MARIANA DE PAULA DREWINSKI

Cogumelos comestíveis do Brasil: diversidade e viabilidade de cultivo

Tese apresentada ao Instituto de Pesquisas Ambientais, da Secretaria de Meio Ambiente, Infraestrutura e Logística como parte dos requisitos exigidos para a obtenção do título de DOUTORA em BIODIVERSIDADE VEGETAL E MEIO AMBIENTE, na Área de Concentração de Plantas Avasculares e Fungos em Análises Ambientais.

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A natureza humana é uma relação entre espécies. (...) Os cereais domesticam os seres humanos. As monoculturas nos dão as subespécies chamadas de raças. O lar isola o amor intraespécies do amor interespécies. Mas os cogumelos coletados nos levam para outro lugar: para as bordas indisciplinadas e as costuras do espaço imperial, onde não se pode ignorar as interdependências entre espécies que nos dão à vida na Terra.

Anna Tsing

RESUMO

Dentre as 27 mil espécies de cogumelos conhecidas, cerca de 2 mil são comestíveis, mas apenas 100 espécies são cultivadas mundialmente. As cepas dos cogumelos mais comumente cultivados no Brasil são, em sua maioria, provenientes de espécies de países de clima temperado, o que demanda um alto custo para a climatização dos ambientes para o sucesso no cultivo. Os indígenas brasileiros conhecem e consomem diversas espécies de cogumelos encontrados nas matas, e essas espécies de ocorrência natural podem apresentar-se bastante promissoras para estudos de cultivo e para a futura inserção no mercado de cogumelos comestíveis. Dessa forma, o objetivo deste trabalho foi conhecer os cogumelos comestíveis que ocorrem no Brasil e estudar a potencialidade de cultivo de espécies coletadas na Mata Atlântica. Com base em novas coleções e em registros bibliográficos, nós reportamos a ocorrência de 408 espécies de cogumelos comestíveis silvestres no Brasil, das quais 349 podem ser consumidas com segurança e 59 necessitam de alguma condição para serem consumidas adequadamente. Dentre as 408 espécies comestíveis, 83 espécies apresentam registros consistentes de ocorrência no Brasil com base em dados moleculares e/ou pela existência de tipos nomenclaturais brasileiros. As espécies *Auricularia cornea*, *Auricularia fuscosuccinea*, *Irpex rosettiformis* e *Laetiporus gilbertsonii* foram avaliadas quanto ao desenvolvimento micelial *in vitro* em diferentes temperaturas e em dois substratos de cultivo. A temperatura de 30 °C e o substrato a base de serragem de eucalipto favoreceram o desenvolvimento micelial das quatro espécies estudadas. No teste de cultivo em blocos, foi possível a obtenção de basidiomas das espécies *A. cornea*, *A. fuscosuccinea* e *I. rosettiformis*. Apesar do sucesso no cultivo do micélio de *L. gilbertsonii*, não foi possível a obtenção de basidiomas para essa espécie. Este é o primeiro registro de cultivo exitoso da espécie *I. rosettiformis*. Os basidiomas das três espécies produzidas foram analisados quanto à composição nutricional e mineral, e apresentaram conteúdo de carboidratos variando de 54 % a 71 %, fibra bruta de 3 % a 27 %, proteína bruta de 10 % a 25 %, lipídios de 0,8 % a 10 %, e cinzas de 4 % a 8 %. Dentre os minerais analisados, potássio e fósforo foram os elementos mais abundantes nas amostras estudadas. Mediante ao exposto, pode-se afirmar que existe um enorme potencial associado ao cultivo de espécies de cogumelos silvestres do Brasil. Pesquisas sobre o cultivo dessas espécies podem levar à descoberta de isolados com maior produtividade e mais bem adaptados às condições locais do que as linhagens de espécies comumente comercializadas, além da diversificação da produção e da valorização da biodiversidade brasileira.

Palavras-chave: *Auricularia cornea*, *Auricularia fuscosuccinea*, cogumelos silvestres, cultivo de cogumelos, domesticação, *Hydnopolyporus fimbriatus*, *Irpex rosettiformis*, *Laetiporus gilbertsonii*.

ABSTRACT

Among the 27,000 known mushroom species, about 2,000 are edible, but only 100 species are cultivated worldwide. The strains of mushrooms most commonly cultivated in Brazil are, in general, from species collected in temperate climate, which demands a high cost for acclimatization of the environment for successful cultivation. Brazilian indigenous groups know and consume several species of mushrooms found in the forests, and these naturally occurring species can be very promising for studies on cultivation and future insertion in the edible mushroom industry. Thus, the objective of this work was to summarize the edible mushrooms that occur in Brazil and to study the potential of cultivating species collected in the Atlantic Rainforest. Based on new collections and bibliographic records, we report the occurrence of 408 species of wild edible mushrooms in Brazil, of which 349 can be safely consumed and 59 need some condition to be consumed properly. Among the 408 edible species, 83 species have consistent records of occurrence in Brazil based on molecular records and/or the existence of Brazilian nomenclatural types. The species *Auricularia cornea*, *Auricularia fuscosuccinea*, *Irpex rosettiformis* and *Laetiporus gilbertsonii* were evaluated for *in vitro* mycelial development at different temperatures and in two substrates. The temperature of 30 °C and the substrate based on eucalyptus sawdust favored the mycelial development of the four studied species. In the experiment of cultivation in blocks, it was possible to obtain basidiomata of the species *A. cornea*, *A. fuscosuccinea* and *I. rosettiformis*. Despite the success in cultivating *L. gilbertsonii* mycelium, it was not possible to obtain basidiomata for this species. This is the first record of successful cultivation of the species *I. rosettiformis*. The mushrooms of the three species produced were analyzed for nutritional and mineral composition, and showed carbohydrate content ranging from 54 % to 71 %, crude fiber from 3 % to 27 %, crude protein from 10 % to 25 %, lipids from 0.8 % to 10 %, and ash from 4 % to 8 %. Among the analyzed minerals, potassium and phosphorus were the most abundant elements in the studied samples. Thus, it can be stated that there is a huge potential for the cultivation of wild edible mushrooms in Brazil. Research on the cultivation of these species can lead to the discovery of strains with higher productivity, and more adapted to local conditions than the lineages of commonly commercialized species, in addition to diversifying mushroom production and valuing Brazilian biodiversity.

Keywords: *Auricularia cornea*, *Auricularia fuscosuccinea*, domestication, *Hydnopolyporus fimbriatus*, *Irpex rosettiformis*, *Laetiporus gilbertsonii*, mushroom cultivation, wild edible mushrooms.

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Apresentação

Esta tese contém uma introdução geral sobre o tema, seguido por capítulos apresentados em formato de artigos científicos, já nas normas das revistas para as quais serão enviados para publicação. O primeiro capítulo aborda o aspecto de diversidade do projeto, trazendo informações sobre a ocorrência de cogumelos comestíveis silvestres no Brasil. O segundo capítulo trata dos estudos de domesticação das espécies *Auricularia fuscosuccinea* e *Laetiporus gilbertsonii*. O terceiro capítulo aborda o primeiro cultivo de *Auricularia cornea* com um isolado silvestre do Brasil, e o quarto e último capítulo relata o primeiro registro de cultivo da espécie *Irpex rosettiformis*. Após os capítulos são apresentadas algumas considerações pessoais sobre o desenvolvimento do projeto com intuito de compartilhar algumas dicas para quem deseja estudar o assunto.

Introdução

Os fungos compreendem um grupo monofilético de organismos que divergiu dos animais há aproximadamente 1 bilhão de anos (Taylor e Berbee 2006). Estudos sobre a diversidade do reino Fungi apresentaram avanços substanciais a partir do uso das técnicas moleculares, principalmente a partir da amplificação de regiões do DNA por meio de reações em cadeia da polimerase (Peay *et al.* 2016). Em relação ao número de espécies do reino, as estimativas são variáveis. Em um trabalho recente, Hawksworth e Lücking (2017) estimaram a existências de 2,2 a 3,8 milhões de espécies de fungos, sendo que apenas 148 mil espécies são conhecidas atualmente (Antonelli *et al*. 2020). Essa discrepância nos números de espécies estimadas e conhecidas se deve a alguns fatores como: a existência de *habitats* e áreas geográficas pouco estudadas, particularmente nas regiões tropicais e em *hotspots* da biodiversidade; a existência de espécies crípticas; e a dificuldade no estudo de espécies que não apresentam estruturas macroscópicas (Hawksworth e Lücking 2017).

Algumas espécies, principalmente dos filos Basidiomycota e Ascomycota, desenvolvem estruturas reprodutivas macroscópicas, popularmente conhecidas como cogumelos. Mueller *et al*. (2007) estimaram a existência de 53 a 110 mil espécies de cogumelos, mas a grande maioria permanece desconhecida. Dentre as 27 mil espécies de cogumelos conhecidas (Mueller *et al*. 2007; Li *et al*. 2021), cerca de 2.000 são comestíveis (Li *et al*. 2021). Apesar da grande diversidade de cogumelos comestíveis, apenas cinco gêneros constituem cerca de 85 % da produção mundial de cogumelos (Royse *et al*. 2017). Em primeiro lugar, responsável por 22 % da produção mundial, está o gênero *Lentinula* Earle, representado pelo cogumelo shiitake, *Lentinula edodes* (Berk.) Pegler. O gênero *Pleurotus* (Fr.) P. Kumm. está na segunda posição,

representando 19 % da produção mundial, seguido por *Auricularia* Bull., em terceiro lugar, com cerca de 17 % da produção mundial. Em quarto e quinto lugares estão os gêneros *Agaricus* L. e *Flammulina* P. Karst., contribuindo com 15 % e 11 % da produção mundial, respectivamente (Royse *et al*. 2017).

A produção de cogumelos em escala mundial tem apresentado crescimento desde o início dos anos 2000, passando de 1 bilhão kg de cogumelos produzidos em 1978 para 27 bilhões kg em 2012, e 34 bilhões kg em 2013 (Royse *et al*. 2017). Da mesma forma, o consumo mundial médio de cogumelos também cresceu de forma expressiva, sendo que a estimativa de consumo em 1997 era de 1 kg pessoa/ano, e aumentou para 4 kg pessoa/ano em 2012 (Royse 2017). Seguindo a tendência mundial, a fungicultura é uma atividade em expansão no Brasil (Gomes *et al.* 2016). Segundo a Associação Nacional dos Produtores de Cogumelos (ANPC 2022), os principais produtores do Brasil estão localizados nos estados de São Paulo (nas cidades de Mogi das Cruzes, Pinhalzinho, Ibiúna, Sorocaba, Salto, Cabreúva, Juquitiba e Valinhos) e Paraná (nas cidades de Castro, Tijucas do Sul e Curitiba), mas o cultivo também está presente em Minas Gerais, Rio de Janeiro, sul da Bahia, Pernambuco e Rio Grande do Sul. Porém, a ausência de estimativas sobre o cultivo de cogumelos no Brasil dificulta a quantificação do número exato de produtores em atividade em outros estados e no país como um todo (ANPC 2022).

O cultivo de cogumelos no Brasil iniciou a partir do conhecimento de imigrantes Asiáticos, principalmente vindos do Japão e da China e instalados no estado de São Paulo, que trouxeram essa prática de cultivo de seus ancestrais (Dias 2010). Dessa forma, São Paulo tornou-se um centro de referência no cultivo de cogumelos, trazendo grande importância para a economia do estado (Dias 2010). Atualmente, São Paulo é o estado que mais produz e consome cogumelos (Gomes *et al.* 2016). Gomes *et al*. (2016) realizaram um censo entre janeiro e fevereiro de 2016 e registraram mais de 500 produtores de cogumelos localizados em 93 municípios do estado de São Paulo, a maioria nas proximidades da capital. Desses produtores, aproximadamente 52 % produzem *Agaricus bisporus* (J.E. Lange) Imbach, 24 % produzem espécies do gênero *Pleurotus*, 16 % cultivam *Lentinula edodes*, 2 % produzem o cogumelo do sol, *Agaricus subrufescens* Peck (também conhecido como *Agaricus blazei* Murrill), e 4 % produzem outras espécies, como *Ganoderma lucidum* (Cutis) P. Karst., *Pholiota nameko* (T. Itô) S. Ito & S. Imai e *Flammulina velutipes* (Cutis) Singer.

As cepas dos cogumelos mais comumente cultivados representam, em sua maioria, espécies provenientes de áreas de clima temperado (Stamets 2000). Apesar da existência de muitos estudos de taxonomia e filogenia dos cogumelos de ocorrência em regiões tropicais e subtropicais, existem poucos estudos sobre a domesticação dessas espécies e possível

introdução de isolados nativos no mercado de cogumelos comestíveis (Thawthong *et al*. 2014). Para o Brasil, poucos trabalhos registraram o cultivo de espécies isoladas a partir de cogumelos de ocorrência natural, como o estudo de Ruegger *et al*. (2001), com o cultivo de *Oudemansiella "canarii"* (Jungh.) Höhn. em bagaço de cana de açúcar e serragem de eucalipto; e o de Maki e Paccola-Meirelles (2002), com o cultivo de *Macrolepiota bonaerensis* (Speg.) Singer em substrato composto de húmus e solo.

No Brasil, várias espécies silvestres são consumidas por grupos étnicos e já foram citadas em estudos etnomicológicos, principalmente para a Floresta Amazônica (Prance 1973; Fidalgo e Prance 1976; Fidalgo e Hirata 1979; Vargas-Isla *et al*. 2013; Sanuma *et al*. 2016). Sanuma *et al.* (2016) registraram o consumo de 15 espécies de cogumelos por indígenas Sanöma, parte do povo Yanomami, que vivem no extremo norte de Roraima, próximo à fronteira com a Venezuela. Os indígenas consomem os cogumelos que encontram na floresta e que também crescem nas roças de mandioca (Sanuma *et al*. 2016). Na maioria das vezes são as mulheres mais velhas que coletam os cogumelos e os preparam cozidos em água ou embrulhados em folhas e assados na brasa (Sanuma *et al*. 2016). Essas espécies, assim como outras de ocorrência natural nas matas brasileiras, podem ser bastante promissoras para estudos de cultivo e futura inserção no mercado nacional e internacional de cogumelos comestíveis. Para o cultivo comercial de cogumelos, algumas características são importantes de serem avaliadas, como: velocidade de crescimento do micélio e capacidade de adaptação no substrato; potencial nutritivo; textura e palatabilidade dos basidiomas (Lajolo 1970).

Lechner e Albertó (2011) avaliaram o crescimento e a eficiência biológica de basidiomas produzidos a partir do cultivo de 14 cepas de *Pleurotus*, de ocorrência natural, isoladas de coletas na Argentina. Nesse estudo, uma cepa de *Pleurotus albidus* cultivada em palha de trigo obteve a maior eficiência biológica, superando até mesmo uma cepa comercial de *Pleurotus ostreatus*. Para melhorar a produtividade é importante não apenas avaliar quais os melhores substratos para o cultivo, mas também conhecer e utilizar as cepas de ocorrência natural, tanto para preservação da diversidade genética das espécies, quanto para aumentar a possibilidade de produção comercial em seu local de origem (Lechner e Albertó 2011).

Vários resíduos orgânicos são gerados e descartados durante o processamento agrícola e agroindustrial, e quando corretamente utilizados podem fornecer nutrientes para a produção de alimentos e outros insumos de relevância industrial (Chang e Miles 2004). Para o cultivo de cogumelos, diversos resíduos e insumos podem ser utilizados como substrato: bagaço de bocaiuva (Cardoso *et al*. 2013), bagaço de cana de açúcar (Cardoso *et al*. 2013), capim elefante (Bernardi *et al*. 2009), palha de arroz (Bonatti *et al*. 2004), palha de milho (Dias *et al*. 2003), resíduos de bananeira (Carvalho *et al*. 2012), resíduos de coco (Marino e Abreu 2009), resíduos

madeireiros (Sales-Campos *et al*. 2010), entre outros. Esses resíduos representam uma fonte abundante e renovável de substratos, podendo ser utilizados para o cultivo de cogumelos como alternativa de reaproveitamento (Sales-Campos *et al.* 2010).

Em pequenas propriedades, o cultivo de cogumelos é uma alternativa de renda para os produtores, pois o cultivo de algumas espécies é relativamente fácil e não necessita de grande quantidade de mão de obra e tampouco de uma grande área para produção (Stamets 2000); além de proporcionar uma diversificação na produção agrícola e demandar baixo custo de investimento (Easin *et al.* 2017). Dessa forma, a produção de cogumelos enquadra-se muito bem na proposta de uma agricultura ecológica, pois, além de não utilizar produtos químicos para o cultivo, representa uma alternativa eficiente para o aproveitamento dos resíduos agrícolas (Easin *et al.* 2017), resultando na produção de um alimento rico em nutrientes e que também é considerado um produto da agricultura de base ecológica (Abreu *et al.* 2009). Além disso, o substrato utilizado para o cultivo de cogumelos, ao final do processo, pode ser utilizado como adubo orgânico, na biorremediação de solos contaminados, como composto para produção de outros cogumelos, e até mesmo para alimentação animal (Sales-Campos *et al.* 2010; Oliveira *et al.* 2015).

O mercado brasileiro de produtos alimentares tem apresentado grandes mudanças, com expressivo crescimento das vendas de produtos ecológicos e certificados, principalmente nas capitais e nas regiões Sul e Sudeste (Abreu *et al.* 2009). Além disso, a preocupação com a saúde humana tem aumentado a busca dos consumidores por alimentos mais saudáveis e ecológicos (Aida *et al.* 2009). Aos poucos, os cogumelos nativos também têm ganhado espaço no mercado brasileiro, e alguns *chefs* têm se dedicado à inclusão de cogumelos nativos nos pratos de seus restaurantes, como Felipe Schaedler, do Banzeiro, em Manaus; Rafael Morente, do Pindorama, em Paraty; Alex Atala, do D.O.M., em São Paulo; e Manu Buffara, do Manu Buffara, em Curitiba. Porém, ainda não existe volume de produção para inclusão destes cogumelos nativos nos menus (Orenstein 2014).

Sob o ponto de vista nutricional, tanto os cogumelos silvestres quanto os cultivados possuem proteína de alta qualidade, contendo todos os aminoácidos essenciais, que são aqueles que precisam ser obtidos, por nós, humanos, por meio da alimentação (Chang e Miles 2004; Barros 2008; Vetter 2019). Os cogumelos também são ricos em carboidratos, fibras e minerais, principalmente potássio e fósforo (Chang e Miles 2004; Kalac 2012; Vetter 2019). Além disso, o conteúdo de lipídios é baixo e composto sobretudo por ácidos graxos insaturados (pelo menos 70 %), especialmente pelo ácido linoleico, um fator significativo para considerar os cogumelos como um alimento saudável (Chang e Miles 2004; Kavishree *et al*. 2008).

Sob o ponto de vista medicinal, os cogumelos também contêm uma variedade de compostos bioativos como polissacarídeos, proteoglicanos, terpenoides, compostos fenólicos, esteroides, entre outros (Elsayed *et al*. 2014; Sokovic *et al*. 2016), com comprovadas atividades anti-inflamatória, antimicrobiana, antioxidante, antitumoral, antidiabética, imunomoduladora, dentre outras (Chihara *et al*. 1970; Mau *et al*. 2001; Elmastas *et al*. 2007; Aida *et al*. 2009; Kim *et al*. 2010; Lee *et al*. 2013; Elsayed *et al*. 2014; Sokovic *et al*. 2016; Chaturvedi *et al*. 2018). Assim, os cogumelos podem ser referidos como alimentos nutracêuticos devido ao seu valor nutricional e pelos benefícios que proporcionam à saúde (Barros *et al*. 2008; Vetter 2019).

Dessa forma, a pesquisa sobre o potencial de cultivo de cogumelos silvestres e a obtenção de novos isolados torna-se importante e necessária, como forma de adaptação da tecnologia de produção dos cogumelos comerciais às condições, substratos e espécies locais, além de ampliar o conhecimento sobre as espécies de ocorrência natural, e da possibilidade de inserção de linhagens com maior produtividade no mercado. Para isso, é necessário um trabalho que começa desde a coleta de cogumelos nativos, passando por uma correta identificação taxonômica e seguindo para diferentes testes de parâmetros para produção, tais como: temperatura e substrato ideal de crescimento micelial, produção do inoculante e obtenção de substrato adequado para o cultivo, além de análises bromatológicas para determinar a composição nutricional dos cogumelos produzidos.

No contexto previamente exposto, surge a questão norteadora deste trabalho: quais são os cogumelos comestíveis silvestres que ocorrem na Mata Atlântica e são viáveis para serem cultivados? Para responder a essa questão, parte-se da hipótese de que: os isolados de cogumelos comestíveis silvestres possuem capacidade de adaptação aos substratos comumente utilizados para o cultivo de cogumelos comerciais e podem ser promissores para futura inserção no mercado nacional de cogumelos comestíveis, apresentando boa produtividade e eficiência biológica.

Capítulo I

Over 400 food resources from Brazil: evidence-based records of wild edible mushrooms

Over 400 food resources from Brazil: evidence-based records of wild edible mushrooms

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ABSTRACT: Many species of mushroom-forming fungi have been harvested in the wild and used for food and medicine for thousands of years. In Brazil, the knowledge of the diversity of wild edible mushrooms remains scattered and poorly studied. Based on new samples, bibliographic records revision, and searches through the GenBank, we recorded 408 species of wild edible mushrooms in Brazil, of which 349 can be safely consumed and 59 need some process to be consumed safely. Additionally, other 149 species represent taxa with unclear evidence of consumption or unconfirmed edibility status. A total of 83 of the 408 edible species represents consistent records in Brazil based on molecular data and/or Brazilian nomenclatural types. Other 325 records represent species that need further taxonomic investigations to confirm their identity and occurrence in the country, with 41 of them being usually consumed by the Brazilian population. The remaining 284 species can represent new food resources for the country. We generated 156 DNA sequences, representing 39 species within 28 genera. Edible mushrooms are an important non-wood forest product and the knowledge about them adds value to the local biodiversity and the population, increasing the incentive to conservation allied to sustainable rural development.

KEYWORDS: biodiversity, Brazilian edible mushrooms, phylogeny, species list, wild edible fungi, funga.

1. Introduction

Wild edible mushrooms (WEM)[1] have been harvested and used by people for food and medicine in more than 90 countries for thousands of years (Li et al., 2021). The oldest evidence of fungi consumption by humans is based on food debris from dental calculus samples from Neanderthals, that became extinct around 40,000 years ago (Higham et al., 2014; Weyrich et al., 2017), and Magdalenian individuals that lived around 18,700 years ago in El Mirón Cave, Spain (Morales & Straus, 2015; Power et al., 2015).

Taking into account the diversity of fungi between 2.2 to 3.8 million species (Hawksworth & Lücking, 2017) and the proportion of 18.75 % mushroom-forming fungi (Hawksworth, 2001), the estimated number of macrofungi species is between 412,500 and 712,500 species. Despite the magnitude of the numbers, the real diversity is poorly known. Currently, about 148,000 species of fungi are recognized (Antonelli et al., 2020) of which 27,750 are mushrooms if we consider the proportion estimated by Hawksworth (2001).

Traditional knowledge remains an important source of recognition of the edibility of wild fungi (Boa, 2004). Recently, Li et al. (2021) published a review of the world's edible mushroom species and proposed a system for categorizing species in a final edible status. The authors recorded 2,189 edible species, of which 2,006 can be safely consumed and 183 require some preparation or have been associated with allergic reactions.

Edible mushrooms are generally low in fat and energy and rich in carbohydrates, fibers, high-quality proteins (usually having a complete array of essential amino acids), vitamins, and minerals (Cheung, 2010; Wani et al., 2010; Kakon et al., 2012; Tang et al., 2016). They also contain bioactive molecules, such as polysaccharides with antioxidant, antitumoral, antidiabetic, antifungal, antiviral, and immunomodulatory activities (Cheung, 2010; Wani et al., 2010; Kakon et al., 2012; Tang et al., 2016; Castro-Alves et al., 2017). Additionally, wild edible mushrooms are a healthy natural resource and may be higher in protein and lower in fat than commercial species (Barros et al., 2008).

The use of wild mushrooms by contemporary human populations varies according to different geographic regions, from the long and notable traditional use in China (Wu et al., 2019) and Mexico (López-García et al., 2020; Pérez-Moreno et al., 2020) to more restricted consumption by the indigenous people in South America (Pérez-Moreno et al., 2021a). In Brazil, Fidalgo (1965) was the pioneer in ethnomycological studies, recording that Brazilian

[1] Although macrofungi of different forms have distinctive popular names (mushrooms, brackets, puffballs, truffles, false-truffles, cup fungi etc), we will refer to wild edible macrofungi as wild edible mushrooms (WEM) throughout the text.

indigenous people from the Amazon region recognize fungi and differentiate them from plants and animals, and sometimes designating them as food or medicine.

Sir Ghillean T. Prance, a British botanist, also left a huge contribution to ethnomycological study in Brazil (Prance, 1972, 1973; Fidalgo & Prance, 1976; Prance, 1984, 1986). Prance (1972) conducted an ethnobotanical comparison between four indigenous Amazonian communities during a general plant collecting expedition in 1971, in which the use of four edible fungi was recorded. In Prance's study, the Waikás (Yanomami ethnic group) were the only community observed using fungi as part of their diet, but he has heard that the Sanöma group (also Yanomami) recognized and ate many mushrooms. Oswaldo Fidalgo and G.T. Prance returned to the Sanöma village in 1974 and recorded 21 species of edible macrofungi consumed by this Yanomami group, most of them collected from cassava plantations (Fidalgo & Prance, 1976). The authors reported that due to lack of fishing and hunting, the Sanöma used caterpillars, larvae, and fungi to provide protein in their diet (Fidalgo & Prance, 1976).

Another important ethnomycological study from Brazil was carried out with the Caiabi, Txicão, and Txucarramãe groups in the Xingu Indigenous Park, in the state of Mato Grosso, in the southern part of the Brazilian Amazon Forest (Fidalgo & Hirata, 1979). In this study, 26 indigenous mycological terms have been mentioned and discussed. For the Caiabi group, most of the red or brown mushroom species are considered inedible, whilst some white or black mushroom species are considered edible (Fidalgo & Hirata, 1979). Among the fungi collected during the expedition, the Caiabi mentioned a single species for medicinal use, *Pycnoporus sanguineus* (L.) Murrill, but no mushrooms consumed by the Caiabi group were collected in the expedition. The Txicão group reported the consumption of some mushrooms, two of them collected during the expedition: *Lentinus crinitus* (L.) Fr. and *Auricularia fuscosuccinea* (Mont.) Henn. (Fidalgo & Hirata, 1979). For the Txucarramãe group, fungi are used only as a last resource, in the absence of other food (Fidalgo & Hirata, 1979).

More recently, in the 21st century, some other works have been published reviewing previous studies and updating and systematizing the information on edible species based on ethnomycological records (Góes-Neto & Bandeira, 2003; Cardoso et al., 2010; Vargas-Isla et al., 2013). According to Vargas-Isla et al. (2013), the genera *Auricularia*, *Favolus*, *Lentinula*, *Lentinus*, *Panus*, and *Pleurotus* are the most reported as edible by the indigenous and traditional groups of the Amazon region. In 2016, Sanuma et al. (2016) published a book as result of a joint effort of researchers, including non-indigenous and the Sanöma group, the Yanomami people who inhabit the Brazilian Amazon Forest. The book presented 15 species of WEM used

by this ethnic group, all harvested from wood because the Sanöma group does not consume species that grow on the soil (Sanuma et al., 2016).

For other regions and ethnic groups from Brazil, little is known about the consumption habits of wild mushrooms. Meijer (2001) reported the use of *Agaricus arvensis* Schaeff. and *Auricularia fuscosuccinea* by European and Japanese immigrants in the state of Paraná, Southern Brazil. Recently, two species were recorded as edible for the first time based on ethnomycological records from Southeastern Brazil. Trierveiler-Pereira (2019) reported the consumption of *Neofavolus subpurpurascens* (Murrill) Palacio & Robledo, and Prado-Elias et al. (2022) recorded the edibility of *Phlebopus beniensis* (Singer & Digilio) Heinem. & Rammeloo by rural communities in the state of São Paulo. Ishikawa et al. (2017) carried out a bibliographic survey and reported the occurrence of about 90 edible mushroom species in the state of São Paulo, but the authors only mentioned the name of 12 wild species with potential to test cultivation conditions.

Despite these aforementioned works and considering the enormous biodiversity in Brazil, the knowledge about the diversity of wild edible fungi remains scattered and poorly documented and used for food. Thus, based on bibliographical records, new sampling, and molecular identification with DNA sequences of specimens from Brazil, we aim to summarize the current knowledge about the diversity of wild edible mushrooms in the country and to categorize the gathered data to certify the occurrence and consumption of each species recorded.

2. Materials and Methods

2.1 Bibliographical research

From the global list of edible and poisonous species published by Li et al. (2021), we carried out searches in the literature for the record of WEM species in Brazil. Searches for the current name and synonyms of the species were based on the 'Flora e Funga do Brasil' project (http://floradobrasil.jbrj.gov.br/) and on Brazilian checklists (Putzke, 1994; Meijer, 2001, 2006; Baltazar & Gibertoni, 2009; Trierveiler-Pereira & Baseia, 2009; Sá et al., 2013; Sulzbacher et al., 2013; Coimbra, 2014, 2015; Alvarenga & Xavier-Santos, 2015; Meiras-Ottoni et al., 2017) and macrofungal species guides (Pegler, 1997; Meijer, 2008; Neves et al., 2013; Sanuma et al., 2016; Putzke & Putzke, 2017, 2019; Santos, 2017; Timm, 2018, 2021; Trierveiler-Pereira, 2019, 2022). In addition, the Google Scholar (https://scholar.google.com/) search and authors' personal bibliographic database were also consulted. All the original literatures were checked, and the current species names and synonyms were based primarily on the Index Fungorum database (http://www.indexfungorum.org/), unless taxonomic and identification notes were added (see Supplementary Information Table 1). Species records identified as affinis (aff.) were

not included in the list because they do not represent the species whose edibility is known. The data recovered from the literature are compiled in the Supplementary Information Table 1.

2.2 Sampling

We carried out opportunistic collections of WEM in three different Brazilian biomes and domains from eight Brazilian states: the Atlantic Forest domain, in the states of Espírito Santo, Paraná, Rio de Janeiro, Rio Grande do Sul, and São Paulo; the Pantanal, in the state of Mato Grosso do Sul; and in the Cerrado, in the state of Maranhão and Tocantins (Figure 1). Strain isolation was performed in the field whenever possible. For this, fragments of the mushroom context were inoculated into Petri dishes containing Potato Dextrose Agar (PDA) medium and were incubated at 25 °C until complete mycelial growth. The dried vouchers of the collected specimens are deposited at the Herbarium SP (Maria Eneyda P.K. Fidalgo), and the mycelial cultures at the 'Coleção de Culturas de Algas, Fungos e Cianobactérias', both at the 'Instituto de Pesquisas Ambientais' (São Paulo, SP, Brazil). Duplicates of the dried specimens are at the Fungarium IFungi (FIFUNGI) from the IFungiLab at the 'Instituto Federal de Educação, Ciência e Tecnologia de São Paulo' (São Paulo, SP, Brazil). This study is according to the Brazilian legislation on access to genetic biodiversity heritage and is registered in the 'Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado' (SisGen #A1886D5).

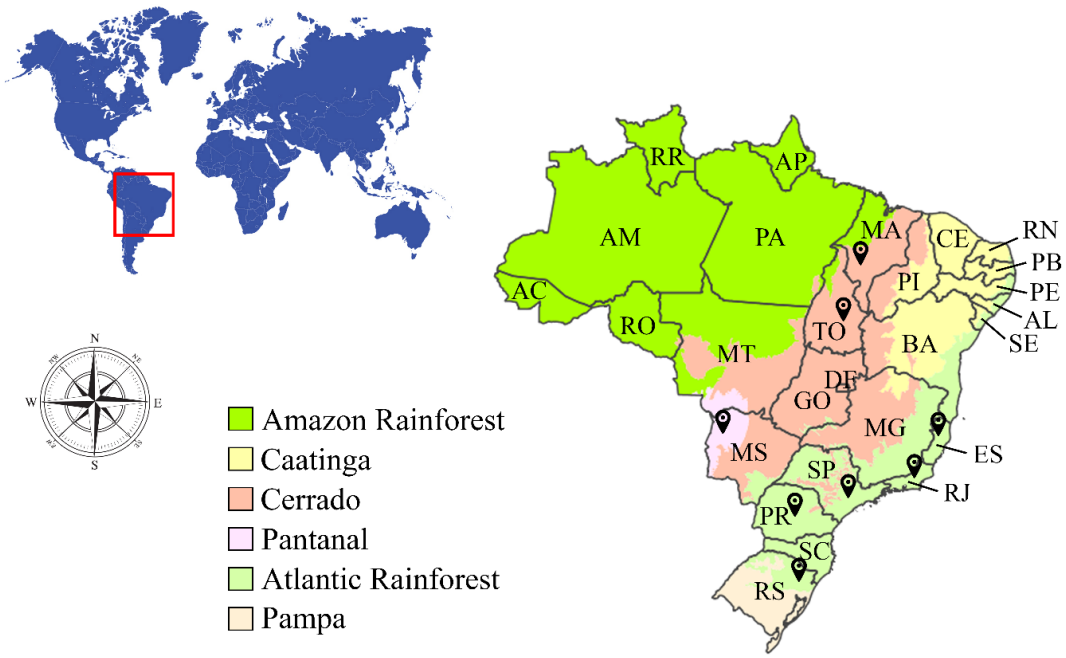

FIGURE 1 Map of the Brazilian federative units and biomes. Colored areas are the Brazilian biomes (IBGE 2019) and the black points represent the sampling sites.

2.2.1 Molecular studies

Total DNA was extracted from cultures or from small pieces of dried specimens, following a modified CTAB extraction method (Doyle & Doyle, 1987). The nuc ITS1 – 5.8S – ITS2 (ITS) region was amplified and sequenced using the primer pair ITS1F and ITS4R (White et al., 1990). The PCR reactions were carried out in 25 µl volume reaction using the following cycling program: an initial denaturation step at 95 °C for 2 min, followed by 34 cycles of 45 sec denaturation at 94 °C, 70 sec annealing at 50 °C, and 2 min extension at 72 °C; the reaction ended with a final extension of 10 min at 72 °C and cooling to 4 °C. The PCR products were visualized in 1 % agarose gel electrophoresis. The amplified products were purified with QIAquick PCR Purification Kit and sequenced at MacroGen (South Korea) using the same primer pair. The generated sequences were manually reviewed and edited with Geneious v.8.1 (Kearse et al., 2012).

2.2.2 Available sequences

All newly DNA sequences generated in this work are deposited at the GenBank database. Additional searches were conducted in GenBank based on the metadata generated by Menolli & Sánchez-García (2020) to retrieve sequences from samples of edible mushrooms previously recorded in Brazil. All data from new and previously available sequences are compiled in the Supplementary Information Table 1.

2.2.3 Phylogenetic analyses

Phylogenetic analyses were carried out to confirm the identity of the sequences recovered from the WEM from Brazil. The matrices for the analyses were built mainly by genus taxonomic rank. We used the Basic Local Alignment Search Tool (BLAST) to find similarity between the sequences of Brazil's specimens with those available at GenBank. Alignment of each ITS sequence dataset was performed using MAFFT (v7.505) (Katoh et al., 2019) and manually optimized using AliView (v. 1.26) (Larsson, 2014). Subsequently, the CIPRES Science Gateway (v. 3.3) (Miller et al., 2010) was used to perform the Maximum Likelihood (ML) analyses by using the IQ-TREE (v. 2.1.2) (Nguyen et al., 2015). ML search using IQ-Tree automatically selected the best substitution model and thereafter performed a thorough bootstrap with 1,000 replicates. The resulting trees were visualized and configured using iTOL (Letunic & Bork, 2019). Bootstrap support values are placed at the top of the branches. Values less than 80 % bootstrap support are not shown.

2.3 Data organization

We used the edibility information for each recorded species based on the Word Edible Status (WES) proposed by Li et al. (2021) and detailed in Table 1. For each consulted reference, we recovered the documented data of the identification and consumption of each species from Brazil's mushrooms to categorize the Record of Occurrence in Brazil (ROB) and the Documentation of Consumption in Brazil (DCB), according to the system proposed in Table 1. All data are compiled in the Supplementary Information Table 1.

TABLE 1 Categories used to classify the wild edible mushroom species occurring in Brazil.

Category	Code	Description
World Edible Status (WES)	**E1**	Clear evidence that a species has been consumed without any adverse or harmful effects
	E2	Clear evidence that a species has been consumed after it has been cooked or prepared in such a way that it is safe and suitable for consumption. It also includes edible species that can cause allergic reactions or adverse responses when eaten with alcohol, for example.
	E3	Evidence of safe consumption is uncertain or incomplete
	U	Unconfirmed edibility
	P	Causes adverse and harmful reaction when consumed
Record of Occurrence in Brazil (ROB)	**D**	Occurrence confirmed based on molecular data (DNA sequence)
	T	Occurrence confirmed based on a nomenclatural type from Brazil
	M	Occurrence based on complete morphological description*
	S	Occurrence based on a short morphological description*
	L	Occurrence registered only in a list
Documentation of Consumption in Brazil (DCB)	**C**	Clear record or documentation of consumption in Brazil
	R	Reports as edible in Brazil but with no clear documentation of consumption
	N	No documentation of consumption in Brazil

*To categorize the morphological descriptions presented in the references as M or S, it was considered the expertise of the taxonomists (authors of this work) that have worked on the data curation of each group of fungi.

Based on the combination of the World Edible Status (WES), the Record of Occurrence in Brazil (ROB), and the Documentation of Consumption in Brazil (DCB), we propose a final status to the Brazilian Edible Mushrooms (BEM) to categorize the occurrence of these mushroom species in Brazil, according to Table 2.

TABLE 2 Categories used to determine the final status of the Brazilian Edible Mushrooms (BEM).

Code	Description*
BEM1	Edible species that clearly occurs and is consumed in Brazil or that represents a new food resource for the country (E1+D+C; E1+D+R; E1+D+N; E1+T+C; E1+T+R; E1+T+N)
BEM2	Edible species (after some previous preparing or cautions) that clearly occurs and is consumed in Brazil or that represents a new food resource for the country (E2+D+C; E2+D+R; E2+D+N; E2+T+C; E2+T+R; E2+T+N)
BEM3	Edible species consumed in Brazil but that requires further studies to confirm its identity and occurrence in the country (E1+M+C; E1+S+C; E1+L+C)
BEM4	Edible species (after some previous preparing or cautions) consumed in Brazil but that requires further studies to confirm its identity and occurrence in the country (E2+M+C; E2+S+C; E2+L+C)
BEM5	Edible species not clearly consumed in Brazil but that represents a new food resource for the country after further studies to confirm its identity and occurrence in Brazil (E1+M+R; E1+M+N; E1+S+R; E1+S+N; E1+L+R; E1+L+N)
BEM6	Edible species (after some previous preparing or cautions) not clearly consumed in Brazil but that represents a new food resource for the country after further studies to confirm its identity and occurrence in Brazil (E2+M+R; E2+M+N; E2+S+R; E2+S+N; E2+L+R; E2+L+N)
BEM7	Species that clearly occurs in Brazil but with unclear or missing evidence that has been consumed (E3+D+R; E3+D+N; E3+T+R; E3+T+N)
BEM8	Species with unclear or missing evidence to consumption and that requires further studies to confirm its identity and occurrence in Brazil (E3+M+R; E3+M+N; E3+R+S; E3+R+N; E3+L+R; E3+L+N)
BEM9	Species that clearly occurs in Brazil but with unconfirmed edibility, including few poisonous records (U+D+R; U+D+N; U+T+R; U+T+N)
BEM10	Species with unconfirmed edibility, including few poisonous records, and that requires further studies to confirm its identity and occurrence in Brazil (U+M+R; U+M+N; U+S+R; U+S+N; U+L+R; U+L+N)
P1	Poisonous species that clearly occurs in Brazil and causes adverse and harmful reactions when consumed (P+D+R; P+D+N; P+T+R; P+T+N)
P2	Poisonous species that causes adverse and harmful reactions when consumed but requires further studies to confirm its identity and occurrence in Brazil (P+S+R; P+S+N; P+L+R; P+L+N)

*The meaning of the codes combined in this description can be consulted in Table 1.

3. Results

3.1 Brazilian Edible Mushrooms

From the global list of 2,786 macrofungal species (Li et al., 2021) plus the 11 species considered here as edible, we gathered records of the occurrence of 557 species in Brazil distributed in 10 edible categories (BEM1 to BEM10) plus 15 poisonous species (Figure 2). The complete dataset contains more than 3,500 records of species occurrence from over 600 references (Supplementary Information Table 1).

For *Amanita dulciodora* C.C. Nascimento, Sá & Wartchow, *Auricularia brasiliana* Y.C. Dai & F. Wu, *Auricularia tremellosa* (Fr.) Pat., *Cookeina speciosa* (Fr.) Dennis, *Filoboletus gracilis* (Klotzsch ex Berk.) Singer, *Gyroporus austrobrasiliensis* A.C. Magnago & R.M. Silveira, *Lactarius hepaticus* Plowr., *Marasmiellus cubensis* (Berk. & M.A. Curtis) Singer, *Panus tephroleucus* (Mont.) T.W. May & A.E. Wood, *Pleurotus magnificus* Rick, and *Trechispora thelephora* (Lév.) Ryvarden, the edibility status was defined in this work based on the authors' experiences and previous bibliographic records (Milenge Kamalebo et al., 2018; Ruan-Soto et al., 2021; Albert & Milliken, 2009; Prado-Elias et al., 2022; Campi et al., 2023; Timm, 2021; Bononi, 1984).

Auricularia brasiliana and *Auricularia tremellosa* were considered edible because they are part of two complexes of species recognized as edible (Wu et al., 2021). *Gyroporus austrobrasiliensis* was recently described (Magnago et al., 2018) and considered edible based on the author's personal experience (A.C. Magnago, pers. comm.). *Amanita dulciodora* was recently described (Nascimento et al., 2018) and considered E3 because it is used as food by the community where the species was collected (C.C. Nascimento, pers. comm.) but the evidence of safe consumption is incomplete.

For five species, the WES was considered different from that proposed by Li et al. (2021): *Inonotus obliquus* (Fr.) Pilát was considered E1 instead of P because there was no record of the species as poisonous, instead it is considered medicinal (Saar, 1991; Perevedentseva, 2013; Zhang et al., 2015; Stojkovic et al., 2019); *Lactarius taedae* Silva-Filho, Sulzbacher & Wartchow and *Polyporus pes-simiae* Berk. was considered E3 instead of E1 for not having clear evidence of its use as food; *Stropharia coronilla* (Bull.) Quél. was considered U instead of E2 due to records of the species as toxic (Aroche et al., 1984; Chang & Mao, 1995) as well as edible (Villarreal & Perez-Moreno, 1989; Montoya-Esquivel et al., 2001); and *Chlorophyllum molybdites* (G. Mey.) Massee was considered P instead of E2 due to a poisoning case of a family in Brazil after the ingestion of this mushroom (Meijer et al., 2007).

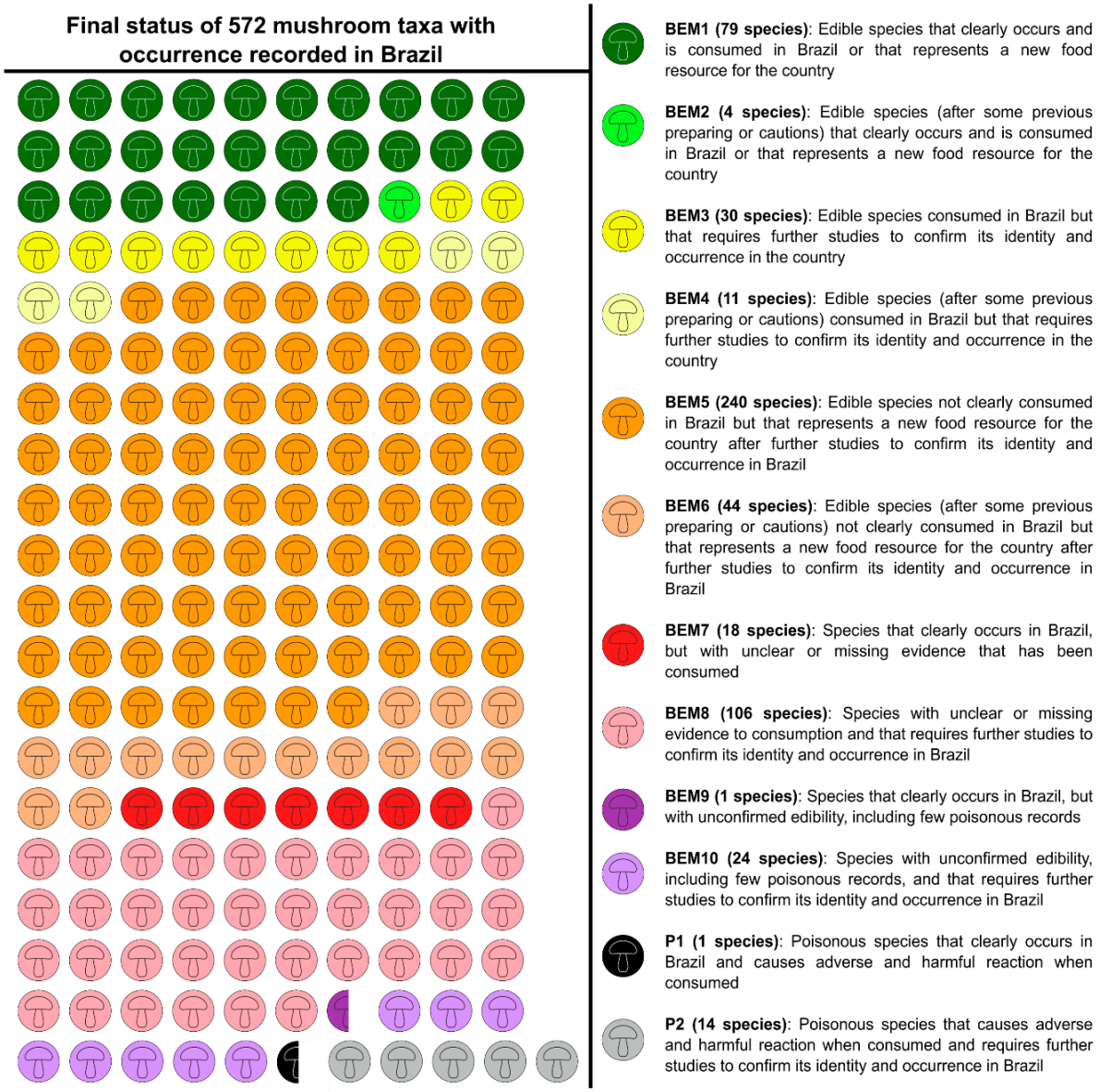

FIGURE 2 Final status of 572 macrofungi with occurrence recorded in Brazil.

There are records of 408 wild edible mushrooms in Brazil, of which 349 species can be consumed safely (BEM1, BEM3, BEM5), and 59 species that need some preparation to be safely consumed (BEM2, BEM4, BEM6). Among the 408 WEM recorded in the country, 83 species have a consistent record of occurrence in Brazil based on molecular data and/or Brazilian nomenclatural types (Table 3, Figure 4–7), being classified as BEM1 (79 species) and BEM2 (four species). Among the 83 species classified as BEM1 and BEM2, 51 species are clearly consumed in Brazil, 8 species have uncertain or incomplete evidence of consumption in Brazil, and 24 species are not consumed in the country and can be used as a new food resource. A total of 41 WEM species were classified as BEM3 (30 species) and BEM4 (11 species), which represent edible species consumed in Brazil but that requires further studies to confirm

its identity and occurrence in Brazil. Most of the species were classified within BEM5 (240 species) and BEM6 status (44 species), which comprises edible species not clearly consumed in Brazil and that their occurrences were recorded based only on morphological characters. Other 149 species represent taxa with unclear or missing evidence for consumption (BEM7 and BEM8) or unconfirmed edibility status (BEM9 and BEM10), of which 19 (BEM7+BEM9) clearly occur in Brazil and 130 (BEM8+BEM10) require further studies to confirm their identity and occurrence in Brazil.

Finally, 15 species represent poisonous taxa, including one species that clearly occurs in Brazil [*Meiorganum curtisii* (Berk.) Singer] and 14 species that require further studies to confirm their identity and occurrence in Brazil: *Bolbitius titubans* (Bull.) Fr., *Chlorophyllum molybdites*, *Clitocybe rivulosa* (Pers.) P. Kumm., *Conocybe apala* (Fr.) Arnolds, *Conocybe tenera* (Schaeff.) Fayod, *Deconica merdaria* (Fr.) Noordel., *Hebeloma sacchariolens* Quél., *Lepiota cristata* (Bolton) P. Kumm., *Leucoagaricus badhamii* (Berk. & Broome) Singer, *Leucocoprinus birnbaumii* (Corda) Singer, *Lysurus arachnoideus* (E. Fisch.) Trierv.-Per. & K. Hosaka, *Mutinus caninus* (Huds.) Fr., *Psathyrella corrugis* (Pers.) Konrad & Maubl., and *Tapinella panuoides* (Fr.) E.-J. Gilbert.

TABLE 3 Species of wild edible mushrooms from Brazil that clearly occur and are consumed in the country or that represent a new food resource for Brazil. BEM 1 represents the species that can be safely consumed, and BEM2 those that can be consumed after some previous preparation and with caution.

