversity.

Using the sequences generated from Brazilian samples and others sequences available in Genbank, phylogenetic analysis were made, rooted with an out group based on previous works (Larsson *et al*., 2006; Decock *et al*. 2007).

For *Fomitiporia neotropica*, *Phellinus amazonicus* and the four new *Phylloporia* species, the taxa selection for inclusion in analysis was possible thanks to previous analysis and large dataset made by Decock *et al.* at MUCL. Besides, macro-micromorphological analysis of all specimens and an ecological characterization were carried out.

In the present work, more than 6oo specimens of poroid Hymenochaetaceae were examined, including specimens collected by the author, other researchers and specimens deposited in local herbaria. The analyzed materials were not only from Southern Brazil, but also from Europe and South America, thanks to the herbarium MUCL. The list of genera and species studied is presented in Chapter I. The new species descriptions, discussions, illustrations and comments concerning studied species are presented in the articles included in this thesis, as Chapters (I-IV). However, some taxonomic problems to be solved will be presented in forthcoming works, still under preparation. This is the case of ***Phellinus*** sp. (***P. gabonensis*** Decock and Yombiyeni **morpho-ecological complex**) and some species belonging to *Fuscoporia* (of which the *Fuscoporia wahlbergi* complex).

From the species identified, the most abundant was found to be *Fuscoporia gilva var. licnoide* (with 80 specimens), followed by *Fuscoporia wahlbergii* (with 54) and *Fuscoporia ferrea* (with 44). Some species appear to be rare, with few records. It is the case of *Phellinus lopezzi*, *Phellinus detonsus*, *Fomitiporia dryophila* and *Fulvifomes durissimus* for instance. Combining the results of the specimens analyzed with literatture records, 63 poroid Hymenochaetaceae species are recognized from Southern Brazil, corresponding to nine genera. The most represented genera with are *Phellinus* (8 species), *Fuscoporia* (8 species) and *Inonotus* (8 species).

Rio Grande do Sul is the most representative state, with the higher number of species in the studied area, with 35 species. 26 species were found in Paraná and 25 from Santa Catarina. Only 18 species are shared by these three States.

In the manuscripts presented in this work, six new species are described, based in phylogenetic analysis, including multilocus sequences (Chapter II, III and IV). Two new combinations are also proposed. New records from Brazil and Southern Brazil are also presented (Chapter I).

-*Fomitiporia neotropica*, *Phellinus amazonicus*, *Phylloporia loguerciae*, *Phylloporia neopectinata, Phylloporia turbinata* and *Phylloporia subchrysita* are described as new to science, based on molecular phylogenetic analyzes, including multilocus sequences.

-Two new combinations are proposed: *Fomitiporia bambusarum* and *Fulvifomes rhytiphloeus*.

-*Phellinus* sp. (*P. gabonensis* Decock and Yombiyeni morpho-ecological complex) is a new record for South America.

-New occurrences are considered to Brazil: *Fomitiporia dryophyla*, *Fulvifomes durissimus* and *Phellinus lopezzi.*

Many of the species found in this work were unknown for region or for any of the three states, and had their geographical distribution extended.

-*Fomitiporia dryophila, Fomitiporia neotropica, Fulvifomes durissimus, Fulvifomes membranaceus, Inonotus portoricensis, Inonotus pseudoglomeratus, Phellinus detonsus, Phellinus* sp. (*P. gabonensis* Decock and Yombiyeni morpho-ecological complex), *Phellinus lopezii, Phellinus shaferi, Phylloporia loguerciae*, *Phylloporia neopectinata, Phylloporia turbinata* and *Phylloporia subchrysita*, are new records for the Southern Brazil.

-*Cyclomyces iodinus*, *Fomitiporia dryophila, Fulvifomes durissimus, Fulvifomes membranaceus, Fulvifomes merrillii*, *Fomitiporia neotropica, Inonotus linteus*, *Inonotus portoricensis, Phellinus detonsus*, *Phellinus* sp. (*P. gabonensis* Decock and Yombiyeni morpho-ecological complex), *Phellinus lopezii, Phellinus shaferi*, *Phylloporia loguerciae, Phylloporia neopectinata, Phylloporia turbinata* and *Phylloporia subchrysita,* are registered for the first time to Rio Grande do Sul.

-Are considered to be new records from Santa Catarina state: *Fuscoporia palmicola, Fomitiporia neotropica, Inonotus micantissimus, Inonotus portoricensis, Inonotus pseudoglomeratus, Phellinus caryophylleus, Phellinus detonsus*, *Phellinus* sp. (*P. gabonensis* Decock and Yombiyeni morpho-ecological complex), *Phellinus shaferi* and *Phylloporia loguerciae.*

-*Fulvifomes rhytiphloeus, Fuscoporia contigua, Fuscoporia ferrea, Fuscoporia rhabarbarina, Inonotus* sp.*, Phellinus anchietanus, Phellinus caryophylleus, Phellinus detonsus* and *Phellinus shaferi* are registered for the first time to Paraná state.

5. CONCLUSIONS

Hymenochaetaceae constitutes one of the larger groups of wood-inhabiting, wood-decomposing fungi. They are diverse and play diverse key ecological roles in all forest ecosystems. They may enhance tree growth by forming symbiotic, mycorrhizal associations, benefical for both partners. It is the case for instance of the Coltricioid species. At the opposite range, they may be parasitic to the root system or trunk, eventually killing the tree. It is the case for instance of *Phylloporia* or *Fulvifomes* species. Most of them participate in the recycling of the dead wood as saprotrophs.

The understanding of the forest functioning passes through the knowledge of all its individual components, biotic or abiotic (who / what is there? Who is doing what?) and of all their interactions, (who interact / with who?). Here is the key role of the taxonomists.

Identifications of wood-inhabiting Hymenochaetaceae are confronted to several major problems. Still, the vast majority of species are defined based on diagnostic morphological characters and comparison with voucher herbarium specimens – *viz* type specimens – that are usually old and in very variable conditions. The morphological species concept is many times limited by the paucity of characters available, and a very uncertain interpretation about their variability. Little is known about the extent of variability within populations and their pertinence for delimiting species. Life cycles are variable as well as complex and may affect evolutionary patterns in ways that are difficult to interpret (Petersen and Hughes 1999). Furthermore, many times, the species concept used is based on material originating from the northern temperate area or various tropical areas and extended uncritically to other areas.

Therefore, delimiting species concept on the sole basis of a few uncertain morphological features and uncertain reference material reveal many times challenging for the taxonomists working with Hymenochataceae. *A fortiori*, dealing with such morphospecies concepts is almot unachievable for the end users of taxonomic data that are biologists, ecologists, and conservation biologists.

Other descriptors are necessary, as highlighted by Amalfi *et al*. (2012) and Amalfi and Decock (2013), to delimit species in the Hymenochaeaceae. These includes now molecular, DNA sequence data, but should also integrate ecological, biological and biogeographical data. Integrating multiple complementary data to achieve a "global" or "holistic" species concept was dealt with in detail in Ascomycota, exemplifed by

Quaedvlieg *et al.* (2014). Quaedvlieg *et al.* (2014) developed an approach similar to that suggested by Decock *et al.* (2007), Amalfi *et al*. (2011) and Amalfi and Decock (2013) integrating multiple complementary descriptors that results in a "Consolidated Species Concept" (CSC). This should certainly be applied more extensively to the all poroid Hymenochaetaceae.

In this thesis, we studied in much detail the case of several "morphospecies" concepts including the *Fomitiporia "punctata"* (*F. robusta* complex), the *Phellinus gabonensi*s morpho-ecological complex, the *Phylloporia pectinata* and the *P. chrysita* morphospecies / morpho-ecological types.

So far, 24 species of *Phylloporia* were accepted and validly published. Four species are here added. However, the species number is more likely larger and many species might be described when the host relationships will be better understood. *Phylloporia* species are thought to be host specific but the host is still rarely considered.

In the present thesis, we have tried to apply a broader concept to the poroid Hymenochaetaceae in Southern Brazil. It was not possible in the time available to cover in such way the totality of *Phellinus s.l* species occurring in the areas considered. The synopsis provides a first step to undertake more detailed studies. We are conscient that the species concept used here might reveal more complex. The examples treated in the other publication and manuscripts argue for such a multilple approach.

A considerable improvement in this work accomplishment was only possible when came the opportunity to work directly with colleagues having complementary specialities in different research groups.

We believe we gave the first step towards this integration, and we hope that this represents the beginning of a cooperation network involving research groups in Brazil (from South to Northeast) and other countries.

We hope that this thesis and the manuscripts will be of utility for those who are interested in the study of the Fungi. Finally, we believe that this work has contributed not only for the knowledge of the studied group, and might be also useful as a divulgation tool for these organisms to students and interested in mycology, including ecologist, conservation.

6. PERSPECTIVES

In Brazil, there are few specialists in Hymenochaetaceae. An analysis of the studies involving the family and published until now in Brazil, allows us to point two great gaps to be filled: the lack of in-deep integrated approaches to characterize and define the species present in Brazil; the lack of field studies and development of pure culture in order to develop molecular, DNA-based phylogenetic studies, and ahead, physiological studies.

Based on the results presented in the articles that compose chapters I – IV, it can be stated that the number of poroid Hymenochaetaceae found in Southern Brazil (Table I and Chapter I) represents a result which could be taken as reference, but cautiously.