Taxon*	WES	ROB	DCB	BEM	Distribution in Brazilian states	Distribution in Brazilian biomes
Agaricus meijeri	E1	T(M)	C	BEM1	PR, RS	Atlantic Rainforest
Agaricus subrufescens	E1	D◊	C	BEM1	PR, RS, SP	Atlantic Rainforest
Amanita craseoderma	E1	T(M)	N	BEM1	AM, RO	Amazon Rainforest
Amauroderma omphalodes	E1	T(D)	N	BEM1	AL, AM, BA, MG, MS, MT, PA, PE, PR, RJ, RO, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Arachnion album	E1	D◊	N	BEM1	PE, PR, RS, SP	Atlantic Rainforest, Cerrado, Pampa, urban area
Armillaria puiggarii	E1	T(M)	N	BEM1	RS, SP	Atlantic Rainforest

Auricularia brasiliana	E1*	T(D)	N	BEM1	AL, BA, CE, MA, MT,PE, PI, RO	
Auricularia cornea	E1	D♦	C	BEM1	AC, CE, DF, GO, MA, PB, PE, PR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Auricularia fuscosuccinea	E1	D♦	C	BEM1	AC, AM, GO, MT, PA, PB, PE, PR, RJ, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Auricularia tremellosa	E1*	D♦	C*	BEM1	AC, AM, GO, MA	Amazon Rainforest, Cerrado
Boletinellus rompelii	E1	T(D◊)	C*	BEM1	DF, PR, RS, SP	Atlantic Rainforest, *Pinus* plantation, Cerrado
Boletus edulis	E1	D♦	C	BEM1	RS, SP	*Pinus* plantation
Bresadolia paradoxa	E1	D	C	BEM1	RS, RR, SP	Amazon Rainforest, Atlantic Rainforest
Cantharellus guyanensis	E1	D♦	C	BEM1	AM, PB, PE, PR, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Clavulinopsis laeticolor	E1	D♦	N	BEM1	RS, SC	Atlantic Rainforest
Cookeina colensoi	E1	D♦	C*	BEM1	BA, MT, PR, RS, SC, SP	Atlantic Rainforest, Cerrado
Cookeina tricholoma	E1	T(D♦)	C	BEM1	BA, AM, MA, PA, PR, RJ, SC, SP	Amazon Rainforest, Atlantic Rainforest
Cookeina venezuelae	E1	D♦	C*	BEM1	PR, SP	Atlantic Rainforest
Coprinellus radians	E1	D◊	N	BEM1	MG, RS	Atlantic Rainforest (endophyte of *Solanum cernuum*)
Coprinus comatus	E1	D◊♦	C	BEM1	PR, RS, SP	Atlantic Rainforest, Cerrado
Cotylidia aurantiaca	E1	T(M)	C*	BEM1	AM, PA, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest
Cymatoderma dendriticum	E1	D♦	N	BEM1	PB, PE, PR, SE, RS, SC, SP	Atlantic Rainforest
Dactylosporina steffenii	E1	T(M)	R	BEM1	PE, PR, RS, SP	Atlantic Rainforest
Favolus brasiliensis	E1	T(D♦)	C	BEM1	AM, BA, MG, MT, PA, PR, RJ, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Favolus radiatifibrillosus	E1	T(M)	C	BEM1	AC, AM, BA, PA, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Favolus rugulosus	E1	T(D♦)	C	BEM1	PR, RS, SP	Atlantic Rainforest
Favolus yanomamii	E1	T(D)	C	BEM1	AM, ES, MT, PA, RR	Amazon Rainforest, Atlantic Rainforest

Gyroporus austrobrasiliensis	E1*	T(D)	C*	BEM1	RS	Atlantic Rainforest
Irpex lacteus	E1	D◊	N	BEM1	AP, MS, PA, PE, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Irpex rosettiformis	E1	T(D♦)	C	BEM1	AC, BA, GO, MS, MT, PR, RO, RR, RS, SC, SP	Atlantic Rainforest, Amazon Rainforest, Cerrado
Laccaria lateritia	E1	D♦	C*	BEM1	SC, SP	*Eucalyptus dunnii* plantation
Lactarius hepaticus	E1*	D♦	C*	BEM1	SP	*Pinus* plantation
Lactarius quieticolor	E1	D	C	BEM1	RS	*Pinus* plantation
Laetiporus gilbertsonii	E1	D♦	C*	BEM1	ES, SP	Atlantic Rainforest
Lentinula boryana	E1	T(D)	C	BEM1	BA, PR, RS, SP	Atlantic Rainforest
Lentinula raphanica	E1	D♦	C	BEM1	AM, SP	Amazon Rainforest, Atlantic Rainforest
Lentinus berteroi	E1	D♦◊	C	BEM1	AM, CE, MG, PE, PR, RJ, RN, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Lentinus crinitus	E1	D♦	C	BEM1	AL, AP, AM, BA, DF, ES, MS, MT, PA, PB, PE, PR, RJ, RN, RO, RR, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado, Pantanal
Lentinus scleropus	E1	T(M)	C*	BEM1	AM, RS, SP	Amazon Rainforest, Atlantic Rainforest
Lentinus swartzii	E1	T(M)	N	BEM1	AM, BA, MG, MS, MT, PE, SP, RJ	Amazon Rainforest, Atlantic Rainforest, Caatinga, Pantanal
Lepista sordida	E1	D♦	C	BEM1	PR, RJ, RS, SP	Atlantic Rainforest
Macrocybe praegrandis	E1	T(M)	R	BEM1	PB, PE, MG, MT, SP, RS	Atlantic Rainforest
Macrocybe titans	E1	D♦	C	BEM1	PR, RN, SP	Atlantic Rainforest
Marasmius cladophyllus	E1	T(D)	N	BEM1	AM, PA, PE, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest
Marasmius haematocephalus	E1	T(M)	N	BEM1	AM, MA, MG, PA, PE, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Neofavolus subpurpurascens	E1	D	C	BEM1	RS, SP	Atlantic Rainforest
Ophiocordyceps melolonthae	E1	D◊	N	BEM1	PR, RS	Atlantic Rainforest
Oudemansiella cubensis	E1	D♦	C	BEM1	AM, MT, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga

Oudemansiella platensis	E1	D♦◊	C	BEM1	DF, ES, PR, RS, SP	Atlantic Rainforest, Cerrado
Panus ciliatus	E1	D	N	BEM1	DF, ES, PR, RS, SP	Atlantic Rainforest
Panus neostrigosus	E1	D	C	BEM1	AM, DF, MG, PR, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest
Panus strigellus	E1	D♦◊	C	BEM1	AM, DF, PR, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest
Panus velutinus	E1	T(D♦◊)	C	BEM1	AM, MG, MT, PA, PE, PR, RJ, RN, RO, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Phallus indusiatus	E1	D	C*	BEM1	AM, CE, ES, MA, MS, PA, PB, PR, RJ, RS, RN, RO, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Phillipsia domingensis	E1	D♦	R	BEM1	BA, PR, RJ, RS, SP	Atlantic Rainforest
Phlebopus beniensis	E1	D	C	BEM1	GO, PB, PR, RS, SP	Atlantic Rainforest, Cerrado
Pholiota bicolor	E1	T(M)	C	BEM1	PR, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Pleurotus albidus	E1	T(D♦)	C	BEM1	AM, MG, PR, RJ, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Pleurotus djamor	E1	D♦	C	BEM1	AM, AP, MS, MT, PA, PB, PE, PR, RJ, RO, RR, RS, SC, SP, TO	Amazon Rainforest, Atlantic Rainforest, Pantanal
Pleurotus fuscosquamulosus	E1	D	N	BEM1	SP	Atlantic Rainforest
Pleurotus magnificus	E1*	T(M)	C*	BEM1	RS	Atlantic Rainforest
Pleurotus pulmonarius	E1	D♦	C	BEM1	MS, PR, RS, SP	Atlantic Rainforest, Cerrado
Pleurotus rickii	E1	T(D)	C	BEM1	RS, SP	Atlantic Rainforest
Pluteus harrisii	E1	D	N	BEM1	MG, PR, SP	Atlantic Rainforest
Pluteus longistriatus	E1	D	N	BEM1	SP	Atlantic Rainforest
Podoscypha brasiliensis	E1	T(M)	N	BEM1	AC, PA, PR	Amazon Rainforest, Atlantic Rainforest
Podoscypha nitidula	E1	T(M)	N	BEM1	GO, PB, PR, PE, RN	Cerrado, Atlantic Rainforest
Polyporus indigenus	E1	T(M)	C	BEM1	AM, PA, RO	Amazon Rainforest
Polyporus sapurema	E1	T(M)	R	BEM1	AC, BA, ES, PR, RS, SP, SC	Amazon Rainforest, Atlantic Rainforest
Pseudofistulina radicata	E1	D♦	N	BEM1	RJ, SP	Atlantic Rainforest
Rigidoporus amazonicus	E1	T(M)	N	BEM1	AC, SC	Amazon Rainforest, Atlantic Rainforest

Ripartitella brasiliensis	E1	T(D♦)	R	BEM1	PE, PR, RS, SP	Atlantic Rainforest
Russula parazurea	E1	D♦	N	BEM1	SP	Exotic trees
Schizophyllum commune	E1	D◊	C*	BEM1	AL, AP, BA, DF, MG, MT, PA, PB, PE, PR, RO, RN, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Sclerotinia sclerotiorum	E1	D	N	BEM1	DF, GO, MG, PR	Cerrado, Caatinga, phytopatogen in *Crotalaria spectabilis*
Suillus salmonicolor	E1	D♦	R	BEM1	PR, RS, SC, SP	Atlantic Rainforest, *Pinus* plantation
Tremella fuciformis	E1	T(D♦)	C*	BEM1	AM, BA, DF, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Tuber floridanum	E1	D	C*	BEM1	RS	Pecan plantation
Volvariella bombycina	E1	D	R	BEM1	PR, RS, SP	Atlantic Rainforest
Calvatia cyathiformis	E2	D◊	R	BEM2	PA, PE, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado, Pampa
Coprinellus disseminatus	E2	D◊	C	BEM2	AM, DF, PA, PB, PR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Endophyte of *Hevea*
Lentinus concavus	E2	D♦	C	BEM2	AC, MS, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Pantanal
Trametes versicolor	E2	D◊	N	BEM2	BA, MS, PA, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado

Taxon*: the complete citation for each species with their authorities can be consulted in the Supplementary Information Table 1. WES: World Edible Status, ROB: Record of occurrence in Brazil, DCB: Documentation of consumption in Brazil, BEM: Brazilian edible mushroom. The complete description of the WES, ROB, DCB, and BEM categories can be consulted in Tables 1 and Figure 2. The complete name of Brazilian states and federative units can be consulted in Table 4. E*: edibility status defined in this work, C*: consumption in Brazil recorded in this work based on the authors' experience, D♦: identity confirmed based on DNA sequence generated in this work, D◊: identity confirmed based on unpublished DNA sequence recovered from GenBank, T(D): occurrence confirmed based on nomenclatural type from Brazil and DNA sequence, T(M): occurrence confirmed based on nomenclatural type from Brazil and complete morphological description.

The 408 wild edible mushroom species belong to 184 genera in 76 families (classification based on He et al., 2019 for Basidiomycota and Wijayawardene et al., 2018 for Ascomycota), and the vast majority of species belongs to the phylum Basidiomycota (388 species or 95,09 %). From these 408 species, the families with the highest number of genera (Figure 3) are Polyporaceae (17 genera and 44 species), Agaricaceae (11 genera and 41 species), Physalacriaceae (six genera and nine species), Lycoperdaceae (five genera and 14 species), Omphalotaceae (five genera and 16 species), and Strophariaceae (five genera and 12 species). *Agaricus* was the genus with the highest number of recorded edible species (21 species) followed by *Pleurotus* (14 species), *Lentinus* (13 species), *Laccaria* (10 species), *Auricularia* (nine species), and *Macrolepiota* (eight species). Considering only the 83 species classified as BEM1 and BEM2, the genera with the highest number of species that clearly occur in Brazil are: *Pleurotus* (six species), *Lentinus* (five species), *Favolus* (four species), *Auricularia* (four species), *Panus* (four species), and *Cookeina* (three species).

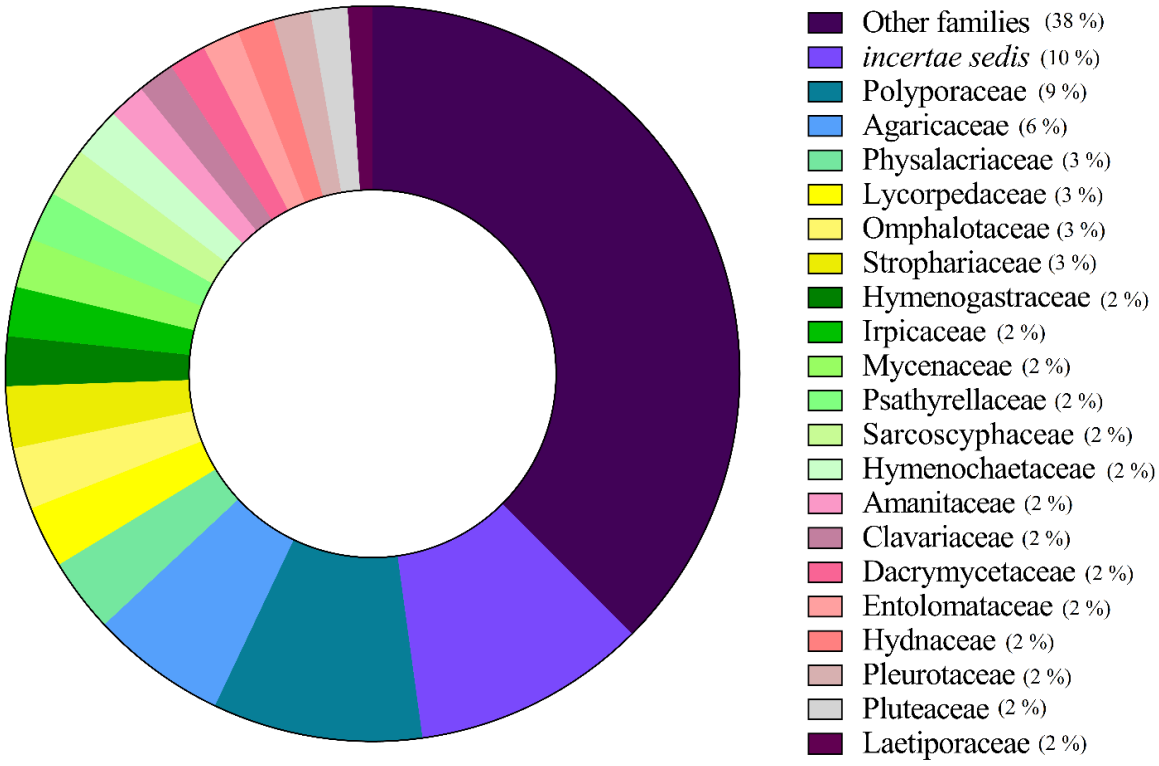

FIGURE 3 Relative proportion into families of the 408 wild edible mushroom species with record in Brazil.

FIGURE 4 Brazilian edible mushrooms classified as BEM1. A. *Arachnion album*, B. *Auricularia brasiliana*, C. *Auricularia cornea*, D. *Auricularia fuscosuccinea*, E. *Auricularia tremellosa*, F. *Boletinellus rompelii*, G. *Boletus edulis*, H. *Bresadolia paradoxa*, I. *Cantharellus guyanensis*, J. *Clavulinopsis laeticolor*, K. *Cookeina colensoi*, L. *Cookeina tricholoma*, M. *Cookeina venezuelae*, N. *Coprinellus radians*, O. *Coprinus comatus*, P. *Cymatoderma dendriticum*, Q. *Dactylosporina steffenii*, R. *Favolus brasiliensis*, S. *Favolus radiatifibrillosus*, T. *Favolus rugulosus*, Scale bars a–e, i–o, q–t = 1 cm, f–h, p = 3 cm. Photo courtesy of: (A,B,Q) Larissa Trierveiler-Pereira; (C,D,K,O,P,R) Mariana Drewinski; (E,M) Marina Corrêa-Santos; (F) Altielys Magnago; (G) Sthefany Viana; (H) Amanda Micalloni; (I) Cristiano C. Nascimento; (J) Ariadne Furtado; (L) Nelson Menolli Jr.; (N) Báraba L.B. Schünemann; (S) Tamile Rodrigues; (T) Denis Zabin.

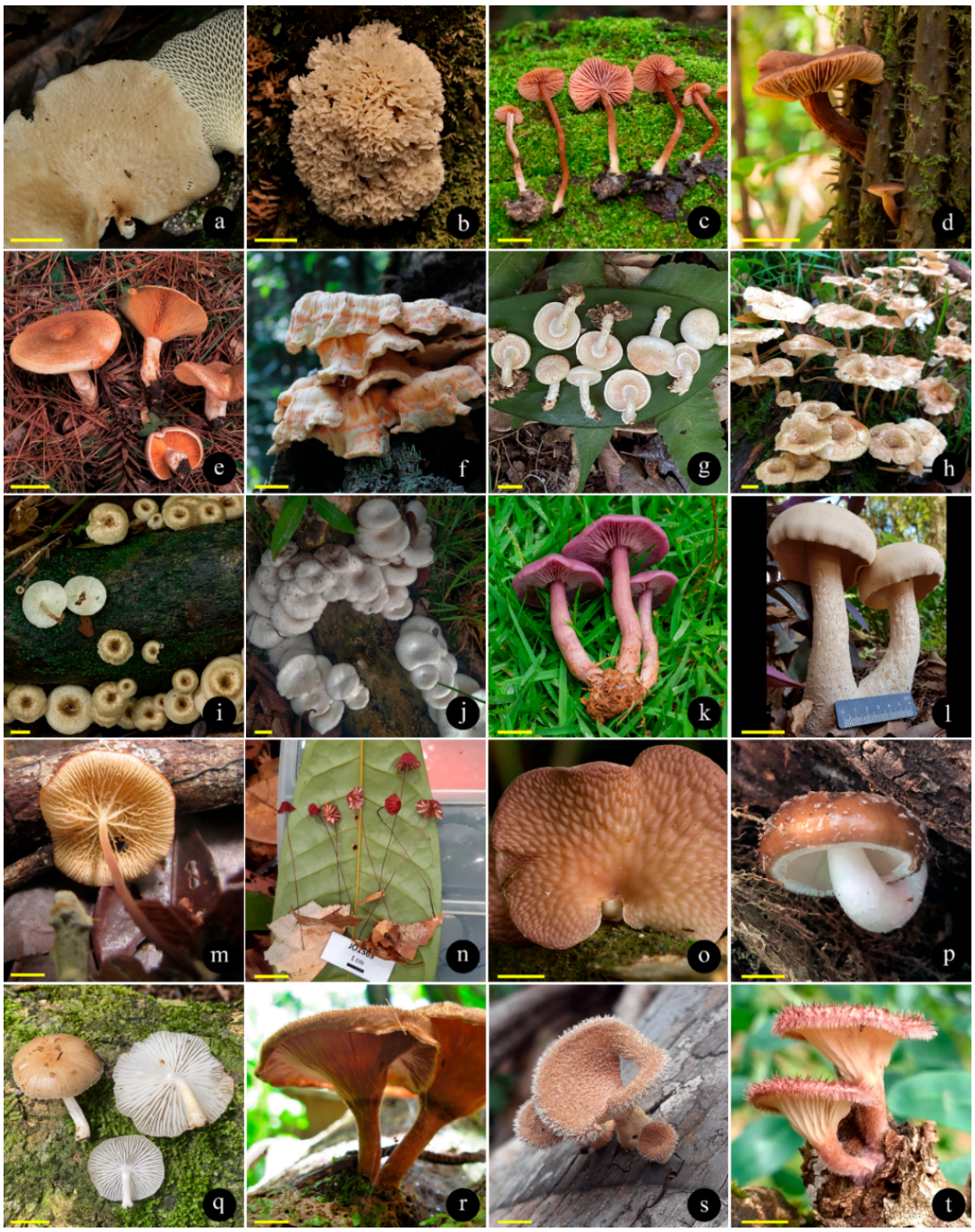

FIGURE 5 Brazilian edible mushrooms classified as BEM1. A. *Favolus yanomamii*. B. *Irpex rosettiformis*, C. *Laccaria lateritia*, D. *Lactarius hepaticus*, E. *Lactarius quieticolor*, F. *Laetiporus gilbertsonii*, G. *Lentinula raphanica*, H. *Lentinus berteroi*, I. *Lentinus crinitus*, J. *Lentinus scleropus*, K. *Lepista sordida*, L. *Macrocybe titans*, M. *Marasmius cladophyllus*, N. *Marasmius haematocephalus*, O. *Neofavolus subpurpurascens*, P. *Oudemansiella cubensis*, Q. *Oudemansiella platensis*, R. *Panus ciliatus*, S. *Panus neostrigosus*, T. *Panus strigellus*. Scale bars a, c, g–k, m–t = 1 cm, b, d–f, l = 3 cm. Photo courtesy of: (B,I,J) Marina Corrêa-Santos; (C,K,O,S) Denis Zabin; (D) Cristiano C. Nascimento; (E,H,P,Q,T) Mariana Drewinski; (A,F) Altielys Magnago; (G) Nelson Menolli Jr.; (L) Maria Alice Neves; (M,N) Jadson Oliveira; (R) Fernanda Karstedt; (S) Ruby Vargas-Isla.

FIGURE 6 Brazilian edible mushrooms classified as BEM1. A. *Panus velutinus*, B. *Phallus indusiatus*, C. *Phillipsia domingensis*, D. *Phlebopus beniensis*, E. *Pleurotus albidus*, F. *Pleurotus djamor*, G. *Pleurotus magnificus*, H. *Pleurotus pulmonarius*, I. *Pleurotus rickii*, J. *Pluteus harrisii*, K. *Pluteus longistriatus*, L. *Podoscypha brasiliensis*, M. *Podoscypha nitidula*, N. *Polyporus sapurema*, O. *Pseudofistulina radicata*, P. *Rigidoporus amazonicus*, Q. *Ripartitella brasiliensis*, R. *Russula parazurea*, S. *Schizophyllum commune*, T. *Suillus cothurnatus*. Scale bars c, e–t = 1 cm, a–b, d = 3 cm. Photo courtesy of: (A,C,F) Denis Zabin; (B) Larissa Trierveiler-Pereira; (D) Maria Alice Neves; (E,N,R,S) Nelson Menolli Jr.; (G,H,O,Q) Mariana Drewinski; (I,J) Fernanda Karstedt; (K) Marina Capelari; (L,M,P) Tatiana Gibertoni; (T) Altielys Magnago.

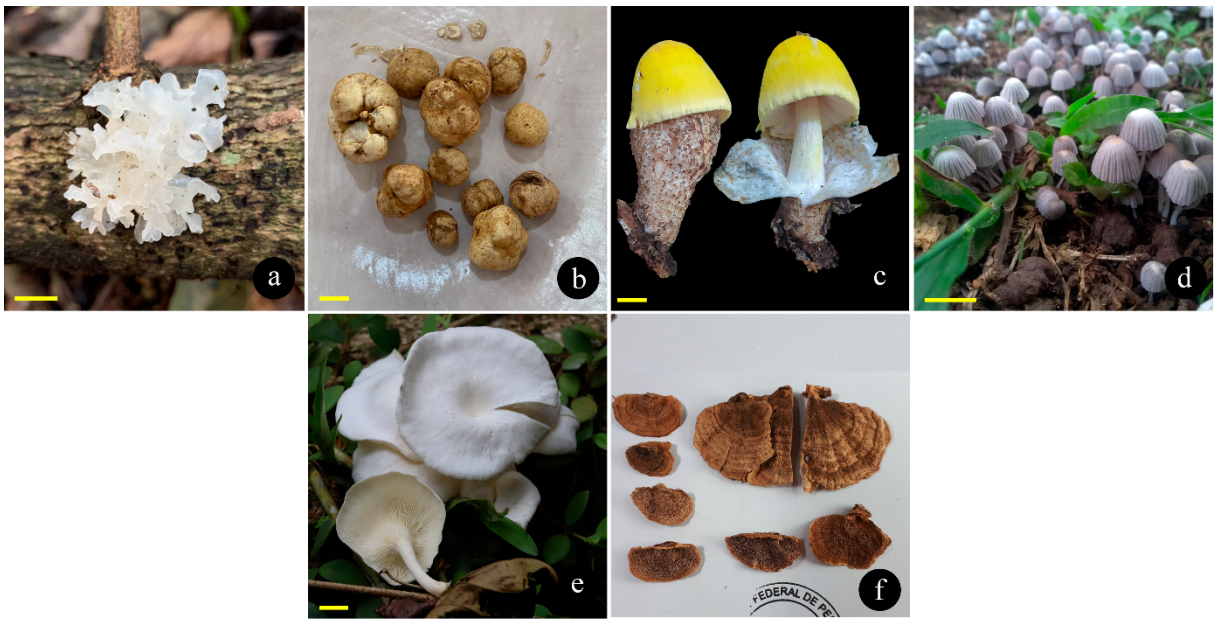

FIGURE 7 Brazilian edible mushrooms classified as BEM1 (A–C) and BEM2 (D–F). A. *Tremella fuciformis*, B. *Tuber floridanum*, C. *Volvariella bombycina*, D. *Coprinellus disseminatus*, E. *Lentinus concavus*, F. *Trametes versicolor*. Scale bar = 1 cm. Photo courtesy of: (A,B,D) Mariana Drewinski; (C) Cristiano C. Nascimento; (E) Marina Corrêa-Santos; (F) Tatiana Gibertoni.

The Brazilian states (Table 4) with the highest number of recorded WEM species are Rio Grande do Sul (260 species), São Paulo (199 species), and Paraná (168 species). The states with the lowest number of WEM species recorded are Sergipe (eight species), Piauí (five species) and Tocantins (one species). Considering only the 83 species classified as BEM1 and BEM2, the Brazilian states with the highest number of species that clearly occur there are: São Paulo (66 species), Rio Grande do Sul (59 species), and Paraná (52 species). The species with the highest number of records were *Pycnoporus sanguineus* (41 records in 16 states), *Lentinus tricholoma* (38 records in 17 states), and *Lentinus crinitus* (44 records in 20 states).

TABLE 4 Distribution of the 408 species of wild edible mushrooms recorded from Brazil.

Brazilian states	BEM 1	BEM 2	BEM 3	BEM 4	BEM 5	BEM 6	Total
AC (Acre)	8	1	3	-	2	-	**14**
AL (Alagoas)	4	-	4	-	5	-	**13**
AM (Amazonas)	26	1	13	-	23	1	**64**
AP (Amapá)	4	-	2	-	8	-	**14**
BA (Bahia)	14	1	6	-	11	1	**33**
CE (Ceará)	4	-	1	1	5	1	**12**
DF (Distrito Federal)	10	1	4	-	4	-	**19**

ES (Espírito Santo)	7	-	1	-	4	1	**13**
GO (Goiás)	7	-	1	-	5	-	**13**
MA (Maranhão)	6	-	2	-	5	-	**13**
MG (Minas Gerais)	13	-	2	-	9	-	**24**
MS (Mato Grosso do Sul)	8	2	1	-	11	3	**25**
MT (Mato Grosso)	14	-	3	-	14	-	**31**
PA (Pará)	17	3	9	-	20	-	**49**
PB (Paraíba)	11	1	5	-	14	1	**32**
PE (Pernambuco)	20	1	8	1	28	5	**63**
PI (Piauí)	1	-	-	1	2	1	**5**
PR (Paraná)	49	3	12	7	86	11	**168**
RJ (Rio de Janeiro)	19	1	5	-	19	2	**46**
RN (Rio Grande do Norte)	7	-	3	-	7	2	**19**
RO (Rondônia)	14	-	8	1	14	-	**37**
RR (Roraima)	13	1	5	1	4	-	**24**
RS (Rio Grande do Sul)	55	4	18	11	138	34	**260**
SC (Santa Catarina)	20	1	8	3	33	5	**70**
SE (Sergipe)	2	-	2	-	4	-	**8**
SP (São Paulo)	62	4	16	8	90	19	**199**
TO (Tocantins)	1	-	-	-	-	-	**1**

The description of the codes for the Brazilian Edible Mushroom (BEM) status can be consulted in Table 2 and Figure 2.

Regarding the distribution of species in Brazilian biomes (Figure 8), most of the 408 WEM species are recorded for the Atlantic Rainforest (316 species) and the Amazon Rainforest (108 species), with 36 species recorded for both biomes. For the Cerrado biome, 71 WEM species were recorded, of which 19 are also recorded for the Atlantic Rainforest and 18 are also found in the Atlantic and Amazon Rainforests. For the Caatinga, 36 edible species were recorded, of which ten species were also recorded for the Atlantic and Amazon Rainforests, whilst nine of them also occur in Cerrado and the Atlantic and Amazon Rainforest biomes. The Pantanal and Pampa biomes registered the lowest number of edible species, 11 and 17, respectively. Other 32 species were recorded in exotic forests (mainly *Pinus* spp. and *Eucalyptus* spp. plantations). These species belong to the genera *Amanita*, *Boletus*, *Chalciporus*, *Clavulina*, *Laccaria*, *Lactarius*, *Pisolithus*, *Ramaria*, *Rhizopogon*, *Russula*, *Suillus*, and *Tuber*, and they form ectomycorrhizal associations (Rinaldi et al., 2008) with non-native species and were introduced with the symbiotic tree. Considering only the 83 species classified as BEM1 and BEM2, 72 species were recorded for the Atlantic Rainforest and 39 species for the Amazon Rainforest.

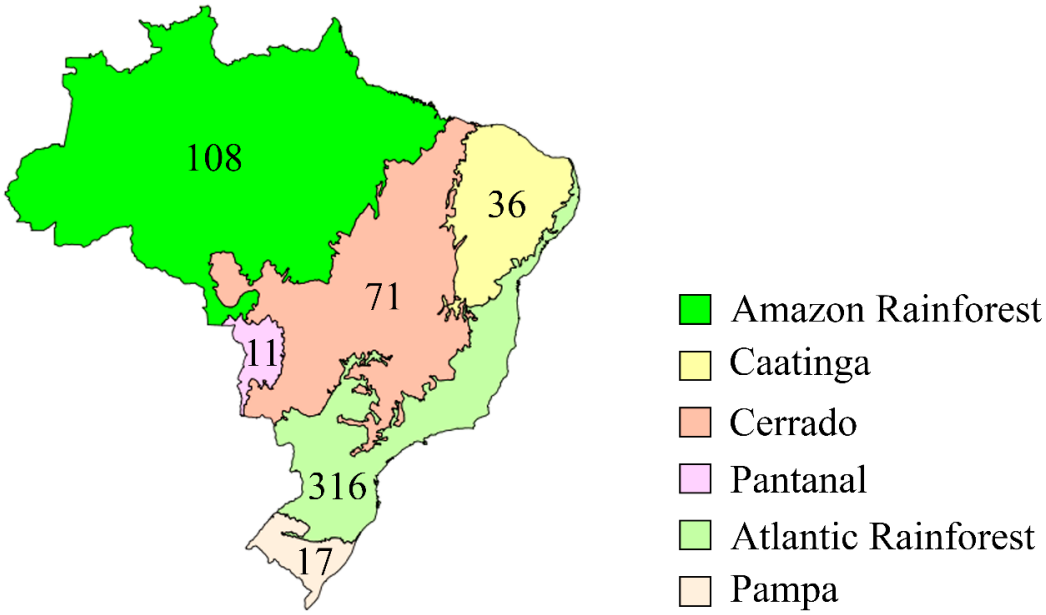

FIGURE 8 Distribution of the 408 wild edible mushrooms species in the Brazilian biomes.

A total of 33 WEM species have a nomenclatural type associated with specimens collected in Brazil and were classified as BEM1. Other ten species with Brazilian holotype were classified as BEM7 due to the World Edible Status E3 of the species (Li et al., 2021). Among the species with a Brazilian holotype and classified as BEM1, *Amauroderma omphalodes* (Berk.) Torrend, despite not knowing its consumption in Brazil, was one of the best distributed taxa in the country, being reported in 22 references for 13 states; followed by *Panus velutinus* (Fr.) Sacc. that was reported in 32 references for 12 states; *Favolus brasiliensis* (Fr.) Fr., reported in 23 references for 11 states; and *Irpex rosettiformis* C.C. Chen & Sheng H. Wu, reported in 36 references for 11 states. Data on the distribution of species in Brazilian states and biomes (Supplementary Information Table 1) were based only on information that was explicit in the literature consulted or from newly samples from known biomes, and thus the interpretation of distribution must be done with caution because not all references specify the Brazilian state and biome where the specimens were collected.

3.2 Molecular studies

3.2.1 New records based on newly molecular data

We generated 156 new sequences (149 ITS and seven LSU) representing 39 species within 28 genera (information on the GenBank accession numbers and phylogenetic trees are available in the Supplementary material). For 16 species we provide the first ITS sequences from specimens collected in Brazil: *Boletus edulis* Bull., *Clavulinopsis laeticolor* (Berk. & M.A. Curtis) R.H.

Petersen, *Cookeina colensoi* (Berk.) Seaver, *Cookeina tricholoma* (Mont.) Kuntze, *Cookeina venezuelae* (Berk. & M.A. Curtis) Le Gal, *Cymatoderma dendriticum* (Pers.) D.A. Reid, *Laccaria lateritia* Malençon, *Lactarius hepaticus* Plowr., *Lentinus concavus* (Berk.) Corner, *Lepista sordida* (Schumach.) Singer, *Macrocybe titans* (H.E. Bigelow & Kimbr.) Pegler et al., *Oudemansiella cubensis* (Berk. & M.A. Curtis) R.H. Petersen, *Pseudofistulina radicata* (Schwein.) Burds., *Ripartitella brasiliensis* (Speg.) Singer, *Russula parazurea* Jul. Schäff., and *Tremella fuciformis* Berk.

Based on newly generated sequences, we report for the first time the occurrence of *Lactarius hepaticus* and *Russula parazurea* in Brazil. Additionally, 15 wild edible species are new records for the following Brazilian states: Maranhão (*A. tremellosa*), Tocantins [*Pleurotus djamor* (Rumph. ex Fr.) Boedijn], Mato Grosso do Sul (*P. djamor*), Espírito Santo [*Laetiporus gilbertsonii* Burds. and *Oudemansiella platensis* (Speg.) Speg.], Rio de Janeiro [*L. sordida*, *Phillipsia dominguensis* (Berk.) Berk. ex Denison, and *T. fuciformis*], Rio Grande do Norte (*M. titans*), São Paulo (*B. edulis*, *Ca. guyanensis*, *C. venezuelae*, *C. tricholoma*, *La. hepaticus*, *L. concavus*, *O. platensis*, and *R. parazurea*), and Paraná (*O. platensis*).

3.2.2 Sequences identification

We recovered 313 sequences previously available in Genbank that are related to 76 names of wild edible mushroom species collected in Brazil. The ML analyses confirmed the specific identity of 287 sequences representing 63 species (Supplementary Information Figure S1–S42), but 26 sequences of 13 species are unconfirmed (Table 5) as discussed below.

TABLE 5 Unconfirmed sequences available in Genbank of supposed wild edible mushrooms collected in Brazil.

Taxa	GenBank access	Reference	Identity
Bjerkandera adusta	KJ832002	Martin et al. (2015)	Misidentified (Supplementary Information Figure S4)
Bolbitius demangei	KX246930	Melo et al. (2016)	Unconfirmed (Supplementary Information Figure S5)
Coriolopsis rigida	KR812261 MN991225	Reis et al. (2015) unpublished	Misidentified Misidentified
Daldinia concentrica	JX944137	Sia et al. (2013)	Misidentified (Supplementary Information Figure S15)
Laccaria lateritia	KY081710 KY081711	Sulzbacher et al. (2018)	Misidentified (Supplementary Information Figure S19)
Mycena chlorophos	KJ831841	Martin et al. (2015)	Misidentified (Supplementary Information Figure S26)

Ophiocordyceps sobolifera	AY754003 AY746002 AY745997	Rubini et al. (2005)	Misidentified (Supplementary Information Figure S27)
Oudemansiella canarii	HQ534101 HQ377277	Vieira et al. (2012)	Misidentified (Supplementary Information Figure S28)
	AY216474	Unpublished	Misidentified (Supplementary Information Figure S28)
	KJ620018	Unpublished	Misidentified (Supplementary Information Figure S28)
Panus similis	MT669126 MT669127 MT669128	Unpublished	Misidentified (Supplementary Information Figure S29)
Panus tephroleucus	MN602052	Unpublished	Unconfirmed (Supplementary Information Figure S29)
Phanerochaete sordida	HQ377285 HM997134	Vieira et al. (2012)	Misidentified (Supplementary Information Figure S30)
	KR812274	Reis et al. (2015)	Misidentified (Supplementary Information Figure S30)
	JX944113	Sia et al. (2013)	Misidentified (Supplementary Information Figure S30)
Rigidoporus lineatus	KP859302	unpublished	Misidentified (Supplementary Information Figure S34)
Rigidoporus microporus	KP859298 KP859300	unpublished	Misidentified (Supplementary Information Figure S34)

The sequence KJ832002 named as *Bjerkandera adusta* (Willd.) P. Karst. by Martin et al. (2015) probably corresponds to *Bjerkandera mikrofumosa* Ryvarden (Supplementary Information Figure S4), a species later described from Venezuela (Ryvarden, 2016) but without notes on edibility. The misidentified sequence is from a strain isolated from the rubber tree *Hevea brasiliensis* (Willd. ex A. Juss.) Müll. Arg. (Martin et al., 2015).

The sequence KX246930 named as *Bolbitius demangei* (Quél.) Sacc. & D. Sacc.by Melo et al. (2016) may not represent this taxon (Supplementary Information Figure S5). The sequence grouped in a clade with four sequences named as *Bolbitius coprophilus* (Peck) Hongo (KR425554, KR425555, KR425556, and KR425557) and one sequence named as *B. demangei* (AF261520). Considering that *B. coprophilus* and *B. demangei* are morphologically hardly distinguishable from each other and that the real distributions of these taxa require further investigation (Malysheva et al., 2015), we prefer not to consider the record of this sample from Brazil under *B. demangei*.

Both sequences named as *Coriolopsis rigida* (Berk. & Mont.) Murrill in Genbank (KR812261 and MN991225) are clearly misidentified because when the sequences were BLASTed in GenBank, both showed similarity with sequences of Ascomycota representatives (mainly *Diaporthe* spp. and *Phomopsis* spp.).

The sequence JX944137 was misidentified as *Daldinia concentrica* (Bolton) Ces. & De Not. by Sia et al. (2013). The sequence clustered (Supplementary Information Figure S15) in a clade with sequences named as *Nodulisporium* sp. (KC881196, MG751287, MT140325, and MT140324), *Daldinia* sp. (MK764756) from Argentina, one sequence identified as *Daldinia placentiformis* (Berk. & M.A. Curtis) Theiss. (AM749939) from South Africa, and two sequences from the newly described species *Daldinia chiangdaoensis* Srikit. et al. (MN153850 and MN153851) from Thailand (Wongkanoun et al., 2020). The clade containing the sequences AY616681, AY616682, AY616683 (Triebel et al., 2005), AF176954, AF176955, AF176956, AF176957, and AF176958 (Johannesson et al., 2000) probably represents *D. concentrica sensu stricto* (Supplementary Information Figure S15).

Two sequences (KY081710 and KY081711) named as *Laccaria lateritia* Malençon by Sulzbacher et al. (2018) grouped in a well-supported clade that is phylogenetically distant from the one that represent *L. lateritia sensu stricto* (Supplementary Information Figure S19). Despite this placement, the occurrence of *L. lateritia* in Brazil was confirmed based on a new sequence generated in this study from a material collected growing in an area with *Eucalyptus* sp. (Supplementary Information Figure S19).

The ML analysis showed that the sequence KJ831841 named as *Mycena chlorophos* (Berk. & M.A. Curtis) Sacc. by Martin et al. (2015) is actually *Mycena deeptha* Aravind. & Manim. (Supplementary Information Figure S26), a bioluminescent species described from India (Aravindakshan et al., 2012). The sequence of the fungus from Brazil is from a strain isolated from *Hevea brasiliensis*.

Three sequences (AY754003, AY746002, and AY745997) named as *Ophiocordyceps sobolifera* (Hill ex Watson) G.H. Sung et al. [as *Cordyceps sobolifera* (Hill ex Watson) Berk. & Broome] by Rubini et al. (2005) clustered with sequences identified as *Clonostachys* sp., *Clonostachys byssicola* Schroers, and *Clonostachys rosea* (Preuss) Mussat (Supplementary Information Figure S27), and thus they do not represent *O. sobolifera*.

The name *Oudemansiella canarii* (Jungh.) Höhn. has been reported to several Brazilian states (Supplementary Information Table 1). There are three sequences (AY216474, HQ377277, and HQ530141) from Brazilian samples named as *O. canarii* available in GenBank but none represents the species and probably belong to another genus, although they are clustered sister to sequences (HQ331046, HQ331047, and HQ331094) from South Korea previously misidentified as *O canarii* (Supplementary Information Figure S28). Alberti et al. (2020) studied samples from Argentina and showed the Argentinean sequences clustered in two clades called by them as *O. canarii* and *O. cubensis*. The sequences generated in this work from specimens collected in Brazil also grouped in these two clades (Supplementary Information

Figure S28). In our ML analysis (Supplementary Information Figure S28), the sequences named as *O. canarii* from China, India, and Sri Lanka grouped in a different clade that probably represents *O. canarii sensu stricto*, which was described based on material from Java, Indonesia (Petersen et al., 2008). Ten new sequences obtained in this study are grouped in the clade with the epitype of *O. platensis* (GQ892789), including an additional Brazilian sequence previously named as *O canarii* (KJ620018). Other four new sequences clustered in the clade named by Alberti et al. (2020) as *O. canarii*, but which actually represent the *O. cubensis* based on the macromorphology of the pileus with very abundant dark scales overall (Berkeley & Curtis, 1868; Petersen & Hughes, 2010). Thus, the occurrence of *O. cubensis* and *O. platensis* in Brazil is confirmed based on morphological and DNA data.

The sequences MT669126, MT669127 and MT669128 named as *Panus similis* (Berk. & Broome) T.W. May & A.E. Wood clustered in a clade different (Supplementary Information Figure S29) from the one that represent *P. similis sensu stricto* (KY630517, KM411466, and KR818820). The species *P. similis* was described based on material collected in Malaya (Pegler, 1983), and the Brazilian specimens represented by these sequences may represent a new species (Menolli pers. comm.). The sequence MT669118, named as *Panus ciliatus* (Lév.) T.W. May & A.E. Wood, grouped within a clade (Supplementary Information Figure S29) containing majority sequences (MG719287, MN622763, KR818817, OM102535) from Tropical Asia most likely misidentified as *P. conchatus* (Bull.) Fr. and an additional unnamed sequence (KM870912) from a Brazilian material that corresponds to the same specimen (SP446150 = FK1890) from which the sequence MT669118 was obtained. *Panus ciliatus* was described based on a type from Indonesia (Léveillé, 1844), whilst *P. conchatus* was based on a type from Sweden (Bulliard, 1787), and in the tree the latter species formed a clade majority composed of samples from North Hemisphere (e.g., China, Finland, Germany, Russia, Sweden, the United Kingdom, and the USA) and thus unrelated to the sequences from the Tropical collections misidentified as *P. conchatus*. The Brazilian collection named as *P. ciliatus* and used in our molecular analysis was studied by Sousa-Guimarães (2018) and it fits the morphological concept of *P. ciliatus* instead of the concept of *P. conchatus* (Pegler, 1983). Thus, considering this morphological data, the origin of the type specimens of both names under this clade, and the geographical distribution of the samples within the recovered clades with sequences under *P. ciliatus* and *P. conchatus* (Supplementary Information Figure S29), *P. ciliatus* seems to have a Pantropical distribution including Brazil, although further taxonomic studies are necessaries to clarify the names attributed to collections broadly distributed. Finally, for the last doubtful sequences of *Panus* collections, the sequence MN602052 named as *P. tephroleucus* from a Brazilian collection grouped in a clade with many other Brazilian sequences named as *P. fulvus*

(Berk.) Pegler & R.W. Rayner and a sequence from Argentina named *P. badius* Berk. (Supplementary Information Figure S29). Many of these Brazilian materials from which were obtained the sequences named as *P. fulvus* have been studied by Sousa-Guimarães (2018), and according to their morphological studies, the collections within this clade fits to the morphological concept of *P. fulvus* according Corner (1981) and thus they are different from *P. tephroleucus*, according to Pegler (1983) concept. On the other hand, the sequence MN602052 from a Brazilian collection named as *P. tephroleucus* was generated from a pure culture (CMINPA1860), most likely without morphological records of the basidiomata to certify its identification. Considering that *P. fulvus* and *P. tephroleucus* are morphologically distinct (Corner, 1981; Pegler, 1983) and that the names attributed to collections in this clade involve at least three taxa that require further investigation, we prefer not to consider the record of this sample from Brazil under *P. tephroleucus*.

There are four Brazilian sequences in GenBank named as *Phanerochaete sordida* (P. Karst.) J. Erikss. & Ryvarden (HQ377285, HM997134, KR812274, and JX944113) by Vieira et al. (2012), Sia et al. (2013), and Reis et al. (2015), but they do not represent this taxon (Supplementary Information Figure S30). Although previous studies with ITS data supported that *P. sordida* is a species complex (Koker et al., 2003; Wu et al., 2010; Volobuev et al., 2015), the sequences from Brazilian collections clustered in a different clade from the one with specimens from Finland, Sweden, Germany, and Russia, which probably represent *P. sordida sensu stricto* that was described based on northern Europe collections (Volobuev et al., 2015). The sequence KP859302 named as *Rigidoporus lineatus* (Pers.) Ryvarden [current name *Physisporinus lineatus* (Pers.) F. Wu et al.,] is also misidentified and probably belongs to another species because it did not group with the identified sequences of *P. lineatus* (Supplementary Information Figure S34). Two sequences (KP859298, KP859300) identified as *Rigidoporus microporus* (Sw.) Overeem do not correspond to this taxon because they are clustered within a broad clade that contains species of *Physisporinus*, a genus with similar morphological characteristics to those of *Rigidoporus* but belonging to the order Polyporales (Supplementary Information Figure S34). The genus *Rigidoporus* is polyphyletic (Justo et al., 2017) and was traditionally assigned to Polyporales. However, recent studies showed that the genus actually belongs to Hymenochaetales (Oghenekaro et al., 2014, 2020; Wu et al., 2017). *Rigidoporus microporus* causes white root rot disease on various tropical crop species (Oghenekaro et al., 2014; Saidi et al., 2023). Oghenekaro et al. (2014) studied isolates from Africa, Asia, and the Americas, and observed the presence of three putative species within the *R. microporus* complex: one species with an African distribution, one distributed in Southeast Asia, and another in South/Central America. Oghenekaro et al. (2014) confirmed the presence

of *R. microporus* in Brazil and generated three ITS sequences (KJ559477, KJ559478, and KJ559479) from Brazilian collections that grouped with sequences from Cuba (KJ559482) and Peru (KJ559481, KJ831928, and KJ559480).

4. Discussion

The number of 408 species recovered as the WEM occurring in Brazil must be interpreted with caution because it includes taxa that need further taxonomic and systematics investigation, although this number is a starting point for future studies on WEM from Brazil. The implementation of sequencing procedures has revealed misidentifications even with species of high economic and cultural importance around the world. Wu et al. (2014) performed morphological and phylogenetic analyses and concluded that the most important cultivated species of *Auricularia* in China, *Auricularia heimuer* F. Wu et al., has been misidentified for years as *Auricularia auricula-judae* (Bull.) Quél., a species originally described from and probably restricted to Europe (Wu et al., 2021). A similar example also is found in Brazil, where Silva-Filho et al. (2020), based on molecular and morphological identification approaches, recently confirmed that come specimens commercialized in Brazil as *Lactarius deliciosus* (L.) Gray actually represents *Lactarius quieticolor* Romagn.

In addition to assisting in the delimitation and certification of species identity, DNA-barcoding also can be a powerful tool for a reliable identification and quality control of food products (Ángeles-Argáiz & Garibay-Orijel, 2020). Dentinger and Suz (2014) used DNA-sequencing to analyze a commercial packet of dried porcini and found three undescribed species of mushrooms inside it. In the same way, Cutler II et al. (2021) also used molecular analysis to study 16 food products labeled as containing wild mushrooms and verified that only five products contained the species described on the label and, more alarmingly, that some products contained species of dubious edibility or potentially toxic (Cutler II et al., 2021). Misidentification and potentially intentional mislabeling in other food products, including endangered species, such as shark meat (Almerón-Souza et al., 2018), seafood (Minoudi et al., 2020; Giusti et al., 2023) and other fish meat (Liu et al., 2022), have also been found with the aid of molecular techniques.

Considering the importance of molecular and distribution studies for an accurate identification of species, 83 edible species were considered to have a robust occurrence record in Brazil. These species (within BEM1 and BEM2 categories) are those that have DNA sequences available from Brazilian specimens or those that were originally described from Brazil. Other 325 species need taxonomic studies to confirm their identity and occurrence in the country (species categorized in BEM3–BEM6) because many have been mentioned only in

lists (69 species) or based on short and incomplete morphological descriptions (109 species). A total of 41 species (BEM3+BEM4) needs to be studied more urgently because they are species consumed by part of the Brazilian population. The species categorized in BEM5 and BEM6 add up to 284 taxa that are not consumed in Brazil but can represent new food resources for the country after their identity and occurrence in Brazil are confirmed. Among the 325 species that require additional studies on their identification, we highlight some taxa that most likely do not occur in the country or that involve taxonomic issues to be better investigated.

Auricularia delicata (Mont. ex Fr.) Henn. is a wild edible species commonly reported to Brazil for more than 120 years (Hennings, 1900; Teixeira, 1945; Batista et al., 1966; Fidalgo, 1968; Lowy, 1971; Capelari & Maziero, 1988; Goés-Neto, 1996; Drechesler-Santos et al., 2008; Alvarenga & Xavier-Santos, 2015; Santos, 2017; Couceiro et al., 2019; Cavalcante et al., 2021; Nascimento et al., 2021) but that represents a species complex, with probably a different taxon restricted to the country. Wu et al. (2021) accepted *A. tremellosa* as an independent species within the *A. delicata* complex based on morphological and phylogenetic analyses. They studied six Brazilian specimens and the characters studied fit in *A. tremellosa*, a species originally described from Mexico. *Auricularia delicata* was originally described from Western Africa (Fries, 1830) and may have a more restricted distribution (Wu et al., 2021). Regarding the geographical distribution of *Auricularia* species, Wu et al. (2021) concluded that most species are restricted to a unique continent, whereas few species are widely distributed, e.g., *Auricularia cornea* Ehrenb.

The genus *Agaricus*, although containing the largest number of WEM species recorded here (21 species), still needs to be better investigated in the country since only two species, *Agaricus meijeri* Heinem. and *Agaricus subrufescens* Peck, were categorized in BEM1. The identification of *Agaricus* species can be challenging since the species have a limited number of morphological characteristics that can change due to environmental factors and intraspecific variability (Zhao et al., 2011). Phylogenetic studies have shown that tropical and non-tropical species of *Agaricus* are generally grouped in distinct clades, and new tropical species have been identified and described (Zhao et al., 2011, 2016; Chen et al., 2017; Ortiz-Santana et al., 2021; Medel-Ortiz et al., 2022).

Favolus tenuiculus P. Beauv. is another example of species that probably does not occur in Brazil but remains under many records in the country for more than 80 years (Torrend, 1938; Singer, 1961; Bononi et al., 1981; Rajchenberg & Meijer, 1990; Loguercio-Leite, 1990, 1992; Loguercio-Leite & Wright, 1991; Bononi, 1992; Gugliotta & Capelari, 1995; Gerber, 1996; Góes-Neto, 1999; Gonçalves & Loguercio-Leite, 2001; Groposo & Loguercio-Leite, 2002, 2005; Gibertoni & Cavalcanti, 2003; Góes-Neto et al., 2003; Gibertoni et al., 2004; Gibertoni

et al., 2007; Meijer, 2006, 2008; Silveira, 2006; Louza & Gugliotta, 2007; Abrahão et al., 2012; Neves et al., 2013; Santos, 2017; Timm, 2018; Couceiro et al., 2019). Although *Favolus brasiliensis* have been treated as synonymous of *Favolus tenuiculus* [= *Polyporus tenuiculus* (P. Beauv.) Fr.], the latter is considered a dubious name (Palacio et al., 2021) originally described from Nigerian material (Palisot-Beauvois, 1804) and most likely is not the correct name to be applied for Brazil's materials. *Favolus brasiliensis* is the type species of the genus *Favolus* and was described from Brazil (Fries, 1828). Based on molecular investigations, Palacio et al. (2021) studied *Favolus* from the Neotropics and concluded that *F. brasiliensis* is a valid name that represents a species complex with at least two phylogenetic lineages. In addition, they described two other species that are very similar to *F. brasiliensis*: *Favolus yanomami* Palacio & Menolli and *Favolus rugulosus* Palacio & R.M. Silveira, both edible. *Favolus yanomami* received this name in honor to the Yanomami people, who use these mushrooms as food (Sanuma et al., 2016 as *Polyporus philippinensis*). Despite this information, as not all specimens recorded in the consulted bibliographies as *F. tenuiculus* were studied and re-identified, the record of *F. tenuiculus* remains on the list as BEM3, requiring further taxonomic investigations.

Some worldwide cultivated species have been reported from Brazil and here classified as BEM3, such as *Lentinula edodes* (Timm, 2018, 2021) and *Pleurotus ostreatus* (Jacq.) P. Kumm. (Rick, 1938, 1961; Singer, 1953; Batista & Bezerra, 1960; Pereira, 1988; Meijer, 2001, 2006, 2008; Lyra et al., 2009; Couceiro et al., 2019; Putzke & Putzke, 2019; Cavalcante et al., 2021). However, recent molecular studies with samples from Brazil and/or other countries from the Neotropics show that they probably do not occur in Brazil (Menolli Jr. et al., 2014a; Menolli et al., 2022).

These are just a few examples of the importance of accurate taxonomic studies with wild edible species. In addition to systematic investigations, it is also important to carry out ethnomycological studies in Brazil to better investigate the relationships of people with fungi and the possible occurrence of currently unknown edible species or to confirm the edibility of already known species. Studies from the last two decades, mostly based on morphological and molecular data, have described new species of fungi from Brazil in genera that are known to contain edible species, such as *Agaricus* (Drewinski et al., 2017), *Amanita* (Nascimento et al., 2018), *Armillaria* (Lima et al., 2008), *Auricularia* (Wu et al., 2021), *Favolaschia* (Capelari et al., 2013), *Favolus* (Palacio et al., 2021), *Gymnopus* (Coimbra et al., 2015), *Lactarius* (Silva-Filho et al., 2018), *Macrolepiota* (Perez et al., 2018; Freitas & Menolli Jr., 2019; Souza et al., 2022), *Marasmius* (Oliveira et al., 2014), *Pluteus* (Menolli et al., 2014b; Menolli Jr. et al., 2015), *Tuber* (Grupe II et al., 2018), and *Volvariella* (Menolli & Capelari, 2008).

Despite the benefits of eating wild mushrooms, there is also a concern related to toxic species. In Brazil, few cases of poisoning by wild mushrooms have been reported in the scientific literature (Meijer, 2001; Meijer et al., 2007), although some other cases have been spread in popular media. Meijer et al. (2007) described in detail the poisoning of four people of the same family by consumption of *Chlorophyllum molybdites* from the state of Paraná, Southern Brazil. *Chlorophyllum molybdites* is similar to edible species of the genus *Macrolepiota* and can be easily confused by untrained people. An accurate identification and use of the correct scientific name are the most useful way to search if the species is edible, medicinal, or poisonous (Boa, 2004). The 15 species classified here as poisonous represent only the taxa that were listed by Li et al. (2021) and do not represent all the toxic species that may occur in Brazil. Therefore, the consumption of wild mushrooms must be done responsibly, especially when it comes from genera with both edible and poisonous species, such as *Agaricus* and *Amanita*. The edible *Amanita craseoderma* Bas and the lethal *Amanita phalloides* (Vaill. ex Fr.) Link, both certainly occurring in Brazil (Bas, 1978; Scheibler, 2019), are good examples of this matter. Thus, if you have doubts about the specific identity of a wild mushroom or its edibility status, do not eat it.

Although there is an incredible biodiversity of WEM, just five genera accounting for 85 % of the world's mushroom supply (Royse et al., 2017): *Lentinula* (22 %), *Pleurotus* (19 %), *Auricularia* (18 %), *Agaricus* (15 %), and *Flammulina* (11 %). While tropical regions have the potential to be a valuable source of cultivable species of mushrooms (Thawthong et al., 2014), most of the strains commonly used for commercial purposes come from species that occur in temperate climate areas, but the techniques that are used to cultivate one species may be applied for cultivating another one, adapting the substrate or altering the growing environment (Stamets, 2000). People around the world enjoy eating mushrooms and there is a huge potential for introducing new domesticated tropical mushrooms to the regional and global market (Thawthong et al., 2014). There are a lot of species with potential for cultivation that could contribute to food self-sufficiency, creation of local jobs, and poverty mitigation, improving the food security and food sovereignty scenario (Pérez-Moreno et al., 2021b).

Mushroom cultivation is an expanding activity in Brazil (Gomes et al., 2016) but it is still restricted to commercial strains of species from temperate climate areas, being the Brazilian production dominated by *P. ostreatus*, *L. edodes*, and *A. bisporus* (Gomes et al., 2016; Ishikawa et al., 2017). Previous papers focused on the cultivation of wild edible mushrooms from Brazil are restricted to the last two decades, with species of the genera *Oudemansiella* (Ruegger et al., 2001) and *Macrolepiota* (Maki & Paccola-Meirelles, 2002). The recent record (Grupe II et al., 2018) of a "true truffle" of the genus *Tuber* in pecan [Carya illinoinensis (Wangenh.) K. Koch]

plantations in Brazil has intensified the study of truffle cultivation in the country (Sulzbacher et al., 2019; Freiberg et al., 2021). Allied to the growing attention in commercial mushrooms is the interest in wild edible mushrooms for both production and consumption. Some mycological tourism initiatives focusing on WEM have already started in the North, Southeastern, and Southern regions of Brazil, and responsible information about edible mushroom species on social media has shown to be very important to increase knowledge in countries with no tradition of foraging wild mushrooms such as Brazil. The increasing interest in foraging and the commercial importance of wild edible fungi emphasize the need for reliable information about species to avoid misidentification and poisoning (Li et al., 2021).

Fungi represent one of the greatest untapped resources of nutritious food in the world (Wani et al., 2010). Boa (2004) summarizes the importance of WEM in three main reasons: i) as a source of food and health benefits; ii) as a source of income, especially for rural people; and iii) to maintain the health of the forests, as fungi constitute fundamental components of the ecosystems. Fungi are not immune to the threats that put animal and plant species at risk (Mueller et al., 2014). Efforts have been made to evaluate fungal species into the red-listing system of the International Union for Conservation of Nature (IUCN) and to emphasize the importance of the conservation of fungi (Mueller et al., Krikorev 2014; Mueller et al., 2022). Currently, there are 597 species of fungi published in the Red List, with 133 of them being used for human food (Mueller et al., 2022). Considering the 407 WEM recorded to Brazil, only 15 species have been already evaluated on the Global Fungal Red List Initiative (Mueller et al., 2022): *Agaricus arvensis* Schaeff., *Agaricus campestris* L., *Agaricus sylvaticus* Schaeff., *Boletus edulis* Bull., *Calocybe gambosa* (Fr.) Donk, *Cantharellus cinnabarinus* (Schwein.) Schwein, *Cantharellus guyanensis* Mont., *Coprinus comatus* (O.F. Müll.) Pers., *Lycoperdon perlatum* Pers., *Suillus granulatus* (L.) Roussel, and *Suillus luteus* (L.) Roussel were assessed as Least Concern; *Pleurotus rickii* Bres., and *Polyporus sapurema* Möller were classified as Near Threatened; *Clavaria zollingeri* was categorized as Vulnerable; and *Rickiella edulis* as Endangered.

The 2030 Agenda for Sustainable Development is a plan of action for people, planet, and prosperity adopted by United Nation Members in 2015, including Brazil. The 17 Sustainable Development Goals summarize the areas of critical importance for humanity and planet (United Nation, 2015). Pérez-Moreno et al. (2021a) linked edible mycorrhizal fungi strategies to achieve 11 of the 17 goals. According to them, edible mushrooms may promote forest sustainability, biodiversity conservation, food supply, nutrition and health, biocultural conservation, women empowerment, and economic development (Pérez-Moreno et al., 2021a). Thus, it is extremely relevant to develop strategies to preserve WEM genetic resources for food

security (Pérez-Moreno et al., 2021b). Edible mushrooms are an important non-wood forest product and the knowledge about them can add value to the forests, increasing the incentive to protect natural areas.

5. Conclusion

We summarized the information about the records of 408 wild edible mushrooms in Brazil, of which 349 species can be consumed safely and 59 species that need some preparation to be safely consumed. Consistent occurrence records were found for 83 species, reinforcing the need for further studies to confirm the specific identity of at least other 325 edible mushrooms reported to Brazil. A total of 41 species needs some urgency in these studies because they represent species consumed by part of the Brazilian population, whereas the other 284 taxa are not consumed in Brazil but can represent new food resources for the country after further studies to confirm its identity. The edible mushrooms may be used not just as an excellent nutritional and functional food but also in industrial applications and in research and development of drugs. Wild edible mushrooms are a valuable natural resource still underutilized and represent a non-timber forest product with important ecological, socio-cultural, medicinal, and economic relevance.

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Conflicts of Interest

The authors declare no conflict of interest.

Data Availability

The sequencing data is available from a public database (https://www.ncbi.nlm.nih.gov/genbank/) and the information is provided in the Supplementary Information Table 1. Other data will be made available on request.

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Supplementary Table 1. Final status of 572 macrofungi with occurrence recorded in Brazil.

Taxon	WES	ROB	DCB	BEM	Brazilian state	Biome
Agaricus meijeri Heinem.	E1	T(M)	C	BEM1	PR, RS	Atlantic Rainforest
Agaricus subrufescens Peck	E1	D◊	C	BEM1	PR, RS, SP	Atlantic Rainforest
Amanita craseoderma Bas	E1	T(M)	N	BEM1	AM, RO	Amazon Rainforest
Amauroderma omphalodes (Berk.) Torrend	E1	T(D)	N	BEM1	AL, AM, BA, MG, MS, MT, PA, PE, PR, RJ, RO, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Arachnion album Schwein.	E1	D◊	N	BEM1	PE, PR, RS, SP	Atlantic Rainforest, Cerrado, Pampa, urban area
Armillaria puiggarii Speg.	E1	T(M)	N	BEM1	RS, SP	Atlantic Rainforest
Auricularia brasiliana Y.C. Dai & F. Wu	E1*	T(D)	N	BEM1	AL, BA, CE, MA, MT,PE, PI, RO	
Auricularia cornea Ehrenb.	E1	D♦	C	BEM1	AC, CE, DF, GO, MA, PB, PE, PR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Auricularia fuscosuccinea (Mont.) Henn.	E1	D♦	C	BEM1	AC, AM, GO, MT, PA, PB, PE, PR, RJ, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Auricularia tremellosa (Fr.) Pat	E1*	D♦	C*	BEM1	AC, AM, GO, MA	Amazon Rainforest, Cerrado
Boletinellus rompelii (Pat. & Rick) Watling	E1	T(D◊)	C*	BEM1	DF, PR, RS, SP	Atlantic Rainforest, Pinus plantation, Cerrado
Boletus edulis Bull.	E1	D♦	C	BEM1	RS, SP	Pinus plantation
Bresadolia paradoxa Speg.	E1	D	C	BEM1	RS, RR, SP	Amazon Rainforest, Atlantic Rainforest
Cantharellus guyanensis Mont.	E1	D♦	C	BEM1	AM, PB, PE, PR, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Clavulinopsis laeticolor (Berk. & M.A. Curtis) R.H. Petersen	E1	D♦	N	BEM1	RS, SC	Atlantic Rainforest
Cookeina colensoi (Berk.) Seaver	E1	D♦	C*	BEM1	BA, MT, PR, RS, SC, SP	Atlantic Rainforest, Cerrado
Cookeina tricholoma (Mont.) Kuntze	E1	T(D♦)	C	BEM1	AL, AM, BA, MA, PA, PR, RJ, SC, SP	Amazon Rainforest, Atlantic Rainforest
Cookeina venezuelae (Berk. & M.A. Curtis) Le Gal	E1	D♦	C*	BEM1	PR, SP	Atlantic Rainforest
Coprinellus radians (Fr.) Vilgalys, Hopple & Jacq. Johnson	E1	D◊	N	BEM1	MG, RS	Atlantic Rainforest (endophyte of Solanum cernuum)
Coprinus comatus (O.F. Müll.) Pers.	E1	D◊♦	C	BEM1	PR, RS, SP	Atlantic Rainforest, Cerrado
Cotylidia aurantiaca (Pat.) A.L. Welden	E1	T(M)	C*	BEM1	AM, PA, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest
Cymatoderma dendriticum (Pers.) D.A. Reid	E1	D♦	N	BEM1	PB, PE, PR, SE, RS, SC, SP	Atlantic Rainforest
Dactylosporina steffenii (Rick) Dörfelt	E1	T(M)	R	BEM1	PE, PR, RS, SP	Atlantic Rainforest

Favolus brasiliensis (Fr.) Fr.	E1	T(D♦)	C	BEM1	AM, BA, MG, MT, PA, PR, RJ, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Favolus radiatifibrillosus Palacio & Silveira	E1	T(M)	C	BEM1	AC, AM, BA, PA, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Favolus rugulosus Palacio & Silveira	E1	T(D♦)	C	BEM1	PR, RS, SP	Atlantic Rainforest
Favolus yanomamii Palacio & Menolli	E1	T(D)	C	BEM1	AM, ES, MT, PA, RR	Amazon Rainforest, Atlantic Rainforest
Gyroporus austrobrasiliensis A.C. Magnago	E1*	T(D)	C*	BEM1	RS	Atlantic Rainforest
Irpex lacteus (Fr.) Fr.	E1	D◊	N	BEM1	AP, MS, PA, PE, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Irpex rosettiformis C.C. Chen & Sheng H. Wu	E1	T(D♦)	C	BEM1	AC, BA, GO, MS, MT, PR, RO, RR, RS, SC, SP	Atlantic Rainforest, Amazon Rainforest, Cerrado
Laccaria lateritia Malençon	E1	D♦	C*	BEM1	SC, SP	Eucalyptus dunnii plantation
Lactarius hepaticus Plowr.	E1*	D♦	C*	BEM1	SP	Pinus plantation
Lactarius quieticolor Romagn.	E1	D	C	BEM1	RS	Pinus plantation
Laetiporus gilbertsonii Burds.	E1	D♦	C*	BEM1	ES, SP	Atlantic Rainforest
Lentinula boryana (Berk. & Mont.) Pegler	E1	T(D)	C	BEM1	BA, PR, RS, SP	Atlantic Rainforest
Lentinula raphanica (Murrill) Mata & R.H. Petersen	E1	D♦	C	BEM1	AM, SP	Amazon Rainforest, Atlantic Rainforest
Lentinus berteroi (Fr.) Fr.	E1	D♦◊	C	BEM1	AM, CE, MG, PE, PR, RJ, RN, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Lentinus crinitus (L.) Fr.	E1	D♦	C	BEM1	AL, AP, AM, BA, DF, ES, MS, MT, PA, PB, PE, PR, RJ, RN, RO, RR, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado, Pantanal
Lentinus scleropus (Pers.) Fr.	E1	T(M)	C*	BEM1	AM, RS, SP	Amazon Rainforest, Atlantic Rainforest
Lentinus swartzii Berk.	E1	T(M)	N	BEM1	AM, BA, MG, MS, MT, PE, SP, RJ	Amazon Rainforest, Atlantic Rainforest, Caatinga, Pantanal
Lepista sordida (Schumach.) Singer	E1	D♦	C	BEM1	PR, RJ, RS, SP	Atlantic Rainforest, Urban area
Macrocybe praegrandis (Berk.) Pegler & Lodge	E1	T(M)	R	BEM1	PB, PE, MG, MT, SP, RS	Atlantic Rainforest
Macrocybe titans (H.E. Bigelow & Kimbr.) Pegler, Lodge & Nakasone	E1	D♦	C	BEM1	PR, RN, SP	Atlantic Rainforest
Marasmius cladophyllus Berk.	E1	T(D)	N	BEM1	AM, PA, PE, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest
Marasmius haematocephalus (Mont.) Fr.	E1	T(M)	N	BEM1	AM, MA, MG, PA, PE, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Neofavolus subpurpurascens (Murrill) Palacio & Robledo	E1	D	C	BEM1	RS, SP	Atlantic Rainforest

Ophiocordyceps melolonthae (Tul. & C. Tul.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora	E1	D◊	N	BEM1	PR, RS	Atlantic Rainforest
Oudemansiella cubensis (Berk. & M.A. Curtis) R.H. Petersen	E1	D♦	C	BEM1	AM, MT, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Oudemansiella platensis (Speg.) Speg.	E1	D♦◊	C	BEM1	DF, ES, PR, RS, SP	Atlantic Rainforest, Cerrado
Panus ciliatus (Lév.) T.W. May & A.E. Wood	E1	D	N	BEM1	DF, ES, PR, RS, SP	Atlantic Rainforest
Panus neostrigosus Drechsler-Santos & Wartchow	E1	D	C	BEM1	AM, DF, MG, PR, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest
Panus strigellus (Berk.) Overh.	E1	D♦◊	C	BEM1	AM, DF, PR, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest
Panus velutinus (Fr.) Sacc.	E1	T(D♦◊)	C	BEM1	AM, MG, MT, PA, PE, PR, RJ, RN, RO, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Phallus indusiatus Vent.	E1	D	C*	BEM1	AM, CE, ES, MA, MS, PA, PB, PR, RJ, RS, RN, RO, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Phillipsia domingensis (Berk.) Berk. ex Denison	E1	D♦	R	BEM1	BA, PR, RJ, RS, SP	Atlantic Rainforest
Phlebopus beniensis (Singer & Digilio) Heinem. & Rammeloo	E1	D	C	BEM1	GO, PB, PR, RS, SP	Atlantic Rainforest, Cerrado
Pholiota bicolor (Speg.) Singer	E1	T(M)	C	BEM1	PR, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Pleurotus albidus (Berk.) Pegler	E1	T(D♦)	C	BEM1	AM, MG, PR, RJ, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Pleurotus djamor (Rumph. ex Fr.) Boedijn	E1	D♦	C	BEM1	AM, AP, MS, MT, PA, PB, PE, PR, RJ, RO, RR, RS, SC, SP, TO	Amazon Rainforest, Atlantic Rainforest, Pantanal
Pleurotus fuscosquamulosus D.A. Reid & Eicker	E1	D	N	BEM1	SP	Atlantic Rainforest
Pleurotus magnificus Rick	E1*	T(M)	C*	BEM1	RS	Atlantic Rainforest
Pleurotus pulmonarius (Fr.) Quél.	E1	D♦	C	BEM1	MS, PR, RS, SP	Atlantic Rainforest, Cerrado
Pleurotus rickii Bres.	E1	T(D)	C	BEM1	RS, SP	Atlantic Rainforest
Pluteus harrisii Murrill	E1	D	N	BEM1	MG, PR, SP	Atlantic Rainforest
Pluteus longistriatus (Peck) Peck	E1	D	N	BEM1	SP	Atlantic Rainforest
Podoscypha brasiliensis D.A. Reid	E1	T(M)	N	BEM1	AC, PA, PR	Amazon Rainforest, Atlantic Rainforest
Podoscypha nitidula (Berk.) Pat.	E1	T(M)	N	BEM1	GO, PB, PR, PE, RN	Cerrado, Atlantic Rainforest
Polyporus indigenus I.J.A. Aguiar & M.A. de Sousa	E1	T(M)	C	BEM1	AM, PA, RO	Amazon Rainforest
Polyporus sapurema Möller	E1	T(M)	R	BEM1	AC, BA, ES, PR, RS, SP, SC	Amazon Rainforest, Atlantic Rainforest
Pseudofistulina radicata (Schwein.) Burds.	E1	D♦	N	BEM1	RJ, SP	Atlantic Rainforest
Rigidoporus amazonicus Ryvarden	E1	T(M)	N	BEM1	AC, SC	Amazon Rainforest, Atlantic Rainforest

Ripartitella brasiliensis (Speg.) Singer	E1	T(D♦)	R	BEM1	PE, PR, RS, SP	Atlantic Rainforest
Russula parazurea Jul. Schäff.	E1	D♦	N	BEM1	SP	exotic trees
Schizophyllum commune Fr.	E1	D◊	C*	BEM1	AL, AP, BA, DF, MG, MT, PA, PB, PE, PR, RO, RN, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Sclerotinia sclerotiorum (Lib.) de Bary	E1	D	N	BEM1	DF, GO, MG, PR	Cerrado, Caatinga, phytopatogen in Crotalaria spectabilis
Suillus salmonicolor (Frost) Halling	E1	D♦	R	BEM1	PR, RS, SC, SP	Atlantic Rainforest, Pinus plantation
Tremella fuciformis Berk.	E1	T(D♦)	C*	BEM1	AM, BA, DF, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Tuber floridanum A. Grupe, Sulzbacher & M.E. Sm.	E1	D	C*	BEM1	RS	Pecan plantation
Volvariella bombycina (Schaeff.) Singer	E1	D	R	BEM1	PR, RS, SP	Atlantic Rainforest
Calvatia cyathiformis (Bosc) Morgan	E2	D◊	R	BEM2	PA, PE, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado, Pampa
Coprinellus disseminatus (Pers.) J.E. Lange	E2	D◊	C	BEM2	AM, DF, PA, PB, PR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Endophyte of Hevea
Lentinus concavus (Berk.) Corner	E2	D♦	C	BEM2	AC, MS, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Pantanal
Trametes versicolor (L.) Lloyd	E2	D◊	N	BEM2	BA, MS, PA, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Agaricus bisporus (J.E. Lange) Imbach	E1	M	C	BEM3	RS	
Auricularia delicata (Mont. ex Fr.) Henn.	E1	M	C	BEM3	AM, BA, DF, GO, MA, MT, PA, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Chalciporus piperatus (Bull.) Bataille	E1	M	C*	BEM3	PB, PR, SC, RS	Atlantic Rainforest, Pinus plantation
Collybia pseudocalopus (Henn.) Singer	E1	L	C	BEM3	RR	Amazon Rainforest
Cookeina sulcipes (Berk.) Kuntze	E1	M	C*	BEM3	BA, PA	Atlantic Rainforest
Coriolopsis daedaleoides (Berk.) Ryvarden	E1	L	C	BEM3		
Favolus tenuiculus P. Beauv.	E1	M	C	BEM3	AC, AL, BA, DF, PA, PB, PE, PR, RJ, RN, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Filoboletus gracilis (Klotzsch ex Berk.) Singer	E1*	S	C	BEM3	AC, AM, PA, PR, RO, RS, SP	Amazon Rainforest, Atlantic Rainforest
Gymnopilus earlei Murrill	E1	M	C	BEM3	MS, PR, RO, RS, SP	Amazon Rainforest, Cerrado, Pantanal
Gymnopilus hispidellus Murrill	E1	M	C	BEM3	AM, RO	Amazon Rainforest

Hydnopolyporus palmatus (Hook.) O. Fidalgo	E1	M	C	BEM3	DF, RJ, RO, RS, SC, SP	Atlantic Rainforest, Amazon Rainforest, Cerrado
Laccaria laccata (Scop.) Cooke	E1	S	C	BEM3	RS, SC, SP	Eucalyptus spp. plantation, Pinus spp. plantation
Lactarius deliciosus (L.) Gray	E1	S	C	BEM3	PR, RS, SC	Pinus plantation, Pampa
Lactocollybia aequatorialis Singer	E1	S	C	BEM3	AM	Amazon Rainforest
Lentinula edodes (Berk.) Pegler	E1	S	C	BEM3	RS	
Lentinus glabratus Mont.	E1	L	C	BEM3	RR	Amazon Rainforest
Lentinus tricholoma (Mont.) Zmitr.	E1	M	C	BEM3	AL, AM, AP, AC, DF, MA, MT, PA, PB, PE, PR, RJ, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Macrolepiota bonaerensis (Speg.) Singer	E1	S	C	BEM3	MG, PR, RS, SP	Atlantic Rainforest, Cerrado
Marasmiellus cubensis (Berk. & M.A. Curtis) Singer	E1*	S	C	BEM3	AM, SP	Amazon Rainforest, Atlantic Rainforest
Marasmiellus subpruinosus (Murrill) J.S. Oliveira	E1	S	C	BEM3	RR, SP	Amazon Rainforest, Atlantic Rainforest
Oudemansiella canarii (Jungh.) Höhn.	E1	M	C	BEM3	AM, PE, PR, RJ, RO, RS, SP	Amazon Rainforest, Atlantic Rainforest
Panus tephroleucus (Mont.) T.W. May & A.E. Wood	E1*	M	C	BEM3	AM, BA, PA, PE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Pleurotus flabellatus Sacc.	E1	L	C	BEM3	AM, SP	Amazon Rainforest
Pleurotus ostreatus (Jacq.) P. Kumm.	E1	M	C	BEM3	AM, PA, PE, PR, RS	Amazon Rainforest, Atlantic Rainforest
Polyporus grammocephalus Berk.	E1	S	C	BEM3	AM, BA, AL, PA, PB, PE, PR, RN, RS, SE	Amazon Rainforest, Atlantic Rainforest
Pycnoporus sanguineus (L.) Murrill	E1	M	C	BEM3	AL, AM, AP, BA, ES, MT, PA, PB, PE, PR, RJ, RN, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Royoporus spatulatus (Jungh.) A.B. De	E1	L	C	BEM3	AM	Amazon Rainforest
Suillus subaureus (Peck) Snell	E1	M	C	BEM3	RS	Atlantic Rainforest, Pinus plantation
Trametes ochracea (Pers.) Gilb. & Ryvarden	E1	S	C	BEM3	RR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Ustilago maydis (DC.) Corda	E1	L	C*	BEM3	CE, MG, PE, PR, SP	Corn plantation
Amanita rubescens Pers.	E2	S	C	BEM4	RS, SP	*Pinus* plantation
Gymnopilus junonius (Fr.) P.D. Orton	E2	S	C	BEM4	RS	
Laetiporus sulphureus (Bull.) Murrill	E2	M	C	BEM4	PR, RS, SC, SP	Atlantic Rainforest
Leucocoprinus cepistipes (Sowerby) Pat.	E2	M	C	BEM4	CE, PI, PR, RO, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga

Macrolepiota procera (Scop.) Singer	E2	M	C	BEM4	PE, RS, SP	Atlantic Rainforest, Urban area
Morchella esculenta (L.) Pers.	E2	M	C*	BEM4	RS	Atlantic Rainforest, Pampa
Ramaria flavobrunnescens (G.F. Atk.) Corner	E2	M	C	BEM4	PR, RS, SC, SP	
Ramaria toxica L.S. Domínguez & R.H. Petersen	E2	M	C	BEM4	PR, RS	*Eucalyptus* plantation
Stropharia rugosoannulata Farl. ex Murrill	E2	M	C	BEM4	PR, RS, SP	Atlantic Rainforest
Suillus granulatus (L.) Roussel	E2	M	C	BEM4	PR, RS, SC, SP	Atlantic Rainforest, *Pinus* plantation
Suillus luteus (L.) Roussel	E2	M	C	BEM4	PR, RS, SP	Atlantic Rainforest, *Pinus* plantation
Agaricus argyropotamicus Speg.	E1	M	R	BEM5	CE, MT, RS, SP	Caatinga, Cerrado, Atlantic Rainforest
Agaricus augustus Fr.	E1	S	R	BEM5	RS	Atlantic Rainforest
Agaricus campestris L.	E1	M	R	BEM5	PE, PR, RS, SP	Atlantic Rainforest
Agaricus comtulus Fr.	E1	S	N	BEM5	RS	Atlantic Rainforest
Agaricus dulcidulus Schulzer	E1	M	R	BEM5	MG, PE, PR, RJ	Atlantic Rainforest
Agaricus endoxanthus Berk. & Broome	E1	M	N	BEM5	PE, RS, SP	Atlantic Rainforest, Pampa
Agaricus fuscofibrillosus (F.H. Møller) Pilát	E1	L	N	BEM5	PR	Atlantic Rainforest
Agaricus langei (F.H. Møller) F.H. Møller	E1	M	R	BEM5	PR, RS	Atlantic Rainforest
Agaricus litoralis (Wakef. & A. Pearson) Pilát	E1	M	N	BEM5	PR, RS	Pampa, Sand dunes
Agaricus osecanus Pilát	E1	L	N	BEM5	PR	Atlantic Rainforest
Agaricus pampeanus Speg.	E1	S	R	BEM5	RS	
Agaricus porphyrizon P.D. Orton	E1	S	N	BEM5	RS	
Agaricus sylvaticus Schaeff.	E1	M	R	BEM5	MG, PR, RO, RS, SP	Atlantic Rainforest, Amazon Rainforest
Agaricus volvatulus Heinem. & Gooss.-Font.	E1	L	R	BEM5	PR, RJ	Atlantic Rainforest
Agrocybe broadwayi (Murrill) Dennis	E1	S	N	BEM5	SP	Atlantic Rainforest
Agrocybe pediades (Fr.) Fayod	E1	M	N	BEM5	GO, PR, RS	Cerrado
Agrocybe praecox (Pers.) Fayod	E1	S	N	BEM5	RS	Atlantic Rainforest
Agrocybe vervacti (Fr.) Singer	E1	S	N	BEM5	RS	Atlantic Rainforest
Amanita strobiliformis (Paulet ex Vittad.) Bertill.	E1	S	N	BEM5	RS	Atlantic Rainforest
Amylosporus campbellii (Berk.) Ryvarden	E1	L	N	BEM5	PR	Atlantic Rainforest
Apioperdon pyriforme (Schaeff.) Vizzini	E1	M	N	BEM5	MG, PB, PE, PR RS, SP	Atlantic Rainforest
Artomyces pyxidatus (Pers.) Jülich	E1	S	N	BEM5	RS	Atlantic Rainforest
Auricularia auricula-judae (Bull.) Quél.	E1	M	R	BEM5	MT, PA, RJ, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado

Auricularia mesenterica (Dicks.) Pers.	E1	M	N	BEM5	AM, GO, MT, PA, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Auricularia nigricans (Sw.) Birkebak, Looney & Sánchez-García	E1	M	R	BEM5	AM, AP, BA, DF, MG, MT, PA, PB, PE, PR, RN, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Auricularia tenuis (Lév.) Farl.	E1	S	N	BEM5	RJ	Atlantic Rainforest
Bolbitius demangei (Quél.) Sacc. & D. Sacc.	E1	M	N	BEM5	PE, PR	on cattle dung
Bovista aestivalis (Bonord.) Demoulin	E1	M	N	BEM5	PE, PR, SP	Atlantic Rainforest, Caatinga, Cerrado
Bovista longispora Kreisel	E1	L	N	BEM5	PR	Atlantic Rainforest
Bovista pila Berk. & M.A. Curtis	E1	M	N	BEM5	PE, SP	Cerrado, Caatinga
Byssomerulius corium (Pers.) Parmasto	E1	M	N	BEM5	AM, BA, CE, RJ, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Callistosporium luteo-olivaceum (Berk. & M.A. Curtis) Singer	E1	M	N	BEM5	PR, RS, SP	Atlantic Rainforest, Cerrado
Calocera cornea (Batsch) Fr.	E1	M	R	BEM5	AM, DF, GO, PA, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Calocybe gambosa (Fr.) Donk	E1	S	N	BEM5	RS	Atlantic Rainforest
Calocybe ionides (Bull.) Donk	E1	S	N	BEM5	RS	Atlantic Rainforest
Calostoma cinnabarinum Desv.	E1	M	N	BEM5	PE, SP	Cerrado, Caatinga
Calvatia sculpta (Harkn.) Lloyd	E1	M	N	BEM5	RN	Atlantic Rainforest
Cantharellus cibarius Fr.	E1	L	N	BEM5	AM	Amazon Rainforest
Cantharellus cinnabarinus (Schwein.) Schwein.	E1	L	N	BEM5	PR	Atlantic Rainforest
Cerioporus varius (Pers.) Zmitr. & Kovalenk	E1	M	N	BEM5	RS, SP	Atlantic Rainforest
Cerrena hydnoides (Sw.) Zmitr.	E1	M	N	BEM5	AL, AM, BA, ES, MT, PA, PB, PE, PR, RN, RO, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Chalciporus trinitensis (Heinem.) Singer, I.J.A. Aguiar & M.H. Ivory	E1	M	N	BEM5	AM	Amazon Rainforest
Chlorophyllum hortense (Murrill) Vellinga	E1	M	N	BEM5	CE, PB, PR, RS, SP	Atlantic Rainforest, Caatinga, Cerrado
Clavaria argillacea Pers.	E1	S	N	BEM5		Atlantic Rainforest
Clavaria fragilis Holmsk.	E1	M	R	BEM5	PR, RS, SC	Atlantic Rainforest
Clavaria fumosa Pers.	E1	M	N	BEM5	SC	Atlantic Rainforest
Clavaria zollingeri Lév.	E1	M	N	BEM5	MA, PA, PE, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest
Clavulina amethystina (Bull.) Donk	E1	S	N	BEM5	RS	
Clavulina cinerea (Bull.) J. Schröt.	E1	M	R	BEM5	MT, RJ, RS	Atlantic Rainforest, Cerrado

Clavulina coralloides (L.) J. Schröt.	E1	S	R	BEM5	MT, PR, RS, SP	Atlantic Rainforest, Cerrado, Pinus plantation
Clavulina rugosa (Bull.) J. Schröt.	E1	S	N	BEM5	RS	Atlantic Rainforest
Clavulinopsis amoena (Zoll. & Moritzi) Corner	E1	M	N	BEM5	AM, RS, SC	Amazon Rainforest, Atlantic Rainforest
Clavulinopsis corniculata (Schaeff.) Corner	E1	L	N	BEM5	MS, PR, RS	Atlantic Rainforest
Clavulinopsis fusiformis (Sowerby) Corner	E1	S	N	BEM5	RS	Atlantic Rainforest
Clavulinopsis helvola (Pers.) Corner	E1	M	N	BEM5	SC	Atlantic Rainforest
Clitocella popinalis (Fr.) Kluting, T.J. Baroni & Bergemann	E1	S	N	BEM5	RS	
Clitocybe brumalis (Fr.) Quél.	E1	L	N	BEM5	RS	Atlantic Rainforest
Clitocybe catinus (Fr.) Quél.	E1	S	N	BEM5	SP	Atlantic Rainforest
Clitopaxillus alexandri (Gillet) G. Moreno, Vizzini, Consiglio & P. Alvarado	E1	S	N	BEM5	RS	Atlantic Rainforest
Clitopilus caelatus (Fr.) Vila & Contu	E1	L	N	BEM5	PR	Atlantic Rainforest
Clitopilus scyphoides (Fr.) Singer	E1	L	N	BEM5	PR	Atlantic Rainforest
Cookeina speciosa (Fr.) Dennis	E1*	M	N	BEM5	AM, RS	Amazon Rainforest
Coprinellus domesticus (Bolton) Vilgalys, Hopple & Jacq. Johnson	E1	S	N	BEM5	RS	
Coprinopsis brunneofibrillosa (Dennis) Redhead, Vilgalys & Moncalvo	E1	M	N	BEM5	PE	
Coprinopsis cinerea (Schaeff.) Redhead, Vilgalys & Moncalvo	E1	M	R	BEM5	PE, PR, RS	
Coprinopsis radiata (Bolton) Redhead, Vilgalys & Moncalvo	E1	S	N	BEM5	MS	
Coprinopsis tuberosa (Quél.) Doveri, Granito & Lunghini	E1	L	N	BEM5	PR	
Coprinus sterquilinus (Fr.) Fr.	E1	S	N	BEM5	PR, RS	Atlantic Rainforest
Cordyceps militaris (L.) Fr.	E1	L	N	BEM5	PR	Atlantic Rainforest
Cortinarius anomalus (Fr.) Fr.	E1	S	N	BEM5	RS	Atlantic Rainforest
Crepidotus applanatus (Pers.) P. Kumm.	E1	M	N	BEM5	RS, SP	Atlantic Rainforest
Crepidotus mollis (Schaeff.) Staude	E1	M	N	BEM5	RS	Atlantic Rainforest
Cuphophyllus pratensis (Fr.) Bon	E1	L	N	BEM5	PR	Atlantic Rainforest
Cyathus striatus (Huds.) Willd	E1	M	N	BEM5	AL, PB, PE, SP, RS	Atlantic Rainforest, Cerrado
Cyclocybe aegerita (V. Brig.) Vizzini	E1	M	R	BEM5	RS	Atlantic Rainforest

Cyclocybe cylindracea (DC.) Vizzini & Angelini	E1	M	N	BEM5	PR, RS, SP	Atlantic Rainforest
Cystoderma amianthinum (Scop.) Fayod	E1	L	N	BEM5	SP	Atlantic Rainforest
Dacrymyces capitatus Schwein.	E1	S	N	BEM5	AM, RS	Amazon Rainforest, Atlantic Rainforest
Dacrymyces chrysospermus Berk. & M.A. Curtis	E1	M	N	BEM5	DF, PR	Atlantic Rainforest, Cerrado
Dacryopinax spathularia (Schwein.) G.W. Martin	E1	M	R	BEM5	AM, DF, GO, MA, PA, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Daedaleopsis confragosa (Bolton) J. Schröt.	E1	L	N	BEM5	PA	Amazon Rainforest
Daldinia concentrica (Bolton) Ces. & De Not	E1	M	N	BEM5	AM, MA, MS, MT, PB, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado, Pantanal
Dentipellis fragilis (Pers.) Donk	E1	S	N	BEM5	SP	Atlantic Rainforest
Echinochaete brachypora (Mont.) Ryvarden	E1	M	N	BEM5	AL, BA, PB, PR, RS, SC, SP	Atlantic Rainforest, Cerrado
Entoloma lividoalbum (Kühner & Romagn.) Kubička	E1	M	N	BEM5	RJ	Atlantic Rainforest
Fomes fomentarius (L.) Fr.	E1	S	N	BEM5	RS	Atlantic Rainforest
Fulvifomes rimosus (Berk.) Fiasson & Niemelä	E1	M	N	BEM5	BA, ES, MS, PA, PB, PR, RN, RS, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Funalia caperata (Berk.) Zmitr. & Malysheva	E1	M	N	BEM5	AL, AM, AC, AP, BA, ES, MT, PA, PB, PE, PR, RJ, RN, RO, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Funalia floccosa (Jungh.) Zmitr. & Malysheva	E1	M	N	BEM5	AL, AP, BA, PA, PB, PE, PR, RO, RR, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Geastrum fimbriatum Fr.	E1	M	N	BEM5	PA, PB, PE, PI, RJ, RN, RO, RS	Amazon Rainforest, Atlantic Rainforest, Caatinga
Geastrum triplex Jungh.	E1	M	N	BEM5	AM, CE, PA, PB, PE, PR, RN, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Gloeoporus thelephoroides (Hook.) G. Cunn.	E1	M	N	BEM5	MG, MS, MT, PA, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado, Pantanal
Guepinia helvelloides (DC.) Fr.	E1	S	N	BEM5	SP	Atlantic Rainforest
Gymnopus androsaceus (L.) Della Magg. & Trassin.	E1	S	N	BEM5	MS, SP	Atlantic Rainforest, Cerrado
Gymnopus fusipes (Bull.) Gray	E1	S	N	BEM5	RS	Atlantic Rainforest
Gymnopus ocior (Pers.) Antonín & Noordel.	E1	S	N	BEM5	RS	Atlantic Rainforest
Gyrodontium sacchari (Spreng.) Hjortstam	E1	M	N	BEM5		
Helvellosebacina concrescens (Schwein.) Oberw., Garnica & K. Riess	E1	S	N	BEM5	SP	Atlantic Rainforest

Heterobasidion annosum (Fr.) Bref.	E1	S	N	BEM5	BA, SP	Atlantic Rainforest
Hohenbuehelia petaloides (Bull.) Schulzer	E1	S	N	BEM5	PR, RO, RS, SP	Amazon Rainforest, Atlantic Rainforest
Hohenbuehelia serotina (Pers.) Singer	E1	L	N	BEM5	RS	Atlantic Rainforest
Hydropus cavipes (Pat. & Gaillard) Dennis	E1	M	N	BEM5	AM, SP	Amazon Rainforest, Atlantic Rainforest
Hygrocybe cantharellus (Schwein.) Murrill	E1	L	N	BEM5	PR	Atlantic Rainforest
Hygrocybe chlorophana (Fr.) Wünsche	E1	S	N	BEM5	RS	Atlantic Rainforest
Hygrocybe coccinea (Schaeff.) P. Kumm.	E1	L	N	BEM5	SP	Atlantic Rainforest
Hygrocybe flavescens (Kauffman) Singer	E1	L	N	BEM5	PR	Atlantic Rainforest
Hygrocybe miniata (Fr.) P. Kumm.	E1	L	N	BEM5	MA, RS, SP	Amazon Rainforest, Atlantic Rainforest
Hymenopellis radicata (Relhan) R.H. Petersen	E1	S	R	BEM5	PE, PR, RS, SP	Atlantic Rainforest
Inonotus obliquus (Fr.) Pilát	E1*	S	N	BEM5	RS	Atlantic Rainforest
Ischnoderma resinosum (Schrad.) P. Karst.	E1	L	N	BEM5	RO	Amazon Rainforest
Laccaria amethystina Cooke	E1	L	N	BEM5	SC	*Eucalyptus dunnii* plantation, *Pinus taeda* plantation
Laccaria bicolor (Maire) P.D. Orton	E1	L	N	BEM5	SC	*Eucalyptus dunnii* plantation, *Pinus taeda* plantation
Laccaria fraterna (Sacc.) Pegler	E1	S	R	BEM5	PR, RS	Atlantic Rainforest, *Eucalyptus* plantation
Laccaria ohiensis (Mont.) Singer	E1	S	N	BEM5	SP	Atlantic Rainforest
Laccaria proxima (Boud.) Pat.	E1	S	R	BEM5	PR, RS, SC	*Eucalyptus dunnii* plantation, *Pinus taeda* plantation
Laccaria pumila Fayod	E1	L	N	BEM5	SC	*Eucalyptus dunnii* plantation, *Pinus taeda* plantation
Laccaria tetraspora Singer	E1	L	N	BEM5	RS, SC	*Pinus* plantation
Laccaria tortilis (Bolton) Cooke	E1	L	N	BEM5	SC	*Eucalyptus dunnii* plantation, *Pinus taeda* plantation
Lactarius argillaceifolius Hesler & A.H. Sm.	E1	L	N	BEM5	SC	*Pinus* plantation
Lactarius camphoratus (Bull.) Fr.	E1	L	N	BEM5	SC	*Pinus* plantation
Lactarius fuliginosus (Fr.) Fr.	E1	S	N	BEM5	RS	
Lactarius hygrophoroides Berk. & M.A. Curtis	E1	S	N	BEM5	SP	Atlantic Rainforest
Lactocollybia epia (Berk. & Broome) Pegler	E1	M	N	BEM5	PE, PR, RS, SP	Atlantic Rainforest, Pampa
Laetiporus portentosus (Berk.) Rajchenb.	E1	S	N	BEM5	SC	Atlantic Rainforest
Lentinellus ursinus (Fr.) Kühner	E1	M	N	BEM5	RS	Atlantic Rainforest

Lentinus arcularius (Batsch) Zmitr.	E1	M	N	BEM5	PA, PE, PR, MS, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Lentinus badius (Berk.) Berk.	E1	S	N	BEM5	RO, SC, SP	Amazon Rainforest, Atlantic Rainforest
Lentinus brumalis (Pers.) Zmitr.	E1	M	N	BEM5	MG, RS, SP	Atlantic Rainforest
Lentinus fasciatus Berk.	E1	L	N	BEM5	RS	Atlantic Rainforest
Lentinus patulus Lév.	E1	M	N	BEM5	RS	Atlantic Rainforest
Lentinus squarrosulus Mont.	E1	L	N	BEM5	RS	Atlantic Rainforest
Lepiota erminea (Fr.) P. Kumm.	E1	S	N	BEM5	RS	Atlantic Rainforest
Leucoagaricus nympharum (Kalchbr.) Bon	E1	S	N	BEM5	RS	Atlantic Rainforest
Limacella guttata (Pers.) Konrad & Maubl.	E1	S	N	BEM5	PR, SP	Atlantic Rainforest
Lycoperdon marginatum Vittad.	E1	M	N	BEM5	PR, RS, SC, SP	Atlantic Rainforest, Pampa
Lyophyllum decastes (Fr.) Singer	E1	L	N	BEM5	PR	Atlantic Rainforest
Macrolepiota colombiana Franco-Mol.	E1	M	R	BEM5	MT, PR, RS	Atlantic Rainforest
Macrolepiota dolichaula (Berk. & Broome) Pegler & R.W. Rayner	E1	M	R	BEM5	SP	Atlantic Rainforest
Macrolepiota excoriata (Schaeff.) Wasser	E1	M	N	BEM5	RS	Atlantic Rainforest
Macrolepiota kerandi (Speg.) Singer	E1	M	R	BEM5	RS	
Macrolepiota mastoidea (Fr.) Singer	E1	M	R	BEM5	MG, RS, SP	Atlantic Rainforest
Macrolepiota zeyheri Heinem.	E1	L	N	BEM5	RS	Atlantic Rainforest
Marasmiellus confluens (Pers.) J.S. Oliveira	E1	S	N	BEM5	RO, RS	Amazon Rainforest, Atlantic Rainforest
Marasmiellus luxurians (Peck) J.S. Oliveira	E1	L	N	BEM5	PR	Atlantic Rainforest
Marasmiellus ramealis (Bull.) Singer	E1	L	N	BEM5	PR	Atlantic Rainforest
Marasmius arborescens (Henn.) Beeli	E1	L	N	BEM5	SP	Atlantic Rainforest
Marasmius cohaerens (Pers.) Cooke & Quél.	E1	S	N	BEM5	RS	Atlantic Rainforest
Marasmius personatus Berk. & M.A. Curtis	E1	S	N	BEM5	RS	Atlantic Rainforest
Melanoleuca grammopodia (Bull.) Murrill	E1	S	N	BEM5	RS	Atlantic Rainforest
Melanoleuca melaleuca (Pers.) Murrill	E1	M	N	BEM5	SP	Atlantic Rainforest
Microporus affinis (Blume & T. Nees) Kuntze	E1	S	N	BEM5	BA, RS	Atlantic Rainforest
Microporus xanthopus (Fr.) Kuntze	E1	S	N	BEM5	RS	Atlantic Rainforest
Micropsalliota brunneosperma (Singer) Pegler	E1	M	N	BEM5	PE	Atlantic Rainforest
Mucidula mucida (Schrad.) Pat.	E1	S	N	BEM5	RS	Atlantic Rainforest

Multiclavula mucida (Pers.) R.H. Petersen	E1	L	N	BEM5	RS	
Mycena galericulata (Scop.) Gray	E1	S	N	BEM5	RS	Atlantic Rainforest
Mycena galopus (Pers.) P. Kumm.	E1	L	N	BEM5	SP	Atlantic Rainforest
Mycoleptodonoides aitchisonii (Berk.) Maas Geest.	E1	L	N	BEM5	SP	Atlantic Rainforest
Naucoria aureobrunnea (Berk. & M.A. Curtis) Cout.	E1	L	N	BEM5	SP	Atlantic Rainforest
Neoclitocybe byssiseda (Bres.) Singer	E1	M	N	BEM5	AM, PR, RS	Amazon Rainforest, Atlantic Rainforest
Neofavolus alveolaris (DC.) Sotome & T. Hatt.	E1	M	R	BEM5	RS	Atlantic Rainforest
Neonothopanus hygrophanus (Mont.) De Kesel & Degreef	E1	L	N	BEM5	MS, PR	Atlantic Rainforest, Pantanal
Nothopanus eugrammus (Mont.) Singer	E1	M	N	BEM5	SP	Atlantic Rainforest
Pachyma cocos (Schwein.) Fr.	E1	L	N	BEM5	AP	Amazon Rainforest
Panaeolus antillarum (Fr.) Dennis	E1	M	N	BEM5	GO, PE, PR, RJ, RS, SC, SP	Atlantic Rainforest, Cerrado
Panus conchatus (Bull.) Fr.	E1	L	N	BEM5	SP	Atlantic Rainforest
Panus similis (Berk. & Broome) T.W. May & A.E. Wood	E1	M	N	BEM5	AM, PR, RS	Amazon Rainforest, Atlantic Rainforest
Parasola conopilea (Fr.) Örstadius & E. Larss.	E1	S	N	BEM5	RS	Atlantic Rainforest
Parasola plicatilis (Curtis) Redhead, Vilgalys & Hopple	E1	M	N	BEM5	CE, MG, PE, PI, RJ, RO, RS, SP	Amazon Rainforest, Atlantic Rainforest
Parmotrema austrosinense (Zahlbr.) Hale	E1	M	N	BEM5	PR, RS, SE, SP	Atlantic Rainforest
Phaeoclavulina abietina (Pers.) Giachini	E1	S	N	BEM5	SP	
Phaeoclavulina cyanocephala (Berk. & M.A. Curtis) Giachini	E1	M	N	BEM5	PR, RJ	Atlantic Rainforest
Phaeoclavulina flaccida (Fr.) Giachini	E1	S	N	BEM5		
Phaeoclavulina ochracea (Bres.) Giachini	E1	S	N	BEM5	RS	
Phaeolus schweinitzii (Fr.) Pat.	E1	L	N	BEM5	AC	Amazon Rainforest
Phaeotremella foliacea (Pers.) Wedin, J.C. Zamora & Millanes	E1	M	R	BEM5	PR, RS	Atlantic Rainforest
Phallus merulinus (Berk.) Cooke	E1	L	N	BEM5	AM	Amazon Rainforest
Phellinus igniarius (L.) Quél.	E1	M	N	BEM5	RS, SP	Atlantic Rainforest
Phlebopus portentosus (Berk. & Broome) Boedijn	E1	M	N	BEM5	PB	Atlantic Rainforest
Pholiota adiposa (Batsch) P. Kumm.	E1	S	N	BEM5	RS	Atlantic Rainforest
Pholiota gummosa (Lasch) Singer	E1	M	N	BEM5	SP	Atlantic Rainforest

Pholiota spumosa (Fr.) Singer	E1	M	N	BEM5	RS, SP	Atlantic Rainforest
Picipes badius (Pers.) Zmitr. & Kovalenko	E1	S	N	BEM5	RS	Atlantic Rainforest
Pleurotus cornucopiae (Paulet) Rolland	E1	M	R	BEM5	RS	Atlantic Rainforest
Pleurotus cystidiosus O.K. Mill.	E1	M	R	BEM5	RS	
Pleurotus dryinus (Pers.) P. Kumm.	E1	M	N	BEM5	RS	
Pleurotus eryngii (DC.) Quél.	E1	S	R	BEM5	MS	Cerrado
Pleurotus floridanus Singer	E1	L	N	BEM5	PR	Atlantic Rainforest
Pleurotus opuntiae (Durieu & Lév.) Sacc.	E1	L	N	BEM5	AP	Atlantic Rainforest
Pluteus cervinus (Schaeff.) P. Kumm.	E1	M	N	BEM5	PR, RS	Atlantic Rainforest
Podoscypha venustula (Speg.) D.A. Reid	E1	S	N	BEM5	PR, RS	Atlantic Rainforest
Postia caesia (Schrad.) P. Karst.	E1	L	N	BEM5	SP	Atlantic Rainforest
Psathyrella candolleana (Fr.) Maire	E1	M	N	BEM5	PR, RS	Atlantic Rainforest, Pampa
Psathyrella coprinoceps (Berk. & M.A. Curtis) Dennis	E1	M	N	BEM5	RS, SP	Atlantic Rainforest
Psathyrella spadiceogrisea (Schaeff.) Maire	E1	S	N	BEM5	RS	Atlantic Rainforest
Psathyrella tuberculata (Pat.) A.H. Sm.	E1	M	N	BEM5		Caatinga
Pseudogymnopilus pampeanus (Speg.) Raithelh.	E1	M	N	BEM5	PR, RS, SP	Atlantic Rainforest
Pseudohydnum gelatinosum (Scop.) P. Karst.	E1	M	R	BEM5	PA, SP	Amazon Rainforest
Psilocybe zapotecorum R. Heim	E1	M	R	BEM5	MT, PR, RS, SP	Atlantic Rainforest, Pantanal
Punctularia strigosozonata (Schwein.) P.H.B. Talbot	E1	L	N	BEM5	PE	Atlantic Rainforest
Pycnoporus cinnabarinus (Jacq.) P. Karst.	E1	L	N	BEM5	SP	Atlantic Rainforest
Ramalina ecklonii (Spreng.) Meyen & Flot.	E1	L	N	BEM5	PR	
Ramaria concolor (Corner) R.H. Petersen	E1	S	N	BEM5	RJ, RS	
Ramaria stricta (Pers.) Quél.	E1	S	N	BEM5	RS	
Ramariopsis kunzei (Fr.) Corner	E1	M	N	BEM5	MA, PR, SC, RS	Amazon Rainforest, Atlantic Rainforest
Ramariopsis pulchella (Boud.) Corner	E1	S	N	BEM5	RJ	
Rhizopogon luteolus Fr.	E1	M	N	BEM5	SP	Cerrado, *Pinus* plantation
Rhodocollybia butyracea (Bull.) Lennox	E1	S	N	BEM5	RS	Atlantic Rainforest
Rhodocollybia maculata (Alb. & Schwein.) Singer	E1	L	N	BEM5	PR	Atlantic Rainforest
Rhodocollybia prolixa (Fr.) Antonín & Noordel.	E1	S	N	BEM5	RS	Atlantic Rainforest

Rickiella edulis (Speg.) Pfister	E1	M	R	BEM5	RS, SP	Atlantic Rainforest
Russula consobrina (Fr.) Fr.	E1	S	N	BEM5	PR, RS, SP	*Pinus* plantation
Russula risigallina (Batsch) Sacc.	E1	S	R	BEM5	RS, SP	Atlantic Rainforest, Cerrado
Russula velenovskyi Melzer & Zvára	E1	L	N	BEM5	PR	
Russula xerampelina (Schaeff.) Fr.	E1	L	N	BEM5	RS	
Scutellinia scutellata (L.) Lambotte	E1	M	N	BEM5	PR, RS, SC	Atlantic Rainforest
Sebacina schweinitzii (Peck) Oberw.	E1	S	N	BEM5	AM	Amazon Rainforest
Stereopsis hiscens (Berk. & Ravenel) D.A. Reid	E1	M	N	BEM5	AM, PR, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Tetrapyrgos alba (Berk. & M.A. Curtis) E. Horak	E1	S	N	BEM5	PR, RJ, RS, SP	Atlantic Rainforest
Thamnomyces chordalis Fr.	E1	M	N	BEM5	AM, RR	Amazon Rainforest
Thelephora vialis Schwein.	E1	M	N	BEM5	SP	Atlantic Rainforest
Trametes cubensis (Mont.) Sacc.	E1	M	R	BEM5	AP, BA, MS, MT, PA, PE, PR, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Pantanal
Tremella aurantia Schwein.	E1	M	N	BEM5	PR, SP	Atlantic Rainforest
Tremellodendropsis tuberosa (Grev.) D.A. Crawford	E1	S	N	BEM5	PR	Atlantic Rainforest
Trichaptum perrottetii (Lév.) Ryvarden	E1	M	R	BEM5	AP, BA, MS, MT, PA, PB, PE, PR, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado, Pantanal
Tricholoma atrosquamosum Sacc.	E1	L	N	BEM5	PR	
Tricholoma evenosum (Sacc.) Rea	E1	M	N	BEM5	SP	Atlantic Rainforest
Tricholoma vaccinum (Schaeff.) P. Kumm.	E1	S	N	BEM5	RS	Atlantic Rainforest
Tricholomopsis aurea (Beeli) Desjardin & B.A. Perry	E1	S	N	BEM5	PA, PR, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Tropicoporus linteus (Berk. & M.A. Curtis) L.W. Zhou & Y.C. Dai	E1	M	N	BEM5	AP, PA, PE, PR, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Vascellum intermedium A.H. Sm.	E1	M	N	BEM5	SP	Atlantic Rainforest
Volvariella taylorii (Berk. & Broome) Singer	E1	S	N	BEM5	PR, RS, SP	Atlantic Rainforest
Volvariella volvacea (Bull.) Singer	E1	M	R	BEM5	PR, RJ, RS	Atlantic Rainforest
Volvopluteus earlei (Murrill) Vizzini, Contu & Justo	E1	M	N	BEM5	PR	Atlantic Rainforest, Caatinga
Wynnea americana Thaxt.	E1	S	N	BEM5	RS	
Xeromphalina campanella (Batsch) Kühner & Maire	E1	L	N	BEM5	AM	Amazon Rainforest
Xeromphalina tenuipes (Schwein.) A.H. Sm.	E1	M	N	BEM5	ES, MG, PR, RJ, RS, SP	Atlantic Rainforest

Xerula pudens (Pers.) Singer	E1	L	N	BEM5	RS	Atlantic Rainforest
Xylaria polymorpha (Pers.) Grev.	E1	M	N	BEM5	AM, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Zhuliangomyces illinitus (Fr.) Redhead	E1	L	N	BEM5	PR	Atlantic Rainforest
Agaricus abruptibulbus Peck	E2	M	N	BEM6	RS	Atlantic Rainforest
Agaricus arvensis Schaeff.	E2	S	R	BEM6	PR, RS	Atlantic Rainforest
Agaricus subrutilescens (Kauffman) Hotson & D.E. Stuntz	E2	M	N	BEM6	SC	*Pinus* plantation
Agaricus sylvicola (Vittad.) Peck	E2	M	R	BEM6	PR, RS	Atlantic Rainforest
Aleuria aurantia (Pers.) Fuckel	E2	S	R	BEM6	RS	
Amanita excelsa (Fr.) Bertill.	E2	S	N	BEM6	RS	Atlantic Rainforest
Armillaria mellea (Vahl) P. Kumm.	E2	L	N	BEM6	RS, SP	Atlantic Rainforest
Bovista plumbea Pers.	E2	M	N	BEM6	PE, SP	Cerrado, Atlantic Rainforest
Bovista pusilla (Batsch) Pers.	E2	M	N	BEM6	PE, RS	Atlantic Rainforest
Calvatia fragilis (Quél.) Morgan	E2	M	R	BEM6	PR, RS, RJ, SP	Atlantic Rainforest, Cerrado, Pampa
Cerioporus squamosus (Huds.) Quél	E2	S	N	BEM6	BA, PR, SP	Atlantic Rainforest
Chlorophyllum rhacodes (Vittad.) Vellinga	E2	M	R	BEM6	MS, RS	Cerrado, Pampa
Clitocybe nebularis (Batsch) P. Kumm.	E2	S	N	BEM6	RS	Atlantic Rainforest, Pampa
Coprinellus micaceus (Bull.) Vilgalys, Hopple & Jacq. Johnson	E2	S	R	BEM6	MS, PR, RS	Atlantic Rainforest, Cerrado
Coprinopsis acuminata (Romagn.) Redhead, Vilgalys & Moncalvo	E2	L	N	BEM6	PR	
Coprinopsis atramentaria (Bull.) Redhead, Vilgalys & Moncalvo	E2	S	N	BEM6	RS	
Coprinopsis picacea (Bull.) Redhead, Vilgalys & Moncalvo	E2	S	N	BEM6	RS	
Fistulina hepatica (Schaeff.) With.	E2	M	N	BEM6	SC	Atlantic Rainforest
Gymnopus dryophilus (Bull.) Murrill	E2	S	N	BEM6	PE, RS	Atlantic Rainforest
Hebeloma mesophaeum (Pers.) Quél.	E2	S	N	BEM6	RS	Atlantic Rainforest
Hygrocybe nigrescens (Quél.) Kühner	E2	M	N	BEM6	PR, RN, SP	Atlantic Rainforest
Infundibulicybe gibba (Pers.) Harmaja	E2	L	N	BEM6	SP	Atlantic Rainforest
Lepista nuda (Bull.) Cooke	E2	S	R	BEM6	RS, SP	Atlantic Rainforest
Leucoagaricus americanus (Peck) Vellinga	E2	M	N	BEM6	RJ	Atlantic Rainforest, Caatinga
Lycoperdon lividum Pers.	E2	M	N	BEM6	RS	Atlantic Rainforest