In that sense, genera such as *Fuscoporia*, *Phellinus s.s*, *Fulvifomes, Fomitiporia, Phylloporia* and *Inonotus*, that were well represented in Southern Brazil, with a high number of species, might be selected as as topics for other PhD thesis.

Preliminary results on other species such as *Fuscoporia wahlbergii* and the other species of the genus as *F. gilva*, with multiple lineages inside a morphospecies concept still bring argument to have a different approach. In that sense, there are strong reasons to believe that the work is still at the beginning.

Furthermore, despite the fact that molecular phylogenetic studies showed *Phylloporia* to be monophyletic, it is still necessary to include sequences of *Phylloporia parasitica* to confirm the taxonomic status of the genus. In addition, it is necessary to include specimens from still unexplored regions, which will contribute, in a significant way, to understand the evolutionary history of the genus.

Ecological aspects, such as distribution and specialization levels with hosts in particular, are important to characterize Hymenochaetoid species, as well as consolidate specific concepts. In this way, other ecosystems or other forest domains also deserve to be explored to complement the data about geographical distribution and ecology of Hymenochaetaceae.

7. REFERENCES

Abrahão MC, Gugliotta AM, Gomes E. 2009. Poliporoides (Basidiomycota) em fragmentos de mata no perímetro urbano de São José do Rio Preto, São Paulo, Brasil. Revista Brasileira de Botânica 32(3): 427–440.

Akhtar M, Blanchette RA, Kirk TK. 1997. Fungal delignification and Biomechanical pulping of wood. Advance in Biochemical Engineering / Biotechnology 57: 160–193.

Almeida Filho OM, Bueno R, Bononi VLR. 1993. Algumas espécies de fungos Basidiomycetes de manguezais do Estado de São Paulo. Hoehnea 20(1/2): 87–92.

Amalfi M, Yombiyeni P, Decock C. 2010. *Fomitiporia* in sub-Saharan Africa: Morphology and multigene phylogenetic analysis support three new species from the Guineo-Congolian rainforest. Mycologia 102: 1303–1317.

Amalfi M, Raymundo T, Valenzuela R, Decock C. 2012. *Fomitiporia cupressicola* sp. nov., a parasite on *Cupressus arizonica*, and additional unnamed clades in the southern USA and northern Mexico, determined by multilocus phylogenetic analyses. Mycologia 104: 880–893.

Amalfi M, Decock C. 2013. *Fomitiporia castilloi* sp. nov. and evidence for multiples clades around *F. apiahyna* in Meso - and South America, representing potential species. Mycologia 105:873–887.

Amorim DS. 2002. Fundamentos de sistemática filogenética. Holos Editora, Ribeirão Preto, 136p.

Azevedo CPL, Guerrero RT. 1993. Estudo biossistemático de espécies do gênero Hymenochaete (Basidiomycetes) no Rio Grande do Sul. Insula 22: 143–176.

Balan DSL, Monteiro RTR. 2001. Decolorization of textile índigo dye by ligninolytic fungi. Journal of Biotechnology 89: 141–145.

Baltazar JM, Trierveiler-Pereira L, Loguercio-Leite C. 2009a. A checklist of xylophilous basidiomycetes (Basidiomycota) in mangroves. Mycotaxon 107: 221–224.

Baltazar JM, Trierveiler-Pereira L, Loguercio-Leite C, Ryvarden L. 2009b. Santa Catarina Island mangroves 3: a new species of *Fuscoporia*. Mycotaxon 101(6): 859–63.

Baltazar JM, Gibertoni TB. 2009. A checklist of the aphyllophoroid fungi (Basidiomycota) recorded from the Brazilian Atlantic Forest. Mycotaxon 109: 439–442.

Baltazar JM, Gibertoni TB. 2010. New combinations in *Phellinus s.l.* and *Inonotus s.l.* Mycotaxon 111: 205–208.

Baltazar JM, Ryvarden L, Gibertoni TB. 2010. The genus *Coltricia* in Brazil: new records and two new species. Mycologia 102: 1253–1262.

Baltazar JM, Drechsler-Santos ER, Ryvarden L, Cavalcanti MAQ, Gibertoni TB. 2012. Contribution to the knowledge of polypores (Agaricomycetes) from the Atlantic forest and Caatinga, with new records from Brazil. Mycosphere 3(3): 267–280.

Bass D, Richards TA. 2011. Three reason to re-evaluate fungal diversity 'on Earth and in the ocean'. Fungal Biology Reviews 25: 159–164.

Batista AC, Bezerra JL. 1960. Basidiomycetes vulgares em o Nordeste Brasileiro. Instituto de Micologia 294: 1–30.

Bernicchia A. 1990. *Polyporaceae s.l.* in Italia. Bologna, Italy: Istituto di Patologia Vegetale, Bologna: pp. 1–594.

Bernicchia A. 2005. *Polyporaceae s.l.* in Italia. Fungi Europaei, ed. Candusso, Italy: pp. 1–808.

Bickford D, Lohman DJ, Sodhi NS, Ng PKL, Meier R, Winker K, Ingram KK, Das I. 2007. Cryptic species as a window on diversity and conservation. Trends in Ecology & Evolution 22: 148–155.

Binder M, Hibbett DS, Larsson KL, Larsson E, Langer E, Langer G. 2005. The phylogenetic distribution of resupinate forms across the major clades of mushroom-forming fungi (Homobasidiomycetes). Systematics and Biodiversity 3(2): 113–157.

Blackwell M. 2011. The Fungi: 1, 2, 3…5.1 million species? American Journal of Botany 98(3): 426–438.

Bondártseva MA, Herrera S, Sandoval D, Sejas F. 1992. Taxonomical problems of the Cuban Hymenochaetaceous fungi. Mikologiya I Fitopatologiya 26: 1–13.

Bononi VLR, Trufem SFB, Grandi RAP. 1981. Fungos macroscópicos do Parque Estadual das Fontes do Ipiranga, São Paulo, Brasil, depositados no Herbário do Instituto de Botânica. Rickia 9: 37–53.

Bononi VLR, Oliveira AKM, Quevedo JR, Gugliotta AM. 2008. Fungos macroscópicos do Pantanal do Rio Negro, Mato Grosso do Sul, Brasil. Hoehnea 35: 489–511.

Bononi VLR. 1979a. Basidiomicetos do Parque Estadual da Ilha do Cardoso: I. Espécies hidnóides. Rickia 8: 63–74.

Bononi VLR. 1979b. Basidiomicetos do Parque Estadual da Ilha do Cardoso: II. Hymenochaetaceae. Rickia 8: 85–99.

Bononi VLR. 1979c. Basidiomicetos do Parque Estadual da Ilha do Cardoso: III. Espécies clavarióides, teleforóides e estereóides. Rickia 8: 105–121.

Bononi VLR. 1984b. Basidiomicetos do Parque Estadual da Ilha do Cardoso: IV. Adições às famílias Hymenochaetaceae, Stereaceae e Thelephoraceae. Rickia 11: 43–52.

Bononi VLR. 1992. Fungos macroscópicos de Rio Branco, Acre, Brasil. Hoehnea 19(1/2): 31–37.

Borba-Silva MA, Ferreira-Lopes V, Drechsler-Santos ER. 2013. New records of *Flaviporus hydrophilus* and *Phellinus portoricensis* (Fungi: Polypores). Check List 9(4):815–817.

Boulet B. 2003. Les champignons des arbres de l'est de l'Amérique du Nord. Les publications du Québec, Québec, Canada: pp. 1–727.

Bowler PJ. 1989. Evolution, the history of an idea. Berkeley: University of Carlifornia Press, 432p.

Brazee NJ, Lindner DL, Fraver S, D'Amato AW, Milo AM. 2012. Wood-inhabiting, polyporoid fungi in aspen-dominated forests managed for biomass in the U.S. Lake States. Fungal Ecology 5: 600–609.

Burford EP, Kierans M, Gadd GM. 2003. Geomycology: fungi in mineral substrata. Mycologist 17(3): 98–103.

Campacci TVS, Gugliotta AMA. 2009. Review of *Amauroderma* in Brazil, with *A. oblongisporum* newly recorded from the neotropics. Mycotaxon 110: 423–436.

Campos EL, Sótão HM, Cavalcanti MAQ, Luz AB. 2005. Basidiomycetesde Manguezais da APA de Algodoal – Maiandeua, Para, Brasil. Boletim do Museu Paraense Emílio Goeldi. Serie Ciências Naturais 1(1): 141–146.

Campos-Santana M, Loguercio-Leite C. 2008. First records of xylophilous *Basidiomycetes* (*Fungi*) in Mondaí, Santa Catarina (Southern Brazil). Biotemas 21(2): 19–26.

Campos-Santana M, Loguercio-Leite C. 2010. Mycodiversity of xylophylous Basidiomycetes (Basidiomycota, Fungi) in Mondaí, Santa Catarina, Brazil: a new addition. Biotemas 23(1): 13–18.

Campos-Santana M, Silveira RMB. 2011. *Phellinus gabonensis* (Hymenochaetaceae Agaricomycota): In: VII Congreso Latinoamericano de Micología, 2011, Costa Rica.

Resúmenes y Programa Latino-Micología innovación y progreso VII Congreso Latinoamericano de Micología 1:71.

Campos-Santana M, Amalfi M, Robledo G, Borges da Silveira RM, Decock C. 2014. *Fomitiporia neotropica*, a new species from South America evidenced by multilocus phylogenetic analyses. Mycological Progress 3: 601–615.

Capelari M, Maziero R. 1988. Fungos Macroscópicos do Estado de Rondônia, Região dos Rios Jaru e Ji-Parana. Hoehnea 15: 28–36.