Lycoperdon perlatum Pers.	E2	M	N	BEM6	PE, PR, SP, RS	Atlantic Rainforest, Cerrado, Pampa
Lycoperdon pratense Pers.	E2	M	N	BEM6	RS, SP	Atlantic Rainforest, Pampa
Mycena pura (Pers.) P. Kumm.	E2	M	N	BEM6	AM, MS, PR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Mycenastrum corium (Guers.) Desv.	E2	S	N	BEM6	RS	
Paxillus involutus (Batsch) Fr.	E2	S	N	BEM6	RS	Atlantic Rainforest
Phaeolepiota aurea (Matt.) Maire	E2	M	N	BEM6	RS, SP	Atlantic Rainforest
Phallus impudicus L.	E2	S	N	BEM6	RS	
Pisolithus arhizus (Scop.) Rauschert	E2	M	N	BEM6	ES, RS, SP	Atlantic Rainforest, Pampa, Pecan plantation
Podaxis pistillaris (L.) Fr.	E2	M	N	BEM6	CE, PB, PE, PI, RN, RS, SP	Atlantic Rainforest, Caatinga, Cerrado, Pampa
Polyporus tuberaster (Jacq. ex Pers.) Fr.	E2	S	N	BEM6	RS, SC	Atlantic Rainforest
Polyporus umbellatus (Pers.) Fr.	E2	S	N	BEM6	RS	Atlantic Rainforest
Protostropharia semiglobata (Batsch) Redhead, Moncalvo & Vilgalys	E2	M	N	BEM6	PR, RS, SP	Atlantic Rainforest
Psathyrella atroumbonata Pegler	E2	L	N	BEM6	SP	Atlantic Rainforest
Psathyrella piluliformis (Bull.) P.D. Orton	E2	S	N	BEM6	RS, SP	Atlantic Rainforest
Ramaria flava (Schaeff.) Quél.	E2	S	N	BEM6	RS	
Rhizopogon roseolus (Corda) Th. Fr	E2	M	N	BEM6	PR, RS, SC, SP	Atlantic Rainforest, Cerrado, Pampa, *Pinus* plantation
Russula foetens Pers.	E2	L	N	BEM6	SP	Atlantic Rainforest
Stropharia aeruginosa (Curtis) Quél.	E2	M	N	BEM6	RS	Atlantic Rainforest
Tremella mesenterica Retz.	E2	M	R	BEM6	SC, SP, RS	Atlantic Rainforest
Agaricus martineziensis Heinem.	E3	D	R	BEM7	RS, SP	Atlantic Rainforest
Agrocybe perfecta (Rick) Singer	E3	T(S)	R	BEM7	PR, RS, SP,	Atlantic Rainforest
Amanita dulciodora C.C. Nascimento, Sá & Wartchow	E3*	T(M)	R	BEM7	BA	Atlantic Rainforest
Amauroderma aurantiacum (Torrend) Gibertoni & Bernicchia	E3	T(D)	R	BEM7	DF, GO, MT, PA, PR, RO, SE, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Clathrus columnatus Bosc	E3	D	N	BEM7	CE, PB, PR, RJ, RS, SC, SP	Atlantic Rainforest, Caatinga, Pampa
Fomitiporella umbrinella (Bres.) Murrill	E3	T(D)	N	BEM7	AL, PA, PE, PR, RN, RO, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest
Ganoderma orbiforme (Fr.) Ryvarden	E3	D	N	BEM7	PB, PE, PR, SP	Atlantic Rainforest, Caatinga

Geastrum saccatum Fr.	E3	T(M)	N	BEM7	AM, PA, PB, PE, PR, RN, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado, Pampa
Grammothele fuligo (Berk. & Broome) Ryvarden	E3	D◊	N	BEM7	RO, SC	Amazon Rainforest, Atlantic Rainforest
Hygrocybe arnoldsii de Meijer	E3	T(M)	N	BEM7	PR, RS	Atlantic Rainforest
Hymenochaete damicornis (Link) Lév.	E3	T(M)	N	BEM7	AL, BA, PA, PB, PE, PI, PR, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado, Pampa
Hysterangium atlanticum Sulzbacher et al.	E3	T(D)	R	BEM7	PB	Atlantic Rainforest
Lactarius taedae Silva-Filho, Sulzbacher & Wartchow	E3*	T(D)	R	BEM7	RS	*Pinus* plantation
Polyporus pes-simiae Berk.	E3*	T(S)	R	BEM7	AM	Amazon Rainforest
Porodisculus pendulus (Fr.) Murrill	E3	D	N	BEM7	SP	Atlantic Rainforest
Rigidoporus microporus (Sw.) Overeem	E3	D	N	BEM7	AC, AM, AP, BA, PA, PB, PE, PR, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Trametes hirsuta (Wulfen) Lloyd	E3	D	N	BEM7	RS, SC, SP	Atlantic Rainforest
Trechispora thelephora (Lév.) Ryvarden	E3*	D	N	BEM7	AL, AM, BA, MG, PA, PB, PE, PR, RN, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest
Abortiporus biennis (Bull.) Singer	E3	M	N	BEM8	PR, RS, SP	Atlantic Rainforest
Agaricus argentinus Speg.	E3	M	R	BEM8	RS	Atlantic Rainforest
Amauroderma subrugosum (Bres. & Pat.) Torrend	E3	L	N	BEM8	PA	Amazon Rainforest
Antrodia heteromorpha (Fr.) Donk	E3	M	N	BEM8	ES, PE, PR, RS, SC, SP	Atlantic Rainforest
Bjerkandera adusta (Willd.) P. Karst.	E3	M	N	BEM8	BA, PR, RS, SC, SP	Atlantic Rainforest
Bolbitius reticulatus (Pers.) Ricken	E3	L	N	BEM8	RS	
Brunneoporus malicola (Berk. & M.A. Curtis) Audet	E3	S	N	BEM8	PR, RS, SP	Atlantic Rainforest
Calvatia rugosa (Berk. & M.A. Curtis) D.A. Reid	E3	M	N	BEM8	PR, RJ, RS, SC, SP	Atlantic Rainforest, Pampa
Campanella junghuhnii (Mont.) Singer	E3	S	N	BEM8	RS	Atlantic Rainforest
Cerioporus mollis (Sommerf.) Zmitr. & Kovalenko	E3	M	N	BEM8	AC, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Cerrena unicolor (Bull.) Murrill	E3	S	N	BEM8	RS	Atlantic Rainforest
Chlorociboria aeruginascens (Nyl.) Kanouse ex C.S. Ramamurthi, Korf & L.R. Batra	E3	M	N	BEM8	PR, RS, SC	Atlantic Rainforest
Chlorociboria aeruginosa (Oeder) Seaver ex C.S.	E3	M	N	BEM8	PR, RS, SC	Atlantic Rainforest

Ramamurthi, Korf & L.R. Batra						
Coltricia cinnamomea (Jacq.) Murrill	E3	S	N	BEM8	AM, PA, PB, PE, PR, RJ, RS, SE	Amazon Rainforest, Atlantic Rainforest
Coprinopsis friesii (Quél.) P. Karst.	E3	S	N	BEM8	RS	
Coprinopsis lagopus (Fr.) Redhead, Vilgalys & Moncalvo	E3	M	N	BEM8	PE, PR, RS	Atlantic Rainforest
Cordyceps farinosa (Holmsk.) Kepler, B. Shrestha & Spatafora	E3	S	N	BEM8	AM, BA, DF, GO, PA, PE, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Corticium roseocarneum (Schwein.) Hjortstam	E3	S	N	BEM8	SC	Atlantic Rainforest
Crinipellis scabella (Alb. & Schwein.) Murrill	E3	S	N	BEM8	RS	Atlantic Rainforest
Crucibulum laeve (Huds.) Kambly	E3	M	N	BEM8	RS, SP	Atlantic Rainforest, Cerrado
Cyathus stercoreus (Schwein.) De Toni	E3	M	N	BEM8	MS, PR, RS, SP	Atlantic Rainforest, Cerrado, Pantanal
Cymatoderma elegans Jungh.	E3	M	N	BEM8	MS	Atlantic Rainforest
Cyptotrama asprata (Berk.) Redhead & Ginns	E3	S	N	BEM8	PR, SP	Atlantic Rainforest
Dacryopinax elegans (Berk. & M.A. Curtis) G.W. Martin	E3	M	R	BEM8	AM, DF, GO, PR, RJ, RS, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Donkia pulcherrima (Berk. & M.A. Curtis) Pilát	E3	M	N	BEM8	PA, PB, PE, PR, RO, RS, SP	Atlantic Rainforest
Earliella scabrosa (Pers.) Gilb. & Ryvarden	E3	M	N	BEM8	AC, AL, AP, AM, BA, PA, PB, PE, PR, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Entoloma conferendum (Britzelm.) Noordel.	E3	L	N	BEM8	PR	Atlantic Rainforest
Entoloma virescens (Sacc.) E. Horak ex Courtec.	E3	M	N	BEM8	CE, SP	Atlantic Rainforest, Caatinga
Fomitiporia punctata (P. Karst.) Murrill	E3	M	N	BEM8	AP, PA, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest
Funalia aspera (Jungh.) Zmitr. & Malysheva	E3	S	N	BEM8	MG, RS, SC, SP	Atlantic Rainforest
Fuscoporia gilva (Schwein.) T. Wagner & M. Fisch.	E3	M	N	BEM8	AC, AL, AM, AP, BA, ES, MS, MT, PA, PB, PE, PR, RJ, RN, RO, RR, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado, Pampa, Pantanal
Fuscoporia wahlbergii (Fr.) T. Wagner & M. Fisch.	E3	M	N	BEM8	BA, PR, RJ, RS, SC, SP	Atlantic Rainforest
Ganoderma applanatum (Pers.) Pat.	E3	M	N	BEM8	AL, AP, BA, ES, PA, PB, PE, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest
Ganoderma lucidum (Curtis) P. Karst.	E3	M	N	BEM8	AP, BA, ES, MS, MT, PA, PE, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Pantanal
Ganoderma resinaceum Boud.	E3	M	N	BEM8	AL, PB, PE, PR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Geastrum javanicum Lév.	E3	M	N	BEM8	CE, MG, PB, PE, PR, RJ, RN	Atlantic Rainforest, Caatinga

Geastrum pectinatum Pers.	E3	M	N	BEM8	CE, PB, PR, RN, RS, SP,	Atlantic Rainforest, Caatinga
Gloeophyllum trabeum (Pers.) Murrill	E3	S	N	BEM8	BA, RS	Atlantic Rainforest
Hapalopilus croceus (Pers.) Donk	E3	S	N	BEM8	RS	Atlantic Rainforest
Holwaya mucida (Schulzer) Korf & Abawi	E3	L	N	BEM8	AM, CE, PA	Amazon Rainforest
Hydnophlebia chrysorhiza (Eaton) Parmasto	E3	L	N	BEM8	PA, PE, RS	Atlantic Rainforest
Hymenochaete microcycla (Zipp. ex Lév.) Spirin & Miettinen	E3	M	N	BEM8	MT, PE, RJ, RS, SC, SP	Atlantic Rainforest
Hymenochaete mougeotii (Fr.) Cooke	E3	L	N	BEM8	RS	Atlantic Rainforest
Hymenochaete rubiginosa (Dicks.) Lév.	E3	L	N	BEM8	RS	Atlantic Rainforest
Inflatostereum glabrum (Pat.) D.A. Reid	E3	M	N	BEM8	AM, MA, PA	Amazon Rainforest
Inonotus hispidus (Bull.) P. Karst.	E3	S	N	BEM8	RS	Atlantic Rainforest
Junghuhnia nitida (Pers.) Ryvarden	E3	M	N	BEM8	Al, PR, RS, SP	Atlantic Rainforest
Lepiota lilacea Bres.	E3	M	N	BEM8	RJ, SP	Atlantic Rainforest
Leucoagaricus rubrotinctus (Peck) Singer	E3	M	N	BEM8	MG, PE, PR, RO, RS	Amazon Rainforest, Atlantic Rainforest, Caatinga
Leucocoprinus fragilissimus (Ravenel ex Berk. & M.A. Curtis) Pat.	E3	M	N	BEM8	AL, AM, CE, PB, PE, PR, RO, RS, SP	Amazon Rainforest, Atlantic Rainforest
Lopharia cinerascens (Schwein.) G. Cunn.	E3	M	N	BEM8	AL, PA, PB, PE, PI, PR, RJ, RN, RO, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga
Marasmiellus candidus (Fr.) Singer	E3	S	N	BEM8	SP	Atlantic Rainforest
Marasmius graminum (Libert) Berk. & Br.	E3	L	N	BEM8	PR	Atlantic Rainforest
Mensularia radiata (Sowerby) Lázaro Ibiza	E3	S	N	BEM8	RS	Atlantic Rainforest
Multiclavula clara (Berk. & M.A. Curtis) R.H. Petersen	E3	L	N	BEM8	RS	
Mycena acicula (Schaeff.) P. Kumm.	E3	S	N	BEM8	CE, SP	Atlantic Rainforest, Caatinga
Mycena chlorophos (Berk. & M.A. Curtis) Sacc.	E3	M	N	BEM8	AM, PR, RJ	Amazon Rainforest, Atlantic Rainforest
Mycena epipterygia (Scop.) Gray	E3	S	N	BEM8	RS	Atlantic Rainforest
Mycena filopes (Bull.) P. Kumm.	E3	L	N	BEM8	RS	*Pinus* plantation
Mycena leaiana (Berk.) Sacc.	E3	S	N	BEM8	AM, SP, RS	Amazon Rainforest, Atlantic Rainforest, Cerrado
Mycena sanguinolenta (Alb. & Schwein.) P. Kumm.	E3	S	N	BEM8	RS	Atlantic Rainforest
Nigrofomes melanoporus (Mont.) Murrill	E3	S	N	BEM8	AL, BA, PB, PE, PR, SP	Atlantic Rainforest

Nigroporus vinosus (Berk.) Murrill	E3	L	N	BEM8	AC, MT, PE, PB, RN, RO, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Ophiocordyceps entomorrhiza (Dicks.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora	E3	L	N	BEM8	SC	
Ophiocordyceps nutans (Pat.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora	E3	L	N	BEM8	PR	Atlantic Rainforest
Oxyporus populinus (Schumach.) Donk	E3	S	N	BEM8	PR, RS	Atlantic Rainforest
Panaeolus solidipes (Peck) Sacc.	E3	S	N	BEM8	RS	Atlantic Rainforest
Panellus pusillus (Pers. ex Lév.) Burds. & O.K. Mill.	E3	M	N	BEM8	AM, BA, PE, PR, SC, SP, RS	Amazon Rainforest, Atlantic Rainforest, Cerrado
Parasola leiocephala (P.D. Orton) Redhead, Vilgalys & Hopple	E3	M	N	BEM8	Northeast, PR	Atlantic Rainforest, Caatinga
Peniophorella odontiiformis (Boidin & Berthier) K.H. Larss.	E3	M	N	BEM8	CE, PB, PE, PI, RS, SC, SP	Atlantic Rainforest, Cerrado
Phaeocollybia christinae (Fr.) R. Heim	E3	L	N	BEM8	RS	
Phanerochaete sordida (P. Karst.) J. Erikss. & Ryvarden	E3	M	N	BEM8	MG, PR, RR, RS, SP	Amazon Rainforest, Atlantic Rainforest, *Pinus* plantation
Phellinopsis conchata (Pers.) Y.C. Daí	E3	S	N	BEM8	PR	Atlantic Rainforest
Phlebia tremellosa (Schrad.) Nakasone & Burds.	E3	L	N	BEM8	PR, RS, SC	Atlantic Rainforest
Phlebiopsis crassa (Lév.) Floudas & Hibbett	E3	M	N	BEM8	CE, PE, PI, RN, SC, SP	Atlantic Rainforest
Pleurotus columbinus Quél.	E3	S	N	BEM8	RS	Atlantic Rainforest
Pluteus thomsonii (Berk. & Broome) Dennis	E3	M	N	BEM8	PR, RS	Atlantic Rainforest
Polyporus rugulosus Lév.	E3	S	N	BEM8	AP	Amazon Rainforest
Porogramme epimiltina (Berk. & Broome) Y.C. Dai, W.L. Mao & Yuan Yuan	E3	S	N	BEM8	PA, SC	Amazon Rainforest, Atlantic Rainforest
Poronidulus conchifer (Schwein.) Murrill	E3	L	N	BEM8	AP	Amazon Rainforest
Pterula subulata Fr.	E3	S	N	BEM8	RJ, RS	
Purpureocillium atypicola (Yasuda) Spatafora, Hywel-Jones & Luangsa-ard	E3	L	N	BEM8	PA	Amazon Rainforest
Rickenella fibula (Bull.) Raithelh.	E3	L	N	BEM8	RS	Pampa
Rigidoporus lineatus (Pers.) Ryvarden	E3	M	N	BEM8	AL, AP, BA, PB, PE, PR, RS, SC	Amazon Rainforest, Atlantic Rainforest, Cerrado
Scytinostroma odoratum (Fr.) Donk	E3	L	N	BEM8	RR	Amazon Rainforest
Sphaerobolus stellatus Tode	E3	M	N	BEM8	RS, SP	Atlantic Rainforest, Cerrado, Pampa
Steccherinum ochraceum (Pers. ex J.F. Gmel.) Gray	E3	S	N	BEM8	PE, PR, RO, SC, SP	Amazon Rainforest, Atlantic Rainforest

Stereum hirsutum (Willd.) Pers.	E3	M	N	BEM8	PA, PR, RS, SP	Amazon Rainforest, Atlantic Rainforest
Stereum ostrea (Blume & T. Nees) Fr.	E3	M	N	BEM8	AM, AL, BA, MS, MT, PA, PB, PE, PR, RJ, RN, RR, RS, SC, SE, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado, Pantanal
Stereum sanguinolentum (Alb. & Schwein.) Fr.	E3	S	N	BEM8	RS	Atlantic Rainforest
Thelephora palmata (Scop.) Fr.	E3	M	N	BEM8	PR, SC	Atlantic Rainforest
Trametes pubescens (Schumach.) Pilát	E3	S	N	BEM8	AC, RS	Amazon Rainforest, Atlantic Rainforest
Trametes trogii Berk.	E3	L	N	BEM8	SP	Atlantic Rainforest
Trametes vernicipes (Berk.) Zmitr., Wasser & Ezhov	E3	S	N	BEM8	RS	Atlantic Rainforest
Trechispora mollusca (Pers.) Liberta	E3	M	N	BEM8	RS, SC	Atlantic Rainforest
Trichaptum abietinum (Pers. ex J.F. Gmel.) Ryvarden	E3	M	N	BEM8	PE, RS, SC, SP	Atlantic Rainforest
Trichaptum biforme (Fr.) Ryvarden	E3	M	N	BEM8	BA, PE, RS, SP	Atlantic Rainforest, Caatinga
Trichocoma paradoxa Jungh.	E3	M	N	BEM8	MG, RS	Atlantic Rainforest
Trichoglossum hirsutum (Pers.) Boud.	E3	M	N	BEM8	GO, PE, PR, RS	Atlantic Rainforest, Cerrado
Trichoglossum walteri (Berk.) E.J. Durand	E3	M	N	BEM8	SC	Atlantic Rainforest
Truncospora ochroleuca (Berk.) Pilát	E3	S	N	BEM8	RS, SC	Atlantic Rainforest
Truncospora tephropora (Mont.) Zmitr.	E3	M	N	BEM8	BA, PA, MT, SC, Northeast	Amazon Rainforest, Atlantic Rainforest, Caatinga
Typhula juncea (Alb. & Schwein.) P. Karst.	E3	S	N	BEM8	PR, RS	Atlantic Rainforest
Vitreoporus dichrous (Fr.) Zmitr.	E3	S	N	BEM8	AL, AM, MG, PE, PR, RJ, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Caatinga, Cerrado
Xylobolus frustulatus (Pers.) P. Karst.	E3	M	N	BEM8	AL, RJ, SP	Atlantic Rainforest
Xylodon flaviporus (Berk. & M.A. Curtis ex Cooke) Riebesehl & Langer	E3	M	N	BEM8	AL, PB, PE, PR, RN, SC, SP	Amazon Rainforest, Atlantic Rainforest, *Pinus* plantation
Wynnea gigantea Berk. & M.A. Curtis	U	D	N	BEM9	RS	Atlantic Rainforest
Astraeus hygrometricus (Pers.) Morgan	U	M	N	BEM10	PB, PE, ES	Atlantic Rainforest, Caatinga
Boletellus ananas (M.A. Curtis) Murrill	U	M	N	BEM10	AM	Amazon Rainforest
Clitocybe dealbata (Sowerby) P. Kumm.	U	S	N	BEM10	RS	Atlantic Rainforest, Pampa
Clitocybe phyllophila (Pers.) P. Kumm.	U	S	N	BEM10	RS	Atlantic Rainforest
Echinoderma asperum (Pers.) Bon	U	S	N	BEM10	RS	Atlantic Rainforest
Entoloma bloxamii (Berk. & Broome) Sacc.	U	M	N	BEM10	PB, PR	Atlantic Rainforest
Exidia glandulosa (Bull.) Fr.	U	M	N	BEM10	PR	Atlantic Rainforest

Hygrocybe conica (Schaeff.) P. Kumm.	U	M	N	BEM10	PR, RN, RS, SC, SP	Atlantic Rainforest
Lactarius helvus (Fr.) Fr.	U	S	N	BEM10	RS	
Lactarius rufus (Scop.) Fr.	U	S	R	BEM10	PR, RS, SC	*Pinus* plantation
Lenzites betulinus (L.) Fr.	U	M	N	BEM10	PR, RS, SC, SP	Atlantic Rainforest
Lepiota clypeolaria (Bull.) P. Kumm.	U	M	N	BEM10	RS, SP	Atlantic Rainforest
Leucoagaricus leucothites (Vittad.) Wasser	U	S	N	BEM10	PR, RS, SP	Atlantic Rainforest
Pholiota carbonaria (Fr.) Singer	U	M	N	BEM10	PR, SP	Atlantic Rainforest
Pholiota squarrosa (Vahl) P. Kumm.	U	S	N	BEM10	RS	Pampa
Pluteus petasatus (Fr.) Gillet	U	S	N	BEM10	RS	Atlantic Rainforest
Pluteus salicinus (Pers.) P. Kumm.	U	M	N	BEM10	PR	Atlantic Rainforest
Scleroderma bovista Fr.	U	M	N	BEM10	PE, RS, SC, SP	Atlantic Rainforest, Pampa, Pecan plantation
Scleroderma verrucosum (Bull.) Pers	U	M	N	BEM10	BA, PR, RJ, RS	Atlantic Rainforest, Pampa
Stropharia coronilla (Bull.) Quél.	U*	M	N	BEM10	PE, PR, RS, SP	Pampa
Tapinella atrotomentosa (Batsch) Šutara	U	M	N	BEM10	SP	Atlantic Rainforest
Trametes elegans (Spreng.) Fr.	U	M	N	BEM10	AP, BA, MT, PA, PE, PR, RO, RR, RS, SC, SP	Amazon Rainforest, Atlantic Rainforest, Cerrado
Tricholoma sulphureum (Bull.) P. Kumm.	U	S	N	BEM10	RS	
Volvopluteus gloiocephalus (DC.) Vizzini, Contu & Justo	U	M	R	BEM10	PE, PR, RS	Atlantic Rainforest
Meiorganum curtisii (Berk.) Singer	P	D	N	P1	RS	
Bolbitius titubans (Bull.) Fr.	P	M	N	P2	MS, RS, SP,	Atlantic Rainforest, Cerrado, Pantanal
Chlorophyllum molybdites (G. Mey.) Massee	P*	M	N	P2	BA, DF, PB, PE, PI, PR, RJ, RS, SC, SP	Atlantic Rainforest, Caatinga, Cerrado, Pampa
Clitocybe rivulosa (Pers.) P. Kumm.	P	L	N	P2	RS	Atlantic Rainforest
Conocybe apala (Fr.) Arnolds	P	M	N	P2	RS	
Conocybe tenera (Schaeff.) Fayod	P	M	N	P2	RS, SP	Atlantic Rainforest
Deconica merdaria (Fr.) Noordel.	P	M	N	P2	RS, SP	Atlantic Rainforest
Hebeloma sacchariolens Quél.	P	L	N	P2	PR, RS	Atlantic Rainforest
Lepiota cristata (Bolton) P. Kumm.	P	M	N	P2	MS, RS	Cerrado
Leucoagaricus badhamii (Berk. & Broome) Singer	P	S	N	P2	RS	Atlantic Rainforest
Leucocoprinus birnbaumii (Corda) Singer	P	M	N	P2	AM, CE, MS, PR, RS, SP	Amazon Rainforest, Atlantic Rainforest, Pantanal

Lysurus arachnoideus (E. Fisch.) Trierv.-Per. & K. Hosaka	P	M	N	P2	AM, SC	Amazon Rainforest, Atlantic Rainforest
Mutinus caninus (Huds.) Fr.	P	M	N	P2	PB, RO	Amazon Rainforest, Caatinga
Psathyrella corrugis (Pers.) Konrad & Maubl.	P	L	N	P2	PR	Atlantic Rainforest
Tapinella panuoides (Fr.) E.-J. Gilbert	P	M	N	P2	PR, RS	Atlantic Rainforest

WES*: edibility status defined in this work; D♦: identity confirmed based on DNA sequence generated in this work; D◊: identity confirmed based on unpublished DNA sequence recovered from GenBank; C*: consumption in Brazil recorded in this work.

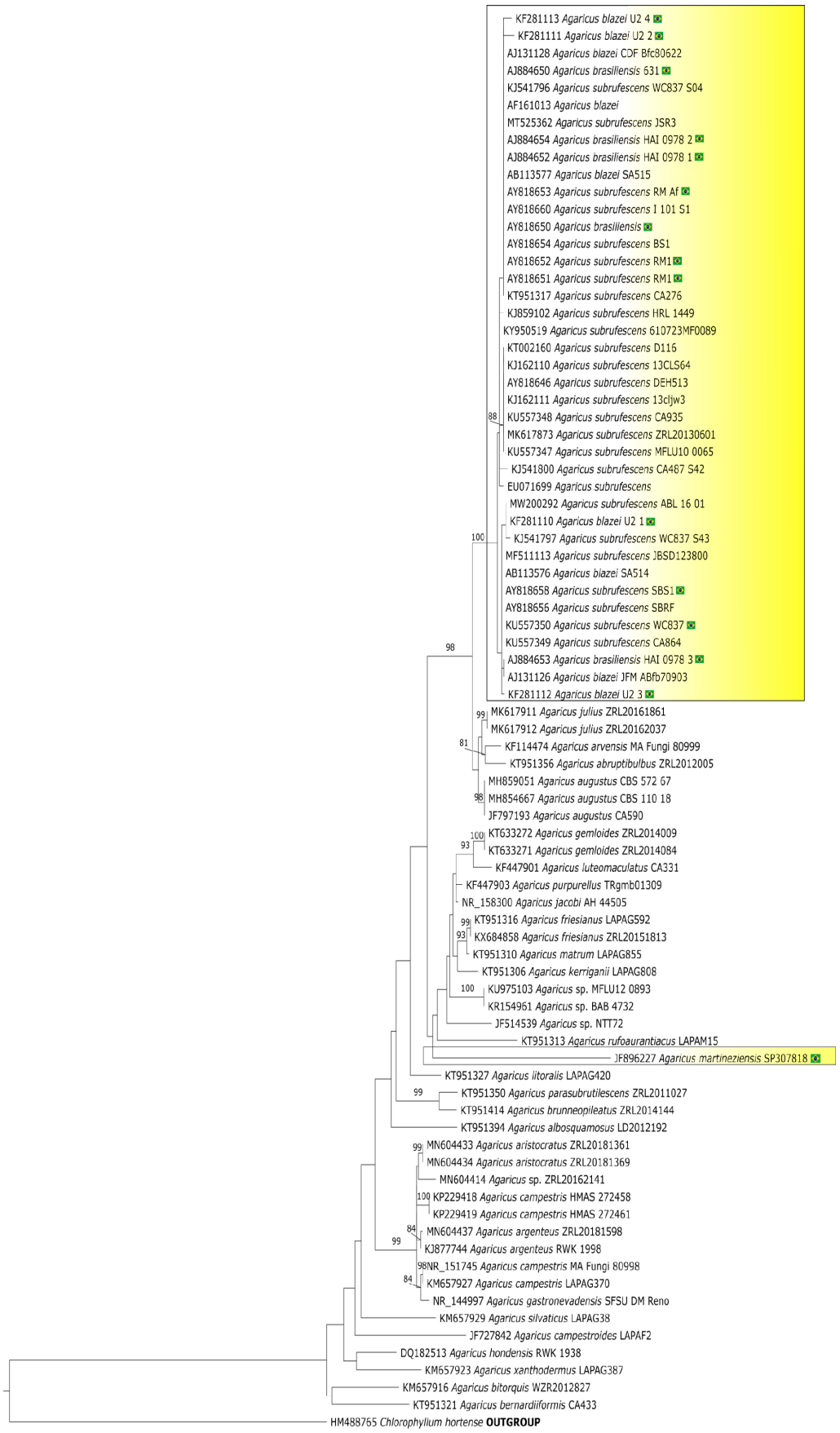

Figure S1. Maximum Likelihood (ML) tree of *Agaricus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Agaricus subrufescens* and *Agaricus martineziensis*.

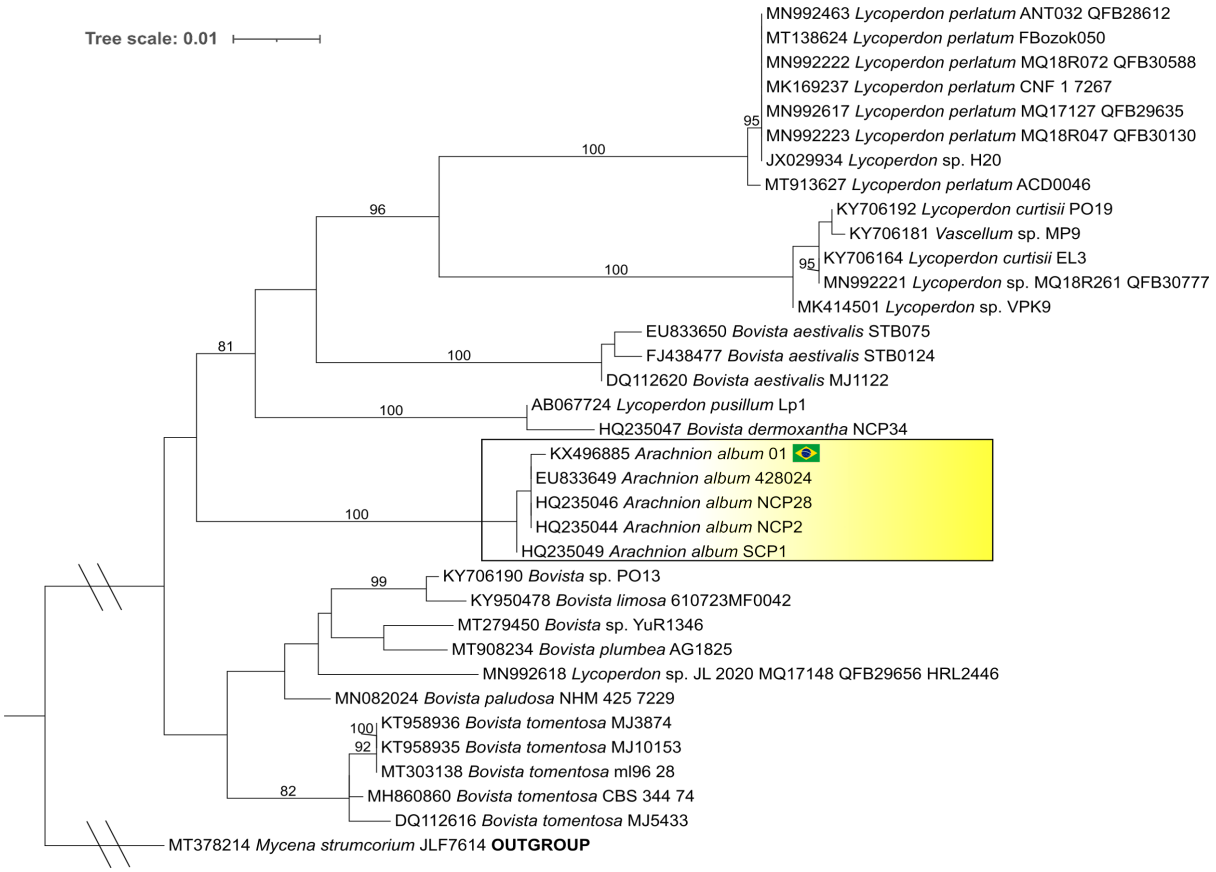

Figure S2. Maximum Likelihood (ML) tree of *Arachnion* and related genera based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Arachnion album*.

Figure S3. Maximum Likelihood (ML) tree of *Auricularia* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Auricularia cornea*, *Auricularia fuscosuccinea* complex and *Auricularia tremellosa*. The sequences in bold were generated in this work.

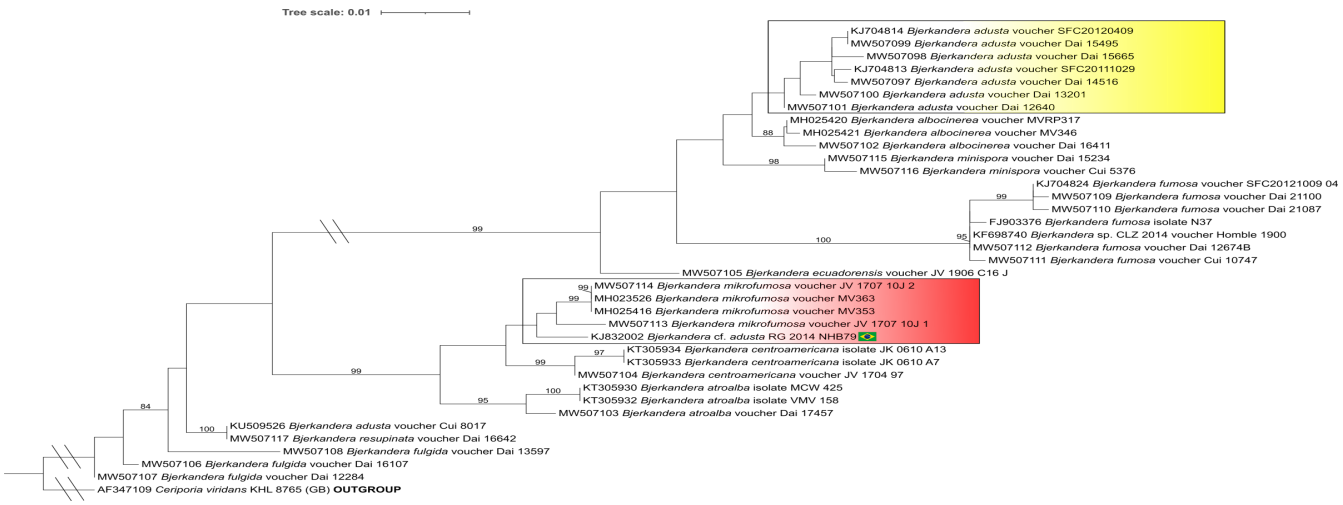

Figure S4. Maximum Likelihood (ML) tree of *Bjerkandera* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Bjerkandera adusta*. The red highlight represents the clade with the misidentified sequence.

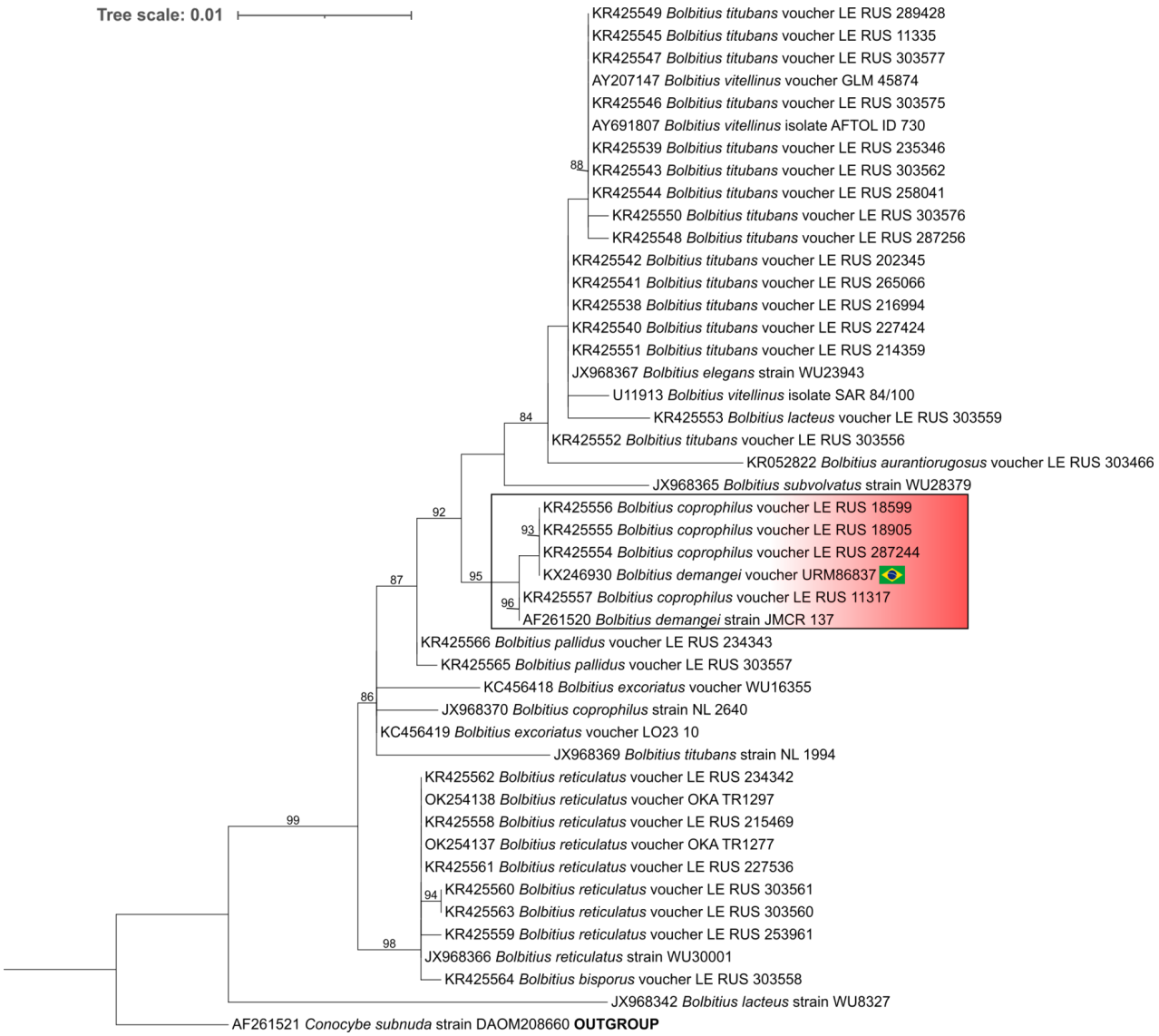

Figure S5. Maximum Likelihood (ML) tree of *Bolbitius* based on LSU data. Branches are labeled with ML bootstrap higher than 80%. The red highlight represents the clade with the unconfirmed sequence.

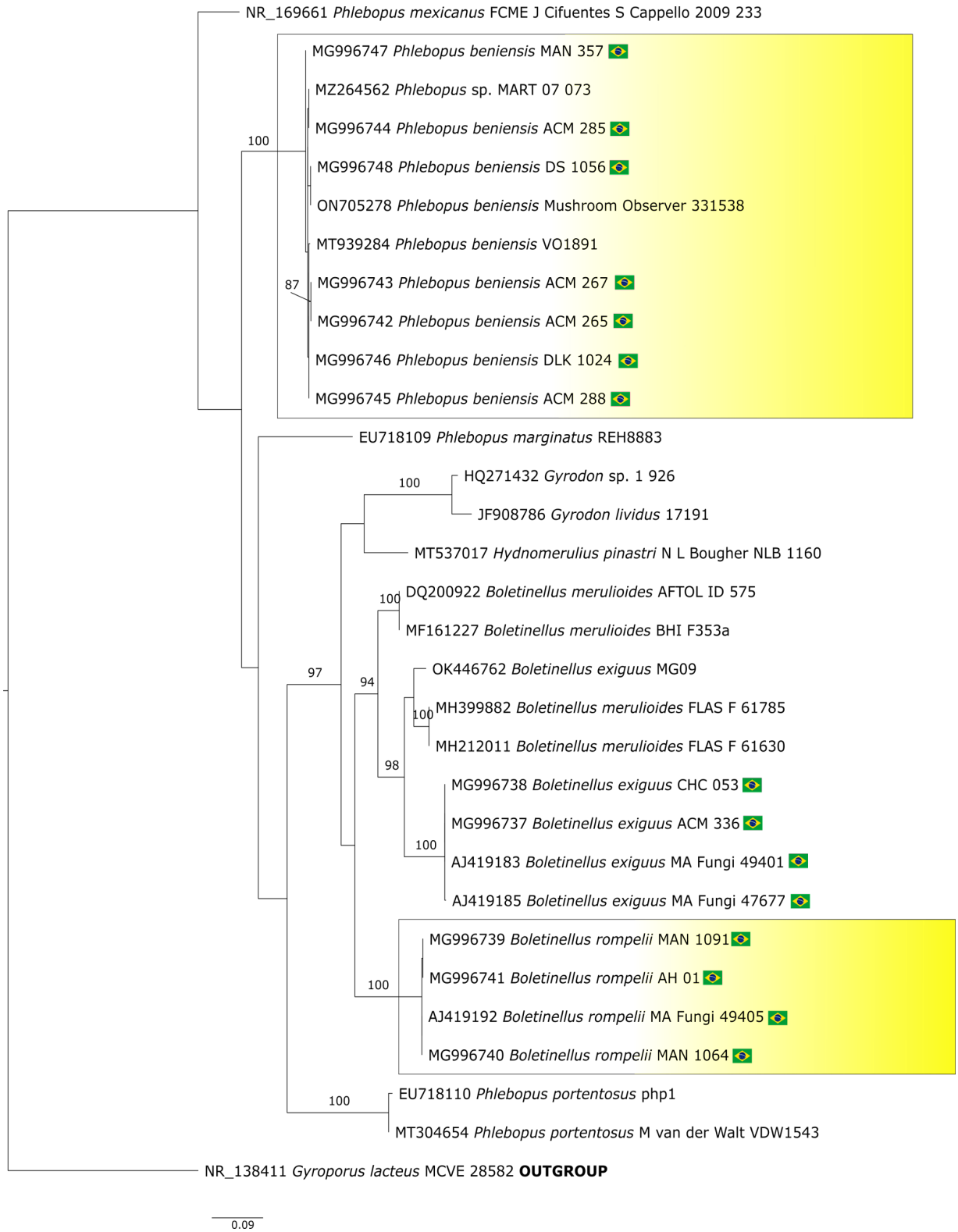

Figure S6. Maximum Likelihood (ML) tree of *Boletinellus* and allied genera based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Boletinellus rompelli* and *Phlebopus beniensis.*

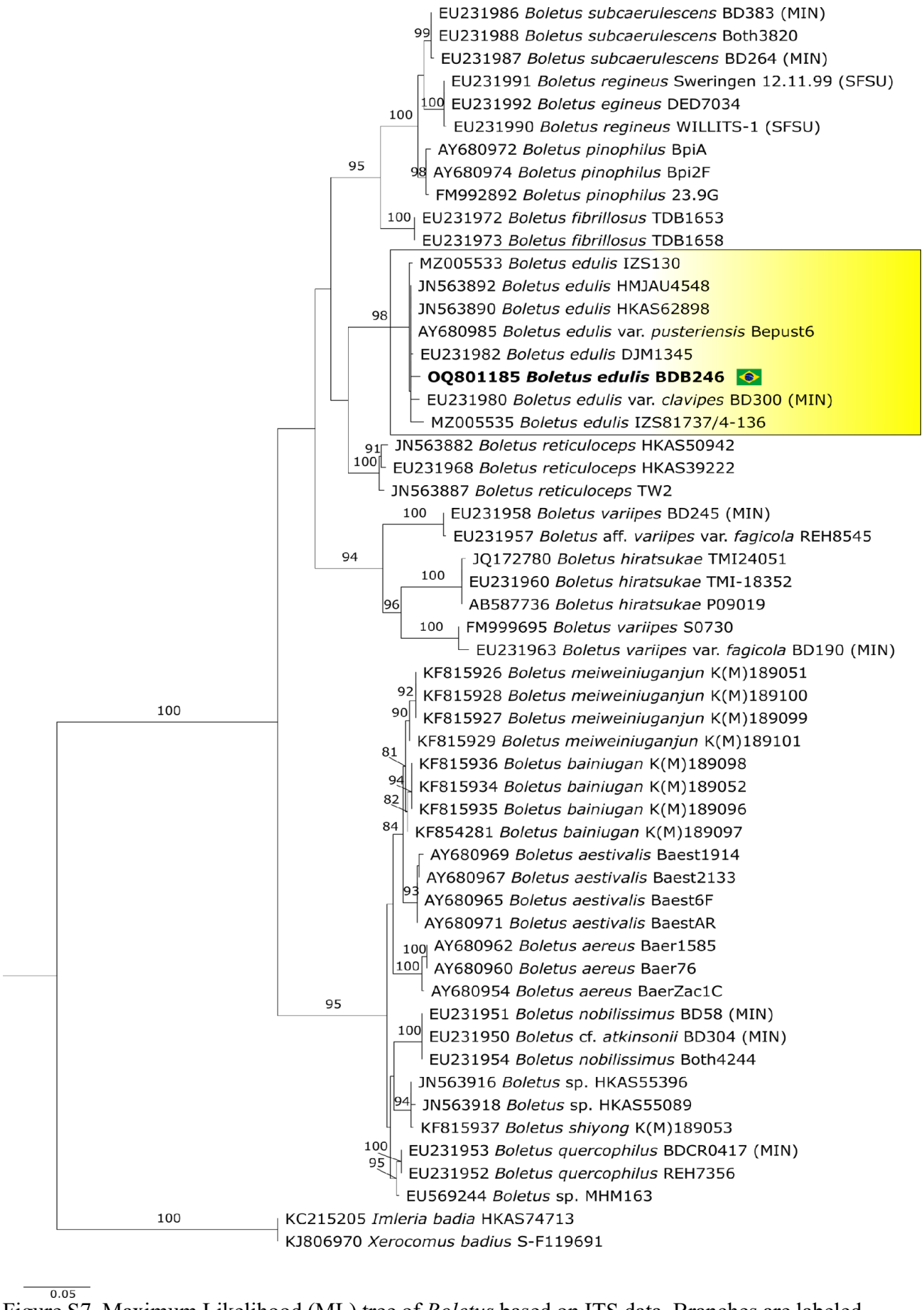

Figure S7. Maximum Likelihood (ML) tree of *Boletus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Boletus edulis*. The sequence in bold was generated in this work.

Figure S8. Maximum Likelihood (ML) tree of *Calvatia* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Calvatia cyathiformis*.

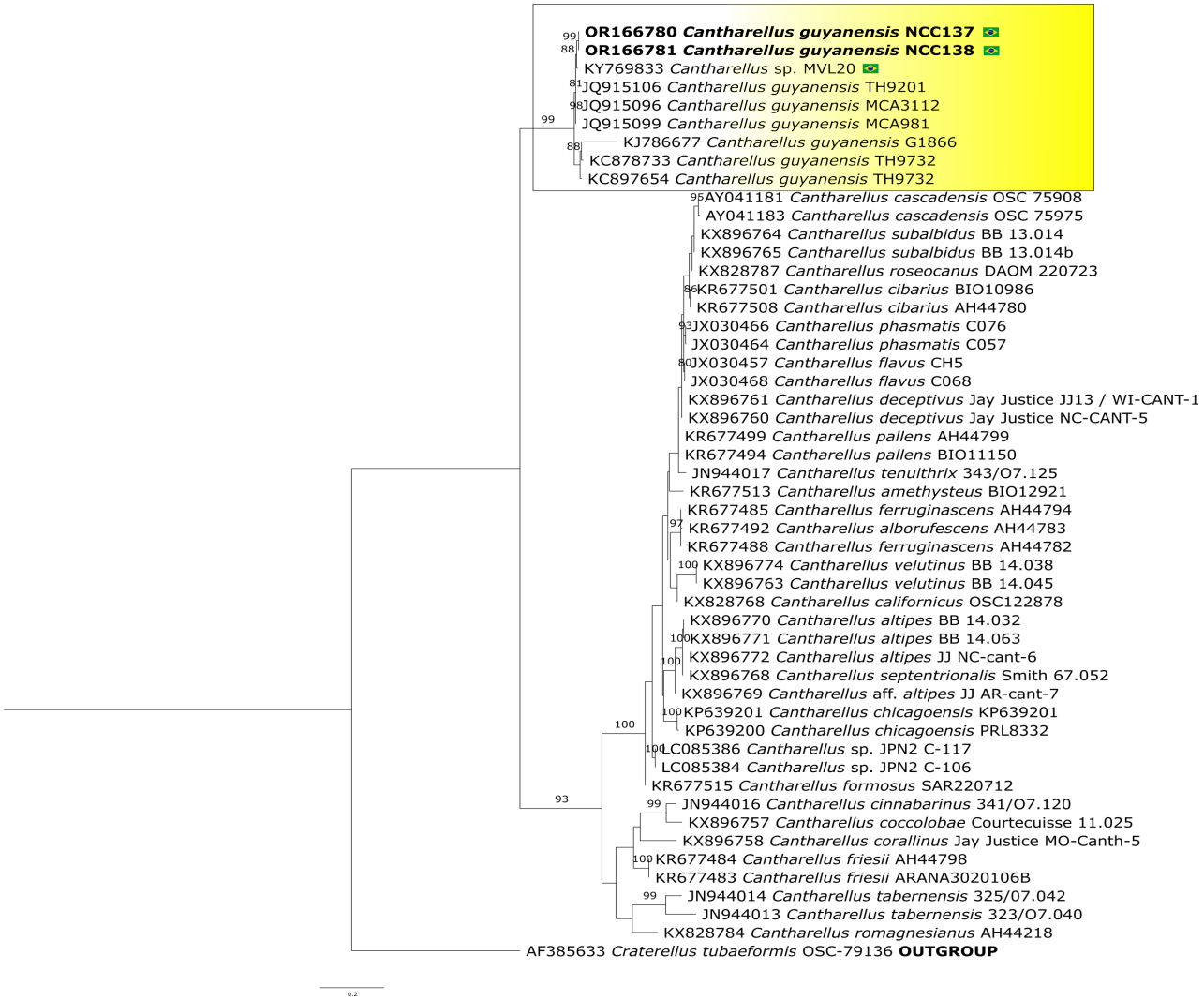

Figure S9. Maximum Likelihood (ML) tree of *Cantharellus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Cantharellus guyanensis*. The sequences in bold were generated in this work.

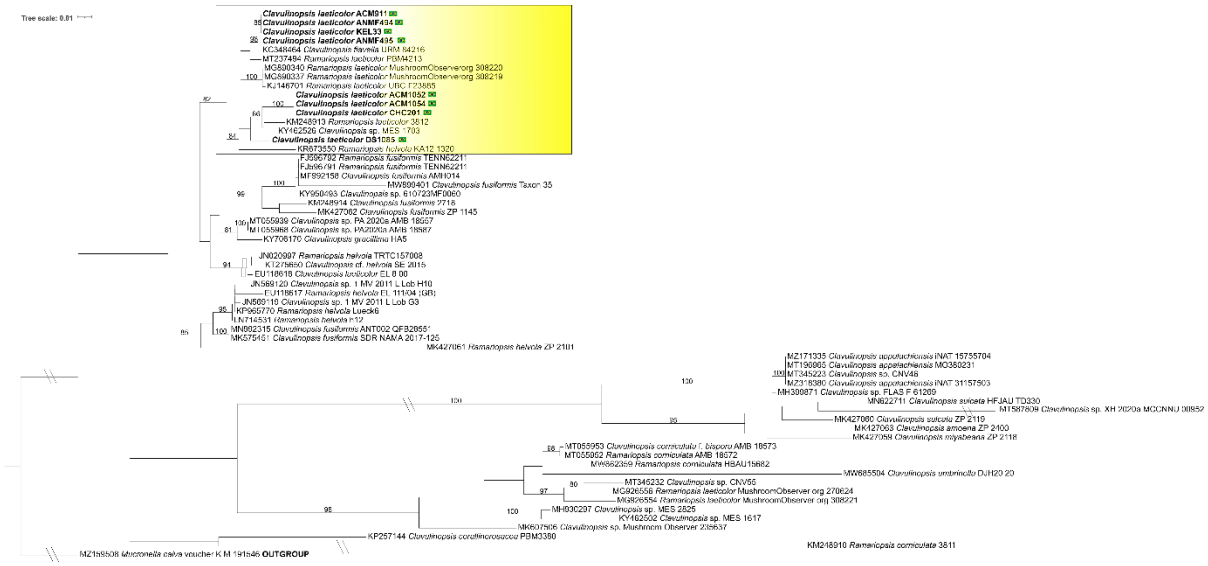

Figure S10. Maximum Likelihood (ML) tree of *Clavulinopsis* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Clavulinopsis laeticolor*. The sequences in bold were generated in this work.

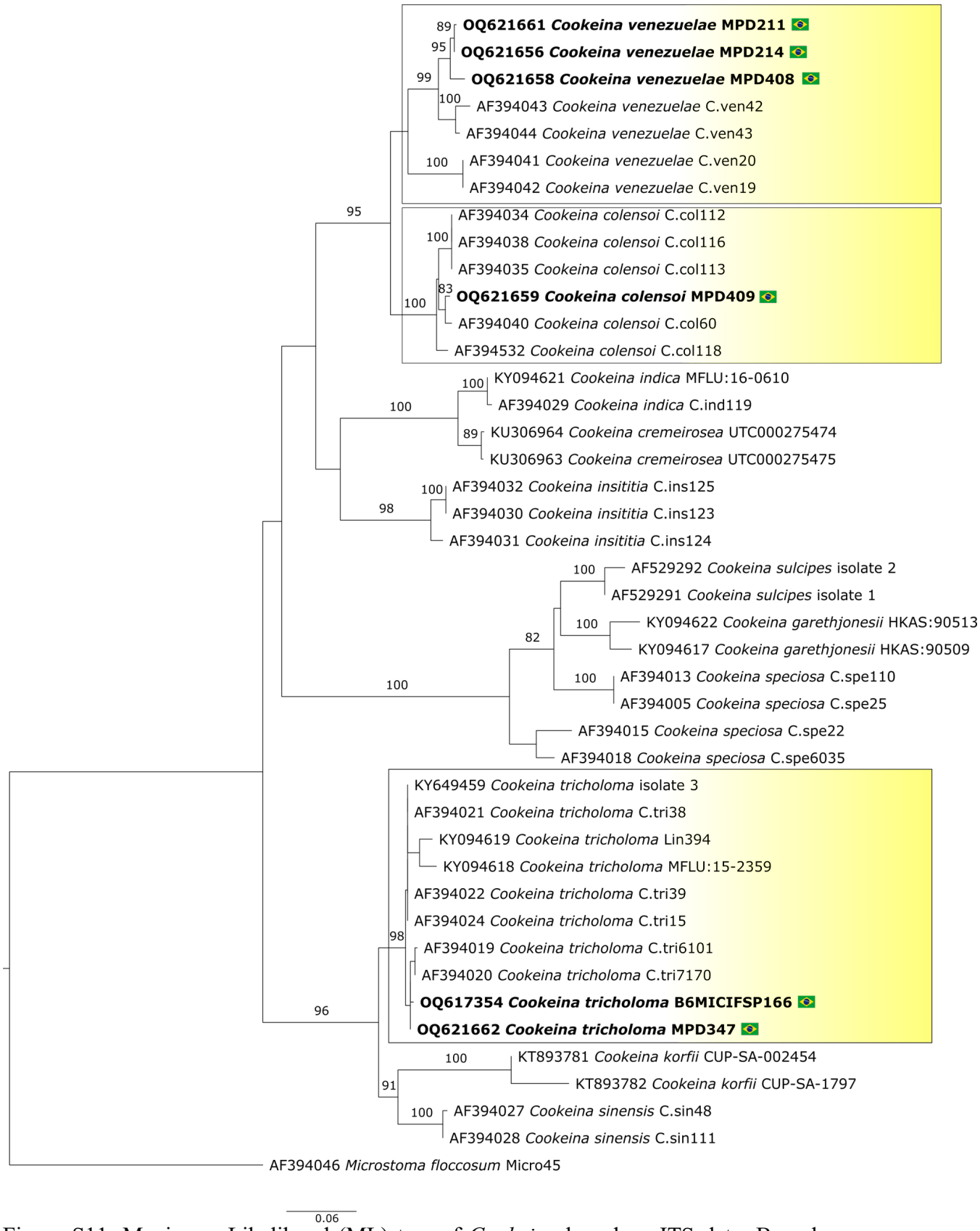

Figure S11. Maximum Likelihood (ML) tree of *Cookeina* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Cookeina colensoi*, *Cookeina tricholoma*, and *Cookeina venezuelae*. The sequences in bold were generated in this work.

Figure S12. Maximum Likelihood (ML) tree of *Coprinellus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Coprinellus disseminatus* and *Coprinellus radians*.

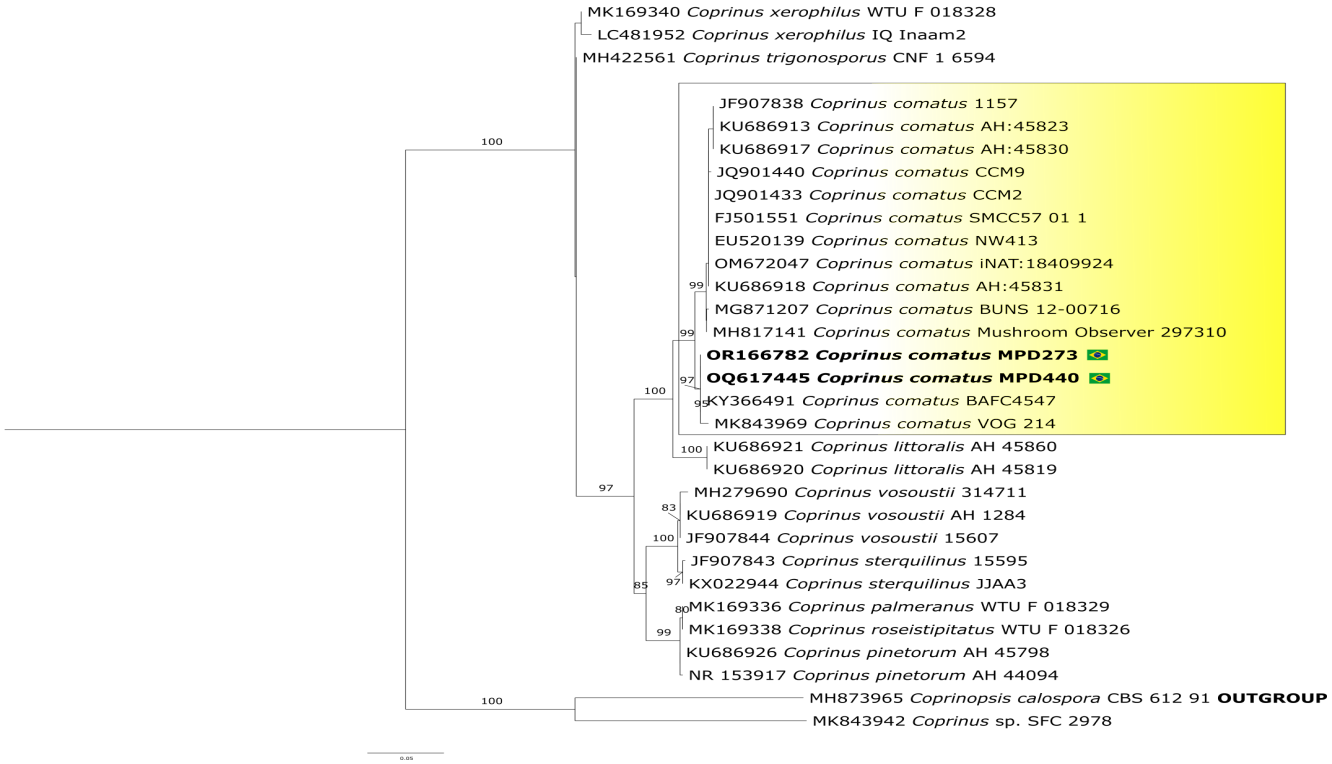

Figure S13. Maximum Likelihood (ML) tree of *Coprinus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Coprinus comatus*. The sequences in bold were generated in this work.

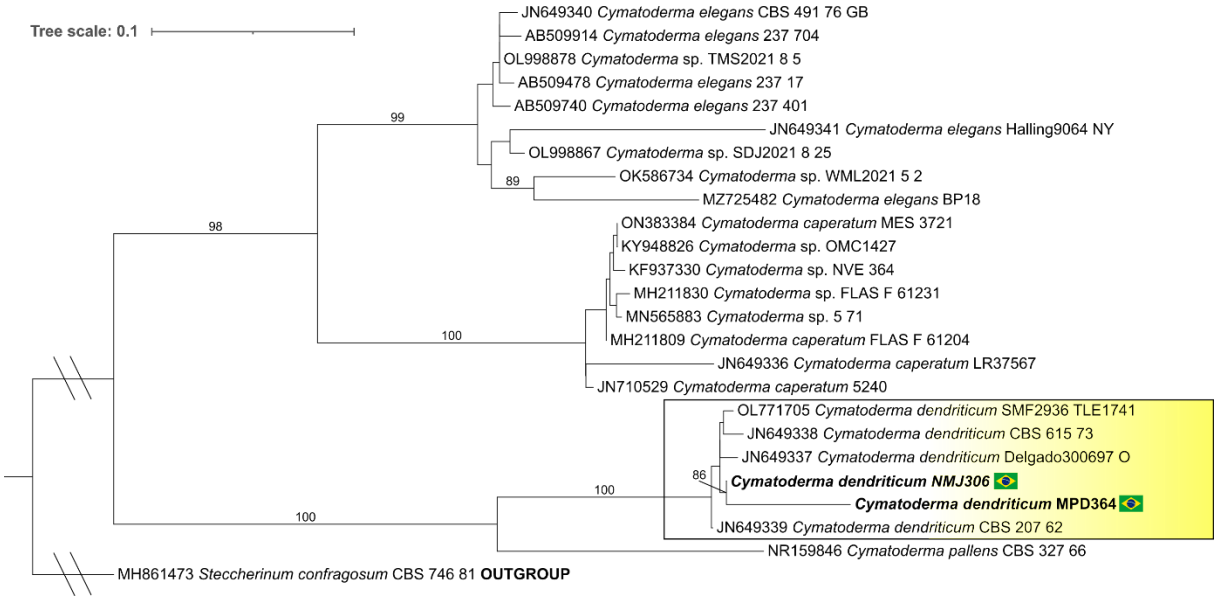

Figure S14. Maximum Likelihood (ML) tree of *Cymatoderma* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Cymatoderma dendriticum*. The sequences in bold were generated in this work.

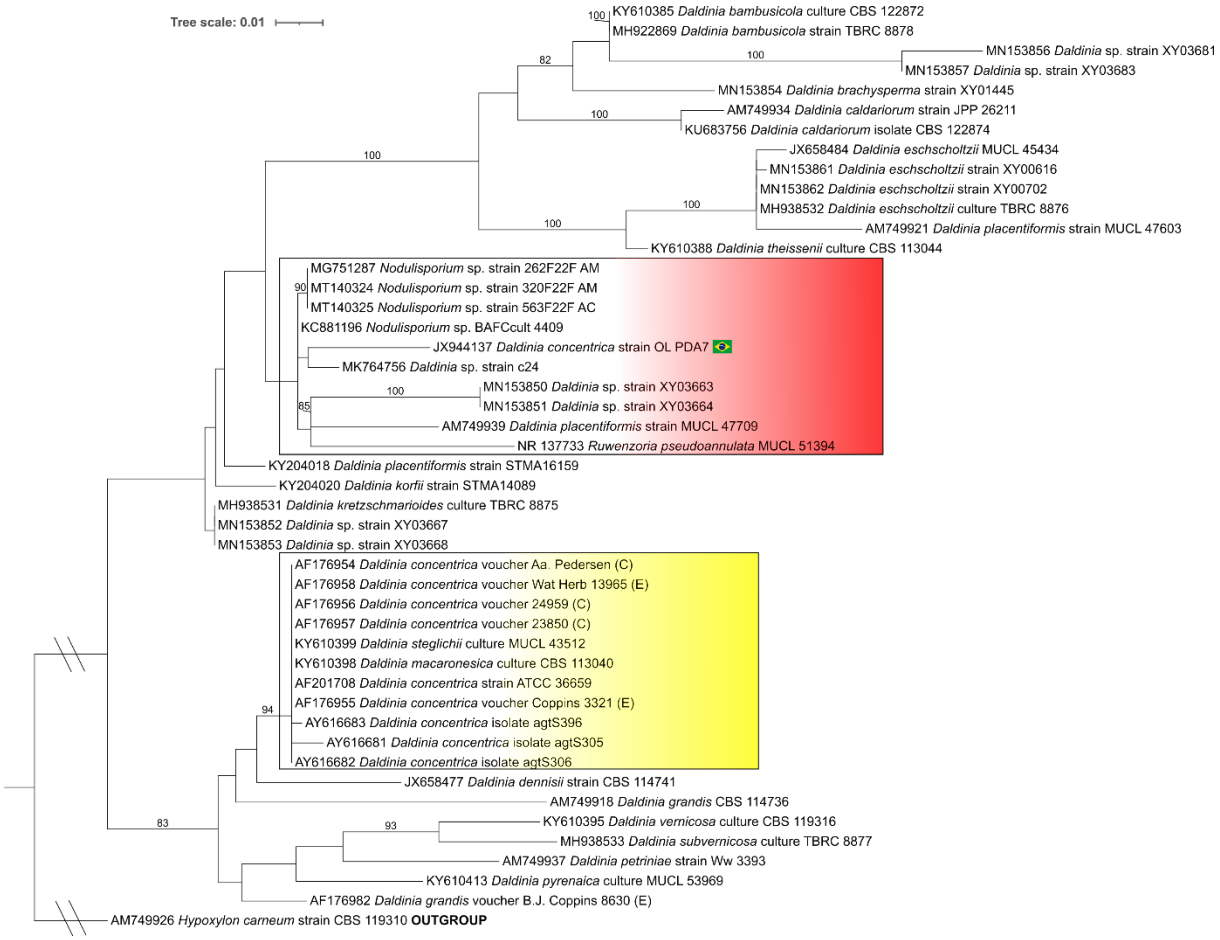

Figure S15. Maximum Likelihood (ML) tree of *Daldinia* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Daldinia concentrica*. The red highlight represents the clade with a misidentified sequence.

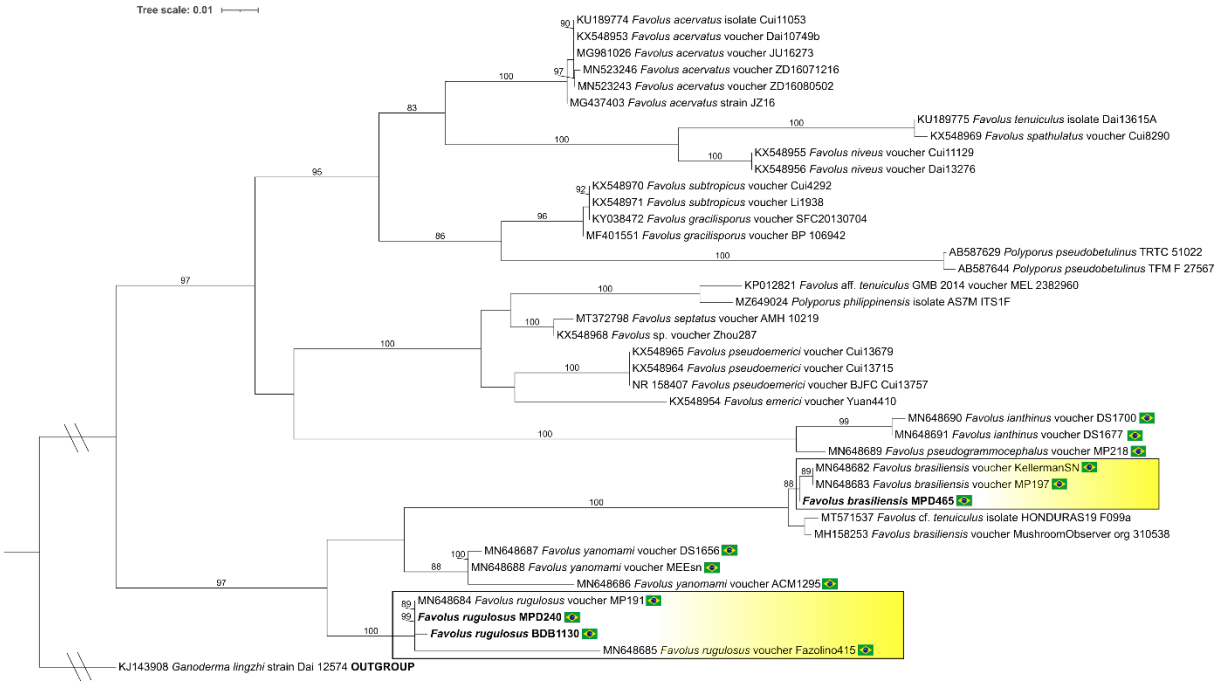

Figure S16. Maximum Likelihood (ML) tree of *Favolus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Favolus brasiliensis* and *Favolus rugulosus*. The sequences in bold were generated in this work.

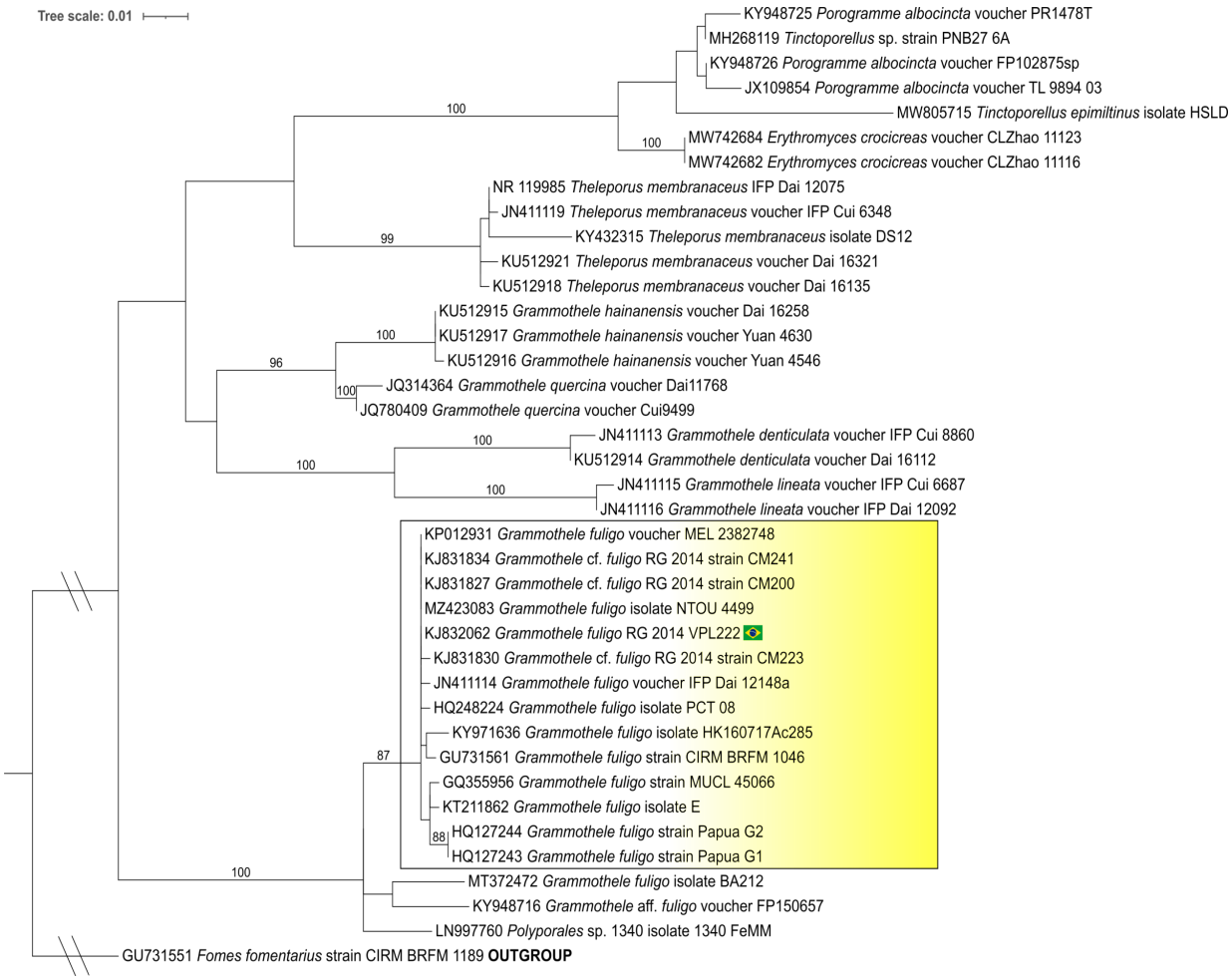

Figure S17. Maximum Likelihood (ML) tree of *Grammothele* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Grammothele fuligo*.

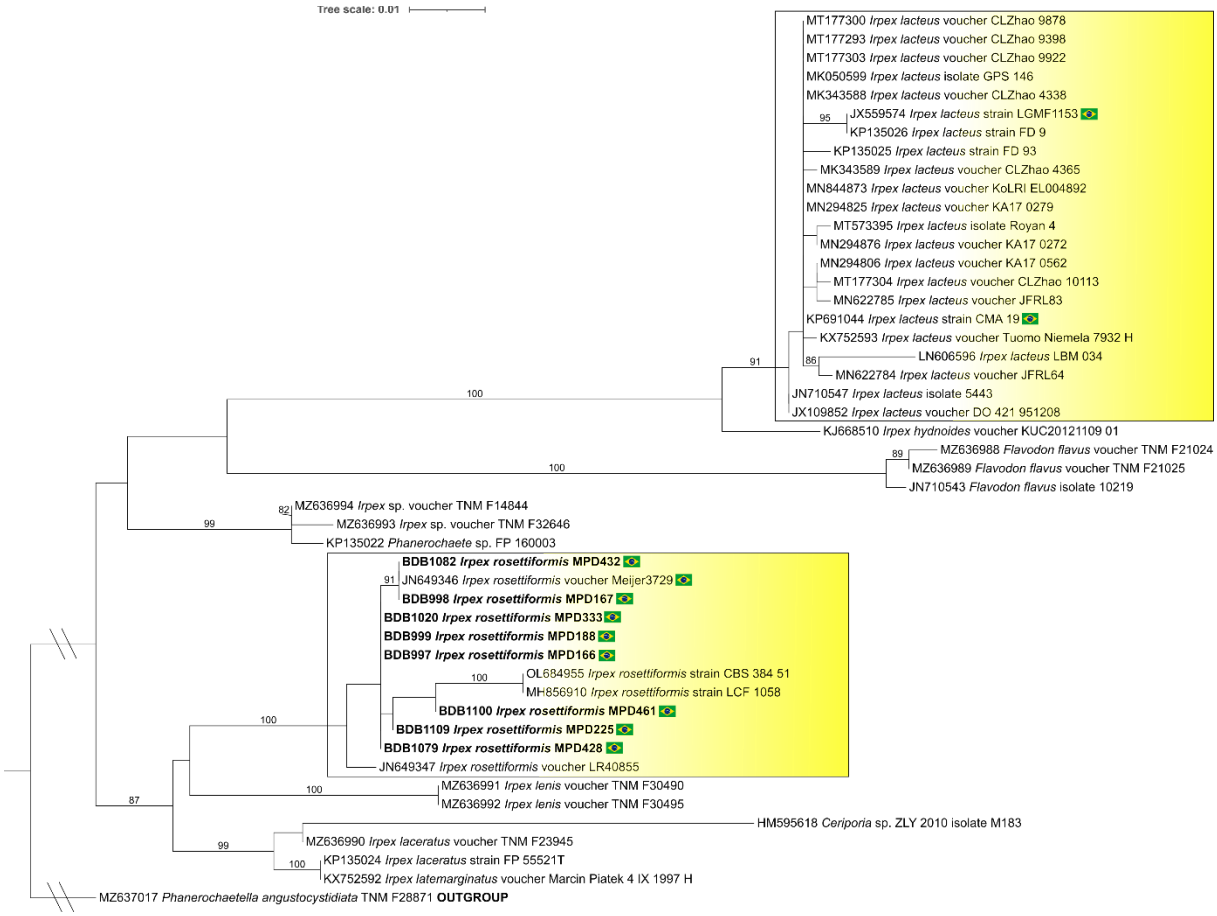

Figure S18. Maximum Likelihood (ML) tree of *Irpex* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Irpex lacteus* and *Irpex rosettiformis*. The sequences in bold were generated in this work.

Figure S19. Maximum Likelihood (ML) tree of *Laccaria* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Laccaria lateritia*. The red highlight represents the clade with misidentified sequences. The sequence in bold was generated in this work.

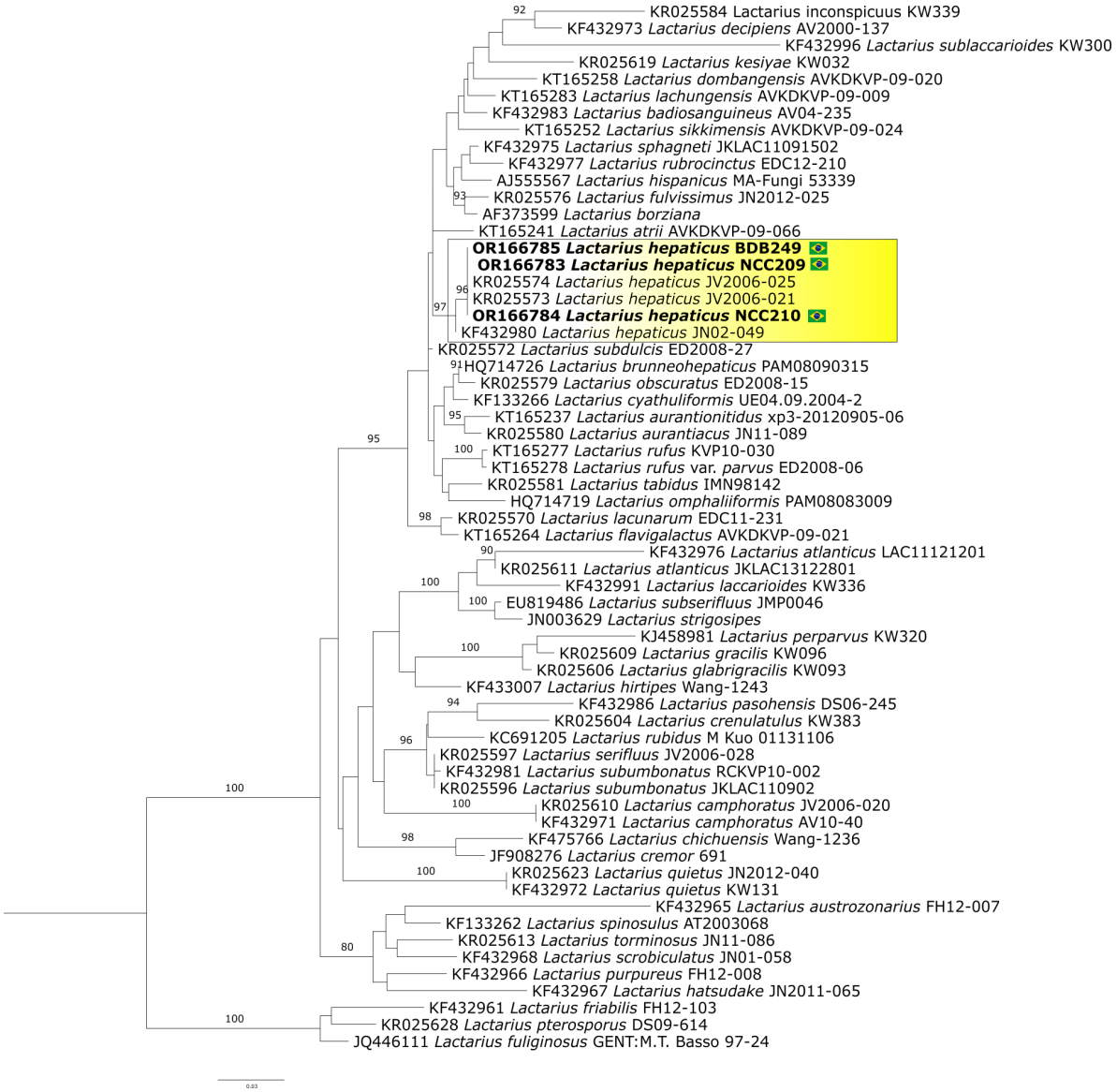

Figure S20. Maximum Likelihood (ML) tree of *Lactarius* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Lactarius hepaticus*. The sequences in bold were generated in this work.

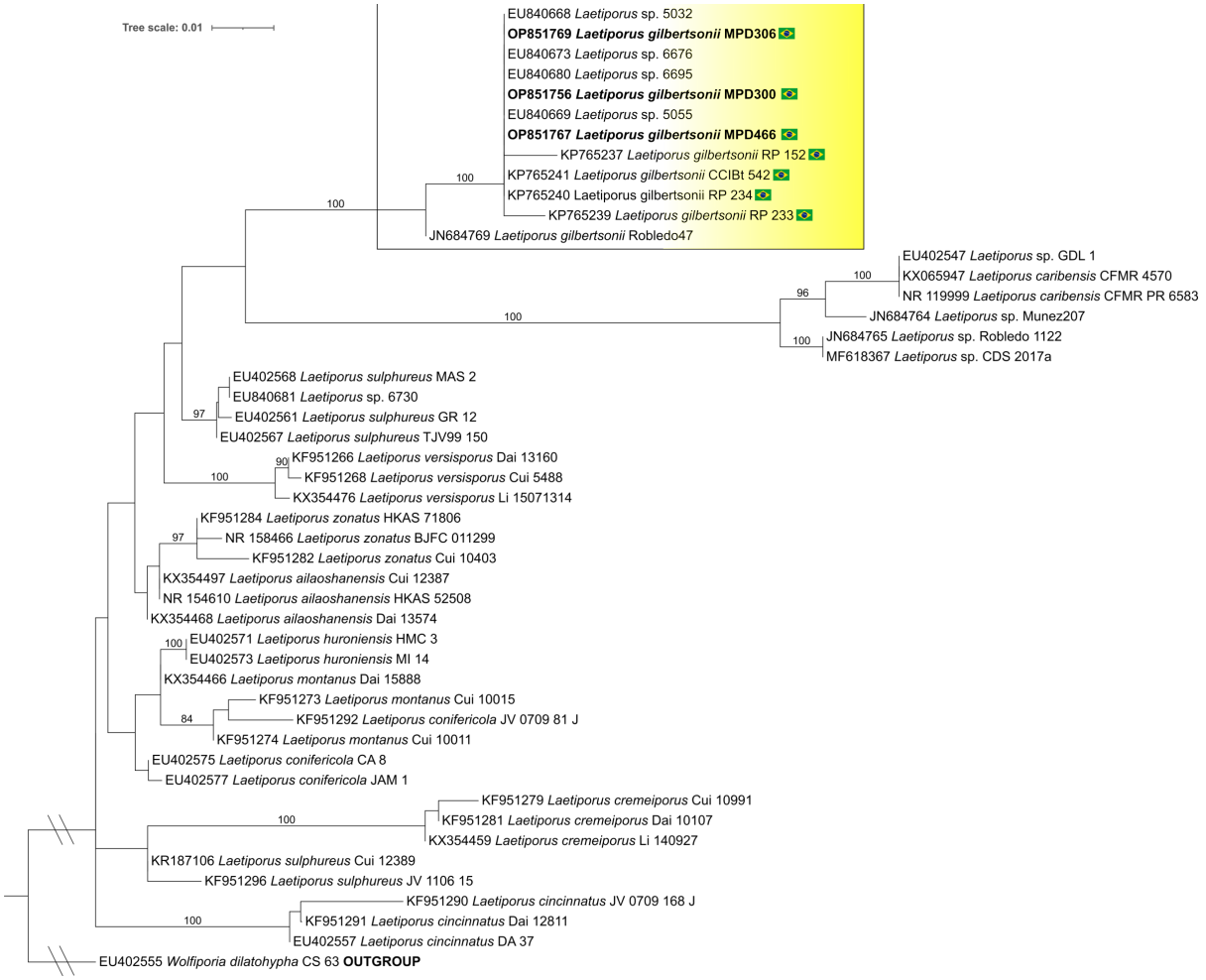

Figure S21. Maximum Likelihood (ML) tree of *Laetiporus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Laetiporus gilbertsonii*. The sequences in bold were generated in this work.

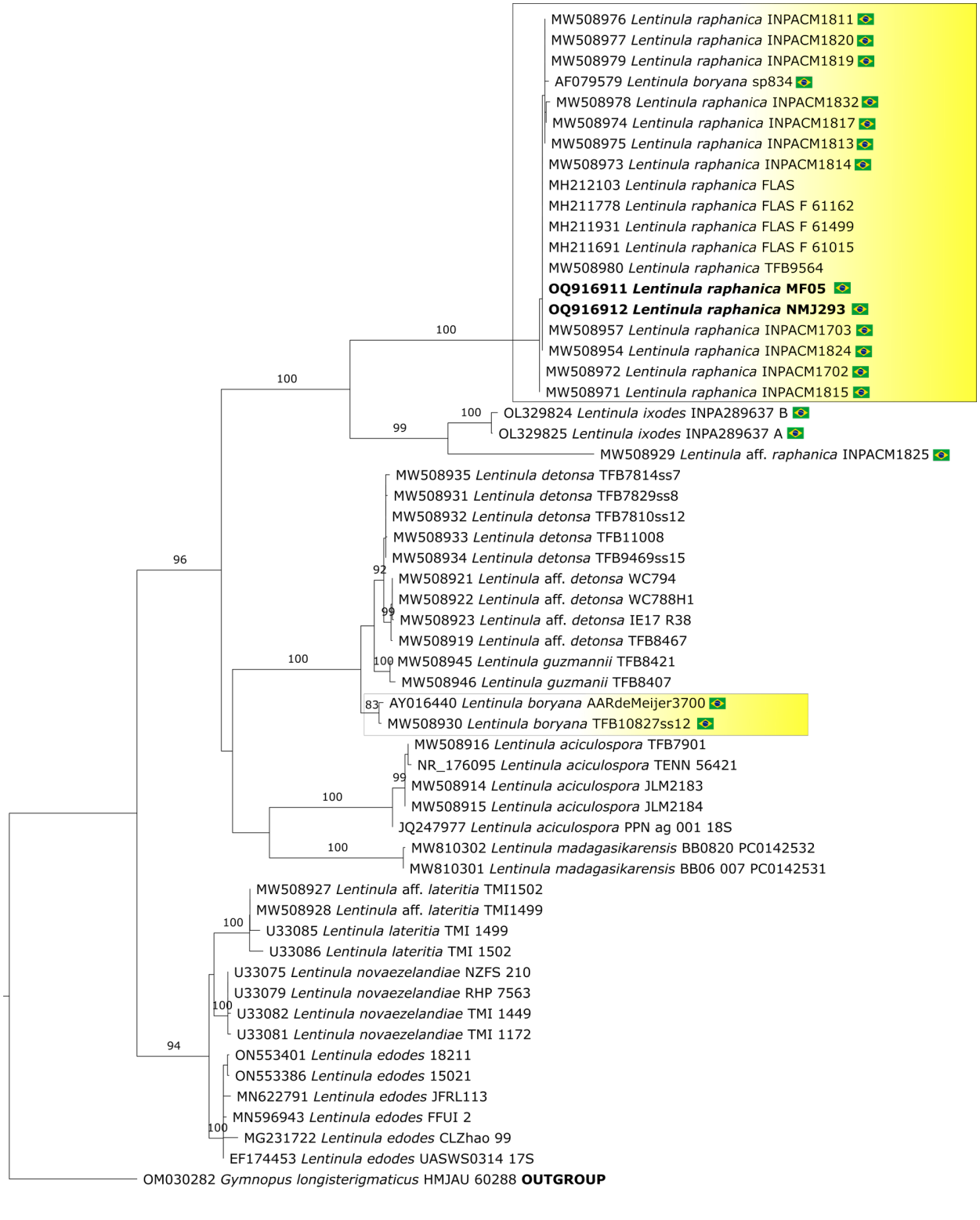

Figure S22. Maximum Likelihood (ML) tree of *Lentinula* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Lentinula boryana* and *Lentinula raphanica*. The sequences in bold were generated in this work.

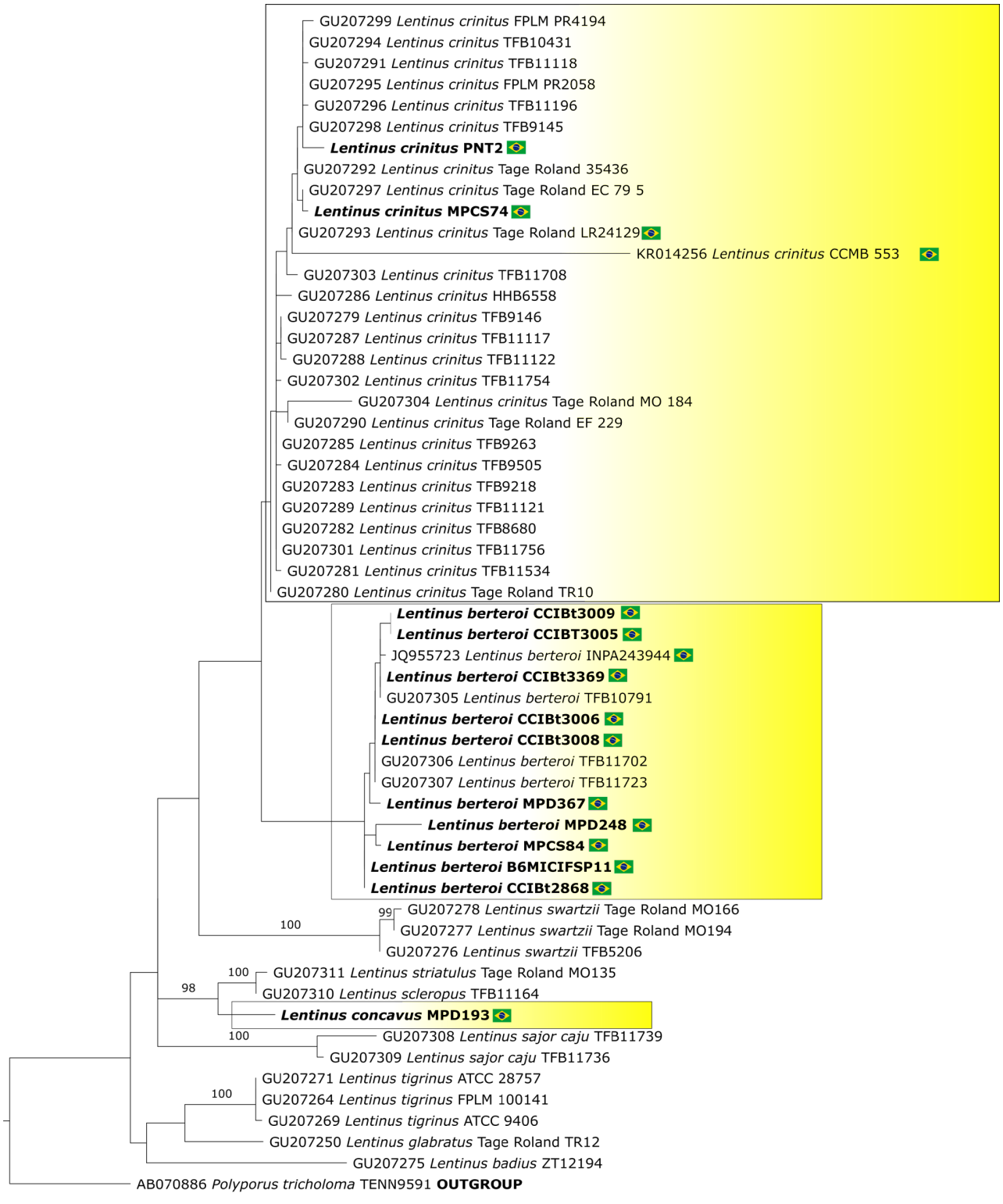

Figure S23. Maximum Likelihood (ML) tree of *Lentinus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Lentinus berteroi*, *Lentinus concavus*, and *Lentinus crinitus*. The sequences in bold were generated in this work.

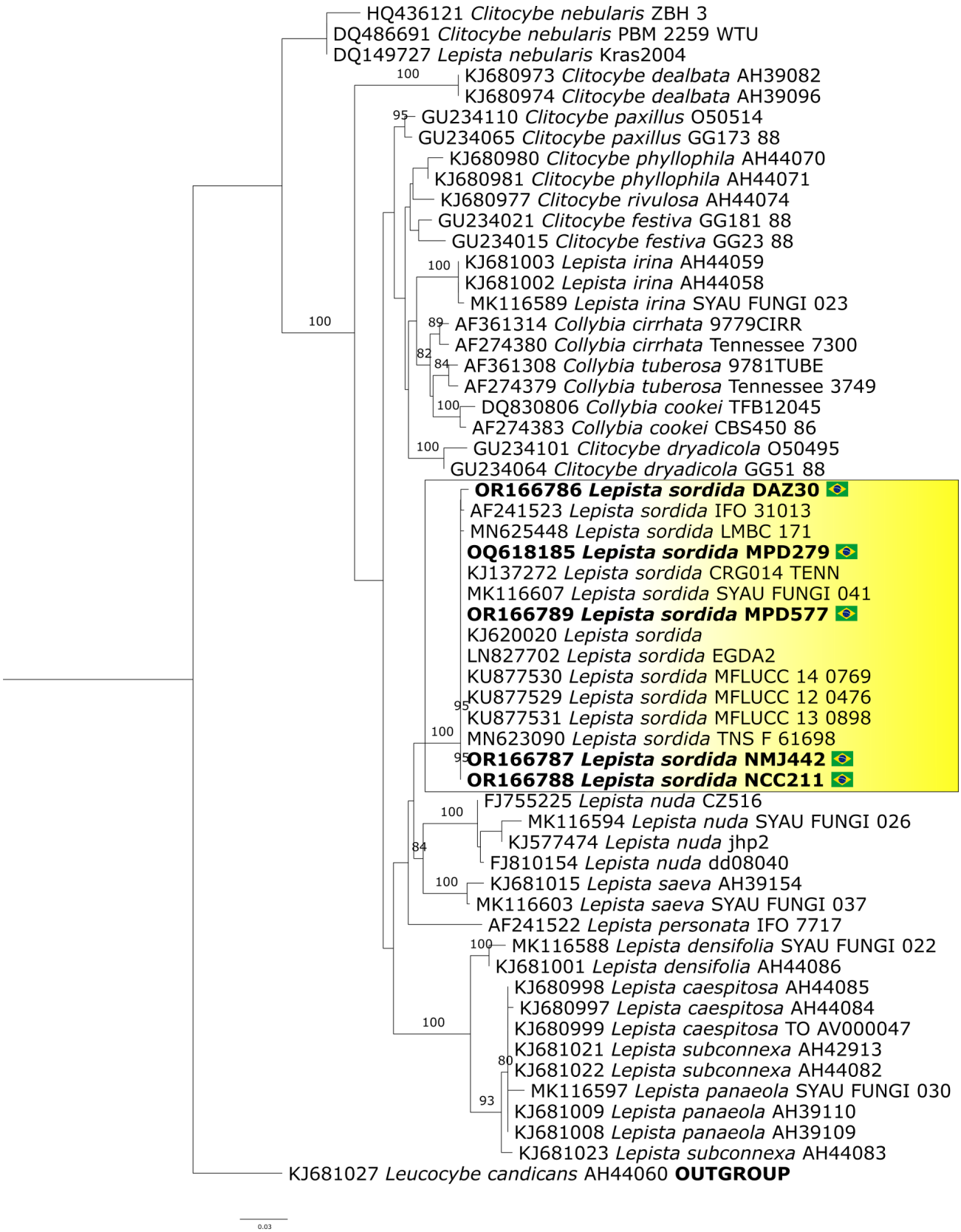

Figure S24. Maximum Likelihood (ML) tree of *Lepista* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Lepista sordida*. The sequences in bold were generated in this work.

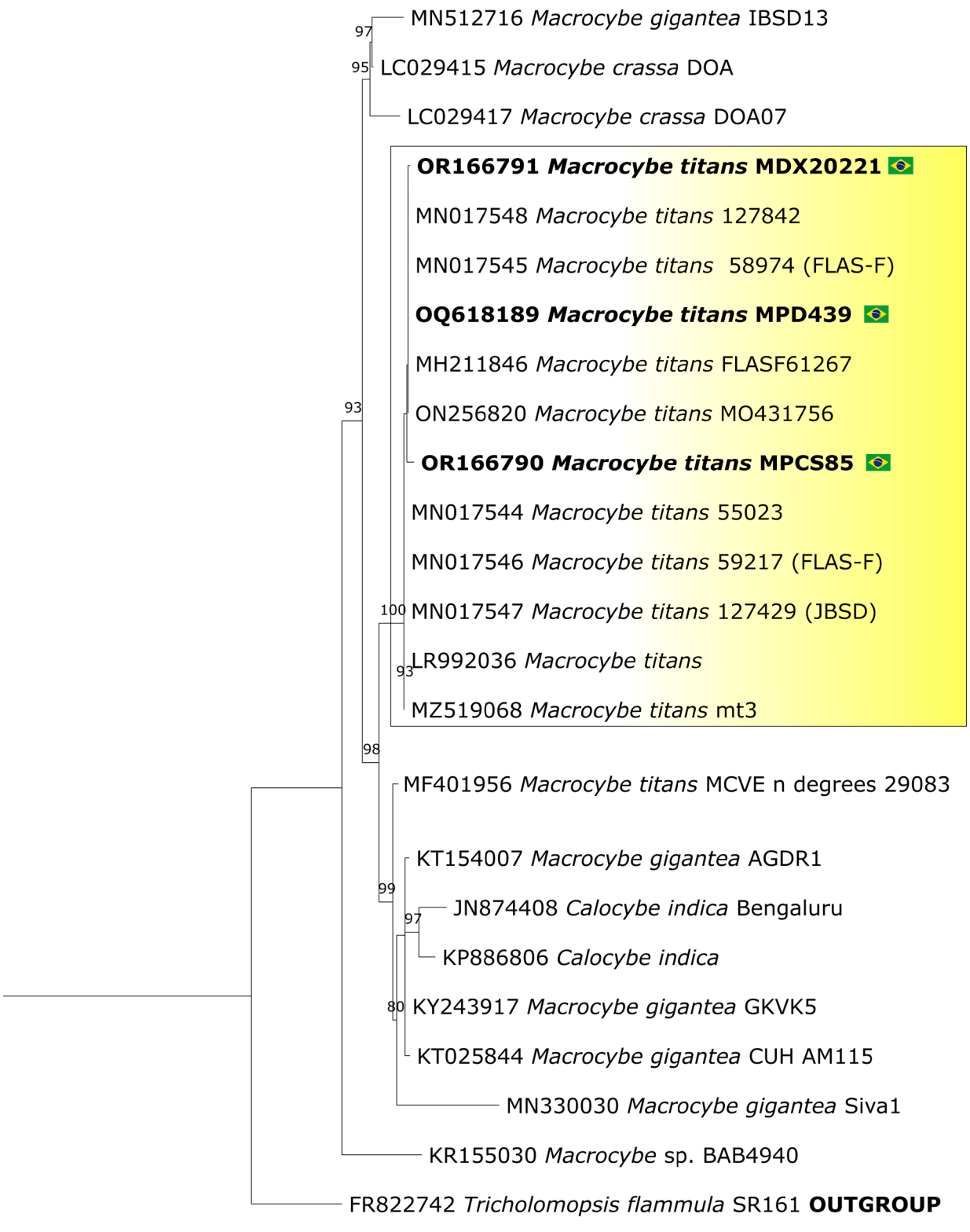

Figure S25. Maximum Likelihood (ML) tree of *Macrocybe* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Macrocybe titans*. The sequences in bold were generated in this work.

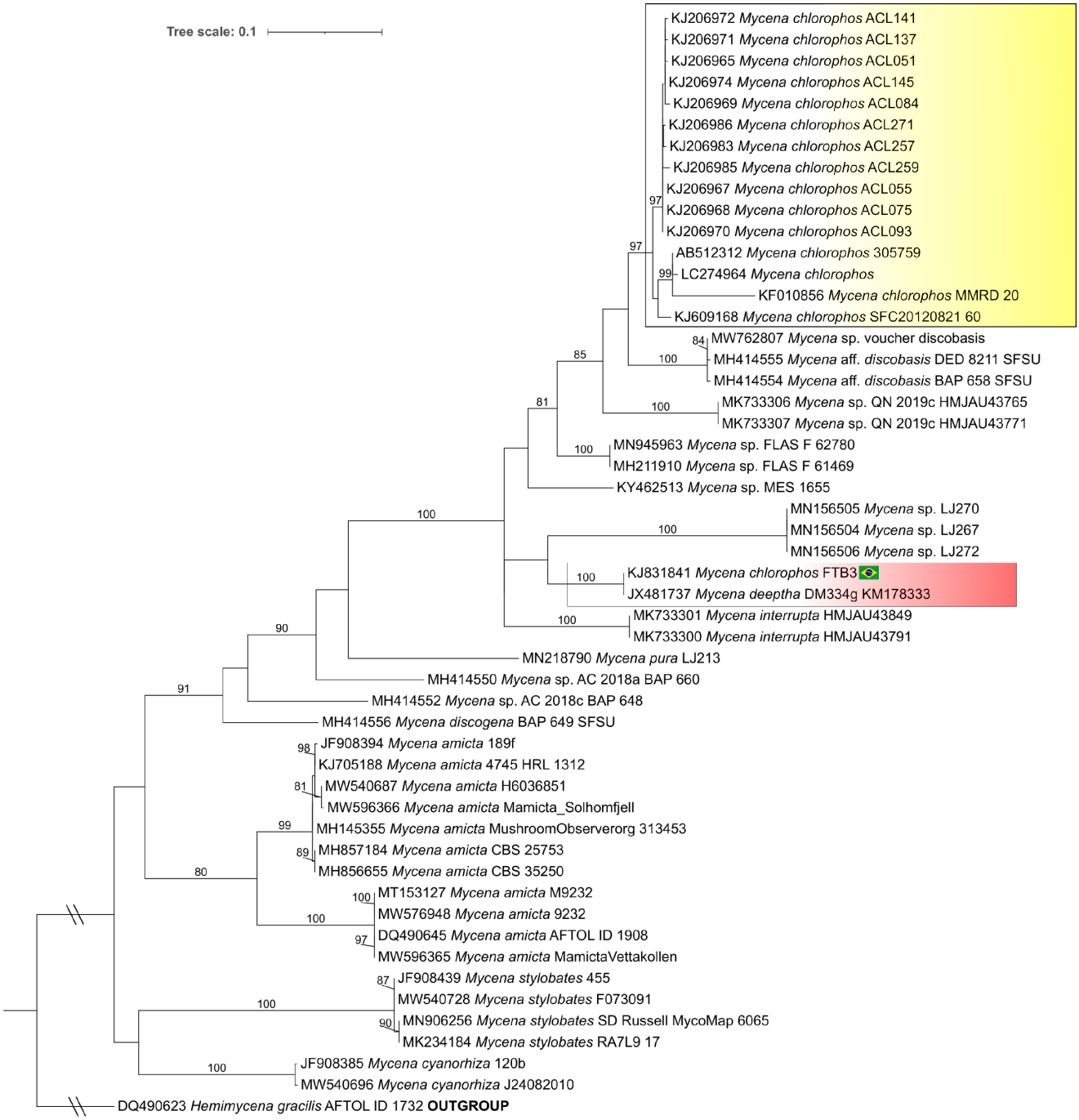

Figure S26. Maximum Likelihood (ML) tree of *Mycena* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Mycena chlorophos*. The red highlight represents the clade with the misidentified sequence.

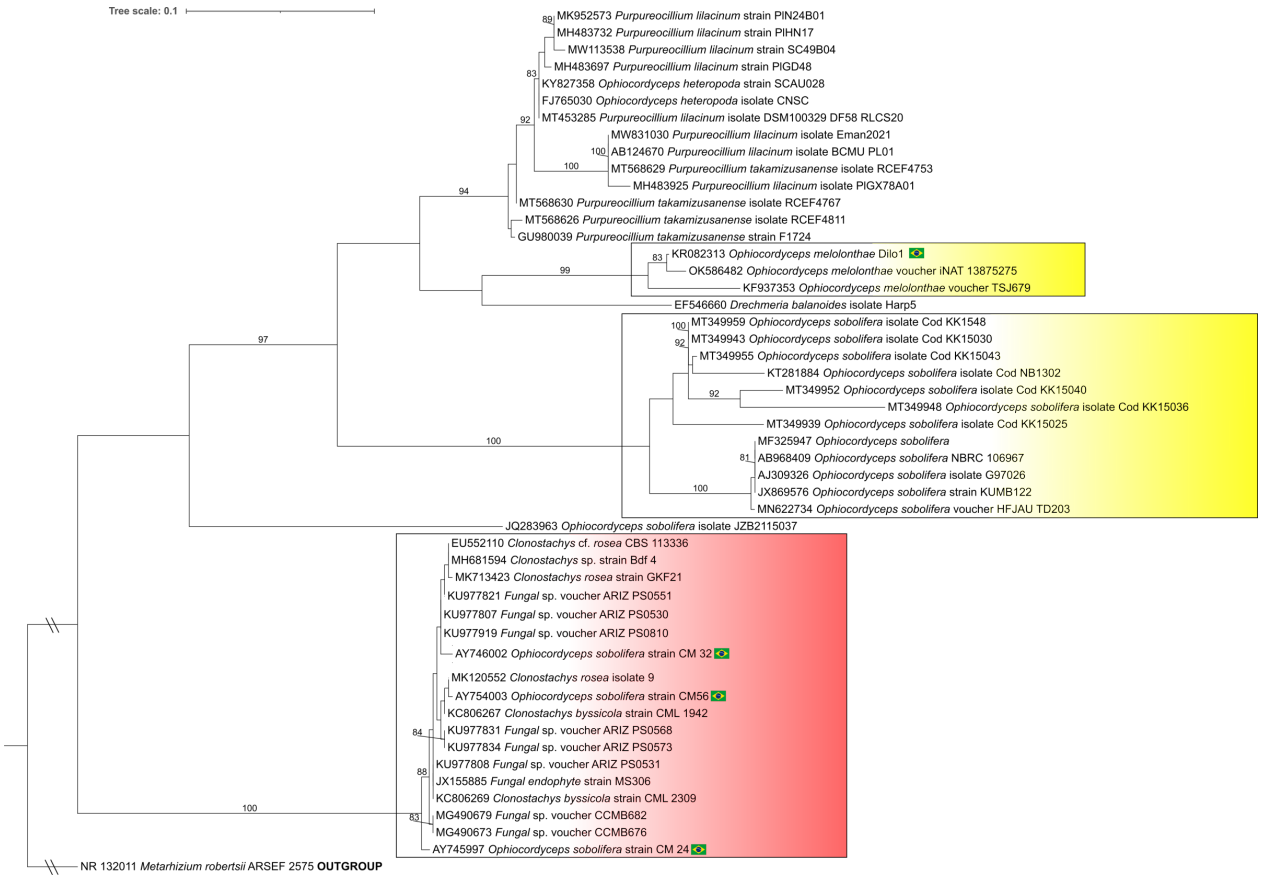

Figure S27. Maximum Likelihood (ML) tree of *Ophiocordyceps* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Ophiocordyceps melolonthae* and *Ophiocordyceps sobolifera*. The red highlight represents the clade with the misidentified sequences.

Figure S28. Maximum Likelihood (ML) tree of *Oudemansiella* and allied genera based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Oudemansiella canarii*, *Oudemansiella cubensis*, and *Oudemansiella platensis*. The red highlight represents the clade with the misidentified sequences. The sequences in bold were generated in this work.