Capelari M, Gugliotta AM, Figueiredo MB. 1998. O estudo de fungos macroscópicos no Estado de São Paulo. *In*: C.A. Joly & C.E.M. Bicudo (eds.). Biodiversidade do Estado de São Introdução – 28 Paulo, Brasil: Síntese do conhecimento ao final do século XX. 2: Fungos macroscópicos e plantas. FAPESP, São Paulo, pp. 11–23.

Carlile MJ, Watkinson SC, Gooday GW. 2001. The Fungi. Elsevier Academic Press, 588p.

Carranza-Morse J. 1992. Pore fungi of Costa Rica. II. Mycotaxon 43: 351–369.

Castresana J. 2000. Selection of conserved blocks from multiple alignments for their use in phylogenetic analysis. Molecular Biology and Evolution 17: 540–552.

Cavalcanti MAQ. 1976. Introdução ao conhecimento dos basidiomicetos poliporóides da zona da mata de Pernambuco. 200f. Tese de Livre-Docência, Universidade Federal de Pernambuco, Recife.

Coelho G, Wright JE. 1996. *Phellinus spinescens* sp. nov. on bamboo from South America. Mycotaxon 59: 383–387.

Coelho G, da Silveira RMB, Guerrero RT, Rajchenberg M. 2009. On poroid Hymenochaetales growing on bamboos in Southern Brazil and NE Argentina. Fungal Diversity 36: 1–8.

Coelho G. 1994. Himenoquetáceas com poros (Basidiomycotes) do limite sul da Serra Geral em Santa Maria, RS. 112 f. Dissertação (Mestrado em Botânica). Universidade Federal do Rio Grande do Sul, Brasil, 1994.

Convenção Da Diversidade Biológica. Brasília, 2000. Disponível em: <http://www.mma.gov.br/estruturas/sbf_dpg/_arquivos/cdbport.pdf Acesso em: 20 novembro. 2013.

Corner EJH. 1991. Ad Polyporaceas VII. The xanthochroic polypores. Beihefte zur Nova Hedwigia 101: 1–175.

Cracraft J. 2000. Species concepts in theoretical and applied biology: a systematic debate with consequences. Em: Wheeler QD, Meier R (eds.). Species Concepts and Phylogenetic Theory: a Debate. New York, Columbia University Press.

Cui BK, Dai YC. 2008. Wood-rotting fungi in eastern China 2. A new species of *Fomitiporia* from Wanmulin Nature Reserve, Fujian Province. Mycotaxon 105: 343–348.

Cui BK, Yuan HS, Dai YC. 2010. Two new species of *Phylloporia* (Basidiomycota, Hymenochaetaceae) from China. Mycotaxon 113: 171–178.

Cui BK, Du P, Dai YC. 2011. Three new species of Inonotus (Basidiomycota, Hymenochaetaceae) from China. Mycological Progress 10: 107–114.

Cui BK, Decock C. 2013. *Phellinus castanopsidis* sp. Nov. (Hymenochaetaceae) from southern China, with preliminary phylogeny based on rDNA sequences. Mycological Progress 12: 341–351.

Dai Y-C, Zhang X-Q, Zhou T-S. 2001. New and noteworthy species of Hymenochaetaceae from China. Mycosystema 20: 16–21.

Dai Y-C, Cui BK, Decock C. 2008. A new species of *Fomitiporia* (Hymenochaetaceae, Basidiomycota) from China based on morphological and molecular characters. Mycological Research 112: 375–380.

Dai YC. 1995. Changbai wood-rotting fungi 3. The genus *Phellinidium* (Basidiomecetes) and a new species, *P. aciferum*. Annales Botanici Fennici 32: 63–73.

Dai YC. 1999. *Phellinus sensu lato* (Aphyllophorales, Hymenochaetaceae) in East Asia. Acta Botanica Fenica 166: 1–115.

Dai YC. 2010. Hymenochaetaceae (Basidiomycota) in China. Fungal Diversity 45: 131–343.

Dai YC, Cui BK. 2011. *Fomitiporia ellipsoidea* has the large fruiting body among the fungi. Fungal Biology 115: 813–814.

Darwin C. 1887. The life and letters of Charles Darwin, including an autobiographical chapter. Vol. II. New York: Appleton.

David A, Dequatre B, Fiasson JL. 1982. Two new *Phellinus* with globose, cyanophilous spores. Mycotaxon 14: 160–174.

David A, Rajchenberg M. 1985. Pore fungi from French Antilles and Guiana. Mycotaxon 22: 285–325.

David JC. 2002. A Preliminary Catalogue of the Names of Fungi above the RankofOrder.Constancea83.16.<http://ucjeps.berkeley.edu/constancea/83/>. Acesso em 02/03/2011.

de Queiroz K. 2005. Aunified concept of species and its consequences for the future of taxonomy. Proceedings of the California Academy of Sciences. 56: 196–215.

de Queiroz K. 2007. Species Concepts and Species Delimitation. Systematic Biology 56(6): 879–886.

Decock C, Ryvarden L. 1997. *Phellinus anchietanus* (Basidiomycetes, phyllophorales) sp. nov. from Brazil. Cryptogamie Mycologie 18: 22–225.

Decock C, Bitew A, Castillo G. 2005. *Fomitiporia tenuis* and *Fomitiporia aethiopica* (Basidiomycetes, Hymenochaetales), two undescribed species from the Ethiopian Highlands: taxonomy and phylogeny. Mycologia 97: 124–132.

Decock C, Stalpers JA. 2006. Proposal to conserve the name *Perenniporia* against *Physisporus* with a conserved type (Basidiomycota). Taxon. 55(1): 227–227.

Decock C, Herrera Figueroa S, Robledo G, Castillo G. 2006. *Phellinus caribaeo-quercicolus* sp. nov., parasitic on *Quercus* cubana, taxonomy and preliminary phylogeny. Mycologia 98: 265–274.

Decock C, Herrera Figueroa S, Robledo G, Castillo G. 2007. *Fomitiporia punctata* (Basidiomycota, Hymenochaetales) and its presumed taxonomic synonyms in America: taxonomy and phylogeny of some species from tropical/subtropical areas. Mycologia 99: 733–752.

Decock C, Valenzuela R, Castillo G. 2010. Studies in *Perenniporia s.l.*: *Perenniporiella tepeitensis* comb. nov., an addition to *Perenniporiella*. Cryptogamie Mycologie 31: 419–429.

Decock C, Amalfi M, Castillo. 2013. *Phylloporia nouraguensis* (Hymenochaetales, Basidiomycota), an undescribed species from the Neotropics. Cryptogamie Mycologie 34: 15–27.

Domański S. 1972. *Basidiomycetes: Aphyllophorales. Polyporaceae I. (resupinatae), Mucronoporaceae I (resupinatae)*. US Department of Agriculture Foreign Scientific Publication, Washington DC, USA.

Domański S, Orlos SH, Skirgiello A. 1967. Grzyby (Zagwiowate II, Szczeciniakowate II). – Panstwowe Wydawnictwo Naukowe, 395 pp. (1973 - Fungi: Polyporaceae II (pileatae), Mucronoporaceae II (pilaetae) - U.S. Dep. Commerce, Springfield, pp. 332)

Drechsler-Santos ER, Groposo C, Loguercio-Leite C. 2008a. Additions to the knowledge of lignocellulolytic Basidiomycetes in forests from Santa Catarina, Southern Brazil. Mycotaxon 103: 197–200.

Drechsler-Santos ER, Groposo C, Loguercio-Leite C. 2008b. New records of lignocellulolytic fungi (Basidiomycetes) from the Atlantic Rain Forest in State of Santa Catarina, Brazil. Hoehnea 35(1): 57–61.

Drechsler-Santos ER, Wartchow F, Baseia IG, Gibertoni TB, Cavalcanti MAQ. 2008d. Revision of the Herbarium URM I. Agaricomycetes from the semi-arid region of Brazil. Mycotaxon 104: 9–18.

Drechsler-Santos ER, Gibertoni TB, Góes-Neto A, Cavalcanti MAQ. 2009. A re-evaluation of the lignocellulolytic Agaricomycetes from the Brazilian semi-arid region. Mycotaxon 08: 241–244.

Drechsler-Santos ER, Santos PJP, Gibertoni TB, Cavalcanti MAQ. 2010. Ecological aspects of Hymenochaetaceae in an area of Caatinga (semi-arid) in Northeast Brazil. Fungal Diversity 42: 71–78.

Fiasson JL, Niemelä T. 1984. The Hymenochaetales: a revision of the European poroid taxa. Karstenia 24: 14–28.

Fidalgo MEPK. 1968a. Contribution to the fungi of Mato Grosso, Brasil. Rickia 3: 171–219.

Fidalgo O, Fidalgo MEPK. 1957. Revisão de Fungi São Paulensis. Arquivos do Museu Nacional 43: 157–188.

Fidalgo O, Fidalgo MEPK, Furtado JS. 1965. Fungi of the "cerrado" region of São Paulo. Rickia 2: 55–71.

Fidalgo O, Fidalgo MEPK. 1968. Polyporaceae from Venezuela I. Memoirs of the New York Botanical Garden 17: 1–34.

Fidalgo O, Bononi VLR. 1989. Técnicas de coleta, preservação e herborização de material botânico. Instituto de Botânica, São Paulo.

Fidalgo O. 1962. Rick, o pai da micologia brasileira. Rickia 1: 3–11.

Fidalgo O. 1968. Introdução a história da micologia brasileira. Rickia 3: 1–44.

Fischer M, Binder M. 1995. *Phellinus* species on *Betula.* Mating tests, RFLP analysis of enzymatically amplified rDNA, and relations to *Phellinus alni.* Karstenia 35: 67–84.

Fischer M, Binder M. 2004. Species recognition, geographic distribution, and host-pathogen relationships: a case study in a group of lignicolous Basidiomycetes, *Phellinus s.l.* Mycologia 96: 799–811.

Fischer M, Edwards J, Cunnington JH, Pascoe IG. 2005. Basidiomycetous pathogens on grapevine: a new species from Australia - *Fomitiporia australiensis*. Mycotaxon 92: 85–96.

Fischer M. 1994. Pairing tests in the *Phellinus pini* group. Mycologia 86: 524–539.

Fischer M. 1995. *Phellinus igniarius* and its closest relatives in Europe. Mycological Research 99: 735–744.

Fischer M. 1996. On the species complexes within *Phellinus*: *Fomitiporia* revisited. Mycological Research 100: 1459–1467.

Fischer M. 2002. A new wood-decaying Basidiomycete species associated with Esca of grapevine: *Fomitiporia mediterranea* (Hymenochaetales). Mycological Progress 1: 315–324.

Frøslev TG, Matheny PB, Hibbett DS. 2005. Lower level relationships in the mushroom genus *Cortinarius* (Basidiomycota, Agaricales): a comparison of RPB1, RPB2 and ITS phylogenies. Molecular Phylogenetics and Evolution 37: 602–618.

Fundação SOS Mata Atlântica/INPE. 2013. Atlas dos remanescentes florestais da Mata Atlântica e ecossistemas associados no período de 2012–2013. São Paulo: Fundação SOS Mata Atlântica/INPE.

Furlani J, Loguercio-Leite C. 2005. Basidiomycetes Lignolíticos em Santa Catarina: Rio Tavares, Ilha de Santa Catarina. Insula 34: 7–13.

Gerber AL, Loguercio Leite C. 1997. New records of polypores (Aphyllophorales) from southern Brazil. Mycotaxon 62: 305–318.

Gerber AL, Loguercio Leite C. 2000. Polyporoid wood-rotting fungi (*Basidiomycetes*) II - New record from southern Brazil. Mycotaxon 76: 175–185.

Gerber AL. 1996. Fungos xilófilos poróides (Aphyllophorales) no Morro da Lagoa da Conceição, Ilha de Santa Catarina, SC, Brasil. Insula 25: 3–68.

Gerlach ACL, Campos-Santana M, Gutjahr MC, Loguercio-Leite C. 2013. Wood-decaying Agaricomycetes (Basidiomycota, Fungi): new records for the state of Santa Catarina, Brazil. Acta Botanica Brasilica 27(2): 460–464.

Gibertoni TB, Cavalcanti MAQ. 2003. A Mycological Survey of the Aphyllophorales (Basidiomycota) of the Atlantic Rain Forest in the State of Pernambuco, Brazil. Mycotaxon 87: 203–211.

Gibertoni TB, Parmasto E, Cavalcanti MAQ. 2003. Non-poroid Hymenochaetaceae (Basidiomycota) of the Atlantic Rain Forest in Northeast Brazil. With a preliminary check list of Brazilian species. Mycotaxon 87: 437–443.

Gibertoni TB, Ryvarden L, Cavalcanti MAQ. 2004a. New records of Aphyllophorales (Basidiomycota) in the Atlantic Rain Forest in Northeast Brasil. Acta Botânica Brasílica 18(4): 975–979.

Gibertoni TB, Ryvarden L, Cavalcanti MAQ. 2004b. Poroid fungi (Basidiomycota) of the Atlantic Rain Forest in Northern Brazil. Synopsis Fungorum 18: 33–46.

Gibertoni TB, Ryvarden L, Cavalcanti MAQ. 2004c. Studies in neotropical polypores 18. New species from Brazil. Synopsis Fungorum 18: 44–56.

Gibertoni TB, Santos PJP, Cavalcanti MAQ. 2007. Ecological aspects of Aphyllophorales in the Atlantic Rain Forest in Northeast Brazil. Fungal Diversity 25: 49–67.

Gibertoni TB, Drechsler-Santos ER. 2010. Lignocellulolytic Agaricomycetes from the Brazilian Cerrado biome. Mycotaxon 111: 87–90.

Gilbertson RL, Ryvarden L. 1986. North America Polypores. *Abortiporus* – *Lindtneria*. Fungi Flora, Oslo, v. 1, 433p.

Gilbertson RL, Ryvarden L. 1987. North American Polypores. Part 2. *Megasporoporia* – *Wrightoporia*. Fungiflora, Oslo, Norway: 433–885.

Gilbertson RL. 1979. The genus *Phellinus* (Aphyllophorales: Hymenochaetaceae) in western North America. Mycotaxon 9(1): 51–89.

Góes-Neto A, Loguercio Leite C, Guerrero RT. 2000. Taxonomy and qualitative ecological aspects of poroid Hymenochaetales in a Brazilian seasonal tropical forest. Mycotaxon 76: 197–211.

Góes-Neto A, Loguercio-Leite C, Guerrero RT. 2001. Morphological Cladistic Analysis of Tropical Hymenochaetales (Basidiomycota). Mycotaxon 79: 467–479.

Góes-Neto A, Marques MFO, Andrade JD, Santos DS. 2003. Lignicolous Aphyllophoroid Basidiomycota in an Atlantic forest fragment in the semi-arid caatinga region of Brazil. Mycotaxon 88: 359–364.

Góes-Neto A, Baseia IG. 2006. Filo Basidiomycota. *In*: L.F.P. Gusmão & L.C. Maia (eds.). Diversidade e Caracterização dos Fungos do Semi-Árido Brasileiro. Recife. Associação Plantas do Nordeste 2: 141–160.

Góes-Neto A. 1996. Biodiversidade de Mixomicetos e Fungos Macroscópicos da Reserva Biológica de Una e Áreas Adjacentes (Bahia, Brasil). Sitientibus 15: 91–108.

Góes-Neto A. 1999. Polypore diversity in the State of Bahia, Brazil: A historical review. Mycotaxon 72: 43–56.

Gomes-Silva AC, Gibertoni TB. 2009a. Checklist of the Aphyllophoraceous fungi (Agaricomycetes) of the Brazilian Amazonia. Mycotaxon 108: 319–322.

Gomes-Silva AC, Gibertoni TB. 2009b. Revisão do herbário URM III. Novas ocorrências de Aphyllophorales (Basidiomycetes) para Amazônia brasileira. Revista Brasileira de Botânica 32: 585–594.

Gomes-Silva AC, Ryvarden L, Gibertoni TB. 2009. New and interesting species of *Hymenochaetaceae* from the Brazilian Amazonia Mycological Progress 8: 273–279.

Gomes-Silva AC, Ryvarden L, Gibertoni TB. 2010. Notes on *Trametes* from the Brazilian Amazonia. Mycotaxon 113: 61–71.

Gonçalves GVC, Loguercio Leite C. 2001. Biodiversidade de fungos xilófilos (Basidiomycetes), na Unidade de Conservação Ambiental Desterro (UCAD), Ilha de Santa Catarina, SC. Brazil. Insula 30: 1–19.

Gottlieb AM, Wright JE, Moncalvo JM. 2002. *Inonotus s.l.* in Argentina - morphology, cultural characters and molecular analyses. Mycological Progress 1: 299–313.

Groposo C, Loguercio Leite C. 2002. Fungos poliporóides xilófilos (Basidiomycetes) da Reserva Biológica Tancredo Neves, Cachoeirinha, Rio Grande do Sul, Brasil. Iheringia 57(1): 39–59.

Groposo C, Loguercio Leite C. 2005. Contribution to the lignocellulolytic fungi (Basidiomycetes) of the Atlantic Rain Forest in Southern Brazil. Mycotaxon 92: 103–106.

Groposo C, Loguercio Leite C, Góes-Neto A. 2007. *Fuscoporia* (Basidiomycota, Hymenochaetales) in Southern Brazil. Mycotaxon 101(1): 55–63.

Groposo C. 2002. Inventário da Biodiversidade da Micota (Basidiomycetes) Lignocelulolítica no Parque Estadual da Serra do Tabuleiro, Santa Catarina, Brasil. Monografia (Graduação em Ciências Biológicas), Universidade Federal de Santa Catarina, Florianópolis, 2002.

Guerrero RT, Homrich MH. 1999. Fungos Macroscópicos Comuns no Rio Grande do Sul. 2. ed. Porto Alegre: Universidade/UFRGS. 124 p.

Gugliotta AM, Capelari M. 1995. Polyporaceae from Ilha do Cardoso, SP, Brazil. Mycotaxon 56: 107–113.

Gugliotta AM, Bononi VLR. 1999. Polyporaceae do Parque Estadual da Ilha do Cardoso, São Paulo, Brasil. Boletim do Instituto de Botânica 12: 1–112.

Gusmão LFP, Marques MFO. 2006. Diversity of Fungi in the Brazilian Semi-arid. *In*: L.P. Queiroz, A. Rapini & A.M. Giulietti (eds.). Towards Greater Knowledge of the Brazilian Semi-arid Biodiversity. Ministerio da Ciencia e Tecnologia, Brasilia, pp. 83–86.