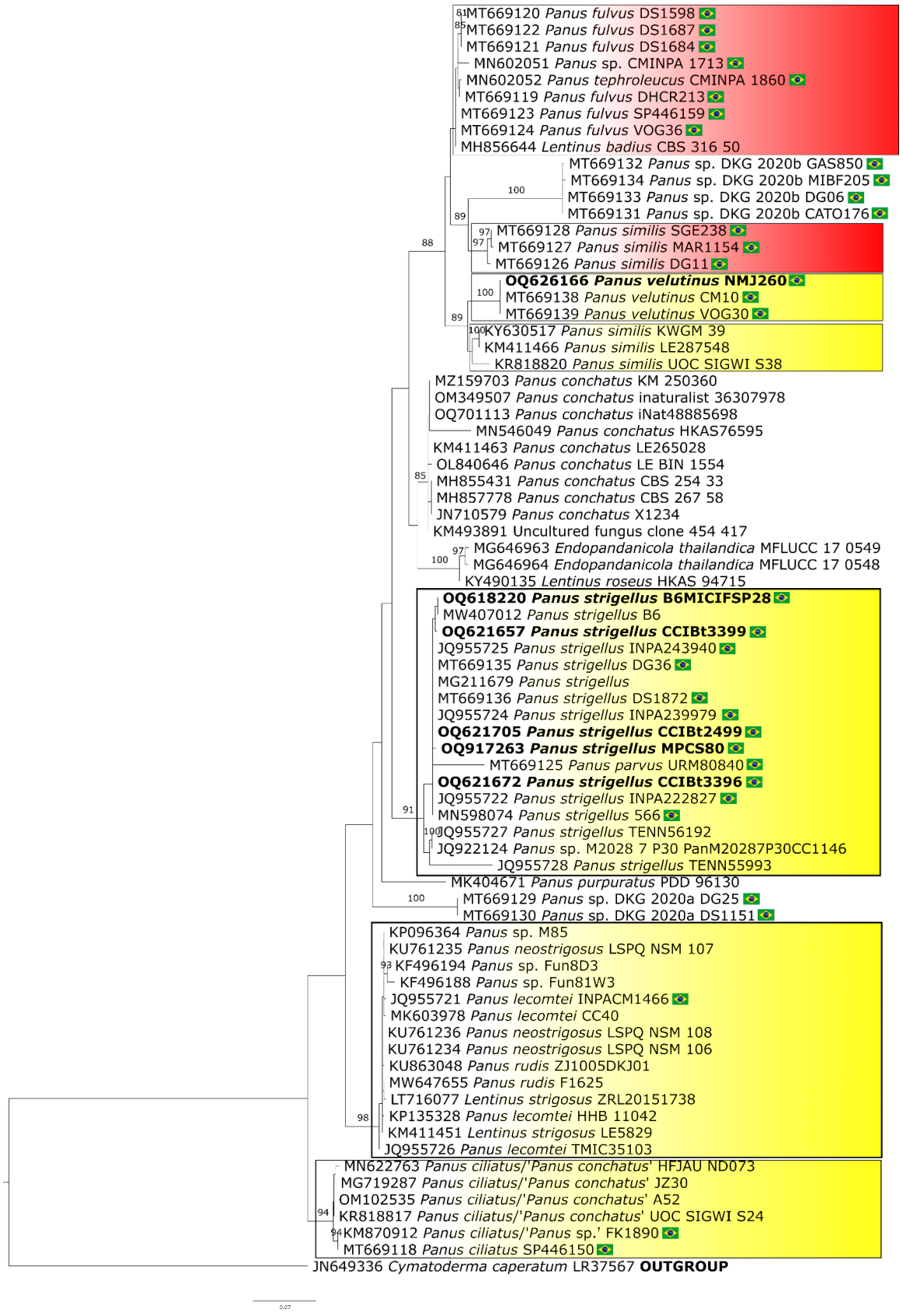

Figure S29. Maximum Likelihood (ML) tree of *Panus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Panus ciliatus*, *Panus neostrigosus*, *Panus similis*, *Panus strigellus*, and *Panus velutinus*. The red highlight represents the clades with the unconfirmed sequences. The sequences in bold were generated in this work.

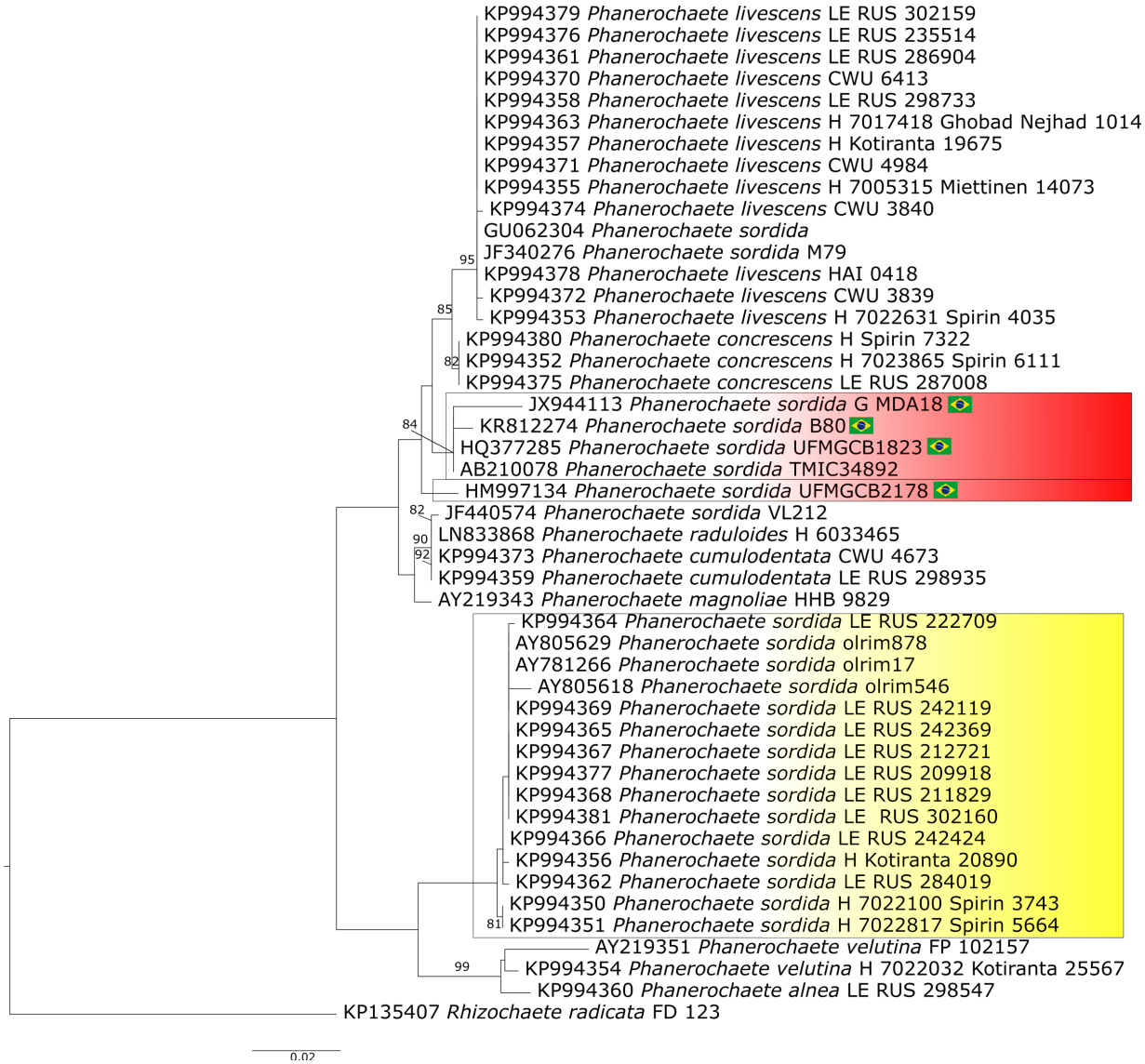

Figure S30. Maximum Likelihood (ML) tree of *Phanerochaete* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Phanerochaete sordida*. The red highlight represents the clades with the misidentified sequences.

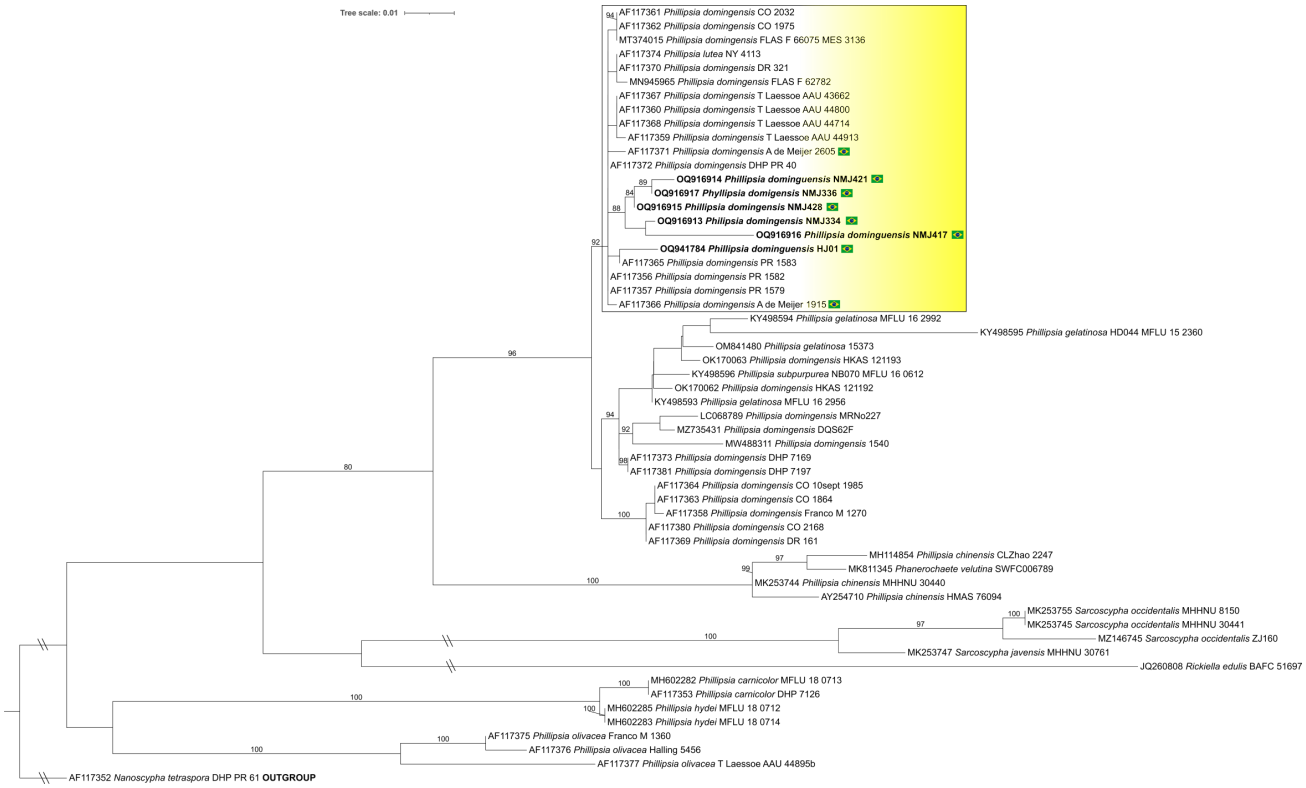

Figure S31. Maximum Likelihood (ML) tree of *Phillipsia* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Phillipsia dominguensis*. The sequences in bold were generated in this work.

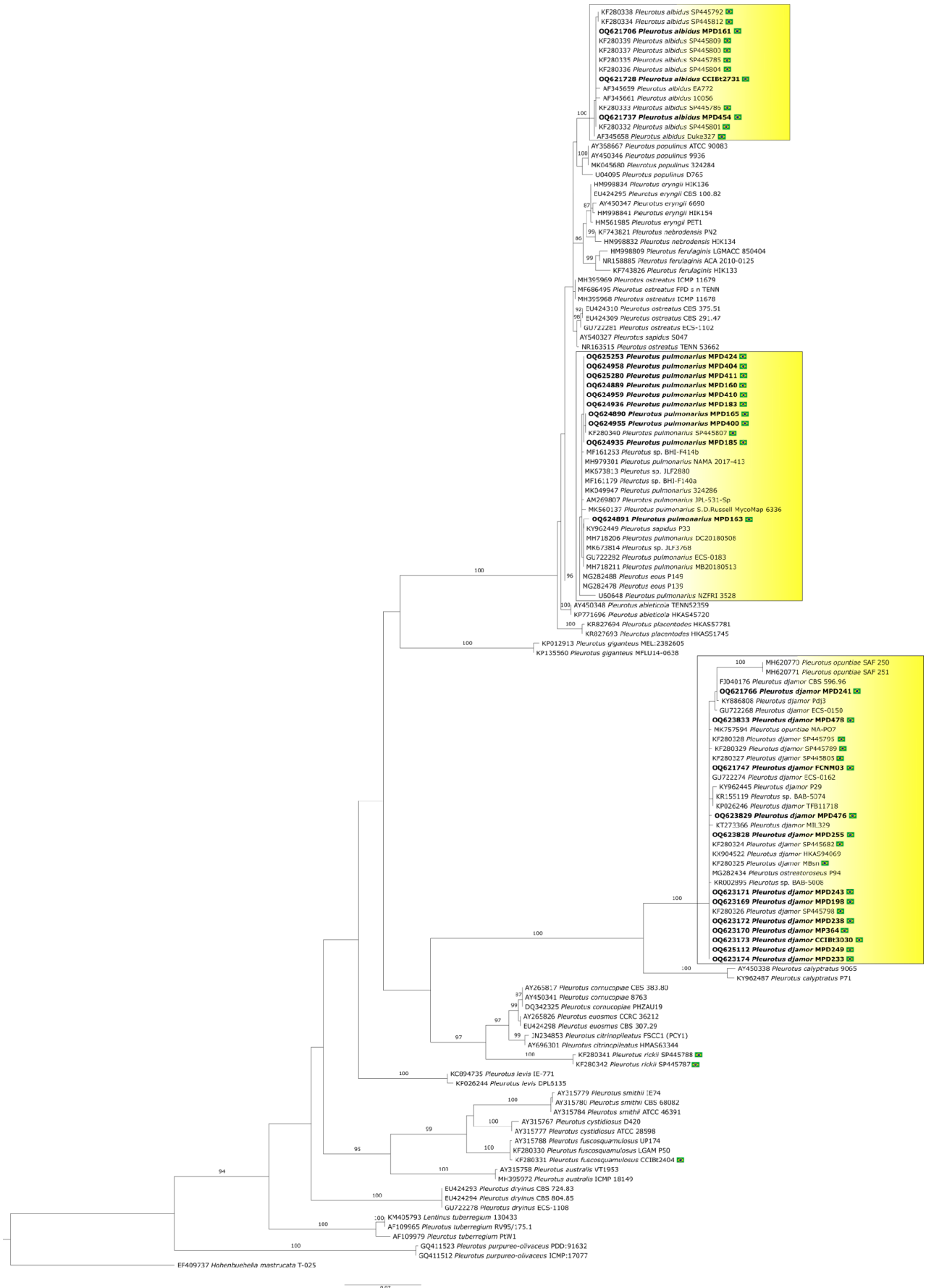

Figure S32. Maximum Likelihood (ML) tree of *Pleurotus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Pleurotus albidus*, *Pleurotus djamor,* and *Pleurotus pulmonarius*. The sequences in bold were generated in this work.

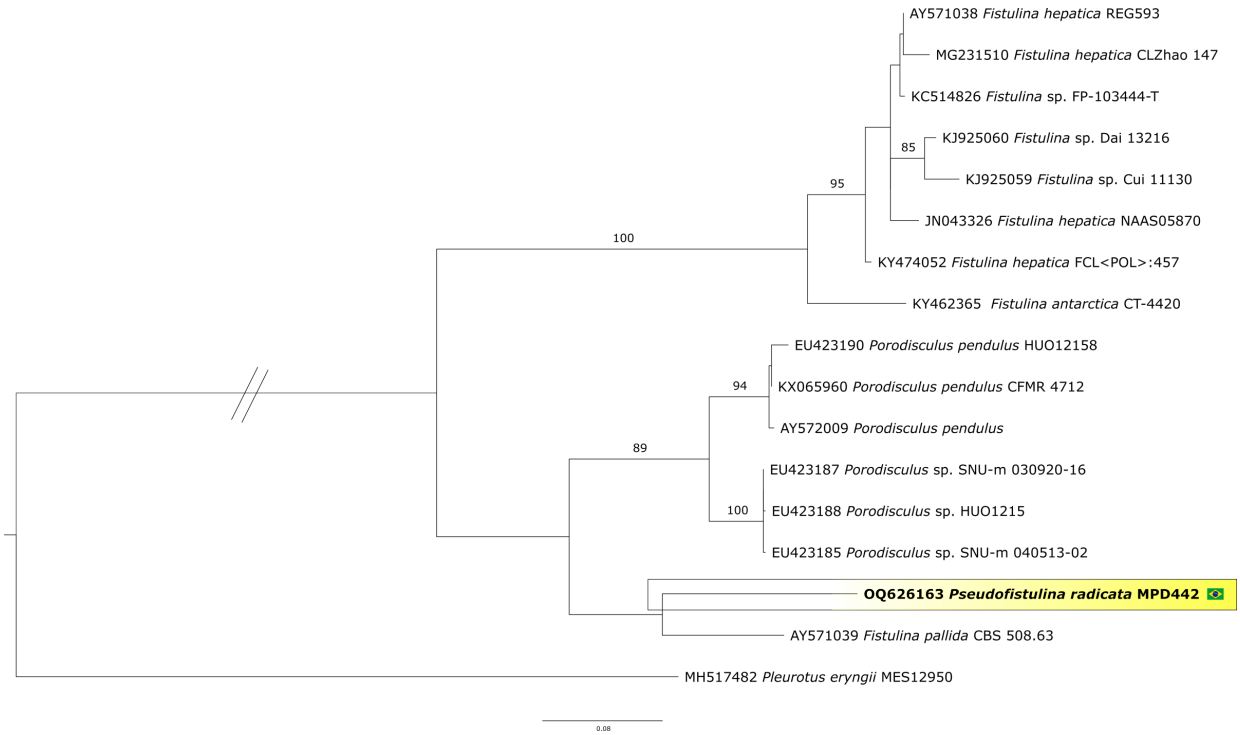

Figure S33. Maximum Likelihood (ML) tree of *Pseudofistulina* and allied genera based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Pseudofistulina radicata*. The sequence in bold was generated in this work.

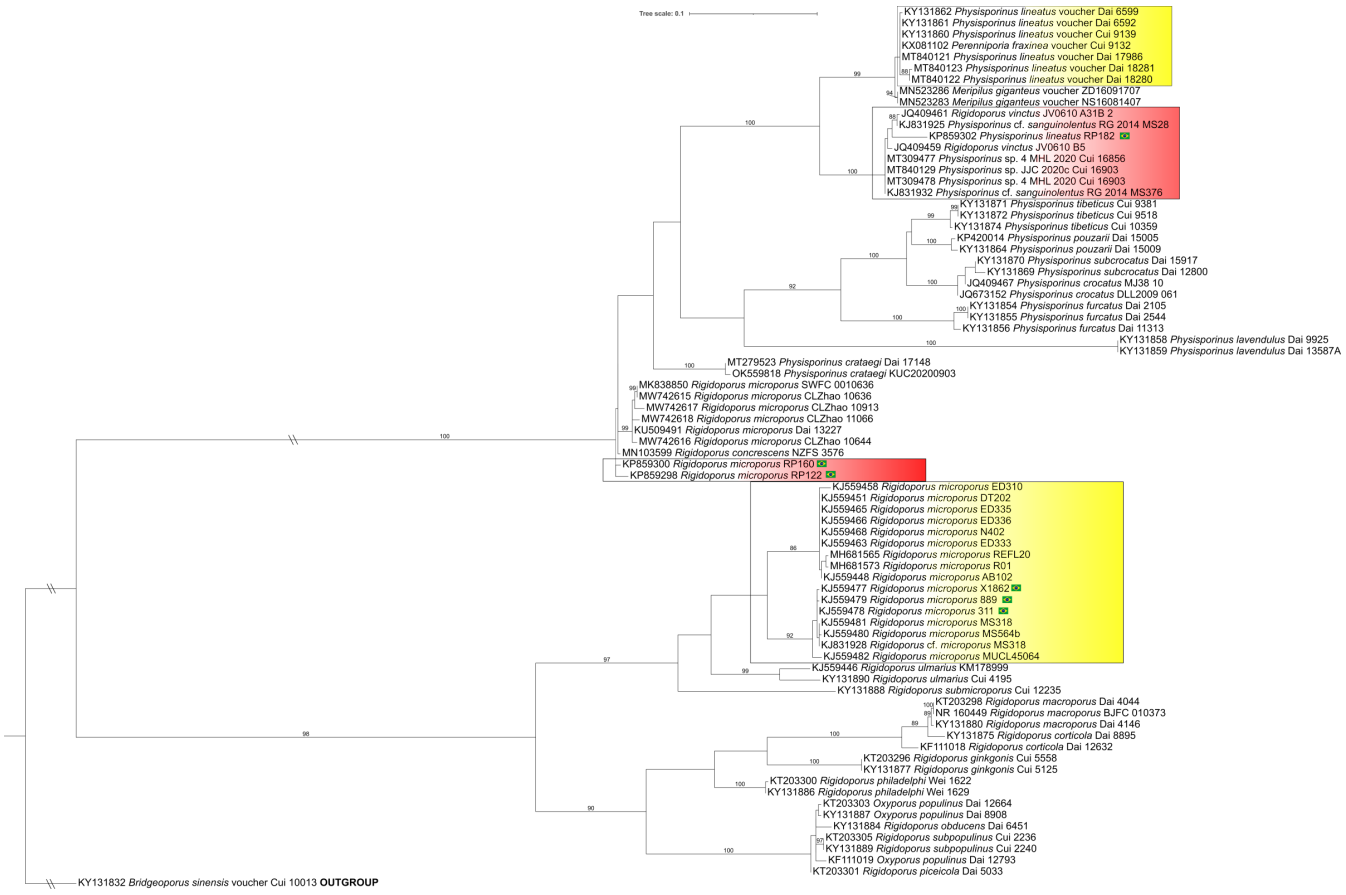

Figure S34. Maximum Likelihood (ML) tree of *Rigidoporus* and allied based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Rigidoporus microporus* and *Physisporinus lineatus*. The red highlight represents the clades with misidentified sequences.

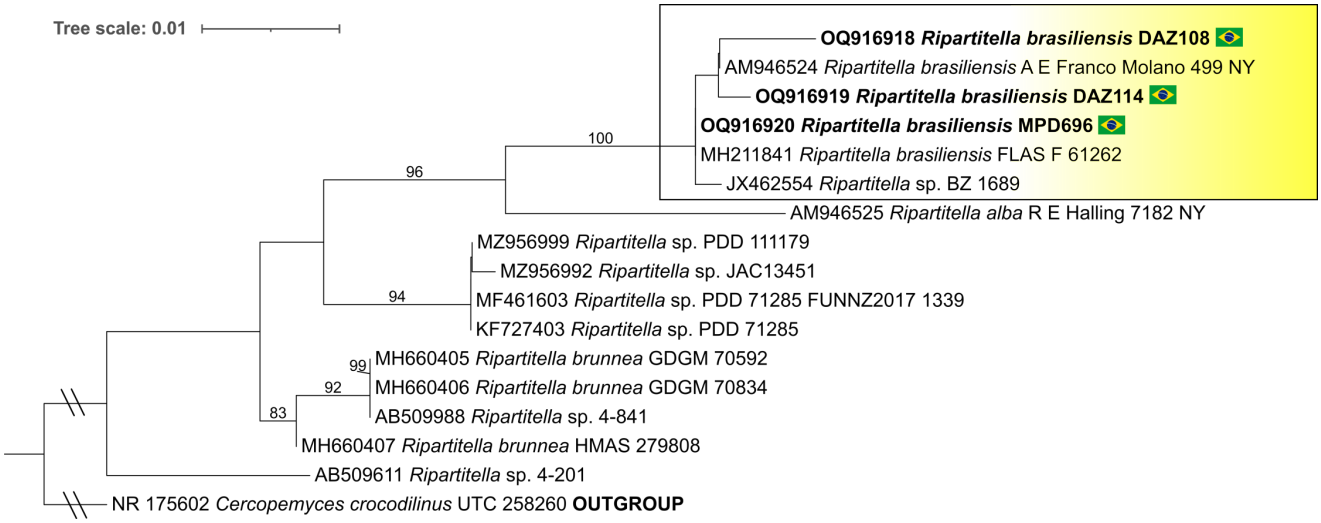

Figure S35. Maximum Likelihood (ML) tree of *Ripartitella* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Ripartitella brasiliensis*. The sequences in bold were generated in this study.

Figure S36. Maximum Likelihood (ML) tree of *Russula* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Russula parazurea*. The sequence in bold was generated in this study.

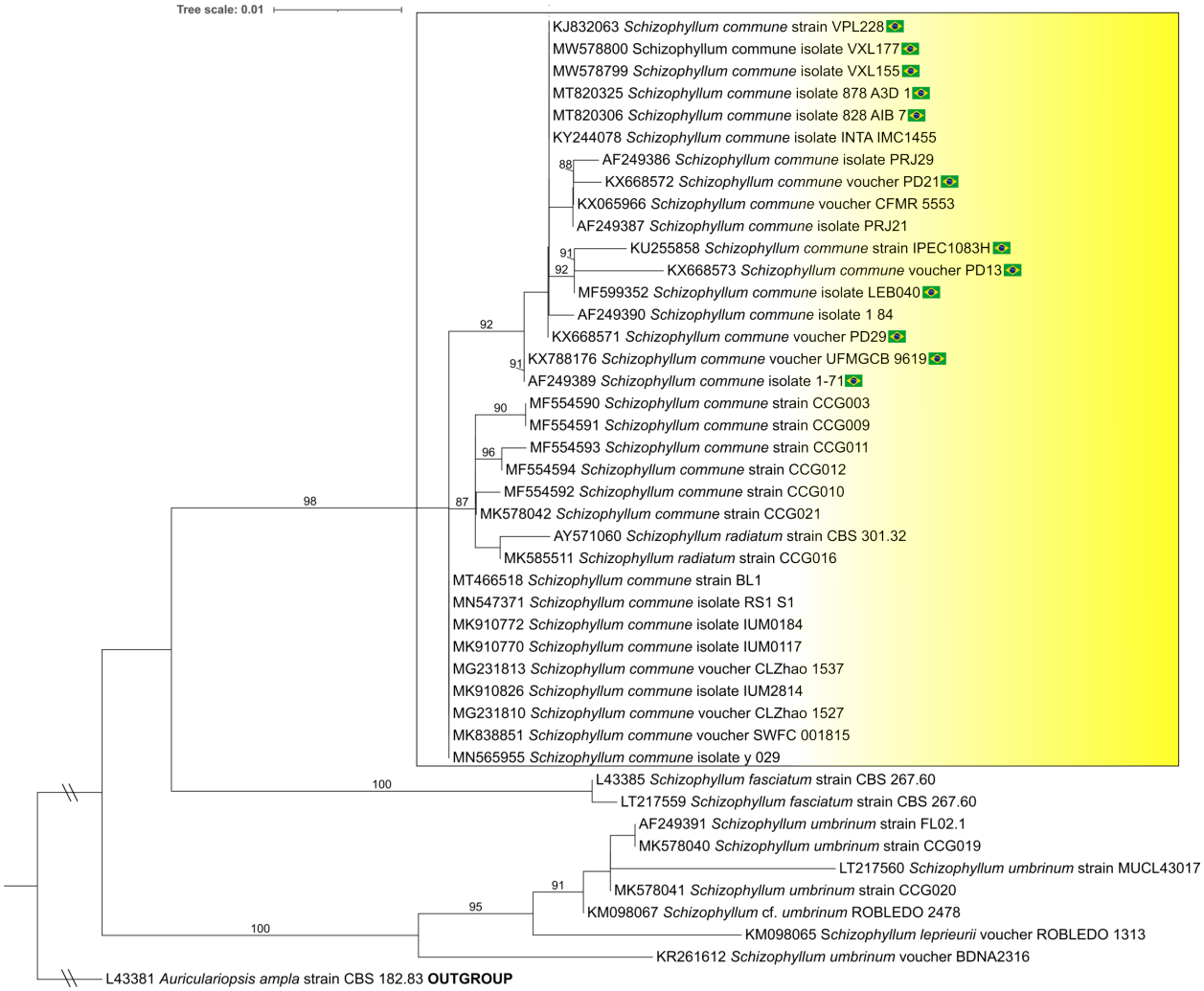

Figure S37. Maximum Likelihood (ML) tree of *Schizophyllum* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Schizophyllum commune*.

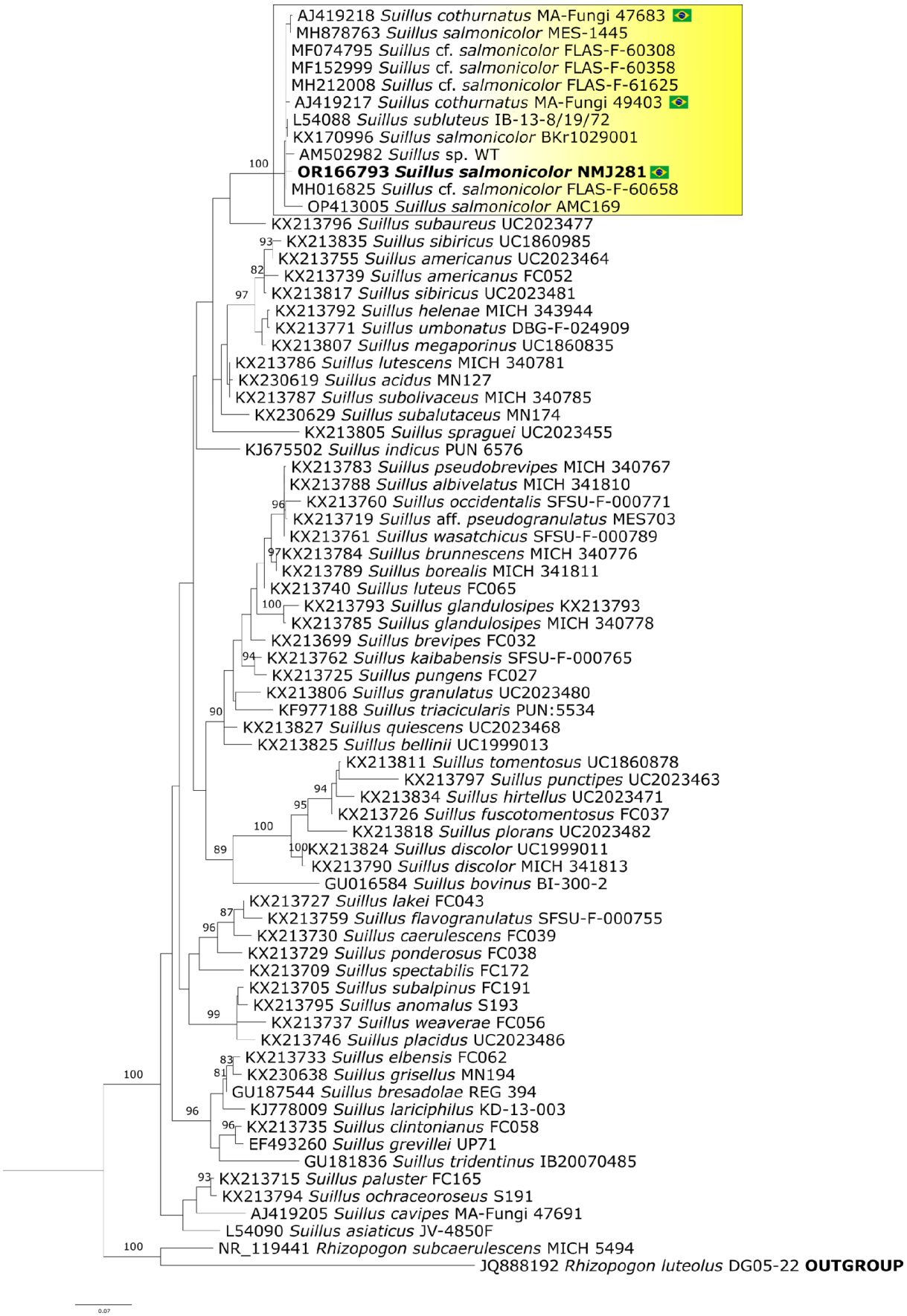

Figure S38. Maximum Likelihood (ML) tree of *Suillus* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Suillus salmonicolor*. The sequence in bold was generated in this study.

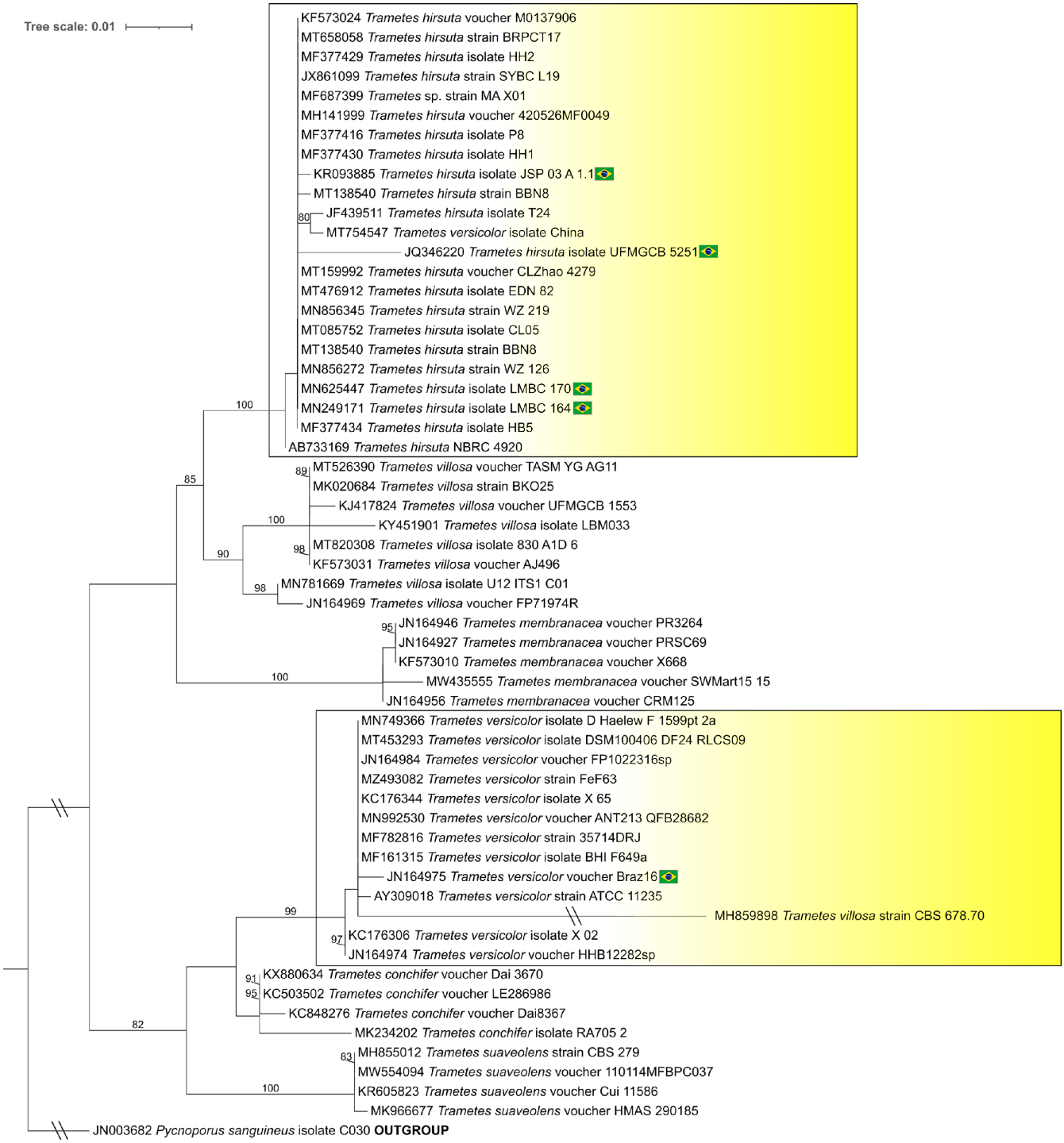

Figure S39. Maximum Likelihood (ML) tree of *Trametes* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Trametes hirsuta* and *Trametes versicolor*.

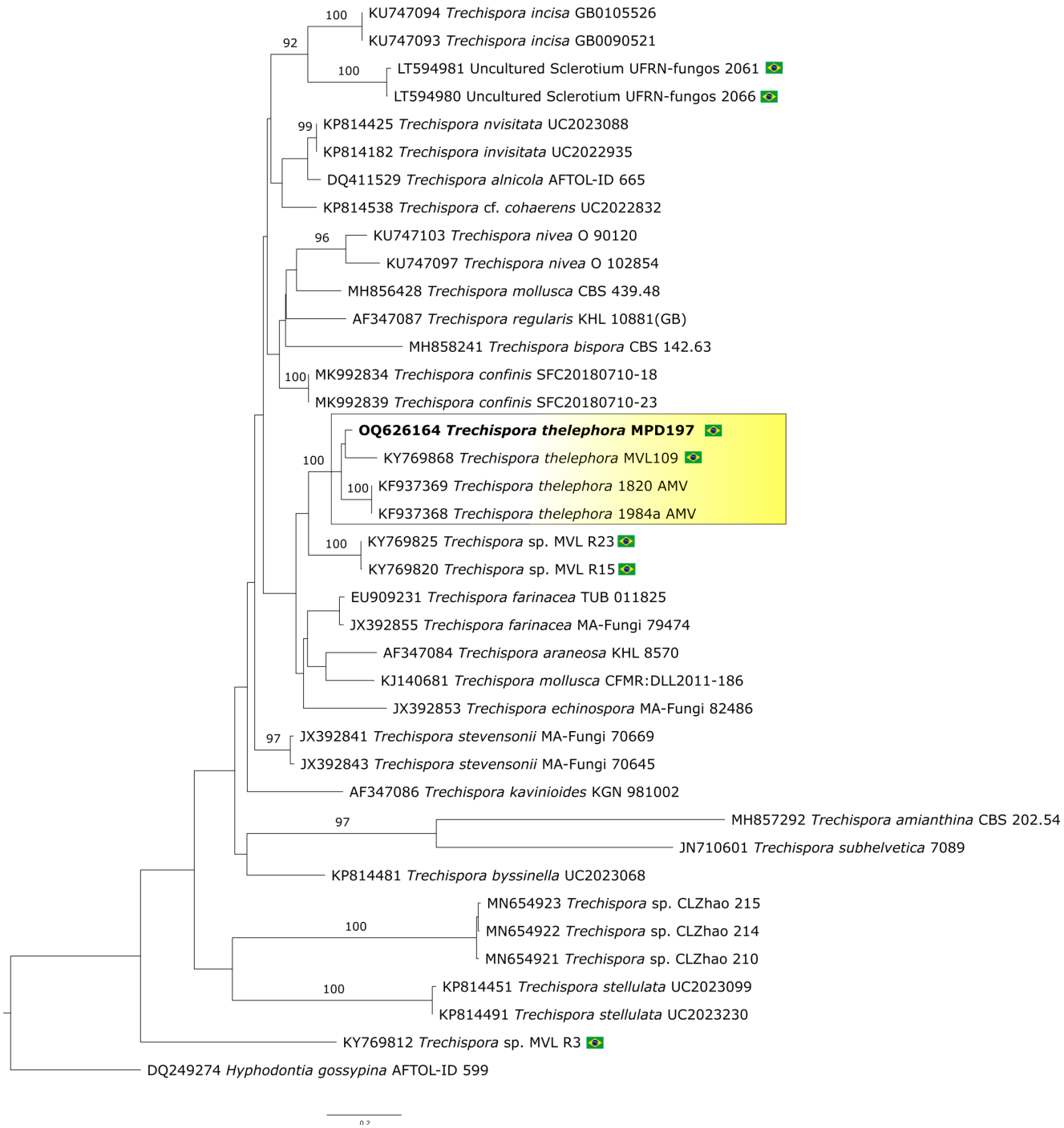

Figure S40. Maximum Likelihood (ML) tree of *Trechispora* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Trechispora thelephora*. The sequence in bold was generated in this study.

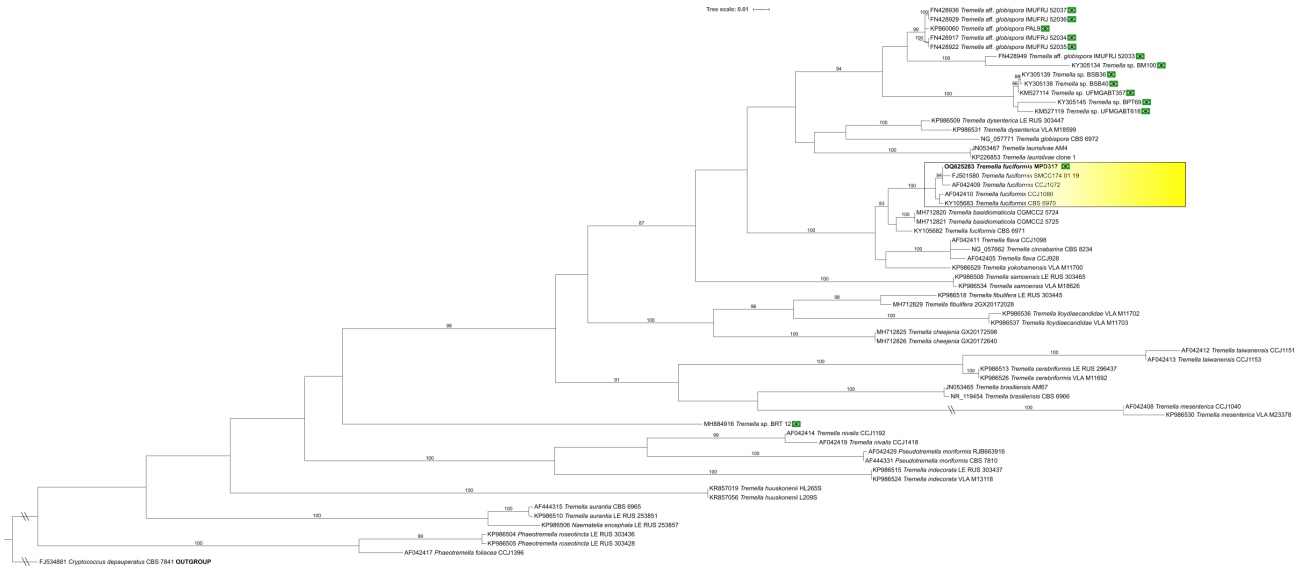

Figure S41. Maximum Likelihood (ML) tree of *Tremella* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Tremella fuciformis*. The sequence in bold was generated in this study.

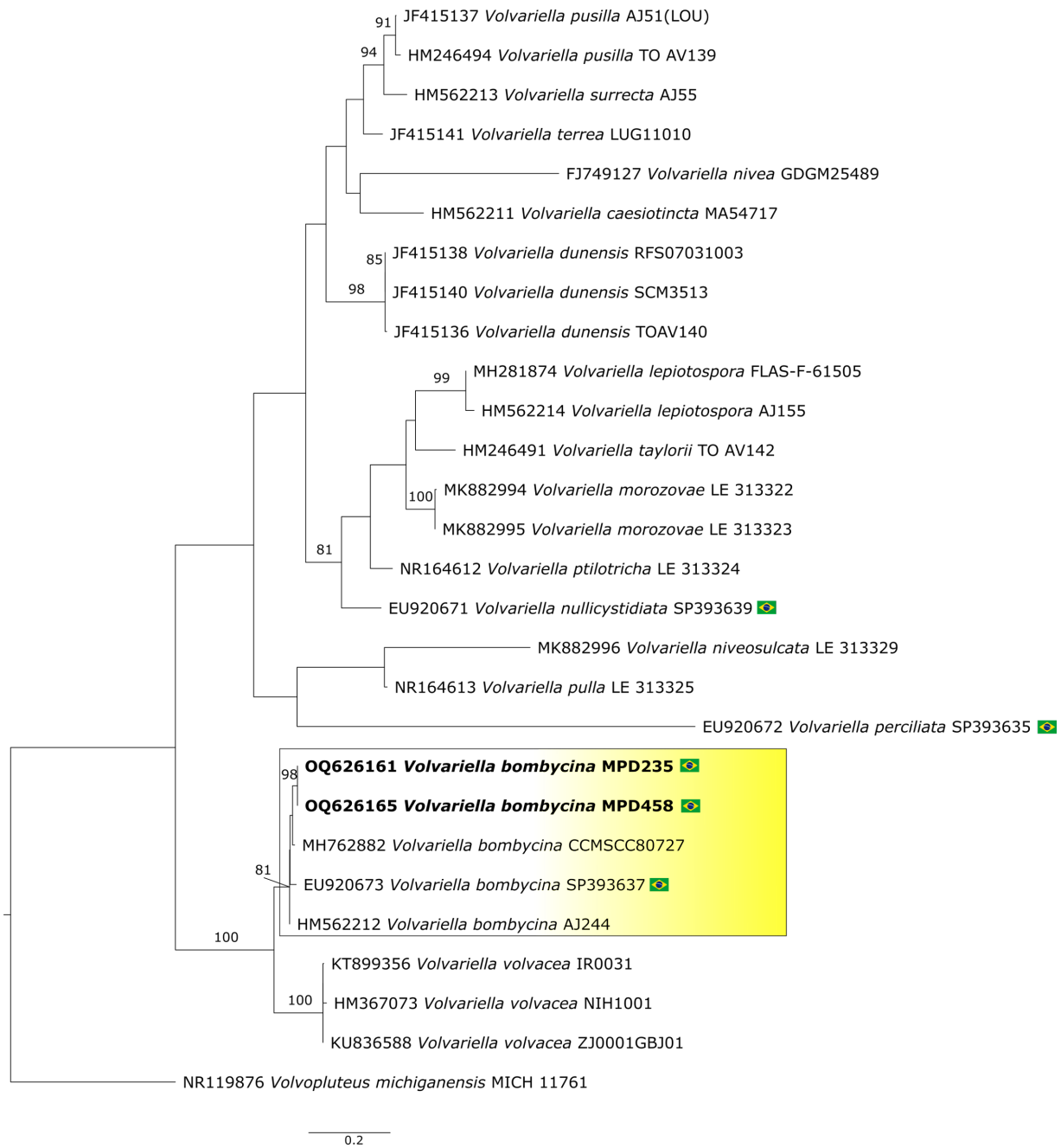

Figure S42. Maximum Likelihood (ML) tree of *Volvariella* based on ITS data. Branches are labeled with ML bootstrap higher than 80%. The highlight in yellow represents the clade of species *Volvariella bombycina*. The sequences in bold were generated in this study.

Capítulo II

Studies on domestication of two species of wild edible mushroom from Brazil

Artigo aceito na revista *Annals of the Brazilian Academy of Sciences*

Studies on domestication of two species of wild edible mushroom from Brazil

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Running title: Domestication of wild edible mushrooms from Brazil

AABC Section: Microbiology

ABSTRACT

There are about 80 species of wild edible mushroom that certainly occur in Brazil and can be used as a natural source of food and medicine. This study aimed to evaluate the in vitro mycelial development in culture media at different temperatures and substrates for cultivation of the edible mushroom species *Auricularia fuscosuccinea* and *Laetiporus gilbertsonii*. Additionally, the cultivation and the nutritional composition of *A. fuscosuccinea* mushrooms were evaluated. The two best wild strains of each species were selected for the in vitro cultivation experiment in two different substrates. Furthermore, an axenic cultivation on sawdust was conduct and the basidiomata produced were evaluated on their nutritional composition. The temperatures that best favored the mycelial growth were 30 °C for *A. fuscosuccinea* and 25 °C and 30 °C for *L. gilbertsonii*. The mycelium of both species developed better in the sterile *Eucalyptus* sawdust substrate. Despite the success in cultivating the mycelium of *L. gilbertsonii*, it was not possible to obtain basidioma for this species. On the other hand, it was possible to produce basidiomata of the two tested wild strains of *A. fuscosuccinea*.

Keywords Atlantic Rainforest, *Auricularia fuscosuccinea*, *Laetiporus gilbertsonii*, mushroom cultivation, nutritional content

INTRODUCTION

Wild edible mushrooms are an important natural source of food, medicine, and income for communities in more than 90 countries (Li et al. 2021). There are about 2,000 species of wild edible mushrooms worldwide (Li et al. 2021), but only approximately 130 have been domesticated (Thawthong et al. 2014). Despite the diversity of edible species, five genera [*Lentinula* Earle, *Pleurotus* (Fr.) P. Kumm., *Auricularia* Bull., *Agaricus* L., and *Flammulina* P. Karst.] constitute about 85 % of the world production of edible mushrooms (Royse et al. 2017). Albertó (2017) summarized the steps for domestication of naturally occurring species in 14 points, from the strain isolation to the nutritional composition. Considering that all these steps are complex, a good starting point is to determine if the wild species to be domesticated can be cultivated using the techniques common for commercial species (Albertó 2017). Among the almost 80 species of wild edible mushroom that certainly occur in Brazil (Drewinski 2023), we focus this work to test few steps for the domestication of Brazilian wild strains of the edible mushrooms *Auricularia fuscosuccinea* (Mont.) Henn. and *Laetiporus gilbertsonii* Burds.

Auricularia fuscosuccinea (Basidiomycota: Auriculariaceae) was originally described from Cuba and occurs in tropical and subtropical regions of the Americas (Wu et al. 2021). Fidalgo & Hirata (1979) reported the use of this species as food by Txicão and Txucarramãe indigenous people from the Xingu National Park in Brazil. Additionally, the use of *A. fuscosuccinea* as food has been recorded by other communities in the Americas (Gamboa-Trujillo et al. 2019; Ruan-Soto et al. 2021). *Auricularia fuscosuccinea* is easily found both in forests and in urban areas, and it has already been recorded for 13 of the 26 Brazilian states: Acre, Amazonas, Mato Grosso, Goiás, Pará, Paraíba, Pernambuco, Paraná, Rio de Janeiro, Rondônia, Rio Grande do Sul, Santa Catarina, and São Paulo (Alvarenga et al. 2015; Drewinski 2023).

Laetiporus gilbertsonii (Basidiomycota: Laetiporaceae) was described based on collections from the Pacific coast of the United States of America (Burdsall Jr & Banik 2001) and has a wide distribution in the Americas, occurring from temperate to tropical and subtropical zones (Lindner and Banik 2008; Banik et al. 2012; Pires et al. 2016; Campi et al. 2022). Recently, Campi et al. (2022) studied the occurrence of the genus *Laetiporus* in South America and concluded that *L. gilbertsonii* is the correct name for the species growing in Southern South America (Campi et al. 2022). In Brazil, the species has been reported for the Southeastern region, in the states of São Paulo (Pires et al. 2016) and Espírito Santo (Drewinski 2023). The species is associated with brown rot mainly of *Eucalyptus* spp. and *Quercus* spp., occurring in both living trees and dead trunks and logs (Burdsall Jr & Banik 2001). As well as for another species of the genus, *Laetiporus sulphureus* (Bull.) Murrill, the species *L.*

gilbertsonii is also known as "chicken of the woods" and present a pronounced flavor, excellent texture and is highly appreciated in gastronomy, although there are no studies on its cultivation. Tropical regions have a great potential to be a rich source of cultivatable fungal species (Thawthong et al. 2014), and Brazil is a good country for this kind of investigations.

MATERIAL AND METHODS

Sampling

Collections were carried out in the Atlantic Rainforest domain, in the Brazilian states of Espírito Santo, Paraná, Rio de Janeiro, and São Paulo (Table 1). From the fresh wild basidiomata, a pure mycelium culture was obtained through the inoculation of fragments of the pileus context into Petri dishes containing sterile PDA (Potato Dextrose Agar) medium. The dried vouchers are deposited at the herbarium SP (at the 'Instituto de Pesquisas Ambientais') and at the fungarium FIFUNGI (IFungiLab, at the 'Instituto Federal de Educação, Ciência e Tecnologia de São Paulo'), and the live cultures are at the 'Coleção de Culturas de Algas, Fungos e Cianobactérias – CCIBt' (at the 'Instituto de Pesquisas Ambientais'). This study is according to the Brazilian legislation on access to biodiversity and is registered in the 'Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado' (SisGen # A4A9200).

Table 1. Data on the Brazilian wild strains of *Auricularia fuscosuccinea* and *Laetiporus gilbertsonii* evaluated in this research.

Species	CCIBt accession	Collector number	Fungarium/ Herbarium accession	GenBank accession	Locality
A. fuscosuccinea	2381	-	-	OP851766	São Paulo, Cananeia
A. fuscosuccinea	2959	-	-	OP851765	Paraná, Curitiba
A. fuscosuccinea	4745	MPD158	SP513097	OP851758	Paraná, Guarapuava, particular property
A. fuscosuccinea	4747	MPD351	SP513098	OP851770	São Paulo, Cananeia, PEIC
A. fuscosuccinea	4748	MPD455	SP513099/ FIFUNGI2	OP851752	São Paulo, São Paulo, PEC
A. fuscosuccinea	4749	MPD497	SP513100	OP851764	São Paulo, Iporanga, PETAR
A. fuscosuccinea	4751	MPD527	SP513101/ FIFUNGI3	OP851753	Rio de Janeiro, Teresópolis, PARNASO
A. fuscosuccinea	4752	MPD539	SP513102/ FIFUNGI4	OP851755	Rio de Janeiro, Teresópolis, PARNASO
A. fuscosuccinea	4753	MPD576	SP513103/ FIFUNGI5	OP851768	São Paulo, Campos do Jordão, PECJ

A. fuscosuccinea	4756	MPD600	SP513104	OP851800	São Paulo, Cananeia, PEIC
A. fuscosuccinea	4757	MPD609	SP513105	OP851757	São Paulo, Iporanga, PETAR
A. fuscosuccinea	4758	MPD614	SP513106	OP851754	São Paulo, Iporanga, PETAR
L. gilbertsonii	4709	MPD300	SP512740	OP851756	Espírito Santo, Santa Teresa, RBAR
L. gilbertsonii	4710	MPD306	SP512741	OP851769	Espírito Santo, Santa Teresa, RBAR
L. gilbertsonii	4718	MPD466	SP513107/ FIFUNGI7	OP851767	São Paulo, São Paulo, PFC

CCIBt: *Coleção de Culturas de Algas, Cianobactérias e Fungos* at the *Instituto de Pesquisas Ambientais*; PETAR: *Parque Estadual Turístico Alto do Ribeira*; PEIC: *Parque Estadual da Ilha do Cardoso*; RBAR: *Reserva Biológica Augusto Ruschi*; PEC: *Parque Estadual da Cantareira*; PARNASO: *Parque Nacional da Serra dos Órgãos*; PECJ: *Parque Estadual Campos do Jordão*; PFC: *Parque Dr. Fernando Costa*.