Gusmão LFP, Melo E, Franca F, Barbosa FF. 2006. O Semi-Arido Brasileiro e os Fungos. *In*: L.F.P. Gusmão & L.C. Maia (eds.). Diversidade e Caracterização dos Fungos do Semi-Árido Brasileiro. Associação Plantas do Nordeste II, Recife, pp. 19–26.

Hann TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41: 95–98.

Hawksworth DL, Kirk PM, Sutton BC, Pegler DN. 1995. Ainsworth & Bisby's Dictionary of the fungi. 8. ed. Egham, International Mycological Institute. 616 p.

Hawksworth DL. 1991. The fungal dimension of biodiversity: magnitude, significance and conservation. Mycological Research 95: 641–655.

Hawksworth DL. 2001. The magnitude of fungal diversity: the 1.5 million species estimate revisited. Mycological Research 105(12): 1422–1432.

Hawksworth DL. 2012. Global species numbers of fungi: are tropical studies and molecular approches contributing to a more robust estimate? Biodiversity and Conservation 21: 2425–2433.

Hennig W. 1966. Phylogenetic Systematics. University of Illinois Pres, Urbana (translatec by D. D. Davis and R. Zangerl), 263p.

Herrera Figueroa S, Bondartseva MA. 1985. Especies del género *Phellinus* (Basidiomycetes: Hymenochaetaceae) nuevas o poco conocidas en Cuba (II). Acta Botanica Cubana 36: 1–18.

Heuhs L, Fogel E, Scaiola G. 1994. Intoxicación por hongos *Amanita phalloides*. Revista Médica del Uruguay 10(2): 138–141.

Hey J. 1997. A reduction of species resolves the species problem. [http://lifesci.rutgers.edu/~heylab/sconcept/A_Reduction_of_Species.pdf].

Hibbett DS, Binder M, Bischoff JF, Blackwell M, Cannon PF, Eriksson OE, Huhndorf S, James T, Kirk PM, Lücking R, Thorsten-Lumbsch H, 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 KD, Ironside JE, Kõljalg U, Kurtzman CP, Larsson KH, Lichtwardt R, Longcore J, Miadlikowska 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*. Mycological Research 111(5): 509–547.

Hjortstam K, Ryvarden L. 1982. Studies in Tropical *Corticiaceae* (Basidiomycetes) IV. Type studies of taxa described by J. Rick. Mycotaxon 15: 261–276.

Hjortstam K, Ryvarden L. 1990. *Lopharia* and *Porostereum* (Corticiacae). Fungiflora, Synopsis Fungorum 4, 68 p.

Hjortstam K, Ryvarden L. 1993. Two new South America species of *Corticiaceae* (Basidiomycetes) with amyloid spores. Mycotaxon 47:81–85.

Hjortstam K, Ryvarden L. 2005a. New taxa and new combinations in tropical corticioid fungi (Basidiomycotina, Aphyllophorales). Synopsis Fungorum 20: 33–41.

Hjortstam K, Ryvarden L. 2005b. Notes on the genus *Epithele* from tropical South America (Basidiomycotina, Aphyllophorales). Synopsis Fungorum 20: 23–32.

Hjortstam K, Ryvarden L. 2007. Checklist of corticioid fungi (Basidiomycotina) from the tropics, subtropics and the southern hemisphere. Synopsis Fungorum 22: 27–146.

Hjortstam K. 2000. Two new species of *Phanerochaete* (Basidiomycotina, Aphyllophorales), and a key to species from subtropical areas. Karstenia 40: 53–62.

Hjortstam K. 2007. A new species of *Paullicorticium* (Basidiomycotina, Aphyllophorales) from Brazil. Synopsis Fungorum 22: 11–13.

Hoff JA, Klopfenstein NB, Mcdonlad GI, Tonn JR, Kim MS, Zambino PJ, Hessburg PF, Rogers JD, Peever TL, Carris LM. 2004. Fungal endophytes in woody roots of Douglas-fir (*Pseudotsuga menziesi*) and ponderosa pine (*Pinus ponderosa*). Forest Pathology 34: 255–271.

Huelsenbeck JP, Ronquist F. 2001. MRBAYES: Bayesian inference of phylogeny. Bioinformatics 17: 754–755.

Hull DL. 1997. The ideal species concept – and why we can't get it. In: Claridge MF, Dawah HA, Wilson MR, eds. Species: The Units of Biodiversity. New York, USA: Chapman & Hall, pp. 357–380.

IBGE - Instituto Brasileiro de Geografia E Estatística. 2013. Geografia do Brasil. Região Sul. Rio de Janeiro: IBGE, v. 2. 419p.

Iganci JRV, Heiden G, Miotto STS, Pennington RT. 2011. Campos de Cima da Serra: the Brazilian Subtropical Highland Grasslands show an unexpected level of plant endemism. Botanical Journal of the Linnean Society 167: 378–393.

Ipulet P, Ryvarden L. 2005. New and interesting polypores from Uganda. Synopsis Fungorum 20, Fungiflora, Oslo, Norway: pp. 87–99.

Jahn H. 1967. Die resupinaten *Phellinus* - Arten in Mitteleuropa. Westfälische Pilzbriefe 6: 37–124.

Jeong WJ, Young WL, Jin SL, Hack SJ. 2005. Phylogeny of *Phellinus* and related genera inferred from combined data of ITS and mitocondrial SSU rDNA sequences. Journal of Biodiversity and Conservation 15(5): 1028–1038.

Jesus MA. 1993. Basidiomicetos lignocelulolíticos de Floresta Nativa e de *Pinus elliottii* Engelm. do Parque Estadual das Fontes do Ipiranga, São Paulo, SP. Hoehnea 20(1/2): 119–126.

Jesus MA. 1996. Contribution to the knowledge of wood-rotting fungi in Brazil. II. Check-list of fungi from Maraca Island, Roraima State. Mycotaxon 57: 323–328.

Job DJ. 1990. Le genre Hymenochaete dans le zone tempérées de I'hémisphère sud. Mycologia Helvetica 4:1–51.

Judd WS, Campbell CS, Kellogg EA, Stevens PF, Donoghue MJ. 2009. Sistemática vegetal: um enfoque filogenético. 3ª ed. São Paulo: ArtMed., Porto Alegre. 632p.

Kimbrough JW, Alves MH, Maia LC. 1995. Basidiomycetes saprofitos presentes em troncos vivos e em folhedo de "Sombreiro" (*Clitoria fairchildiana* [Benth.] Howard). Biologica Brasilica 6(1/2): 51–56.

Kirk PM, Cannon PF, David JC, Stalpers JA. 2001. Ainsworth & Bisby's Dictionary of the Fungi, 9. ed. Wallingford, Oxon: CAB International 624p.

Kirk PM, Cannom PF, David JC, Stalpers JA. 2008. Ainsworth & Bisby's Dictionary of the Fungi, 10. ed. Wallingford, Oxon: CAB International, 771p.

Kornerup A, Wanscher JH. 1963. Taschenlexikon der Farben. Ed. Musterschmidt, Zurich. 282p.

Kornerup AJ, Wanscher H. 1978. Methuen handbook of colour. 3th ed, Eyre Methuen, London. 282p.

Kornerup A, Wanscher JH. 1981. Methuen handbook of color, 3rd Edition. Fletcher & Son Ltd, Great Britain: 282p.

Larsen MJ, Lombard FF. 1988. Studies in the genus *Phellinus*. I. The identity of *Phellinus rickii* with notes on its facultative synonyms. Mycologia 80: 72–76.

Larsen MJ, Cobb-Poulle LA. 1990. *Phellinus* (Hymenochaetaceae): a survey of the World Taxa. Synopsis Fungorum 3: 1–206.

Larsson KH, Parmasto E, Fischer M, Langer E, Nakasone KK, Redhead SA. 2006. Hymenochaetales: a molecular phylogeny for the hymenochaetoid clade. Mycologia 98(6): 926–936.

Leal GR, Gugliotta AM. 2008. Criptógamos do Parque Estadual das Fontes do Ipiranga, São Paulo, SP. Fungos, 9: Meripilaceae. Hoehnea 35(1): 99–110.

Lee SB, Taylor JW. 1990. Isolation of DNA from fungal mycelia and single cells. In: Innis, MA, Gelfand DH, Sninsky JJ, White TJ. PCR protocols, a guide to methods and applications. Academic Press, San Diego, pp. 282–287.

Leite PF. 2002. Contribuição ao conhecimento fitoecológico do sul do Brasil. Ciência & Ambiente 24: 51–73.

Lista de Espécies da Flora do Brasil 2012. Jardim Botânico do Rio de Janeiro. Disponível em: <http://floradobrasil.jbrj.gov.br/>. Acesso em: 12 Maio. 2014

Liu YJ, Whelen S, Hall BD. 1999. Phylogenetic relationships among ascomycetes: evidence from an RNA polymerase II subunit. Molecular Biology Evolution 16(12): 1799 –1808.

Loguercio Leite C, Wright JE. 1991. Contribution to a biogeographical study of the austro-american xylophilous polypores (Aphyllophorales) from Santa Catarina Island, SC., Brazil. Mycotaxon 41(1): 161–167.

Loguercio Leite C, Wright JE. 1995. The genus *Phellinus* (Hymenochaetaceae) on the Island of Santa Catarina, Brazil. Mycotaxon 54: 361–388.

Loguercio Leite C, Michels J, Baltazar JM. 2008a. Austro-American lignolytic polypores (Agaricomycetes) – new records for Southern Brazil. Mycotaxon 104: 205–213.

Loguercio Leite C, Michels J, Baltazar JM. 2008b. New records of lignocellulolytic basidiomycetes (*Fungi*): Parque Estadual da Serra do Tabuleiro (P.E.S.T.), Santa Catarina, Brazil. Biotemas 21(3): 7–14.

Loguercio-Leite C. 1990. Políporos (Basidiomycotina) xilófilos de la Ilha de Santa Catarina, Santa Catarina, Brasil. 312 f. Tese (Doutorado em Ciências Biológicas). Universidad de Buenos Aires, Buenos Aires, Argentina, 1990.

Loguercio Leite C. 1990. Revisão histórica sobre fungos poliporóides (*Aphyllophorales*) xilófilos de Santa Catarina, Brasil. Insula 20: 3–10.

Louza GSG, Gugliotta AM. 2007. *Polyporus* Fr. (Polyporaceae) no Parque Estadual das Fontes do Ipiranga, São Paulo, SP, Brasil. Hoehnea 34(3): 365–382.

Lowe JL. 1957. Polyporaceae of North America. The genus *Fomes*. State University College of Forestry at Syracuse University, Technical Publication 80: 1–97.

Lowe JL. 1966. Polyporaceae of North America. The genus *Poria*. State University College of Forestry at Syracuse University, Technical Publication 90: 1–183.

Lutzoni F, Kauff F, Cox CJ, McLaughlin D, Celio G, Dentinger B, Padamsee M, Hibbett D, James TY, Baloch E, Grube M, Reeb V, Hofstetter V, Schoch C, Arnold AE, Miadlikowska J, Spatafora J, Johnson D, Hambleton S, Crockett M, Shoemaker R,

Sung G-H, Lücking R, Lumbsch T, O'Donnell K, Binder M, Diederich P, Ertz D, Gueidan C, Hansen K, Harris RC, Hosada K, Lim Y-W, Matheny B, Nishida H, Pfister D, Rogers J, Rossman A, Schmitt I, Sipman H, Stone J, Sugiyama J, Yahr R, Vilgalys R. 2004. Assembling the fungal tree of life: progress, classification, and evolution of subcellular traits. American Journal of Botany 91:1446–1480.

Maia HS. 1960. Fungos Diversos. Publicações do Instituto de Micologia do Recife 267: 1–51.

Maia LC, Barros ST, Cavalcanti M. 1996. Fungos. *In*: E.V.S.B. Sampaio, R. Barbosa & S. Mayo (eds.). Estudos botânicos no Nordeste: progressos e perspectivas. Sociedade Botânica do Brasil, Seção Regional Pernambuco, Recife, pp. 9–35.

Maia LC, Gibertoni TB. 2002. Fungos registrados no semi-árido nordestino. *In*: E.V.S.B. Sampaio, A.M. Giulietti, J. Virginio & C.F.L. Gamarra-Rojas (eds.). Vegetação e Flora da Caatinga. Associação Plantas do Nordeste/APNE e Centro Nordestino de Informações sobre Plantas/CNIP, Recife, pp. 163–176.

Maia LC, Yano-Melo A, Cavalcanti MA. 2002. Diversidade de Fungos no Estado de Pernambuco. *In*: M. Taberelli & J.M.C. Silva (eds.). Diagnóstico da biodiversidade de Pernambuco. Editora Massangana, Recife, pp. 15–50.

Mason-Gamer RJ, Kellogg EA. 1996. Testing for phylogenetic conflict among molecular data sets in the tribe Triticeae (Gramineae). Systematic Biology 45: 524–545.

Mata M, Ryvarden L. 2010. Studies in neotropical polypores 27. More new and interesting species from Costa Rica. Synopsis Fungorum 27: 59–72.

Matheny PB, Wang Z, Binder M, Curtis JM, Lim YW, Nilsson RH, Hughes KW, Petersen RH, Hofstetter V, Ammirati JF, Schoch C, Langer GE, McLaughlin DJ, Wilson AW, Crane PE, Frøslev T, Ge ZW, Kerrigan RW, Slot JC, Vellinga EC, Liang ZL, Aime MC, Baroni TJ, Fischer M, Hosaka K, Matsuura K, Seidl MT, Vaura J, Hibbett

DS. 2007. Contributions of *rpb2* and *tef1* to the phylogeny of mushrooms and allies (Basidiomycota, Fungi). Molecular Phylogenetics and Evolution 43: 430–451.

Matheny PB. 2005. Improving phylogenetic inference of mushrooms with *rpb1* and *rpb2* nucleotide sequences (*Inocybe*, Agaricales). Molecular Phylogenetics and Evolution 35: 1–20.

Mayden RL. 1997. A hierarchy of species concepts: the denouement in the saga of the species problem. In: Claridge MF, Dawah HA, Wilson MR (eds.). Species: the units of biodiversity. London: Chapman & Hall.

Mayr E. 1942. Systematics and the Origin of Species. New York, USA: Columbia University Press.

Mayr E. 2001. What Evolution Is. - 327 pp. (Basic Books) New York.

MCNeill J, Barrie FR, Buck WR, Demoulin V, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Marhold K, Prado J, Prud'homme van Reine WF, Smith GF, Wiersema JH, Turland NJ. 2012. Código International de Nomenclatura para Algas, Fungos e Plantas (Código de Melbourn). Melbourne: Koeltz Scientific Books, 2012. Disponível em: <http://www.iapt-taxon.org/nomen/main.php>. Acesso em: 26 jun. 2013.

Meijer AAR. 2006. Preliminary list of the macromycetes from the Brazilian state of Paraná. Boletim do Museu Botânico Municipal 68: 1–55.

Meijer AAR de. 2010. Preliminary list of the macromycetes from the Brazilian state of Paraná: corrections and updating. Boletim do Museu Botânico Municipal 72: 1–10.

Miadlikowska J, Lutzoni F. 2004. Phylogenetic classification of peltigeralean fungi (Peltigerales, Ascomycota) based on ribosomal RNA small and large subunits. American Journal of Botany 91: 449–464.

Moncalvo JM, Nilsson RH, Koster B, Dunham SM, Bernauer T, Matheny PB, Porter TM, Margaritescu S, Weiß M, Garnica S, Danell E, Langer G, Langer E, Larsson E, Larsson KH, Vilgalys R. 2006. The cantharelloid clade: dealing with incongruent gene trees and phylogenetic reconstruction methods. Mycologia 98: 937–948.

Mueller GM, Schmidt JP. 2007. Fungal Biodiversity: what do we know? What do we predict? Biodiversity and Conservation 16:1–5.

Müller K. 2005. SeqState—primer design and sequence statistics for phylogenetic DNA data sets, Applied Bioinformatics 4:65–69.

Munsell L. 1975. Munsell soil color charts.U. S. Dep. Agric. Hand 18 – Soil Survey Manual.

Murril WA. 1907. (Agaricales) Polyporaceae (conclusio). North American Flora 9(1): 1–72.

Niemelä T. 1975. On Fennoscandian polypores. IV. *Phellinus igniarius, P. nigricans* and *P. populicola* sp. nov. Annales Botanici Fennici 12: 93–122.

Novotný C, Rawal B, Bhatt M, Patel M, Sasek V, Molitoris HP. 2001. Capacity of *Irpex lacteus* and *Pleurotus ostreatus* for decolorization of chemically different dyes. Journal of Biotechnology 89: 113–122.

Nuñez M, Ryvarden L. 2000. East Asian Polypores. *Ganodermataceae and Hymenochaetaceae*. Oslo, Fungiflora, 168 p.

Oberwinkler F. 1977. Das neue System der Basidiomyceten. In: Frey, W., Hurka, H., Oberwinkler, F. [Eds.]. Beiträge zur Biologie der niederen Pflanzen. New York: Gustav Fischer Verlag. pp. 59 – 104.

Parmasto E, Parmasto I. 1979. The xanthochroic reaction in Aphyllophorales. Mycotaxon 8: 201 – 232.

Peel MC, Finlayson BL, McMahon TA. 2007. "Updated world map of the Köppen-Geiger climate classification". Hydrology and Earth System Sciences 11: 1633–1644.

Perkins SL. 2000. Species concepts and malaria parasites: detecting a cryptic species of Plasmodium. Proceeding of the Royal Society of London 267: 2345–2350.

Petersen RH, Hugles KW. 1999. Species and speciation in mushrooms. BioSciense 49: 440–452.

Piaggio M. 2008. Aproximación a la biodiversidad en hongos del Uruguay. Simbiosis, 9(10): 12–14.

Pieri M, Rivoire B. 2000. Le genre *Phellinus.* Quelques espèces rares ou critiques en France, avec une clé des espèces du genre *Phellinus s.l.* signalées en Europe occidentale. Bulletin de la Société Mycologique de France. 116: 305–331.

Pilotti M, Gervasi F, Brunetti A. 2005. Molecular Identification of *Fomitiporia mediterranea* and *Eutypa lata*/*Libertella blepharis* in *Platanus* × *acerifolia*. Journal of Phytopathology153: 193–202.

Popoff OF. 2000: Novedades sobre corticoides y polıporos (Basidiomycetes) xilofilos del Nordeste Argentino y Paraguay. PhD thesis, Universidad Nacional de Córdoba, Córdoba (Argentina), pp. 338.

Posada D, Crandall KA. 1998. Modeltest: testing the model of DNA substitution. Bioinformatics 14: 817–818.

Puillandre N, Lambert A, Brouillet S, Achaz G. 2012. ABGD, Automatic Barcode Gap Discovery for primary species delimitation. Molecular Ecology 21:1864–1877.