Species identity

The identification of the collected specimens was made through morphological and molecular characteristics, following specific bibliographies (Lowy 1952; Burdsall Jr. & Banik 2001; Looney et al. 2013; Pires et al. 2016; Wu et al. 2021). For molecular studies, DNA extraction was performed from mycelium obtained in liquid culture following a modified CTAB extraction method. The intergenic ribosomal region (nrITS1-5.8S-ITS2) was amplified by polymerase chain reactions (PCR) with the primers ITS1-F and ITS4 (White et al. 1990). The amplified products were purified with QIAquick PCR Purification Kit and sequenced at MacroGen (South Korea) using the same primer pair. The generated sequences were manually checked and edited with Geneious v.8.1 (Kearse et al. 2012). We used the Basic Local Alignment Search Tool (BLAST) to find similar sequences to build the matrices. Sequences were aligned using MAFFT online (Katoh et al. 2019) and were manually optimized using AliView (Larsson 2014). The ITS region was partitioned into ITS1, 5.8S and ITS2, and the evolution model was estimated for each partition using the BIC (Bayesian Information Criterion) criterion in jModelTest v.2.0 (Darriba et al. 2012). The Bayesian inference (BI) analysis was performed with Mr.Bayes v3.2.7a (Ronquist et al. 2012), with two independent runs, four simultaneous independent chains and 20,000,000 generations with a sample frequency every 1,000 generation. The phylogenetic trees are available as Supplementary material.

Mycelial growth and dry mycelial biomass at different temperatures

Twelve wild strains of *A. fuscosuccinea* and three of *L. gilbertsonii* were evaluated for mycelial growth and dry biomass production in PDA culture medium at different temperatures. After the preparation and solidification of the culture medium (30 mL) in Petri dishes (90 mm diam), a 9.6 mm fragment of the pure culture matrix was inoculated in the center of the plate for each wild strain. The plates were incubated at temperatures of 20 °C, 25 °C, 30 °C and 35 °C in a BOD (Bio-Oxygen Demand) incubator (Vargas-Isla & Ishikawa 2008). The experiment was carried out in 15 replicates per temperature per strain. The diameter of the mycelial growth was measured on the day that one of the replicates of each evaluated wild strain completed the growth on the plate. To evaluate the dry mycelial biomass, the plates were placed in the microwave and heated for 20 seconds to melt the culture medium, then the mycelium was filtered and washed with distilled water and the biomass was dehydrated until constant weight (Vargas-Isla & Ishikawa 2008).

Mycelial development on different substrates

From the results of the mycelial biomass and growth tests at different temperatures, two wild strains of each species were selected for the experiment of mycelial development on two substrates: i) autoclaved, based on eucalyptus sawdust; ii) pasteurized, based on sugarcane bagasse and grass (*Brachiaria* sp.). The sawdust-based substrate was donated by the company Yuri Cogumelos (Sorocaba, São Paulo state, Brazil), which sells blocks for the shiitake production, and is composed of 80 % eucalyptus sawdust and 20 % grass bran, with a moisture content of 68 %. The substrate was distributed in glass jars (600 mL), closed with a metal lid with a cotton filter, and then sterilized in an autoclave at 121 °C for two hours. The substrate JunCao (Jun = mushroom and Cao = grass), based on sugarcane bagasse and grass (*Brachiaria* sp.), was donated by a producer of *Pleurotus ostreatus* from Bragança Paulista city (São Paulo state, Brazil), and is composed of 60 % sugarcane bagasse, 35 % *Brachiaria* sp., and 5 % wheat bran. The substrate was pasteurized with fluent steam for seven days and distributed in sterile glass jars (600 mL). The substrates were inoculated with 1 % of spawn (myceliated wheat grains), which was divided into three fractions and inoculated in three portions on the surface of substrates. The jars were maintained in BOD incubator at 30 °C and the daily growth was measured from the three inoculation points with a pachymeter. The experiment was carried out with 15 replicates per substrate per strain.

Axenic cultivation experiment

The substrate based on eucalyptus sawdust was used for the cultivation in blocks. The substrate (2.5 kg) was packed in polypropylene bags with filters, which were sterilized in an industrial autoclave for 3h and 40min at 121 °C. After sterilization and cooling of the substrate, the packages were inoculated with 2 % of spawn. The packages were incubated in the dark, in a culture chamber, with the temperature set to 30 °C. After complete mycelial growth, the packages were submitted to a rustic cultivation environment, without temperature control, with average temperature of 24 °C (ranging from 7.4 °C to 35.5 °C), average humidity of 64 % (ranging from 34 % to 99 %), and average CO_2 concentration of 659 ppm (ranging from 585 ppm to 745 ppm). To induce primordia, the packages of *A. fuscosuccinea* were cut at the top. For the cultivation of *L. gilbertsonii*, four forms of induction of primordia were tested, following Pleszczynska et al. (2013): i) incubation of the blocks in a refrigerator (7–8 °C) for 24 hours and transfer to the grow environment without opening the package; ii) injection of 300 mL of cold sterile distilled water through the package filter; iii) incubation of the blocks in a refrigerator (7–8 °C) for 24 hours, cutting on the surface of the package and removal of mycelium from the surface of grow block (scratching technique); and iv) cutting on the package surface and scratching technique. The *A. fuscosuccinea* experiment was carried out with 12 replicates and the *L. gilbertsonii* experiment was carried out with eight replicates per treatment. The blocks were monitored for 60 days after primordia induction.

Bromotalogical analyses of *A. fuscosuccinea*

The basidiomata obtained were analyzed for moisture content, ash, crude protein, crude fat, and crude fiber (Zenebon et al. 2008). The bromatological analyzes were carried out at the Bromatology Laboratory of the Animal Production Department at 'Universidade Estadual Paulista Júlio de Mesquita Filho - UNESP', in Dracena, São Paulo, Brazil. The crude protein content was determined indirectly from the total nitrogen value using Kjeldahl method (Zenebon et al. 2008), using the conversion factor of 4.38 (Crisan & Sands 1978). All analyzes were performed in triplicate and the results express the arithmetic mean.

Statistical analyses

For statistical evaluation, the data obtained were submitted to the Shapiro-Wilk normality test and then analyzed using Two-way ANOVA test. The averages were compared by the Tukey test, using level of significance of 0.05 (Vieira 1980). Statistical analyzes were performed using the software GraphPad Prism version 9 (http://www.graphpad.com).

RESULTS

Auricularia fuscosuccinea

The effects of different temperatures on 12 wild strains of *A. fuscosuccinea* growth in PDA are shown in Figure 1. The mycelial growth and dry mycelial biomass were higher at 30 °C ($p \leq 0.05$) with the first wild strains completing the Petri dish colonization in seven days (Figure 3 A–D). Comparing the mycelial growth diameter among all wild strains at 30 °C, there was no difference ($p > 0.05$) between the wild strains CCIBt2381, CCIBt2959, CCIBt4747, CCIBt4748, CCIBt4751, CCIBt4753, CCIBt4756, and CCIBt4758 (Figure 1 A). However, in relation to dry mycelial biomass (Figure 1 B), on the seventh day of colonization at 30 °C, the wild strain CCIBt2381 had the highest biomass production (171.20 mg ± 10.01 mg), followed by the wild strain CCIBt4753 (151.11 mg ± 6.77 mg). Based on these results, the wild strains CCIBt2381 and CCIBt4753 were selected for the substrates experiments.

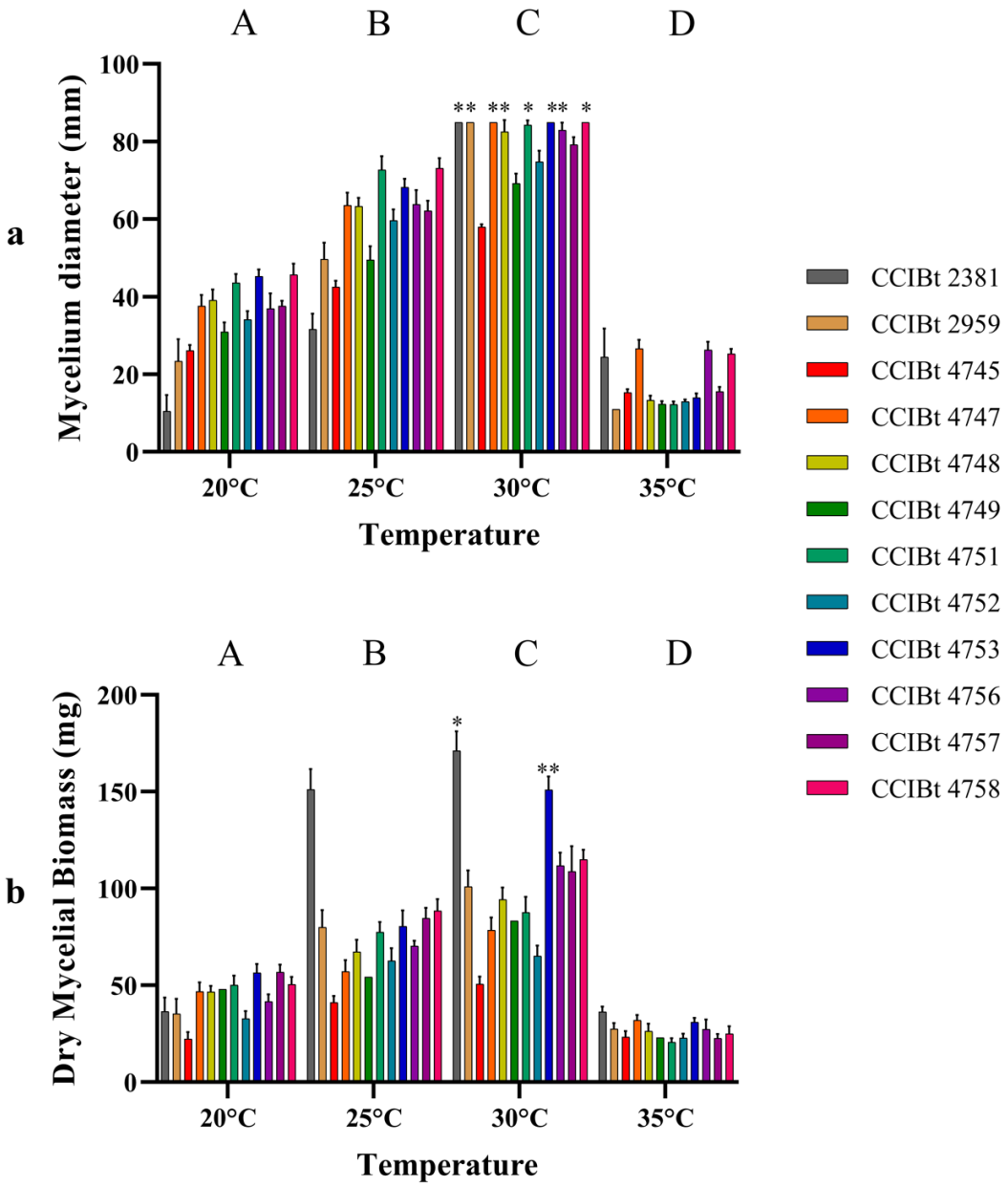

Fig. 1 Effects of different temperatures on growth of 12 Brazilian wild strains of *Auricularia fuscosuccinea* on the seventh day. (a) Mycelium diameter (mm); (b) Dry mycelial biomass (mg). Capital letters compare the means of all wild strains at different temperatures. The asterisk indicates statistical significance by Tukey's test at 0.05 probability of the best values obtained by the wild strain at the best temperature.

The wild strains CCIBt4753 and CCIBt2381 completed the colonization of the eucalyptus sawdust substrate in 21 and 22 days, respectively (Figure 2). The wild strain CCIBt4753, although it took longer to start growing in the sawdust (sixth day), completed the substrate colonization before the other wild strain (CCIBt2381) and presented an average daily growth of 5.21 mm ± 2.99 mm, against 4.88 mm ± 0.96 mm of the wild strain CCIBt2381. In

the JunCao substrate, the wild strain CCIBt2381 showed a good development at the beginning of the experiment (only until the tenth day), with an average daily growth of 1.00 mm ± 1.45 mm, but without surpassing the development in sawdust. The wild strain CCIBt4753 developed little in the JunCao substrate, showing an average growth of 0.26 mm ± 0.36 mm. For both wild strains, the substrate based on eucalyptus sawdust showed better mycelial growth results ($p \leq 0.05$).

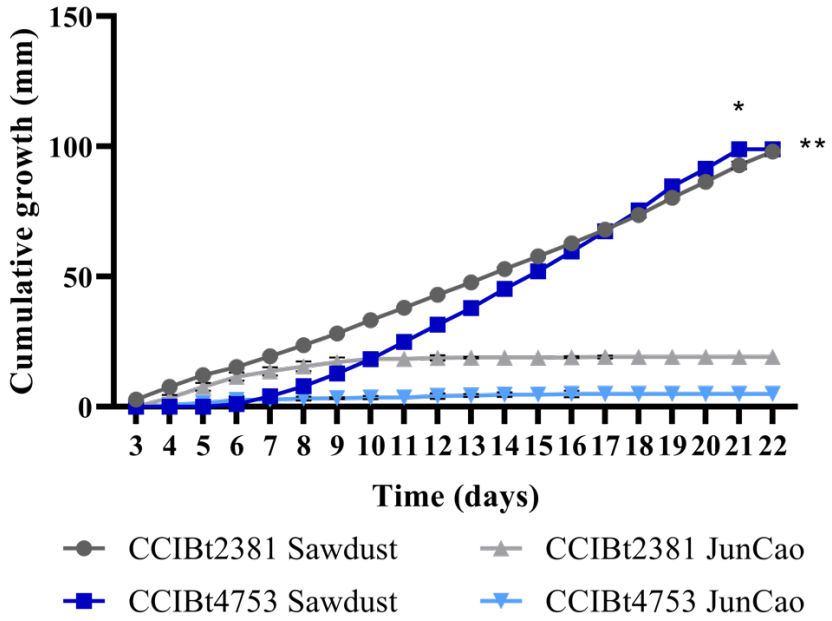

Fig. 2 Cumulative mycelial growth of two Brazilian wild strains of *Auricularia fuscosuccinea* in substrates JunCao and based on eucalyptus sawdust. The asterisk indicates statistical significance by Tukey's test at 0.05 probability.

The wild strain CCIBt2381 took 25 to 27 days to fully colonize the 2.5 kg sawdust substrate block, while the wild strain CCIBt4753 took 28 to 34 days. However, in the blocks with CCIBt4753, primordia were observed from 14 to 17 days after induction, not on the surface but in the lower half of the blocks (Figure 3 E-F), and the harvest were performed 35 days after induction of primordia. The primordia of CCIBt2381 developed 21 days after induction, and the first harvest was performed 45 days after primordia induction (Figure 3 G–H). Nutritional composition of basidiomata produced is shown in Table 2.

Table 2. Nutritional composition of two Brazilian wild strains of *Auricularia fuscosuccinea* produced on sawdust-based substrate.

	CCIBt2381	CCIBt4753
Moisture	12.79 %	12.17 %
Ash	4.79 %	4.49 %
Crude Protein	10.73 %	12.11 %
Crude Fat	0.91 %	0.82 %
Crude Fiber	3.85 %	3.73 %
Carbohydrate	70.78 %	70.41 %

Values are expressed on dry matter. Protein conversion factor N × 4.38

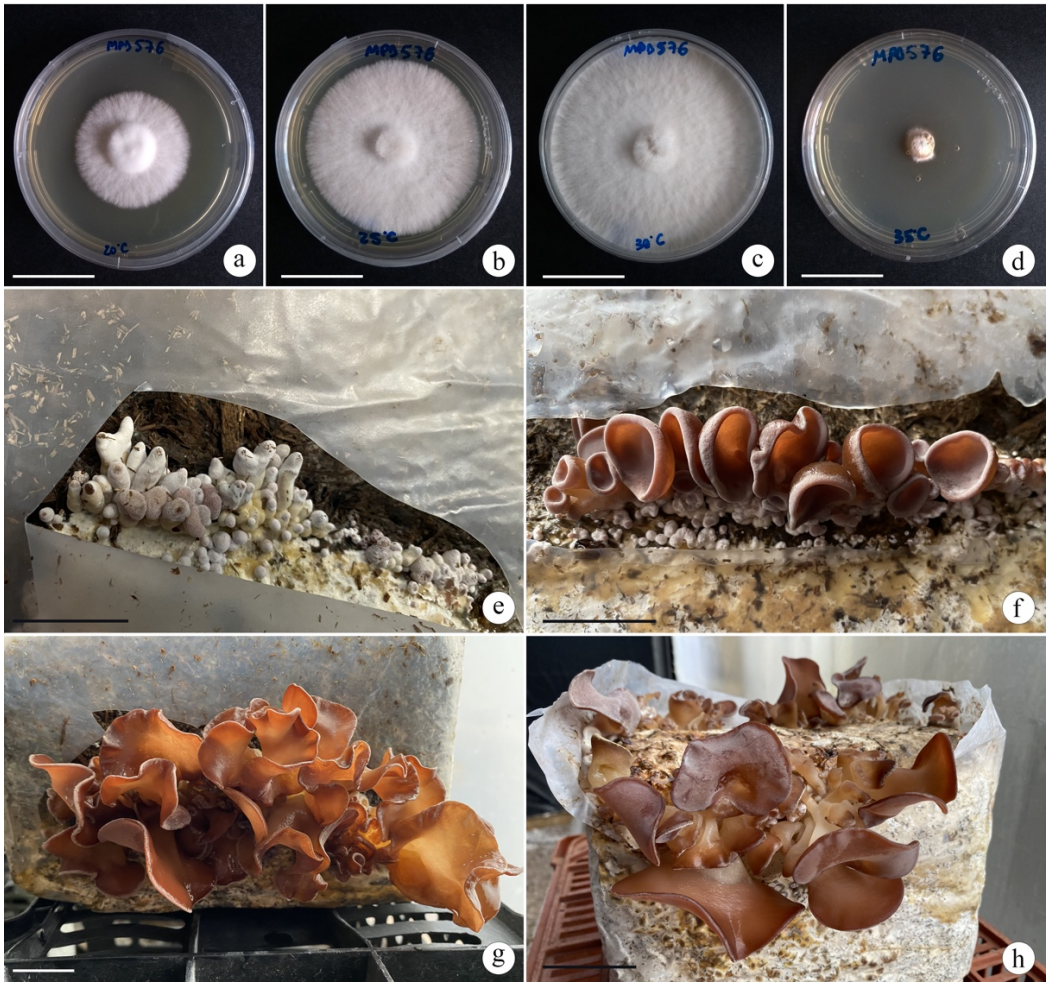

Fig. 3 Cultivation of Brazilian wild strains of *Auricularia fuscosuccinea*. (a–d) Mycelial growth of the wild strain CCIBt4753 in PDA medium on the seventh day; (a) Temperature at 20 °C; (b) Temperature at 25 °C; (c) Temperature at 30 °C; (d) Temperature at 35 °C; (e) Primordia of the wild strain CCIBt4753; (f) Beginning of the basidiomata development of the wild strain CCIBt4753; (g) Basidiomata of the wild strain CCIBt4753 at harvest point; (h) Basidiomata of the wild strain CCIBt2381 at harvest point. Scale bars = 3cm. Photos by Drewinski, M.P.

Laetiporus gilbertsonii

For the three wild strains of *L. gilbertsonii* evaluated, the temperature that best favored the growth of the mycelium was at 30 °C ($p \leq 0.05$), with all the wild strains completing the mycelial growth in the Petri dish in seven days (Figure 4 A; Figure 6 A–D). However, in relation to dry mycelial biomass (Figure 4 B), the values were higher at both 25 °C and 30 °C ($p \leq 0.05$). The wild strain CCIBt4710, despite not showing differences in growth diameter against the other two wild strains evaluated, was the one that obtained the best values ($p \leq 0.05$) of dry mycelial biomass, both at 25 °C (78.71 mg ± 5.10 mg) and 30 °C (78.00 mg ± 4.56 mg).

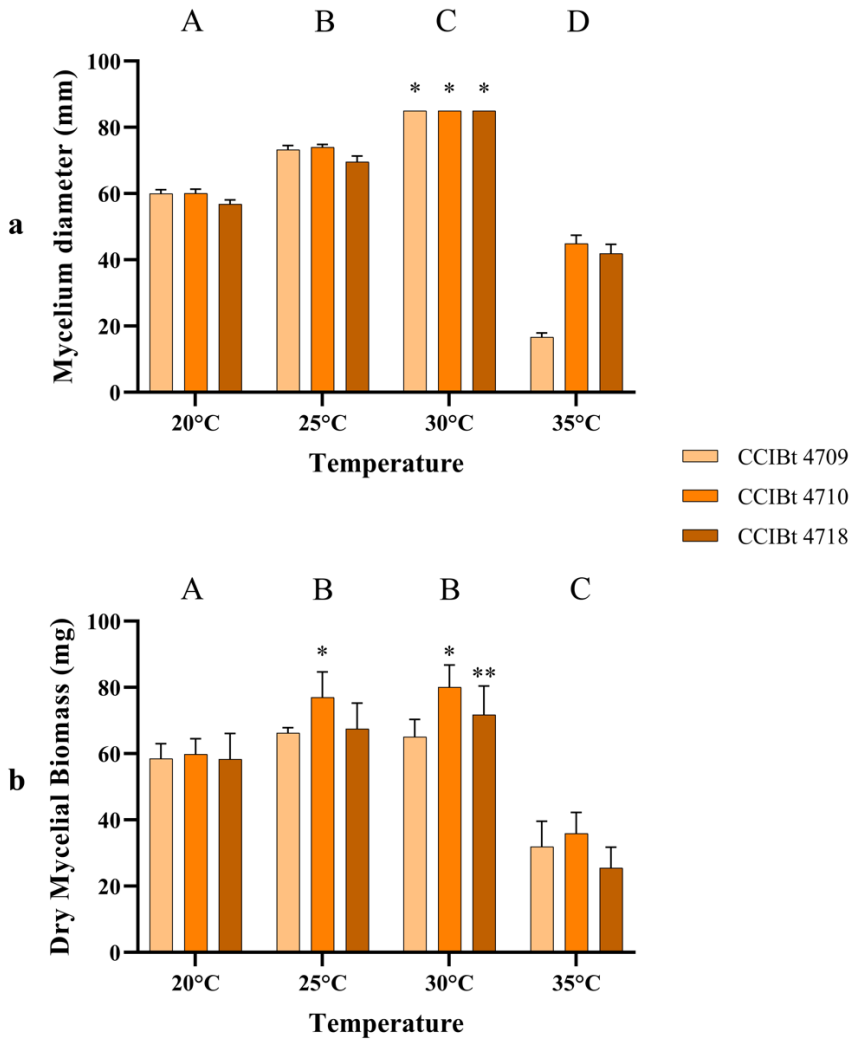

Fig. 4 Effects of different temperatures on growth of three Brazilian wild strains of *Laetiporus gilbertsonii* on the seventh day. (a) Mycelium diameter (mm); (b) Dry mycelial biomass (mg). Capital letters compare the means of all wild strains at different temperatures. The asterisk indicates statistical significance by Tukey's test at 0.05 probability of the best values obtained by the wild strains at each temperature.

The wild strains CCIBt4710 and CCIBt4718 were evaluated in the substrates experiment and completed the colonization of the sawdust-based substrate in 11 and 12 days, respectively (Figure 5). The mycelium of *L. gilbertsonii* is very aerial, fragile, and powdered, but it grew fast in the substrate based on eucalyptus sawdust after the second day from the inoculation. The average daily growth in this substrate was 9.60 mm ± 2.85 mm for the wild strain CCIBt4710 and 9.39 mm ± 2.88 mm for the wild strain CCIBt4718. On the JunCao substrate, the mycelium started to grow on the fourth day after inoculation, and it developed little, with an average daily growth of 0.27 mm ± 0.36 mm for the wild strain CCIBt4710 and 0.16 mm ± 0.24 mm for the wild strain CCIBt4718. The substrate based on eucalyptus sawdust was better for the mycelial development ($p \leq 0.05$) of both wild strains of *L. gilbertsonii* when compared to the JunCao substrate.

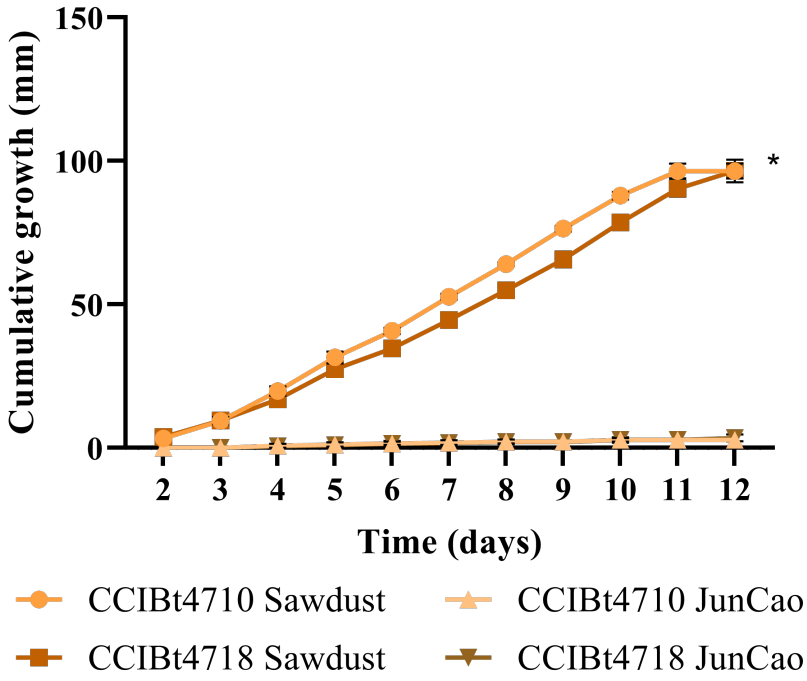

Fig. 5 Cumulative mycelial growth of two Brazilian wild strains of *Laetiporus gilbertsonii* in substrates JunCao and based on eucalyptus sawdust. The asterisk indicates statistical significance by Tukey's test at 0.05 probability.

The wild strains CCIBt4710 and CCIBt4718 were evaluated in the experiment of cultivation in blocks (2.5 kg) with substrate based on eucalyptus sawdust. The wild strains colonized the block quickly (Figure 6 F), taking from 9 to 10 days (CCIBt4710) and from 10 to 11 days (CCIBt4718) to complete the blocks (Figure 6 G). After 30 days of inoculation, the blocks were induced to form primordia. In the blocks in which the bag was opened and/or the surface layer of the mycelium was removed from substrate, there was new mycelial growth

with an intensification of the orange color of the mycelium, but without the formation of primordia. In the blocks where the bag was not opened, it was possible to observe the mycelium growing out of the filter (Figure 6 H–K) in: four bags of the wild strain CCIBt4710 incubated in the refrigerator; one bag of the wild strain CCIBt4710 that was injected cold water through the filter; and one bag of the wild strain CCIBt4718 that was incubated in the refrigerator. Despite the formation of this external mycelial mass, over time other contaminating fungi began to grow on the surface of the mycelium of *L. gilbertsonii* and it was not possible to obtain basidiomata for this species.

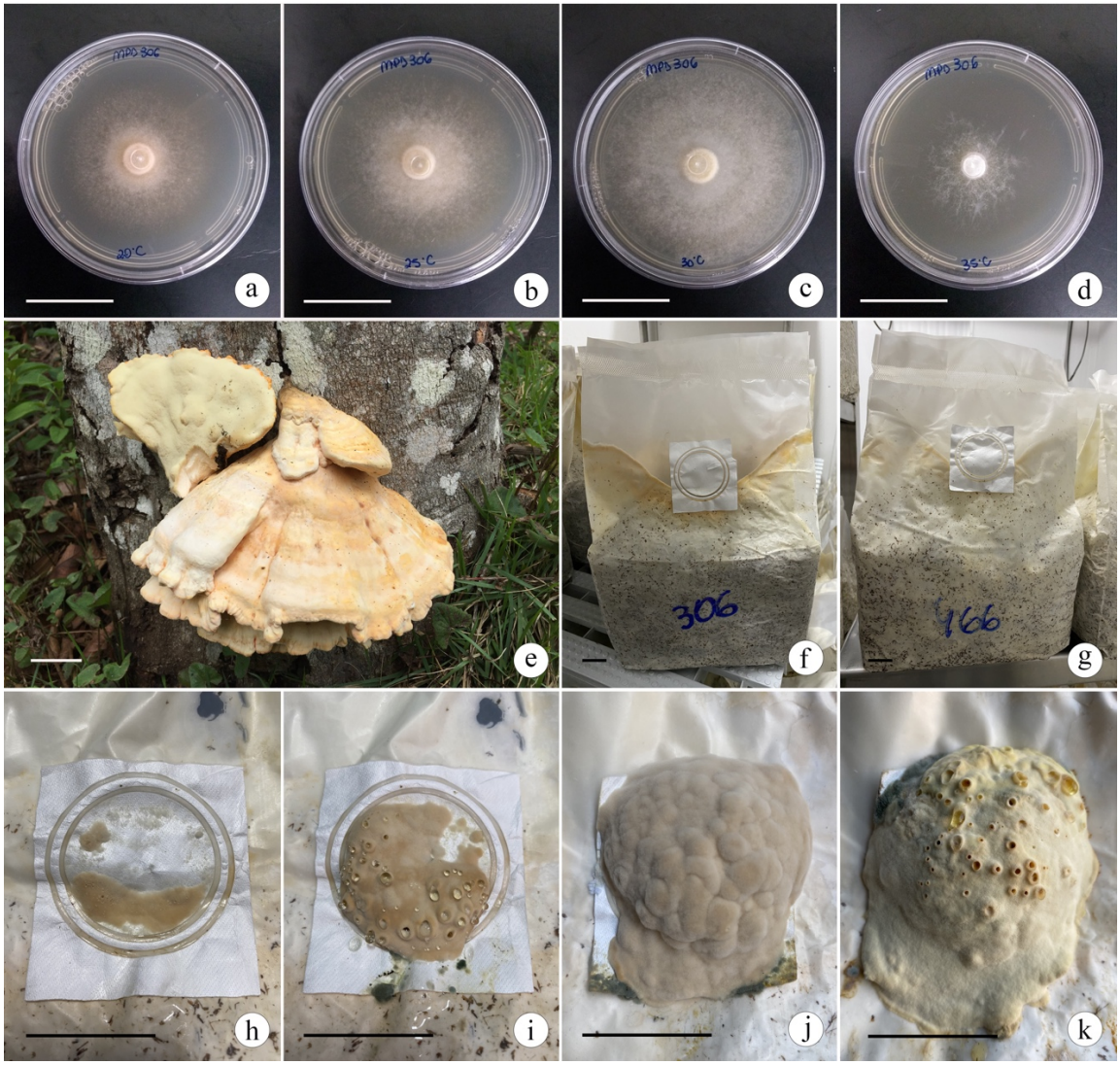

Fig. 6 Cultivation of Brazilian wild strains of *Laetiporus gilbertsonii*. (a–d) Mycelial growth of the wild strain CCIBt4710 in PDA medium on the seventh day; (a) Temperature at 20 °C; (b) Temperature at 25 °C; (c) Temperature at 30 °C; (d) Temperature at 35 °C; (e) Specimen MPD306 (= CCIBt4710) in the field; (f) Fully colonized block CCIBt4710; (g) Fully colonized block CCIBt4718; (h–k) Mycelial growth out of the filter of a block of the wild strain CCIBt4710. Scale bars = 3cm. Photos by Drewinski, M.P.

DISCUSSION

The growth experiments on PDA culture medium at different temperatures showed a better mycelial development of the *A. fuscosuccinea* wild strains at 30 °C. Coniglio et al. (2021) studied five wild strains of *A. fuscosuccinea* from Argentinian Paranaense Rainforest and also indicates 30 °C as the optimal temperature for mycelial development in PDA medium. The evaluated wild strains of *L. gilbertsonii* developed well at both 25 °C and 30 °C. Hitherto, there are no studies on cultivation of *L. gilbertsonii*, only a few studies on another species of the genus, *L. sulphureus*, for which the suitable temperatures for mycelial growth also ranged between 25 °C and 30 °C (Okamura et al. 2000; Luangharn et al. 2014). Normally, tropical mushroom species grow rapidly at 25 °C or higher temperatures, and thus they can be produced in tropical areas more quickly than species from temperate climate areas (Klomklung et al. 2012).

Most studies on the domestication of *A. fuscosuccinea* were published by researchers from Mexico (Castillejos-Puón et al. 1996; Calvo-Bado et al. 1996; Carreño-Ruiz et al. 2014; Morales & Sánchez 2017), although there are studies with specimens from other locations, such as the United States of America, Brazil, Peru, Colombia, and Ecuador (Wong 1993; Vargas et al. 2015; Niño et al. 2017; Rodríguez et al. 2018). Wong (1993) studied two strains of *A. fuscosuccinea* from Brazil with success on the basidiomata production, although the authors did not describe in detail the substrate used neither the cultivation conditions. Here, we demonstrate that it is possible to use eucalyptus sawdust as substrate to produce wild strains of *A. fuscosuccinea*. The use of substrates based on eucalyptus sawdust has already been reported to produce other wild mushrooms such as *A. auricula-judae* (Chen et al. 2013), *Oudemansiella canarii* (Jungh.) Höhn. (Ruegger et al. 2001), and *Gymnopilus pampeanus* (Speg.) Singer (Colavolpe & Albertó 2014).

Regarding the composition of *A. fuscosuccinea* produced in this study, the crude protein values found (10.73–12.11 %) were higher than those obtained by Mau et al. (1998) but lower than those obtained by Sánchez et al. (2018), which found 8.62 % and 13.5 % of crude protein, respectively. For crude fiber, the values obtained here (3.73–3.85 %) were higher than those found by Sánchez et al. (2018) but lower than those recorded by Mau et al. (1998), which found 5.8 % and 11.69 % of crude fiber, respectively. The value of the crude fat in the samples studied here (0.82–0.91 %) was much lower than that found by Mau et al. (1998) and Sánchez et al. (2018) for *A. fuscosuccinea*, which were 4.48 % and 13.5 %, respectively.

This is the first study on cultivation of *L. gilbertsonii*. Regarding on the evaluated substrates, it was possible to observe a fast colonization of the mycelium of *L. gilbertsonii* in the substrate based on eucalyptus sawdust. This result was already expected because the species

occurs naturally in *Eucalyptus* spp. wood (Burdsall Jr. & Banik 2001). Unlike other commercially produced mushroom species, *L. gilbertsonii* is a brown rot fungus and does not produce lignin-degrading enzymes (Burdsall Jr. & Banik 2001). Pleszczynska et al. 2013 were the first to report the successful initiation and development of a *Laetiporus* species mushrooms in large scale experiments. They studied the development of twelve wild strains of *L. sulphureus* from Poland in a substrate based on a mixture of sawdust. Among the twelve studied strains, only two produced basidiomata. It was found that shocking the fungus mycelium with cold water or at low temperature was the most suitable method for forcing *L. sulphureus* basidioma to grow (Pleszczynska et al. 2013). In this study, we tested the same induction methods used by Pleszczynska et al. 2013 for *L. gilbertsonii*, but we were not successful in obtaining primordia and neither producing basidiomata, unfortunately.

Besides the mushrooms, mycelia and the culture media used in the fungi cultivation also have been explored as potential sources of food and bioactive compounds (Cheung 1996; Gan et al. 2012; Ma et al. 2016; Souilem et al. 2017; Stoffel 2019). Compared to mushrooms production, mycelium cultivation has potential advantages for higher production of biomass in a more-compact space over a shorter incubation time (Gan et al. 2012).

CONCLUSION

We obtained twelve wild strains of *A. fuscosuccinea* and three wild strains of *L. gilbertsonii* from the Brazilian Atlantic Rainforest. The temperature that best favored the mycelial growth of *A. fuscosuccinea* was 30 °C. For *L. gilbertsonii*, the temperatures of 25 °C and 30 °C were suitable for the mycelium development. Mycelia of both species better developed in the sterile sawdust substrate, in which it was possible to produce basidiomata of the two wild strains of *A. fuscosuccinea* evaluated. The nutritional values of *A. fuscosuccinea* studied here are similar to those described for other species of the genus. This is the first study on cultivation of *L. gilbertsonii*. Although the mycelia of the two evaluated wild strains of *L. gilbertsonii* colonized the eucalyptus-based substrate quickly, they do not produced primordia neither basidiomata. However, it was possible to observe the mycelium of *L. gilbertsonii* growing out of the filter in some bags in which methods based on low temperature induction were performed. There is a huge potential associated to the collecting, identification, and maintenance of mushroom strains and further studies are needed for domestication and optimization of wild species production.

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AUTHORS CONTRIBUTIONS M.P. Drewinski: Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, and Writing – original draft; M.P. Corrêa-Santos: Data curation, Formal analysis, and Investigation; D.C. Zied: Methodology, Funding acquisition, Resources, Supervision, and Writing – review & editing; N. Menolli Jr.: Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Visualization, and Writing – review & editing.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Figure S1. Bayesian Inference (BI) tree of *Auricularia* based on ITS data. Branches are labeled with BI posterior probability (higher than 0.8). The sequences generated in this work are in **bold**. The highlight represents the clade of species *Auricularia fuscosuccinea*.

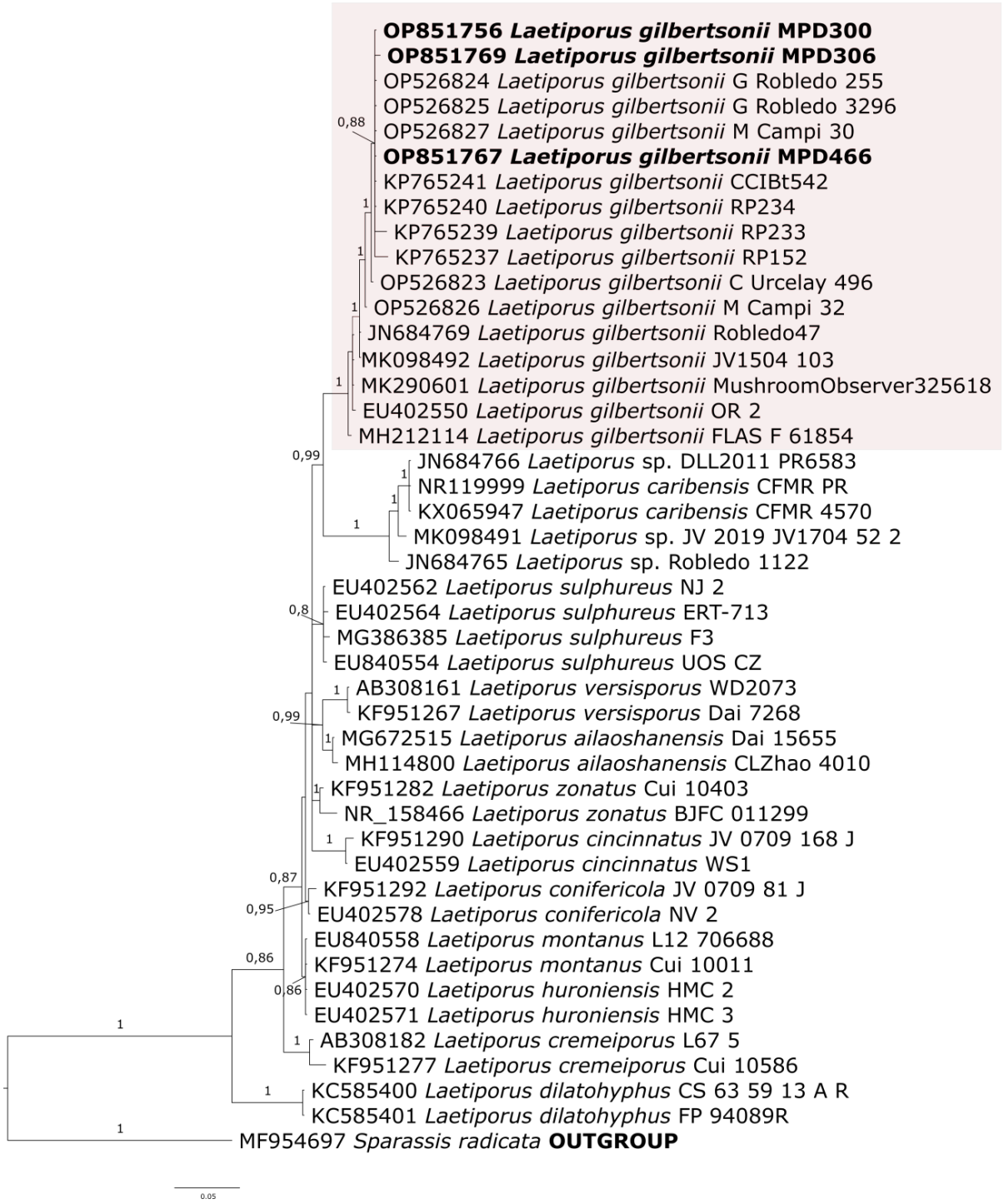

Figure S2. Bayesian Inference (BI) tree of *Laetiporus* based on ITS data. Branches are labeled with BI posterior probability (higher than 0.8). The sequences generated in this work are in **bold**. The highlight represents the clade of species *Laetiporus gilbertsonii*.

Capítulo III

Cultivation of the wood ear Auricularia cornea *using a wild strain from the Brazilian Atlantic Rainforest*

Cultivation of the wood ear *Auricularia cornea* using a wild strain from the Brazilian Atlantic Rainforest

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Abstract

Auricularia cornea has become one of the most important cultivated mushrooms worldwide. Although not remarkably flavorful, *Auricularia* species are very versatile and rehydrate easily after drying, adding a unique and pleasing texture to the dishes. In this study, a wild strain of *A. cornea* from the Brazilian Atlantic Rainforest was successfully cultivated. The wild strain was firstly evaluated for mycelial development at five temperatures and on two different substrates. In the bag production experiment, the blocks were submitted to two cultivation environments and two forms of primordia induction. The temperature that best favored the *A. cornea* mycelium growth was 30 °C, and the preferred substrate was the eucalyptus sawdust. The highest value of biological efficiency (106.90 % ± 13.28 %) was achieved in the treatment incubated in the environment A (average temperature of 24 °C, humidity of 64 %, and CO_2 concentration of 659 ppm) and with cuts on surface of the bags to induce primordia development. The produced wood ears were found to contain 71.02 % carbohydrates, 19.63 % crude fiber, 11.59 % crude protein, 10.19 % crude fat, and 4.24 % ash on dry matter basis. For the mineral content profile, the elements evaluated decreased in the flowing order: K > P > Mg > Ca > Fe > Mn = Zn > Cu. This is the first report on cultivation of a wild strain of *A. cornea*

from Brazil and it represents a great potential for cultivation and future introduction in the national market of edible mushrooms.

Keywords: mineral content, mushroom domestication, mushroom production, nutritional content, tropical mushroom.

Introduction

Auricularia Bull. is an important genus among the jelly fungi due to its popular consumption and medicinal properties [1]. *Auricularia heimuer* F.Wu, B.K. Cui & Y.C. Dai, which has been misidentified as *Auricularia auricula-judae* (Bull.) Quél., is considered the first mushroom to be cultivated, dated 1,400 years ago in China [2]. The cultivation of *Auricularia* species represents about 18 % of the total world mushroom production, which places the genus in third place among the top five most cultivated mushrooms in the world [3].

Auricularia cornea Ehrenb. was originally described based on material collected in Marianna Islands, in the northwestern Pacific Ocean [4]. Morphologically, *A. cornea* is characterized by gelatinous reddish brown to white (albino varieties) basidiomata, which are solitary to gregarious, sessile to substipitate, and sometimes with lobed pileus margin [4, 5]. The upper surface of *A. cornea* basidiomata is densely pilose and the hymenophore surface is usually smooth to shallowly venulose [4-6].

Regarding on its geographical distribution, *A. cornea* is one of the few species of the genus with a wide distribution, occurring in Africa, North and South America, Asia, and Europe [6]. In Brazil, the species has been already reported for the states of Acre, Ceará, Goiás, Maranhão, Paraíba, Paraná, Pernambuco, Rio Grande do Sul, and São Paulo [6-9].

The cultivation of *Auricularia* species is mostly recorded in Southeast Asia [3, 10]. In China, *A. cornea* has become one of the most widely cultivated mushrooms [11]. The species can be growth on various sawdust and wheat straw substrates, and their cultivation methods are similar to those used for other species widely cultivated, such as *Lentinula edodes* (Berk.) Pegler and species of *Pleurotus* (Fr.) P. Kumm. [10, 12, 13].

Naturally occurring strains are an excellent alternative for diversification and improvement of mushrooms production [14]. Despite the global importance of the genus *Auricularia*, the commercial production and research on *Auricularia* species in Brazil are scare. Thus, in this work we report for the first time the successful cultivation of a wild strain of *A. cornea* from the Brazilian Atlantic Rainforest.

Material and methods

Sample collection

The fresh specimen of *A. cornea* (Fig. 1) was collected in the Atlantic Rainforest domain, in the '*Parque Estadual da Ilha do Cardoso, Núcleo Perequê*', in the state of São Paulo, Southeast Brazil. A pure culture was obtained by the inoculation of fragments from the inner part of fresh wood ear into Petri dishes containing sterile PDA (Potato Dextrose Agar) medium. The plates were primarily incubated at 25 °C until complete mycelial growth. The collected basidiomata were dried in a food dehydrator (42 °C) and stored in hermetic plastic bags. The dried voucher (MPD594) is deposited at the Herbarium SP (Maria Eneyda P.K. Fidalgo), accession number SP528779, and the live strain at the '*Coleção de Culturas de Algas, Fungos e Cianobactérias*' (CCIBt), accession number CCIBt4755, both at the '*Instituto de Pesquisas Ambientais*' (São Paulo, SP, Brazil). This study is according to the Brazilian legislation on access to biodiversity and is registered in the '*Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado*' (SisGen # AD7A14A).

Species identification

The identification of the voucher was made through morphological characteristics and the wild strain by molecular characteristics, following specific bibliographies [4-6]. For molecular studies, DNA extraction was performed from mycelium obtained in liquid culture (Potato Dextrose Broth). Total DNA was extracted from frozen mycelium following a modified CTAB extraction method [15]. The intergenic ribosomal region barcoding for fungi [16] was amplified by polymerase chain reactions (PCR) with the primers ITS1-F and ITS4-R [17]. The amplified product was purified with QIAquick PCR Purification Kit and sequenced at MacroGen (South Korea) using the same primer pair. Phylogenetic analysis was carried out to confirm the identity of the generated sequence and the phylogenetic tree is available as Supplementary material.

Mycelial development in culture medium at different temperatures

The mycelial growth and dry biomass production in culture medium were evaluated at different temperatures. The PDA medium was prepared and distributed (30 mL) in Petri dishes (90 mm). After the solidification, a 9.6 mm fragment of the pure culture matrix with the mycelium was inoculated in the center of the plate. The plates were incubated at temperatures of 20 °C, 25 °C, 28 °C, 30 °C, and 35 °C in a BOD (Bio-Oxygen Demand) incubator [18]. The diameter of the mycelial growth and the dry micelial biomass was measured on the day that the mycelium fully colonized the plate. To calculate the dry mycelial biomass, the colonized medium was heated in microwave for 20 seconds to melt, and the mycelium was washed with distilled water, filtered

in a vacuum pump and the biomass was dehydrated until constant weight [18]. The experiment was carried out in fifteen replicates.

Spawn production and mycelial development on two substrates

Wheat grains were used to produce spawn. The grains were washed, boiled in water for 15 minutes, drained in a sieve to remove excess water, and added with 2 % gypsum. While still hot, the grains were placed in glass jars and sterilized in autoclave for 40 minutes at 121 °C [19]. After cooling the grains, three fragments of approximately 10 mm diam were inoculated from the culture medium colonized by the mycelium. The flasks were incubated in a BOD at 30 °C until complete colonization of the grains.

The mycelial development was evaluated in two substrates: i) autoclaved, composed of eucalyptus sawdust; ii) pasteurized, composed of sugarcane bagasse and grass (*Brachiaria* sp.). The sawdust-based substrate was donated by the company '*Yuri Cogumelos*', from Sorocaba city (São Paulo state, Brazil), which sells blocks for shiitake cultivation, and is composed of 80 % eucalyptus sawdust and 20 % grass bran (wheat and rice), with a moisture content of 68 %. The substrate was distributed in glass jars (600 mL) closed with a metal lid with a cotton filter, which were sterilized in an autoclave at 121 °C for two hours. The second evaluated substrate was the JunCao (Jun = mushroom and Cao = grass) substrate, based on sugarcane bagasse and grass (*Brachiaria* sp.). The JunCao substrate was donated by a producer of *Pleurotus ostreatus* (Jacq.) P. Kumm. from Bragança Paulista city (São Paulo state, Brazil), and is composed of 60 % sugarcane bagasse, 35 % *Brachiaria* sp., and 5 % wheat bran. The substrate was pasteurized with fluent steam for seven days and distributed in previously sterilized glass jars (600 mL) closed with a metal lid with a cotton filter. The substrate was inoculated with 1 % of spawn, divided in three portions and inoculated in three parts on the substrates surface. The glass jars of both treatments were incubated in a BOD incubator at 30 °C and the daily growth was measured with a pachymeter. The experiment was carried out with 15 replicates.

Substrate for axenic cultivation

The sawdust substrate was chosen for the cultivation in blocks. The substrate (2.5 kg) was packed in polypropylene bags with filters, which were sterilized in an industrial autoclave at 121 °C for 3h 40min. The packages were inoculated with 2 % of spawn. The packages were incubated in a culture chamber, in the dark, with the temperature set to 30 °C and humidity 60 %.

Fig. 1 Cultivation of *Auricularia cornea*. **a** Specimen MPD594 (=CCIBt4755/SP528779) in the field; **b** Cultivation environment A; **c** Cultivation environmental B; **d** Treatment with cut on the package surface to primordia induction; **e** Treatment with cut on the package surface and removal of mycelium from the surface of grow block (scratching technique). Scale bar = 1 cm. Photos by Drewinski MP

Primordia induction, harvest, and biological efficiency

After complete mycelial growth, the bags were transferred to two cultivation environments (Fig. 1). The conditions of the environment A were: average temperature of 24 °C (ranging from 7.4 °C to 35.5 °C), average humidity of 64 % (ranging from 34 % to 99 %), and average CO_2 concentration of 659 ppm (ranging from 585 ppm to 745 ppm). For the environment B, the

conditions were: average temperature of 22 °C (ranging from 17 °C to 28 °C), average humidity of 71 % (ranging from 55 % to 85 %), and average CO_2 concentration of 1,057 ppm (ranging from 684 ppm to 2,297 ppm).To induce primordia development, two methods were used: i) cut on the package surface (c); and ii) cut on the package surface and removal of mycelium from the surface of grow block by a scratching technique (s). The experiment was carried out with 12 replicates per treatment. The blocks were monitored for 60 days after induction of primordia. The wood ears produced were collected, weighed, and dehydrated with air circulation at a temperature of 35 °C. The day of emergence of primordia (days after induction) and the day of beginning of harvest (days after induction of primordia) were recorded. Yield was expressed as fresh mushroom weight (g) per bag [20]. The Biological Efficiency (BE) was calculated according to the following equation: (fresh basidiomata weight / dry substrate weight) * 100 [20, 21].

Bromotalogical and mineral analyses

The basidiomata produced in the A/c treatment were analyzed for moisture content, ash, crude protein, crude fat, and crude fiber. The bromatological analyses were carried out at the Bromatology Laboratory of the Animal Production Department at '*Universidade Estadual Paulista Júlio de Mesquita Filho*' (Unesp) in Dracena city (São Paulo state, Brazil). All analyses were performed in triplicate and the results express the arithmetic mean. The determination of moisture and dry matter was made by dehydrating the samples in an oven with forced air circulation at 105 °C for 12 hours or until constant weight [22]. The ash content was determined from the incineration of the sample in a muffle furnace at 550 °C [22]. The crude protein content was determined indirectly from the total nitrogen value [22], and the conversion factor used was 4.38, which corresponds to the value used for fungi [23]. The determination of crude fat was made using ether as solvent [22] and the total fiber content was determined with acid and alkaline digestion method [22]. The content of the carbohydrates was estimated by subtracting the content of moisture, ash, crude protein, and crude fat from 100 g of dry matter [24].

Mineral analyses of the basidiomata (A/c treatment) and the initial and final (after 60 days of cultivation) substrates were carried out at the Laboratory of Plant Nutrition at the Faculty of Engineering at '*Universidade Estadual Paulista Júlio de Mesquita Filho*' in Ilha Solteira city (São Paulo state, Brazil). The content of macroelements (N, P, K, Ca, and Mg) and microelements (Cu, Fe, Mn, and Zn) were determined according to Malavolta et al. [25], and Silva [26].

Statistical analyses

The data obtained were submitted to the Shapiro-Wilk normality test and then analyzed using one-way ANOVA test. The averages were compared by the Tukey-Kramer test, using level of significance of 5 % [27]. Statistical analyses were performed using the software GraphPad Prism v. 9.

Results

This is the first study on cultivation of a wild strain of *A. cornea* from Brazil. The ITS sequence of the culture CCIBt4755 (GenBank accession OP852118) showed high similarity (98.4 % identity according to Basic Local Alignment Search Tool) with other sequences of *A. cornea* from China (MN156315) and Japan (LC373497, LC373492, LC373493, and LC373466). Based on the phylogenetic analysis (Supplementary Fig. 1), the sequence of the material studied here grouped together with other sequences from Brazil (MH213358 and MH213359) into the clade of *A. cornea* complex [6]. Thus, based on morphological characters and phylogenetic analysis, we identified the strain CCIBt4755 and the voucher MPD594 SP528779) as *A. cornea*.

The strain CCIBt4755 completed the colonization of the Petri dish in 12 days (Fig. 5) and showed better ($p < 0.05$) growth and dry mycelial biomass (216.47 mg ± 17.41 mg) at 30 °C (Fig. 2). **Among all evaluated temperatures, t**he temperature of 35 °C was the least suitable for the development of *A. cornea* ($p < 0.05$).