Quaedvlieg W, Binder M, Groenewald JZ, Summerell BA, Carnegie AJ, Burgess TI, Crous PW. 2014. Introducing the Consolidated Species Concept to resolve species in the Teratosphaeriaceae. Persoonia 33: 1–40.

Rajchenberg M, Wright JE. 1987. Type studies of Corticiaceae and Polyporaceae Aphyllophorales) described by C. Spegazzini. Mycologia 79: 246–264.

Rajchenberg M, Wright JE. 1998. Two interesting Hymenochaetaceae (Aphyllophorales) from Argentina. Folia Cryptogamica Estonica 33: 119–122.

Rajchenberg M, Meijer A. 1990. New and noteworthy polypores from Paraná and São Paulo States, Brazil. Mycotaxon 38: 173–185.

Rajchenberg M, Robledo GL. 2013. Pathogenic polypores in Argentina. Forest Pathology 43: 171–184

Rajchenberg M. 1984. Basidiomicetos xilofilos de la region mesopotamica (Republica Argentina), V. Polıporos resupinados. Revista de Investigaciones Agropecuarias. INTA 19: 1–105.

Rajchenberg M. 1987a. Type studies of *Polyporaceae* (*Aphyllophorales*) described by J. Rick. Nordic Journal of Botany 7(5): 553–568.

Rajchenberg M. 1987b. Xylophilous Aphyllophorales (Basidiomycetes) from the southern Andean forest, Additions and corrections II. Sydonia 40: 235–249.

Rajchenberg M. 2006. Los Polıporos (Basidiomycetes) de los Bosques Andino Patagonicos de Argentina. Polypores (Basidiomycetes) from the Patagonian Andes Forests of Argentina. Version bilingue. Bibliot. Mycol. Band 201, J. Cramer Verlag, Stuttgart 300p.

Rambaut A, Drummond AJ. 2007. Tracer v1.4, [http://beast.bio.ed.ac.uk/Tracer]. RAxML Web-Servers. Systematic Biology 75: 758–771.

Raymundo T, Valenzuela R, Bautista-Hernandez S, Esqueda M, Cinfuentes J, Pacheco-Mota L. 2012. El género *Fuscoporia* (Hymenochaetales-Basidiomycota) en México. Revista Mexicana de Biodiversidad 84: 50–60.

Raymundo T, Decock C, Valenzuela R, Amalfi M, Cinfuentes J, Pacheco-Mota L. 2013. New record of the genus *Fomitiporia* (Hymenochaetales, Basidiomycota) in Mexico. Revista Mexicana de Biodiversidad 83: 313–328.

Reck MA, Silveira RMB. 2008. Polyporales (Basidiomycota) no Parque Estadual de Itapuã, Viamão, Rio Grande do Sul. Revista Brasileira de Biociências 6(3): 301–314.

Reeb V, Lutzoni F, Roux C. 2004. Contribution of RPB2 to multilocus phylogenetic studies of the euascomycetes (Pezizomycotina, Fungi) with special emphasis on the lichen-forming Acarosporaceae and evolution of polyspory. Molecular Phylogenetics and Evolution 32: 1036–1060.

Rehner SA, Buckley E. 2005. A *Beauveria* phylogeny inferred from nuclear ITS and EF1-a sequences: evidence for cryptic diversification and links to *Cordyceps* teleomorphs. Mycologia 97:84–98.

Rick J. 1960. *Basidiomycetes* eubasidii in Rio Grande do Sul – Brasilia. 4. *Meruliaceae, Polyporaceae, Boletaceae*. Iheringia 7: 193–295.

Rizzo DM, Gieser PT, Burdsall HH. 2003. *Phellinus coronadensis*: a new species from southern Arizona, USA. Mycologia 95: 74–79.

Robert V, Stegehuis G, Stalpers J. 2005. The MycoBank engine and related databases. http://www.mycobank.org.

Robledo GL, Urcelay C, Domínguez L, Rajchenberg M. 2006. Taxonomy, ecology and biogeography of Polypores (Basidiomycetes) from Argentinian *Polylepis* woodlands. Canadian Journal of Botany 84: 1561–1572.

Robledo GL, Urcelay C. 2009. Hongos de la madera en arboles nativos del Centro de Argentina. Córdoba, Argentina: Ed. Univ. Nacional de Córdoba, 201p.

Robledo GL. 2009: Hongos degradadores de la madera de las Yungas argentinas. Diversidad de polıporos (Aphyllophorales, Basidiomycota). PhD thesis, Universidad Nacional de Córdoba, Córdoba (Argentina), 418p.

Ronquist F, Huelsenbeck JP. 2003. MRBAYES 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19:1572–1574.

Ronquist F, Huelsenbeck JP, van der Mark P. 2005. MrBayes 3.1 manual. Tallahassee, Florida: School of Computational Science, Florida State University.

Roy A. 1979. Taxonomy of *Fomes durissimus*. Mycologia 71(5): 1005 –1009.

Ryvarden L, Johansen I. 1980. A preliminary polypore flora of East Africa. Oslo: Fungiflora, 636p.

Ryvarden L, Gilbertson RL. 1994. European polypores 2. *Meripilus–Tyromyces*. Synopsis Fungorum 7, Oslo, Norway: Fungiflora: 392–743.

Ryvarden L, de Meijer AAR. 2002. Studies in Neotropical Polypores 14. New species from the State of Paraná, Brazil. Synopsis Fungorum 15, Oslo, Norway: Fungiflora 15: 34–69.

Ryvarden L. 1978. The Polyporaceae of North Europe. *Volume 2* (Inonotus – Tyromyces), vol 2. Fungiflora, Oslo, pp. 219–507.

Ryvarden L. 1985. Type studies in the Polyporaceae 17. Species described by W.A. Murrill. Mycotaxon 23: 169–198.

Ryvarden L. 1987. New and noteworthy polypores from tropical America. Mycotaxon 28: 525–541.

Ryvarden L. 1990. Type studies in the Polyporaceae - 22. Species described by C. G. Lloyd in Polyporus. Mycotaxon 38: 83–102.

Ryvarden L. 1991. Genera of Polypores. Nomenclature and taxonomy. Synopsis Fungorum 5, Oslo, Norway: Fungiflora: 1–363.

Ryvarden L. 2004. Neotropical Polypores Part. 1 – Introduction, Ganodermataceae & Hymenochaetaceae. Synopsis Fungorum 19: 1–229.

Ryvarden L. 2005. The genus *Inonotus*. A synopsis. Synopsis Fungorum 21: 1–149.

Sampaio AJ. 1916. A flora de Matto Grosso. Arquivos do Museu Nacional 19: 1–127.

Schmit JP, Mueller GM. 2007. An estimate of lower limit of global fungal diversity. Biodiversity and Conservation 16: 99–111.

Sequeira AY, Tálice N. 2008. Hongos comestibles y venenosos del Uruguay. Almanaque 2008, Banco de Seguros del Estado. Montevideo: Mosca.

Silva GT, Gibertoni TB. 2006. Aphyllophorales (Basidiomycota) em áreas urbanas da Região Metropolitana do Recife, PE, Brasil. Hoehnea 33(4): 533–543.

Silveira RMB, Guerrero RT. 1991. Aphylloporales poliporóides (Basidiomycetes) do Parque Nacional de Aparados da Serra, RS. Boletim do Instituto de Biociências 48: 1–127.

Silveira RMB, Coelho G, Cortez VG. 2006. Estudos sobre Macromicetos no sul do Brasil. In: Mariath JE de A; Santos RP. dos (Orgs.). Os avanços da Botânica no início do século XXI: morfologia, fisiologia, taxonomia, ecologia e genética: Conferências Plenárias e Simpósios do 57º Congresso Nacional de Botânica. Porto Alegre: Sociedade Botânica do Brasil, pp. 232–236.

Silveira RMB, Reck MA, Graf LV, Sá FN. 2008. Polypores from a Brazilian pine forest in Southern Brazil: pileate species. Hoehnea 35: 619–630.

Simmons MP, Ochoterena H. 2000. Gaps as characters in sequence-based phylogenetic analyses. Systematic Biology 49: 369–381.

Simmons MP, Pickett KM, Miya M. 2004. How meaningful are Bayesian support values? Molecular Biology and Evolution 21: 188–199.

Singer R. 1975. The Agaricales in modern taxonomy. 3th Edition. Stuttgart: Vaduz. J. Cramer, Germany. 912p.

Sobestiansky G. 2005. Contribution to a macromycete survey of the states of Rio Grande do Sul and Santa Catrina in Brazil. Brazilian Archives of Biology and Technology 48: 437–457.

Song KS, Cho SM, Lee JH, Kim HM, Han SB, Ko KS, Yoo ID. 1995. B-lymphocyte stimulating polysaccharide from mushroom *Phellinus linteus*. Chemical and Pharmaceutical Bulletin 43: 2105–2108.

Souza MA. 1977. Contribuição ao estudo do gênero *Phellinus* da Reserva Florestal do Parque Estadual do Turvo, Tenente Portela, Rio Grande do Sul. 143 f. Dissertação (Mestrado em Botânica Sistemática). Universidade Federal do Rio Grande do Sul, Porto Alegre, 1977.

Spegazzini C. 1880: Fungi Argentini. Anales de la Sociedad Científica Argentina. 9: 278–285.

Stalpers JA. 1978. Identification of wood-inhabiting Aphyllophorales in pure culture. Studies in Mycologie 16: 1–248.

Stamatakis A, Hoover P, Rougemont J. 2008. A rapid bootstrap algorithm for the RAxML Web-Servers. Systematic Biology 75: 758–771.

Swofford DL. 2002. PAUP: Phylogenetic Analysis Using Parsimony. Version 4.0b10. Laboratory of Molecular Systematic, Smithsonian Institute, Washington DC.

Swofford DL. 2003. PAUP*. Phylogenetic Analysis Using Parsimony (*and Other Methods). Version 4. Sinauer Associates, Sunderland, Massachusetts.

Taylor JW, Geiser DM, Jacobson DJ, Kroken S, Kasuga T, Geiser DM, Hibbett DS, Fisher MC. 2000. Phylogenetic species recognition and species concepts in fungi. Fungal Genetics and Biology 31: 21–32.

Taylor JW, Turner E, Pringle A, Dettman J, Johannesson H. 2006. Fungal species: thoughts on their recognition, maintenance and selection. In: Gadd, G.M., Watkinson, S.C., Dyer, P.S. (Eds.), Fungi in the Environment. pp. 313–339.

Teixeira AR. 1950. Himenomicetos brasileiros – V Polyporaceae – 2. Bragantia 10(4): 113–122.

Theissen F. 1911. Polyporaceae austro-brasilienses imprimis rio grandenses. Kaiserlich-Königlichen Hof- und Staatsdruckerei, Wien: 60 p.

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG. 1997. The CLUSTAL_X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acids Research 25: 4876–4882.

Tian XM, Yu HY, Zhou LW, Decock C, Vlasák J, Dai YC. 2013. Phylogeny and taxonomy of the *Inonotus linteus* complex. Fungal Diversity 58: 159–169.

Tomšovský M, Sedlák P, Jankovský L. 2010a. Species recognition and phylogenetic relationships of European *Porodaedalea* (Basidiomycota, Hymenochaetales). Mycological Progress 9: 225–233.

Tomšovský M, Vampola P, Sedlák P, Byrtusová Z, Jankovský L. 2010b. Delimitation of central and northern European species of the *Phellinus ignarius* group (Basidiomycota, Hymenochaetales) based on analysis of ITS and translation elongation factor 1 alpha DNA sequences. Mycological Progress 9: 431–445.

Torrend C. 1915. Les Myxomycetes du Brésil, connus jusqu'ici. Brotéria, Série Botanica. 13: 72–88.

Torrend C. 1940. As Poliporáceas da Bahia e Estados Limítrofes. *In*: Anais da 1ª Reunião Sul-Americana de Botânica (1938) 2: 325–341.

Treiveiler-Pereira L. 2008. Levantamento de Basidiomycetes (Basidiomycota, Fungi) xilófilos nos manguezais do Itacorubi e Rio Tavares, Ilha de Santa Catarina, SC, Brasil. 125 f. Trabalho de Conclusão de Curso (Graduação em Ciências Biológicas). Universidade Federal de Santa Catarina, Florianópolis.

Untereiner WA, Bonjean B, Decock C, Evrard P, de Frahan MH, Jamin N, Massart L, Nélissen L, Robert V, Bosschaerts M, Guissart F, De Brabandere J. 1998. MUCL Catalogue of strains (Fungi-Yeast). 3e Ed. Published by the Belgian Office for Scientific, Technical and Cultural Affairs, Brussels, Belgium.

Valenzuela R, Raymundo T, Cifuentes J, Castillo G, Amalfi M, Decock C. 2011. Two undescribed species of *Phylloporia* from Mexico based on morphological and phylogenetic evidence. Mycological Progress. 10: 341–349.

Valenzuela R, Raymundo T, Decock C, Esqueda M. 2012. Aphyllophoroid fungi from Sonora, México 2. New records from Sierra de Álamos–Río Cuchujaqui Biosphere Reserve. Mycotaxon 122: 51–59.

Valenzuela R, Raymundo T, Cifuentes J. 2013. El género *Inonotus s.l.* (Hymenochaetales: Agaricomycetes) en México. Revista Mexicana de Biodiversidad, S70–S90.

Van Valen L. 1976. Ecological species, multispecies, and oaks. Táxon 25: 233–239.

Vital DM, Capelari M, Gugliotta AM, Bononi VLR. 2000. Bryophytes on Fungi. Tropical Bryology 19: 31–40.

Vlasák J, Kout J. 2011. Pileate *Fomitiporia* species in the USA. New combinations *Fomitiporia calkinsii* and *F. bakeri.* Mycological Progress 10: 445–452.

Vlasák J, Kout J, Vlasák J Jr, Ryvarden L. 2011. New records of polypores from Southern Florida. Mycotaxon 118: 159–176.

Vlasák J, Li HJ, Zhou LZ, Dai YC. 2013. A further study on *Inonotus linteus* complex (Hymenochaetales, Basidiomycota) in tropical America. Phytotaxa 124(1): 25–36.

Wagner T, Fischer M. 2001. Natural groups and revised system for the European poroid Hymenochaetales (Basidiomycota) supported by nLSU rDNA sequence data. Mycological Research 105(7): 773–782.

Wagner T, Fischer M. 2002. Proceeding toward a natural classification of the worldwide taxa *Phellinus* s.l and *Inonotus* s.l. and phylogenetic relationship of allied genera. Mycologia 94: 998–1016.

Wagner T, Ryvarden L. 2002. Phylogeny and taxonomy of the genus *Phylloporia* (Hymenochaetales). Mycological Progress 1: 105–116.

Wang H, Liu YM, Qi ZM, Wang SY, Liu SX, Li X, Wang HJ, Xia XC. 2013. An overview on natural polysaccharides with antioxidant properties. Current Medicinal Chemistry 20(23): 2899–2913.

Wang Z, Luo D, Liang Z. 2004. Structure of polysaccharides from the fruiting body of *Hericium erinaceus* Pers. Carbohydrate Polymers 57: 241–247.

Westphalen MC, Reck MA, Silveira RMB. 2010. Polypores from Morro Santana, Rio Grande do Sul, Brazil. Hoehnea 37: 647–662.

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, Sninsky JJ, White TJ (eds) PCR Protocols: a guide to methods and applications. Academic, New York, pp 315–322.

Wiens JJ, Servedio MR. 2000. Species delimitation in systematics: Inferring diagnostic differences between species. Proceedings of the Royal Society of London Series B-Biological Sciences 267: 631–636.

Willerding A, Loguercio-Leite C. 1994. Hymenochaetaceae Donk. I: *Phellinus* Quélet no Estado de Santa Catarina. São Leopoldo, Resumos XLV Congresso Nacional de Botânica, 322p.

Wright JE, Deschamps JR. 1972. Basidiomicetos xilofagos de los Bosques Andinopatagonicos. Revista de Investigaciones Agropecuárias. INTA ser. 5 Pat. Veg. 9:111–195.

Wright JE, Deschamps JR. 1975. Basidiomicetos xilofilos de la Region Mesopotamica II. Los generos *Daedalea*, *Fomitopsis*, *Heteroporus*, *Laetiporus*, *Nigroporus*, *Rigidoporus*, *Perenniporia* y *Vanderbylia*. Revista de Investigaciones Agropecuárias. INTA ser. 5 Pat. Veg. 12: 127–204.

Wright JE, Deschamps JR. 1977. Basidiomicetos xilofilos de la Region Mesopotamica III. Los generos *Bjerkandera*, *Gloeophyllum*, *Gloeoporus*, *Hirschioporus*, *Hydnopolyporus*, *Phaeocoriollelus*, P*ycnoporus* y *Xerotinus*. Revista de Investigaciones Agropecuárias. INTA ser. 5 Pat. Veg. 13: 27–70.

Wright JE, Blumenfeld S. 1984. New South American species of *Phellinus* (Hymenochaetaceae). Mycotaxon 21: 413–425.

Wright JE, Deschamps JR, Blumenfeld S. 1988. Basidiomycetos xilófilos de la región mesopotámica IV: Especies poroides de la familia Hymenochaetaceae (Inédito).

Wright JE, Wright AM. 2005. Checklist of the Mycobiota of Iguazu National Park (Misiones, Argentina). Boletín de la Sociedad Argentina de Botánica 40: 23–44.

Wright S. 1940. The statistical consequences of Mendelian heredity in relation to speciation. Pages 161–183 *in* The new systematics (J.Huxley, ed.). Oxford University Press, London.

Yombiyeni P, Douanla-Meli C, Amalfi M, Decock C. 2011. Poroid Hymenochaetaceae from Guineo-Congolian rainforest: *Phellinus gabonensis* sp. nov. from Gabon – Taxonomy and phylogenetic relationships. Mycological Progress 10(3): 351–362.

Yombiyeni P, Balezi A, Amalfi M, Decock C. 2014. Poroid Hymenochaetaceae from the Guineo-Congolian rainforest: addition to *Phylloporia*, determined by phylogenetic analyses, morphological, and ecological data. Mycologia (in press).

Zhou LW, Dai YC. 2012. Phylogeny and taxonomy of *Phylloporia* (Hymenochaetales): new species and a worldwide key to the genus. Mycologia 104: 211–222.

Zhou LW, Xue HJ. 2012. *Fomitiporia pentaphylacis* and *F. tenuitubus* spp. nov. (Hymenochaetales, Basidiomycota) from Guangxi, southern China. Mycological Progress 11: 907–913.

Zhou LW. 2013. *Phylloporia tiliae* sp. nov. from China. *Mycotaxon* 124: 361–365.