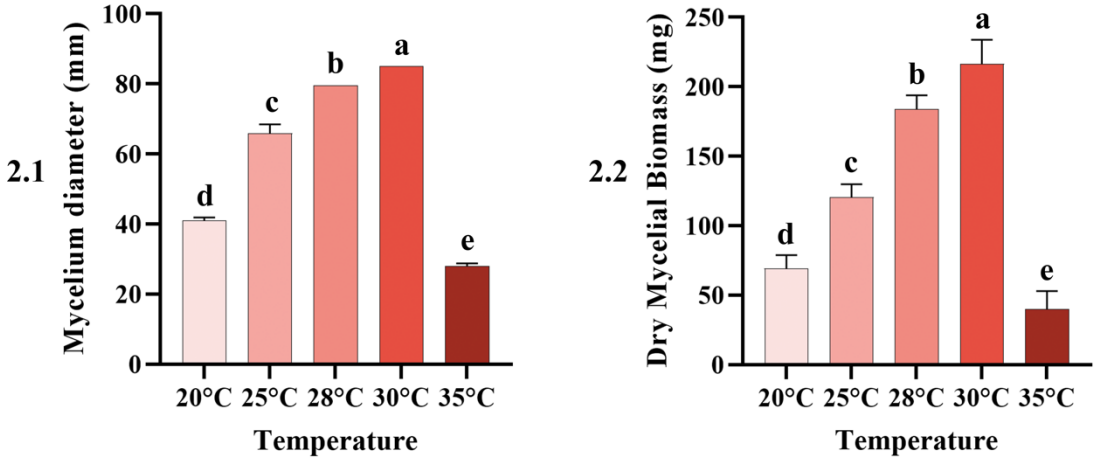

Fig. 2 Effects of different temperatures on mycelial growth of a wild strain (CCIBt4755) of *Auricularia cornea*. **2.1** Mycelium diameter (mm); **2.2** Dry mycelial biomass (mg). There are no differences between treatments if they share the same letter (Tukey-Kramer test after ANOVA for comparisons, $p < 0.05$)

The strain CCIBt 4755 took seven days to fully colonize the wheat grains (100 g) used for spawn, and it started to grow on the sawdust-based substrate on the second day after inoculation (Fig. 3). The mycelium of *A. cornea* developed very well on the sawdust substrate, showing an average daily growth of 6.18 mm ± 1.38 mm, and it fully colonized the substrate in 16 days. In JunCao substrate, the mycelium started to develop on the third day, presenting a daily growth of 2.55 mm ± 1.52 mm. The substrate based on eucalyptus sawdust was more favorable to the development of *A. cornea* mycelium ($p < 0.05$) and so it was selected for the cultivation experiment.

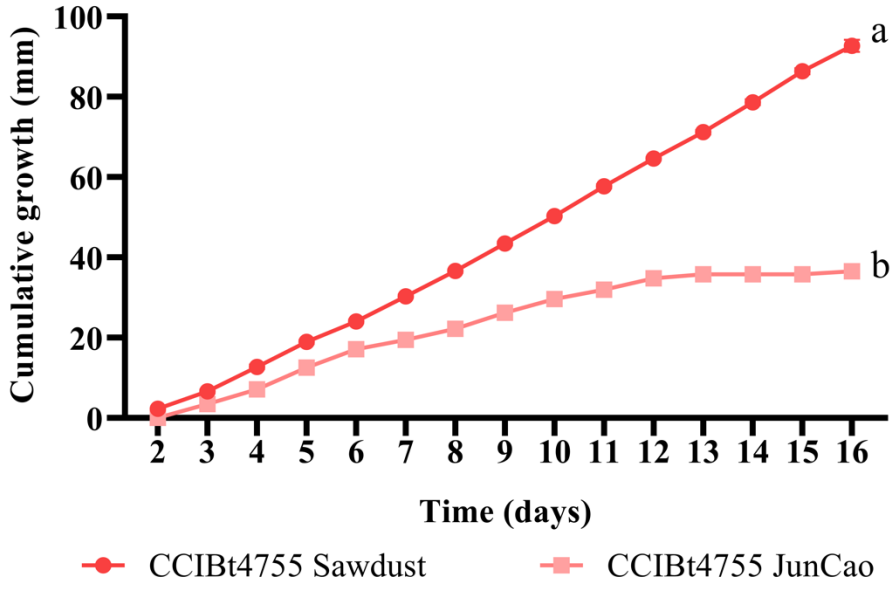

Fig. 3 Mycelial growth of a wild strain (CCIBt4755) of *Auricularia cornea* in substrates based on eucalyptus sawdust and JunCao, based on sugarcane bagasse and grass (*Brachiaria* sp.). There are no differences between treatments if they share the same letter (Tukey-Kramer test after ANOVA for comparisons, $p < 0.05$)

The mycelium of the wild strain CCIBt4755 completed its development in the sawdust substrate (2.5 kg) between 17 and 21 days after inoculation. The primordia began to appear in the first few days after opening the bags (Table 1), growing first on the blocks that were opened in the environment B (B/c). In the treatments in which the scratching method was performed (A/s and B/s), the primordia began to appear first on the sides of the substrate (where the mycelium had not been removed) and then on the substrate top surface. The highest yield ($p <$

0.05) of wood ears was obtained from the bags incubated in the environment A: 908,63 g ± 112,86 g and 784,61 g ± 120,92 g (Table 1).

Table 1 Agronomic evaluation of the wild strain CCIBt4755 of *Auricularia cornea* on eucalyptus sawdust based substrate.

Treatment	Primordia*	Harvest (start)*	Yield ± SD
A/c	4–5 days	17 days	908,63 g ± 112,86 g [a]
A/s	5–7 days on the side, and 7–9 days on the top surface	23 days	784,61 g ± 120,92 g [a]
B/c	2–4 days	20 days	393,56 g ± 108,38 g [b]
B/s	3–4 days on the side, and 8–9 days on the top surface	22 days	353,00 g ± 68,40 g [b]

* Days after primordia induction. A/c: environment A and cut on the package surface. A/s: environment A and cut on package surface and scratching. B/c: environment Band cut on the package surface. B/s: environment Band cut on package surface and scratching. Yield: fresh mushroom weight (g) per bag. SD: standard deviation. There are no differences between treatments if they share the same letter (Tukey-Kramer test after ANOVA for comparisons, $p < 0.05$).

The first basidiomata were harvested from the bags cultivated in the cultivation environment A, without scratching method (A/c). The highest values of Biological Efficiency (BE) were obtained from the A/c treatment (Fig. 5), reaching a value of 106.90 % ± 13.28 %, followed by the A/s treatment (Fig. 5) with 92.31 % ± 14.23 % (Fig. 4). Among the treatments evaluated, the bags maintained in cultivation environment B showed the lowest ($p < 0.05$) BE values, varying from 41.53 % ± 8.05 % (B/s treatment) to 46.30 % ± 12.75 % (B/c treatment) (Fig. 5). The nutritional and mineral compositions of the wood ears from A/c treatment are shown in Table 2.

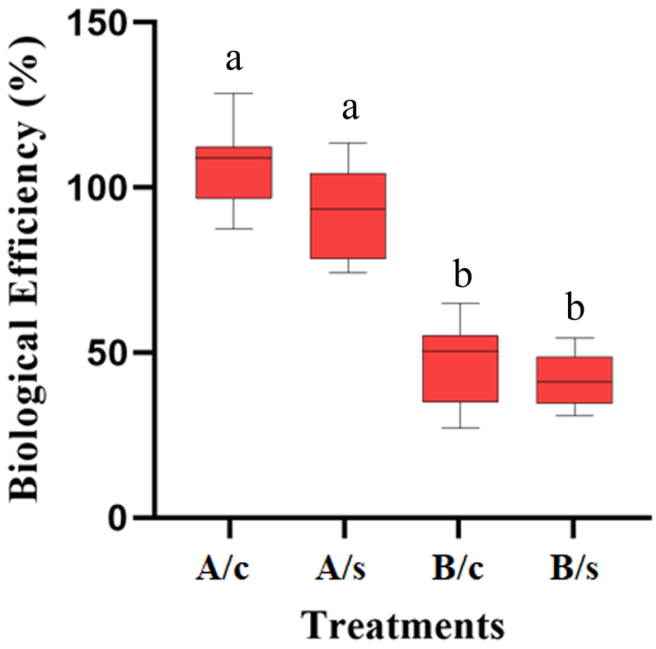

Fig. 4 Biological efficiency (%) of the wild strain CCIBt4755 of *Auricularia cornea* cultivated in eucalyptus sawdust substrate. A/c: cultivation environment A and cut on the package surface. A/s: cultivation environment A and cut on package surface and scratching. B/c: cultivation environment B and cut on the package surface. B/s: cultivation environment B and cut on package surface and scratching. There are no differences between treatments if they share the same letter (Tukey-Kramer test after ANOVA for comparisons, $p < 0.05$)

Table 2 Nutritional and mineral compositions of the wild strain CCIBt4755 of *Auricularia cornea*.

***Auricularia cornea* CCIBt4755 (A/c treatment)**		
Nutrient constituent	Dry matter (%)	97.04
	Moisture (%)	2.96
	Ash (%)	4.24
	Crude protein (%)	11.59
	Crude fat (%)	10.19
	Crude fiber (%)	19.63
	Carbohydrates (%)	71.02
Macroelements	P (mg/Kg)	4,900
	K (mg/Kg)	20,800
	Ca (mg/Kg)	700
	Mg (mg/Kg)	2,200
Microelements	Cu (mg/Kg)	15
	Fe (mg/Kg)	27
	Mn (mg/Kg)	17
	Zn (mg/Kg)	17

A/c: cultivation environment A and cut on the package surface treatment. Values expressed on dry matter. Protein conversion factor N × 4.38.

The substrate pre-cultivation and after 60 days of growth of *A. cornea* was characterized and the results obtained are presented in Table 3. The growth of the mycelium changes the physicochemical characteristics of the substrate and differences were observed between the values of the initial and post cultivation substrate. There was a decrease in the values of moisture, pH, and carbon-nitrogen ratio, since there was a decrease in the percentage of carbon and an increase in the percentage of nitrogen. An increase in electrical conductivity values, macronutrients P, K and Mg, and micronutrients S, Cu, Fe, Mn and Zn were also observed in the post-culture substrate.

Table 3 Characterization of substrate based on eucalyptus sawdust pre-cultivation and after 60 days of cultivation of the wild strain CCIBt4755 of *Auricularia cornea*.

	pre-cultivation substrate	**post-cultivation substrate**
Moisture	68%	57%
pH	6.42	4.43
EC (µS/cm)	966.5	2,222.0
% N	0.57	0.80
% C	53.5	47.8
C/N ratio	93.2	59.8
N (g/Kg)	5.7	8.0
P (g/Kg)	3.1	6.4
K (g/Kg)	5.0	8.7
Ca (g/Kg)	6.3	6.0
Mg (g/Kg)	2.5	4.3
S (g/Kg)	0.9	1.1
B (mg/Kg)	23	15
Cu (mg/Kg)	7	23
Fe (mg/Kg)	243	380
Mn (mg/Kg)	145	183
Zn (mg/Kg)	40	43

EC: electrical conductivity.

Fig. 5 Cultivation of the wild strain CCIBt4755 of *Auricularia cornea*. **a–e** Mycelial growth in PDA medium on twelfth day; **a** Temperature at 20 °C; **b** Temperature at 25 °C; **c** Temperature at 28 °C; **d** Temperature at 30 °C; **e** Temperature at 35 °C; **f** Cultivation block treatment A/c; **g** Cultivation block treatment A/s; **h** Different stages of wood ear development; **i** Cultivation block treatment B/c; **j** An albine wood ear, treatment A/c. Photos by Drewinski MP

Discussion

Among the tested temperatures, 30 °C was that best promote mycelial growth of the wild strain CCIBt4755 of *A. cornea*. For species of the genus *Auricularia*, the temperature considered ideal for the mycelium development is between 24 °C to 30 °C [12, 28]. Determining the optimal temperature for mycelial growth is one of the first steps in the domestication process, and it is important to obtain higher mycelial biomass in a shorter period of time [14].

The mycelial development of *A. cornea* wild strain CCIBt4755 was better in the sterile substrate based on sawdust than in the substrate pasteurized based on sugarcane bagasse and grass. The most common method for cultivation of *Auricularia* species is on logs or on sterilized sawdust [12, 29, 30]. However, it is also possible to produce species of *Auricularia* on JunCao substrates [19, 31, 32] and pasteurized substrates [33, 34].

This is the first report on cultivation of a wild *A. cornea* from the Brazilian Atlantic Rainforest. The wild strain CCIBt4755 has a potential to be cultivated in warm climatic condition, since the highest BE value (106.90 % ± 13.28 %) was achieved in the treatments incubated in the cultivation environment A, with temperature ranging from 7.4 °C to 35.5 °C. Consistent yield of the wild strain of *A. cornea* was obtained even with only three months of production (after primordia induction). The A/c treatment was the best among the treatments tested, with greater precocity of harvest (17 days after primordia induction) and higher yield, 908,63g ± 112,86 g of mushrooms per bag (2.5 kg initial substrate).

Recently, Khan et al. [35] evaluated the production of one wild and three commercial strains of *A. cornea* from China. The highest BE value was found from a commercial strain (94.8 %) and the lowest value was from a wild strain (52.9 %). However, both values obtained by Khan et al. [35] were lower than that obtained in this study with the wild strain CCIBt4755 in A/c treatment. The BE value obtained in A/c treatment (106.90 %) was also higher than the values obtained by Bandara et al. [36], and Thongklang et al. [13] in cultivation of wild strains of *A. cornea* from Thailand, which found BE 16.5 % and 72.46 %, respectively.

On the other hand, the values of BE obtained in this study were lower than that obtained by Liang et al. [32] in the cultivation of *A. cornea* from Taiwan: 148.12 %. Although the cultivated species were called by the author as *Auricularia polytricha* (Mont.) Sacc., the species probably represent *A. cornea* due to the geographic distribution of the *Auricularia* species [6]. According to the recent study by Wu et al. [6], the species *A. polytricha* is a synonym of *Auricularia nigricans* (Sw.) Birkebak, Looney & Sánchez-García, which has its distribution most likely restricted to North America.

According to Tan et al. [37], the mycelium of *A. cornea* develops well on substrates with a C/N ratio between 60:1 to 100:1, and the ideal C/N ratio is 80:1. Chen et al. [38]

concluded that the C/N ratio of 55:1 to 70:1 is optimal for the cultivation of a white mutant strain of *A. cornea* from China. The C/N ratio of the sawdust substrate tested in this work was 93:1 and the best BE value achieved (106.90 %) was lower than those obtained by Liang et al. [32] in substrate based on sawdust and *Panicum repens* L. stalk with C/N ratio of 45:1 (BE 148.12 %), and in substrate based on sawdust and *Pennisetum purpureum* Schumach. with C/N ratio of 79:1 (BE 126.75%).

Regarding on nutritional composition of *A. cornea* wild strain CCIBt4755, carbohydrates were the dominant compound (71.02 %), followed by crude protein (11.59 %), crude fat (10.19 %), and ash (4.24 %). The content of crude protein and ash are similar to those found by Liang et al. [32] for *A. cornea* (9.13 % to 11.46 % of protein, and 3.49 % to 4.81 % of ash) as well as for other species in the genus [1]. The value found for crude fiber (19.63 %) is higher than those recorded by Bandara et al. [1] for *Auricularia* species (3.5 % to 12.5 %), and it is similar to those found by Chen et al. [38] in the study of white strains of *A. cornea* from China, ranging from 13.27 % to 23.70 % depending on the cultivation substrate.

The value of crude fat (10.19 %) from the wild strain CCIBt4755 was much higher than the values generally found for *Auricularia* species, which range from 0.4 % to 4.5 % [1, 32, 38-40]. Akata et al. [41] reported similar crude fat content for the wild species *Russula anthracina* Romagn. (9.46 %) and *Suillus collinitus* (Fr.) Kuntze (13.32 %). In general, the crude fat of mushrooms contains all classes of lipid compounds, including free fatty acids, mono-, di- and triglycerides, sterols, sterol esters, and phospholipids [28]. The high content of unsaturated fatty acids (52 % to 87 %), mainly due to high percentage of linoleic acid, is a significant factor to consider mushrooms as a healthy food [28, 42].

According to the mineral analyses of basidiomata of the wild strain CCIBt4755, potassium (K) is the most abundant macroelement (20,800 mg/kg) followed by phosphorus (4,900 mg/kg), magnesium (2,200 mg/kg), and calcium (700 mg/kg). Potassium is the main mineral component in all mushrooms [43]. Among the microelements evaluated, iron is the most abundant (27 mg/kg), followed by manganese and zinc (17 mg/kg), and copper (15 mg/kg). The mineral content of *A. cornea* CCIBt4755 is similar to that known for most frequently cultivated mushrooms [43]. The wild strain CCIBt4755 showed higher mineral content of potassium, phosphorus, magnesium, copper, and manganese, and lower mineral content of calcium, iron, and zinc than the recently domesticated species *Auricularia thailandica* Bandara & K.D. Hyde from Thailand [44].

Recently, white strains of *A. cornea* have been developed for the cultivation in China [38] and Thailand [36], and consumers in Asia have shown a preference for the albino variety [40, 45]. Curiously, although the wild strain CCIBt4755 did not show characteristics of the

albino variety in the field, the development of a single white basidioma in the middle of the brown basidiomata was observed in only one bag of the A/c treatment (Fig. 5). Despite not being so common, white strains of *Auricularia* species have been reported from wild for different places in the world [36, 46-48]. Unfortunately, we were not able to isolate the pure mycelium from the white basidioma.

Edible mushrooms have been cultivated for centuries, and it is expected that their production will increase further [3, 45, 49]. The development of *Auricularia* cultivation still needs studies on the selection and breeding of new regionalized strains and innovation in the cultivation substrate and simple technology for production [37]. The successful domestication of wild strains by farmers over time has led to a rapid increase in production of species and diversification on mushroom market [3]. The substantial consumption and production of *Auricularia* species, the ease of cultivation, and the absence of large-scale production outside of Asia make it an excellent mushroom for alternative production and diversification in Latin America [10].

Conclusions

The mycelial development of *A. cornea* wild strain CCIBt4755 was favored at a temperature of 30 °C and in a sterile substrate based on sawdust. It was possible to produce basidiomata of the wild strain from the Brazilian Atlantic Rainforest and the tested isolate has a potential to be cultivated in warm climatic condition and with little structure, such as in rustic greenhouses. Every commercially cultivated strain was once wild and the research on domestication are important to understand the optimal conditions for growing these wild strains and to provide new and regional strains.

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Author Contributions Conceptualization: NMJ; Project administration: NMJ; Data curation: MPD; Formal analysis: MPD; Funding acquisition: NMJ, DCZ; Investigation: MPD; Methodology: MPD, DCZ, EPCG, NMJ; Supervision: DCZ, NMJ; Visualization: NMJ;

Resources: MPD, DCZ, NMJ; Software: MPD; Validation: MPD; Writing – original draft: MPD; Writing – review & editing: DCZ, EPCG, NMJ.

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Conflict of interest The authors declare that they have no conflict of interest.

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SUPPLEMENTARY MATERIAL

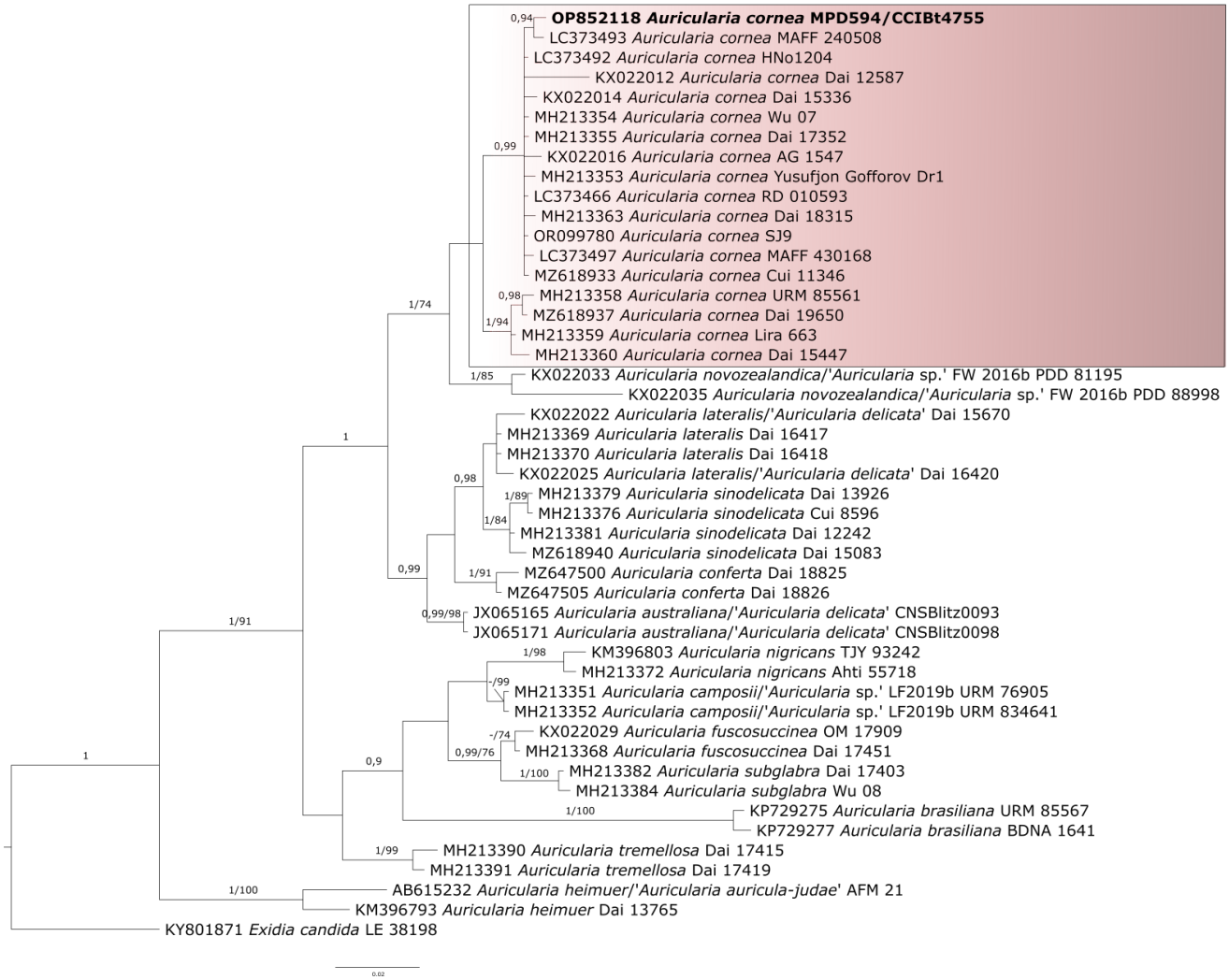

Fig. S1 Bayesian Inference (BI) tree of *Auricularia* based on ITS data. Branches are labeled with BI posterior probability (higher than 0.9), and Maximum Likelihood bootstrap (higher than 70%). The sequence generated in this work is in **bold**. The highlight represents the clade of species *Auricularia cornea*.

Capítulo IV

First successful cultivation of wild strains of Irpex rosettiformis *from the Brazilian Atlantic Rainforest*

First successful cultivation of wild strains of *Irpex rosettiformis* from the Brazilian Atlantic Rainforest

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Abstract

Irpex rosettiformis is an edible macrofungi species that occurs in the tropical and subtropical regions of the Americas. Herein, we report for the first time a successful cultivation of wild strains of *I. rosettiformis* from Brazil. We evaluate the in vitro growth of nine wild strains at five temperatures and on two substrates. The cultivation in bags was carried out on a sawdust-based substrate and the basidiomata produced were evaluated for nutritional and mineral content. The mycelium of the wild strains of *I. rosettiformis* grew better at 28 °C and 30 °C, and the wild strains evaluated in the substrate experiment grew better in the sterile substrate based on eucalyptus sawdust. The highest values of biological efficiency (29.47–30.01 %) were obtained from the wild strain CCIBt4706 from the South of Brazil. Nutritional analyses showed that *I. rosettiformis* contains high values of crude fiber (22.68–27.61 %) and crude protein (18.89–25.63 %). Potassium was the most abundant mineral (33,500 mg/kg), followed by phosphorus (10,800 and 12,500 mg/kg) and magnesium (2,300 and 2,600 mg/kg) in the two tested samples. The species *I. rosettiformis* can be cultivated using traditional methods known for other commercial mushroom species and has the potential to be introduced into the edible mushroom industry.

Keywords – Atlantic Forest, *Hydnopolyporus fimbriatus*, mineral content, mushroom cultivation, nutritional content, wild edible mushroom

Introduction

Irpex rosettiformis (Cooke) C.C. Chen & Sheng H. Wu (Basionym: *Polystictus fimbriatus* Cooke) was originally described as *Polyporus fimbriatus* Fr. based on material collected in Brazil (Fries 1830). This species generally occurs on angiosperm trunk, stump, or buried wood, often forming white to yellowish rosette-like clusters and consisting of numerous, irregular flabelliform lobes that are attached to each other at the base (Reid 1962, Fidalgo 1963, Chen et al. 2021). The hymenial surface is extremely variable and can range from smooth, papillate, hydnoid to poroid morphology (Reid 1962, Fidalgo 1963, Chen et al. 2021).

Irpex rosettiformis is a common species in tropical and subtropical areas of the Americas (Reid 1962, Chen et al. 2021). In Brazil, the species has been already reported for all five region of the country, with records for the states of Acre, Amazonas, Bahia, Goiás, Mato Grosso, Mato Grosso do Sul, Paraná, Rio Grande do Sul, Rondônia, Santa Catarina, and São Paulo (Rick 1960, Capelari & Maziero 1988, Gugliotta & Capelari 1995, Góes-Neto 1999, Ryvarden & Meijer 2002, Drechsler-Santos et al. 2008, Gibertoni & Drechsler-Santos 2010, Welden 2010, Sanuma et al. 2016, Bononi et al. 2017, Abrahão et al. 2019, Menezes-Filho et al. 2022).

The basidiomata of this species are edible and have been reported to be used by traditional communities in Mexico (Villarreal & Perez-Moreno 1989), Guatemala (Flores-Arzú et al. 2012), and Brazil (Sanuma et al. 2016). *Irpex rosettiformis* is consumed by the Sanöma (part of Yanomami indigenous group who live in the Brazilian Amazon Rainforest) cooked in water with salt and pepper or roasted over the coals and wrapped in leaves (Sanuma et al. 2016). The species is also traded by the Sanöma in a mushroom mix called *'Cogumelo Yanomami'* (Yanomami Mushroom) that may contain more than ten mushroom species (Cutler II et al. 2021). The mushrooms present in the mix are collected in the Amazon Rainforest and/or are harvested from trunks of trees felled for cassava plantations and sold as a product of the Sanöma agricultural system (Sanuma et al. 2016). The indigenous pick up the mushrooms as they are needed for food, but they don't seem to make any conscious effort to cultivate them more intensively (Prance 1986). So far, there is no record on cultivation of *I. rosettiformis*.

The world production of cultivated mushrooms has increased more than 30-fold since 1978, and mushroom consumption is expected to continue increasing (Royse et al. 2017). Several new species of edible mushrooms have been successfully domesticated, especially in tropical areas (Bandara et al. 2017, De Leon et al. 2017, Thongbai et al. 2017, Alberti et al. 2021, Sanchez-Ocampo et al. 2022). Tropical regions have the potential to be a rich source of cultivatable fungal species for introducing new mushrooms from tropical climate areas to the global market (Thawthong et al. 2014). Thus, the aim of this study was to evaluate the potential

for cultivation of wild strains of *I. rosettiformis* from Brazil and to analyze the nutritional composition of the mushrooms produced.

Materials & Methods

Mushroom strains

The specimens were collected in fragments of the Atlantic Rainforest domain, in the Brazilian states of Rio de Janeiro, São Paulo, Paraná, and Rio Grande do Sul (Table 1). In field, from the fresh mushrooms, a pure mycelium culture was obtained through the inoculation of fragments from the inner basidioma into Pedri dishes with sterile PDA (Potato Dextrose Agar) medium. The plates were incubated at 25 °C until complete mycelial growth. The basidiomata were dried in a food dehydrator (42 °C) and stored in hermetic plastic bags. The vouchers are deposited at the Herbarium SP (Maria Eneyda P.K. Fidalgo) and the live cultures at the '*Coleção de Culturas de Algas, Fungos e Cianobactérias*' (CCIBt), both at the '*Instituto de Pesquisas Ambientais*' (São Paulo, SP, Brazil). This study is according to the Brazilian legislation on access to biodiversity and is registered in the '*Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado*' (SisGen # A32FE9F).

Table 1 Data on the wild strains of *Irpex rosettiformis* evaluated in this study.

Collector number	CCIBt accession	SP Herbarium accession	GenBank accession	Locality in Brazil
MV581	4366	SP466786	XXX	Itatiaia, RJ, PNI
MV862	4369	SP466793	OQ617933	São Paulo, SP, PEFI
MPD166	4771	SP512771	OP852119	Guarapuava, PR, PMN
MPD167	4706	SP512772	OP852120	Guarapuava, PR, PMN
MPD225	4772	SP512775	OP852121	São Francisco de Paula, RS, FLONA
MPD333	4773	SP512776	OP852130	Cananeia, SP, PEIC
MPD428	4715	SP512778	OP852129	São Luís do Paraitinga, SP, PESM
MPD432	4774	SP512779	OP852177	São Paulo, SP, PEFI
MPD461	4717	SP512781	OP852178	São Paulo, SP, PEFI

RJ – Rio de Janeiro; PNI – Parque Nacional do Itatiaia; PR – Paraná; PMN – Parque Municipal das Araucárias; RS – Rio Grande do Sul; FLONA – Floresta Nacional de São Francisco de Paula; SP – São Paulo; PEIC – Parque Estadual da Ilha do Cardoso; PESM – Parque Estadual da Serra do Mar, núcleo Santa Virgínia; PEFI – Parque Estadual das Fontes do Ipiranga.

Species identification

The specimens were identified based on morphological characteristics of basidiomata and molecular characteristics of the wild strains (Reid 1962, Fidalgo 1963, Chen et al. 2021). For molecular studies, DNA extraction was performed from mycelium obtained in Potato Dextrose Broth. Total DNA was extracted from dried mycelium following a modified CTAB extraction method (Doyle & Doyle 1987). The nuclear ribosomal internal transcribed spacer (ITS) region, considered barcoding for fungi (Schoch et al. 2012), was amplified by polymerase chain reactions with the primers ITS1-F and ITS4-R (White et al. 1990). The amplified products were purified with QIAquick PRC Purification Kit and sequenced using the same primer pair at MacroGen (South Korea). The generated sequences are deposited in GenBank (Table 1). Phylogenetic analyses were carried out to confirm the identity of the generated sequences. Additional sequences were downloaded from GenBank, most of them published in phylogenetic studies for the genus (Chen et al. 2021, Li et al. 2022, Tian et al. 2022). Sequences were aligned with MAFFT online using the default parameters (Katoh et al. 2019), and were manually checked with AliView (Larsson 2014). The Maximum Likelihood (ML) analyses were performed in RAxML v.8 (Stamatakis 2014), under the model GTRGAMMA, with a rapid bootstrap with 1,000 replicates. The Bayesian Inference (BI) analysis was performed in Mr.Bayes v3.2.7 (Ronquist et al. 2012). The ITS region was partitioned into ITS1, 5.8S, and, ITS2, and the evolution model were estimated for each partition with jModelTest v.2 (Darriba et al. 2012), using the BIC criterion. The BI was calculated with two independent runs, four simultaneous independent chains, and 20,000,000 generations, with a sample frequency every 1,000 generation. The softwares RAxML, jModelTest, and Mr.Bayes were used in the CIPRES Science Gateway (Miller et al. 2010). The BI phylogenetic tree is available as Supplementary material.

Mycelial development at different temperatures

Nine wild strains of *I. rosettiformis* were evaluated for mycelial growth and dry biomass production in PDA medium at different temperatures. The sterile medium was distributed (30 mL) in Petri dishes (90 mm diam) and a 9.6 mm fragment of pure matrix with mycelium was inoculated in the center of the plate. The plates were incubated at five temperatures (20 °C, 25 °C, 28 °C, 30 °C, and 35 °C) in a BOD (Bio-Oxygen Demand) incubator. The diameter of mycelium growth was measured on the day that the mycelium of one wild strain fully colonized the medium. To evaluate the dry micelial biomass, the colonized medium was heated for 30 seconds in the microwave to melt and then the mycelium was filtered in a vacuum pump,

washed with distilled water, and the biomass was dehydrated until constant weight (Vargas-Isla & Ishikawa 2008). The experiment was carried out in fifteen replicates.

Spawn production and mycelial development on different substrates

The spawn was prepared in wheat grains. The grains were washed and boiled in water for 15 minutes and then drained and added with 2 % gypsum. The grains (100 g) were placed in jars and sterilized in an autoclave for 40 minutes at 121 °C (Urben 2017). After cooling, the grains were inoculated with three fragments of approximately 10 mm diam from the matrix with pure mycelium. The grains were incubated in a BOD incubator at 30 °C until complete colonization of mycelium.

From the result of the mycelial development at different temperatures, two wild strains were selected for the experiment of mycelial growth on two substrates: i) autoclaved, based on sawdust; ii) pasteurized, based on sugarcane bagasse and grass. The sawdust substrate was donated by company '*Yuri Cogumelos*' (Sorocaba, São Paulo, Brazil), which sells blocks for the production of *Lentinula edodes* (Berk.) Pegler, and were composed of 80 % eucalyptus sawdust and 20 % grass bran (wheat and rice), with a moisture content of 68 %. The substrate was distributed in glass jars (600 mL) that were closed with a metal lid with a cotton filter and then sterilized in an autoclave for two hours at 121 °C. The substrate JunCao (Jun = mushroom, Cao = grass) was donated by a producer of *Pleurotus ostreatus* (Jacq.) P. Kumm., from Bragança Paulista city (São Paulo, Brazil) and was composed of 60 % sugarcane bagasse, 35 % *Brachiaria* sp., and 5 % wheat bran. The substrate was pasteurized with fluent steam for seven days and then distributed in sterile glass jars (600 mL), which were closed with a metal lid with a cotton filter. The substrates were inoculated with 1 % of the spawn, divided in three portions and inoculated in three parts on the surface of the substrates. The jars were incubated in BOD at 30 °C and the daily growth was measured from three inoculation points with a pachymeter. The experiment was carried out with 15 replicates.

Substrate for cultivation, primordia induction, harvest, and biological efficiency

The substrate based on eucalyptus sawdust was used for the axenic cultivation. The sawdust based substrate (2.5 kg) was packed in polypropylene bag with filter, which was sterilized in an industrial autoclave for 3h 40 min at 121 °C. After cooling, the substrate was inoculated with 2 % of spawn. The packages were incubated in a culture chamber, in the dark, at 30 °C and humidity 60 %.

After complete mycelial growth, the packages were transferred to two cultivation environments. The cultivation conditions in the environment A were: average temperature of

24 °C (ranging from 7.4 °C to 35.3 °C), average humidity of 64 % (ranging from 34 % to 99 %), and average CO_2 concentration of 659 ppm (ranging from 585 ppm to 745 ppm). The cultivations conditions in the environment B were as follow: average temperature of 22 °C (ranging from 17 °C to 28 °C), average humidity of 71 % (ranging from 55 % to 85 %), and average CO_2 concentration of 1,057 ppm (ranging from 684 ppm to 2,297 ppm).

Two methods were evaluated to induce primordia: i) cut on the package surface (c) or ii) cut on the package surface and removal of mycelium from the surface of substrate, the scratching method (s). The experiment was carried out with 12 replicates per treatment. The blocks were monitored for 60 days after primordia induction and the mushrooms produced were collected, weighed, and dehydrated with air circulation at 35 °C. The day of emergence of primordia and the day of beginning of harvest were recorded. Yield was expressed as fresh mushroom weight (g) per bag (Estrada et al. 2009). The biological efficiency (BE) was calculated according to the equation: BE = (fresh basidiomata weight / dry substrate weight) × 100 (Estrada et al. 2009, Lechner & Albertó 2011).

Nutritional and mineral composition

The nutritional analyzes were carried out at the Bromatology Laboratoty of the Animal Production Department at '*Universidade Estadual Paulista Júlio de Mesquista Filho*' (Unesp) in Dracena, São Paulo, Brazil. The mushrooms from the A/s treatment of both tested wild strains were analyzed for moisture content, dry matter, ash, crude protein, crude fat, and crude fiber following Zenebon et al. (2008). The value of crude protein was determined indirectly from the total nitrogen value and the conversion factor used was 4.38, the value used for fungi (Crisan & Sands 1978). The content of carbohydrates was estimated by subtracting the content of moisture, ash, crude protein, and crude fat from 100 g of dry matter (Barros et al. 2008a). The mineral analyzes were carried out at the Laboratory of Plant Nutrition at '*Universidade Estadual Paulista Júlio de Mesquista Filho*' (Unesp) in Ilha Solteira, São Paulo, Brazil. The mineral content (N, P, K, Ca, Mg, Cu, Fe, Mn, and Zn) of mushrooms from A/s treatment, initial substrate and post 60 days of cultivation substrate was determined according to Malavolta et al. (1997) and Silva (2009) methods.

Statistical analyses

The data were submitted to the Shapiro-Wilk normality test and analyzed using two-way ANOVA test. The averages were compared by the Tukey test, using 5% as significant level (Vieira 1980). Statistical analyses were performed using GraphPad Prism v.9 software.

Results

Mycelial development at different temperatures

The mycelium of the nine wild strains of *I. rosettiformis* developed well at 28 °C and 30 °C (Figure 1, Figure 4 a–e). The wild strains CCIBt4771, CCIBt4706, CCIBt4772, and CCIBt4369 were the first to complete growth in the Petri dish, taking six days at both 28 and 30 °C (Figure 1.1). Regarding on dry mycelial biomass, there was also no statistical difference ($p > 0.05$) between temperatures 28 and 30 °C (Figure 1.2). The wild strain CCIBt4369 showed the highest ($p < 0.05$) dry mycelial biomass value (183.2 mg ± 13.7 mg) followed by the wild strains CCIBt4706 and CCIBt4772 (153.4 mg ± 9.2 mg and 148.9 mg ± 11.7 mg, respectively) at 30 °C. Based on the performance in the temperature experiment, the wild strains CCIBt4369 and CCIBt4706 were selected for the experiment in cultivation substrates.

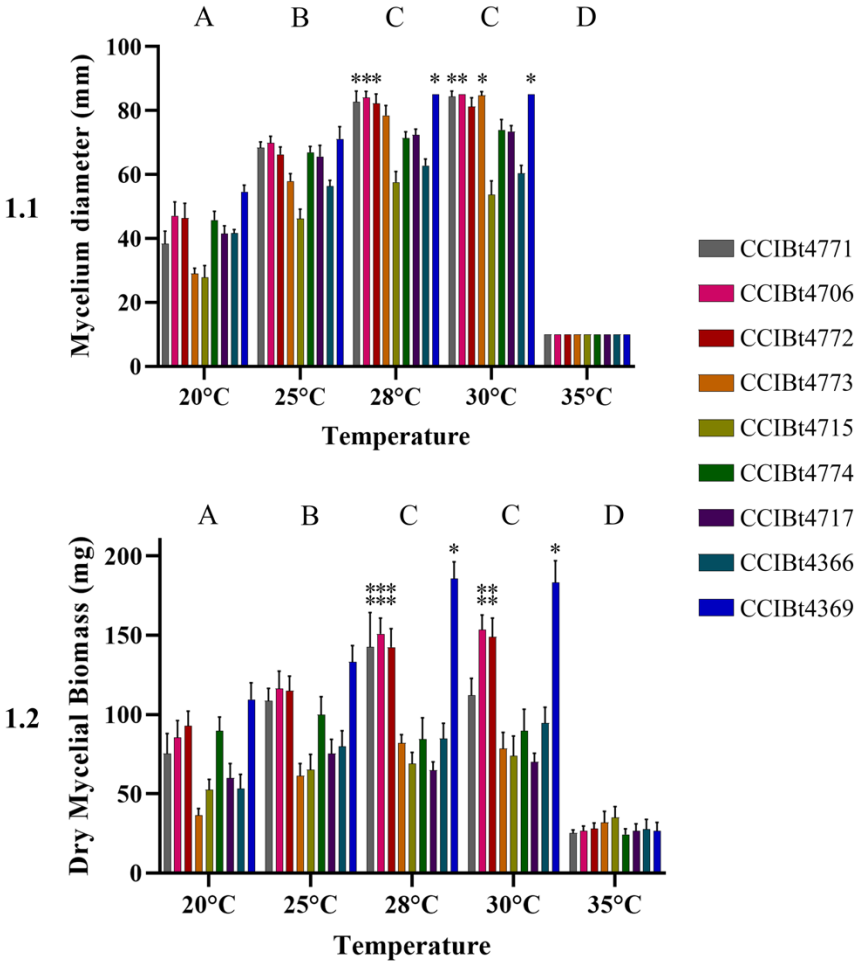

Figure 1 – Effects of temperature on growth of nine wild strains of *Irpex rosettiformis* on the sixth day. 1.1 Mycelium diameter (mm); 1.2 Dry mycelial biomass (mg). Capital letters compare the means of all wild strains at different temperatures. The asterisk indicates statistical significance by Tukey's test at 5 % probability, of the best values obtained by the wild strains at each temperature.

Mycelial development on different substrates

The mycelium of the wild strains CCIBt4369 and CCIBt4706 started to grow in both substrates between the fourth and fifth day after inoculation (Figure 2) and both wild strains completed colonization first on sterile sawdust substrate at 18 (CCIBt4706) and 20 days (CCIBt4369). In the pasteurized JunCao substrate, the mycelium did not develop very well, growing on average 0.45 mm ± 0.51 mm (CCIBt4369) and 0.58 mm ± 0.64 mm daily (CCIBt4706), much lower than the average growth in the sawdust base: 5.35 mm ± 2.20 mm for the wild strain CCIBt4369 and 6.45 mm ± 1.05 mm for the wild strain CCIBt4706. For the tested wild strains of *I. rosettiformis*, the sterile eucalyptus sawdust substrate was more favorable to mycelial development ($p < 0.05$), with emphasis on mycelial growth of the wild strain CCIBt4706 ($p < 0.05$).

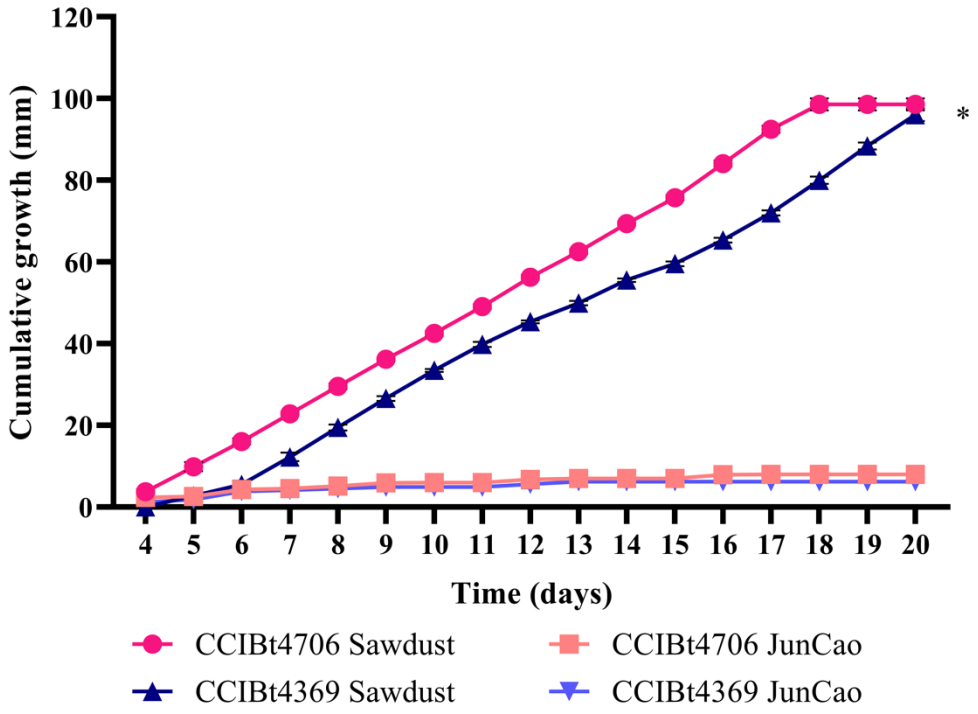

Figure 2 – Mycelial growth of two wild strains of *Irpex rosettiformis* in pasteurized JunCao (sugarcane bagasse and grass) substrate and sterile eucalyptus sawdust substrate. The asterisk indicates statistical significance by Tukey's test at 5 % probability.

Axenic cultivation

The wild strain CCIBt4706 was the first to fully colonize the blocks based on sawdust substrate, taking 25 to 29 days after inoculation, while CCIBt4369 took 27 to 31 days to complete the substrate colonization. The development of primordia was observed earlier in the treatments in which scratching technique was performed (B/s and A/s), except for some blocks of CCIBt4369

from the B/c treatment that appeared in the same period, from three to five days after induction. The first harvest for both wild strains was made from A/s treatment, followed by A/c treatment. The higher yield was obtained from wild strain CCIBt4706 in blocks incubated in the environment A: 240.05 g ± 61.64 g in A/s treatment and 235.74 g ± 36.76 g in A/c treatment; followed by the wild strain CCIBt4369, also from the environment A, with 205.48 g ± 25.49 g in A/s treatment (Table 2).

Table 2 Agronomic evaluation of two wild strains of *Irpex rosettiformis* on eucalyptus sawdust-based substrate.

Treatment	Primordia*	Harvest* (start)	Yield ± SD
CCIBt4706			
A/c	5–10 days	17 days	235.74 g ± 36.76 g [a]
A/s	3–5 days	16 days	240.05 g ± 61.64 g [a]
B/c	5–10 days	22 days	98.94 g ± 19.78 g [c]
B/s	3–5 days	24 days	49.99 g ± 16.46 g [c]
CCIBt4369			
A/c	5–10 days	19 days	151.99 g ± 31.55 g [b]
A/s	3–5 days	16 days	205.48 g ± 25.49 g [ab]
B/c	3–5 days	20 days	169.92 g ± 22.26 g [b]
B/s	3–4 days	24 days	147.89 g ± 25.74 g [b]

* Days after primordia induction. A/c: environment A and cut on the package surface. A/s: environment A and cut on package surface and scratching. B/c: environment B and cut on the package surface. B/s: environment B and cut on package surface and scratching. Yield: fresh mushroom weight (g) per bag. SD: standard deviation. Equal letters do not differ by Tukey's test at 5 % probability.

The highest ($p < 0.05$) values of biological efficiency (BE) were obtained from the wild strain CCIBt4706 (Figure 3) grown in the environment A, both with and without scratching (30.01 % ± 7.71 % and 29.47 % ± 4.60 %, respectively). For the wild strain CCIBt4369, as well as for CCIBt4706, the highest BE value (25.69 % ± 3.19 %) was obtained from blocks cultivated in the environment A (A/s treatment). Among the blocks cultivated in the environment B, the wild strain CCIBt4369 showed better results ($p < 0.05$) with BE values ranging from 18.49 % ± 3.22 % to 21.20 % ± 2.78 % in B/s and B/c treatment, respectively, while the wild strain CCIBt4706 showed BE values from 6.25 % ± 2.06 % to 12.37 % ± 2.47 % in B/s and B/c treatment, respectively. The nutritional and mineral composition of mushrooms produced from B/s treatment is shown in Table 3.

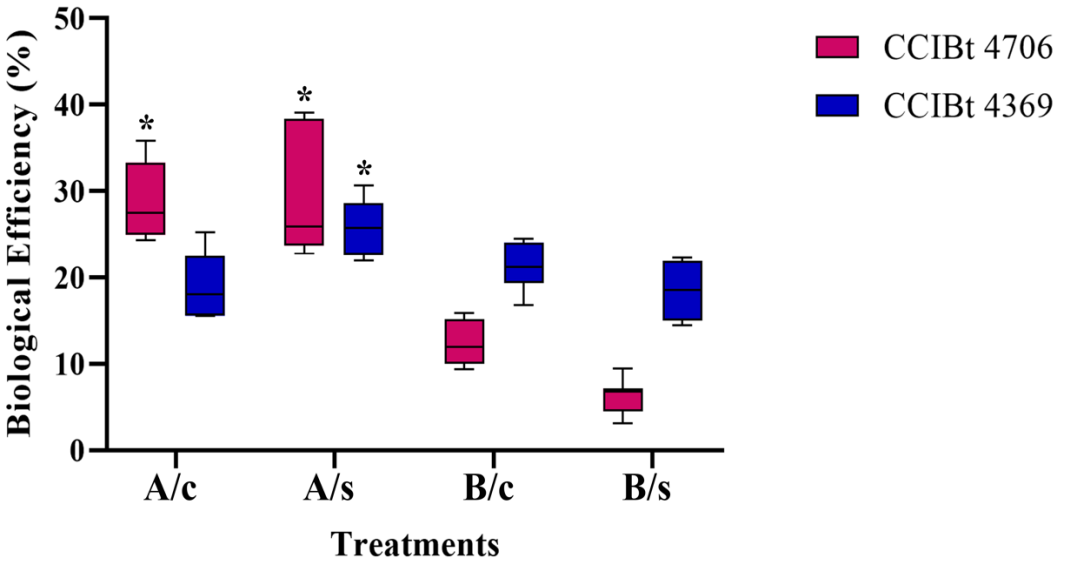

Figure 3 – Biological efficiency of two wild strains of *Irpex rosettiformis* in sawdust-based substrate. The asterisk indicates statistical significance by Tukey's test at 5 % probability. A/c: environment A and cut on the package surface. A/s: environment A and cut on package surface and scratching. B/c: environment B and cut on the package surface. B/s: environment B and cut on package surface and scratching.

The basidiomata of *I. rosettiformis* developed all over the surface of the substrate (Figure 4 h), presenting a more homogeneous form in the treatment in which the scratching technique was performed. Despite being the same species and having been cultivated under the same parameters, the morphology of the produced basidiomata showed differences between the two wild strains tested. The basidiomata of CCIBt4369 developed a more wrinkled and cerebriform morphology, with thicker lobes (Figure 4 g), different from the wild strain CCIBt4706, which presents a flabelliform morphology with thinner lobes (Figure 4 f). It was also observed in CCIBt4369 blocks the formation of a fertile (Figure 5 c) short-erect structure (almost resupinated) (Figure 5 a), a characteristic never before described for the species. This formation is fully adhered to the substrate and when viewed enlarged looks very similar to the rosette-shaped structure characteristic of the species (Figure 5 b).

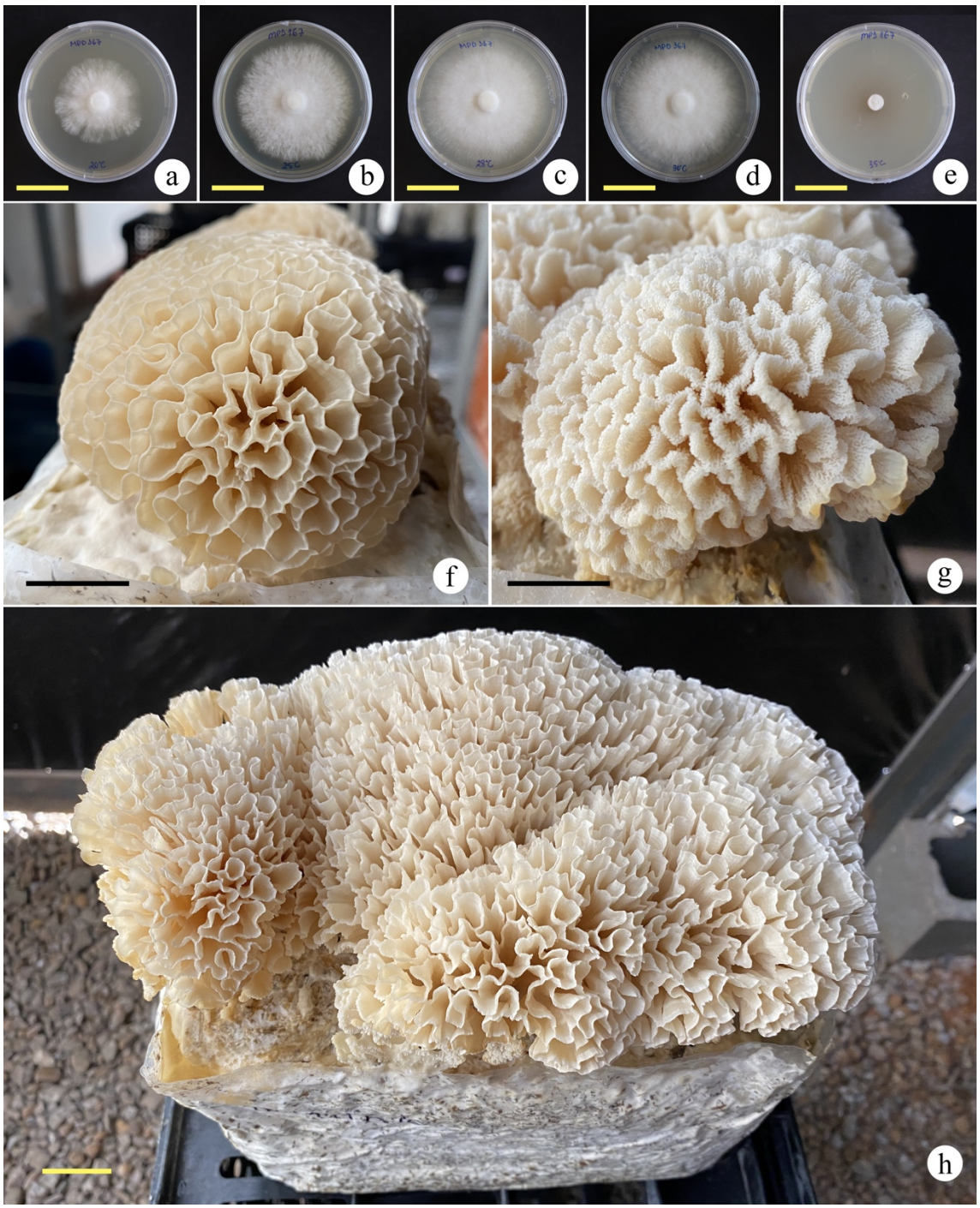

Figure 4 – Mycelial development and cultivation of wild strains of *Irpex rosettiformis*. (a–e) Mycelial growth of the wild strain CCIBt4706 in PDA media on sixth day. (a) Temperature at 20 °C. (b) Temperature at 25 °C. (c) Temperature at 28 °C. (d) Temperature at 30 °C. (e) Temperature at 35 °C. (f) Basidioma (CCIBt4706) from A/c treatment. (g) Basidioma (CCIBt4369) from A/s treatment. (h) Cultivation block (CCIBt4706) of A/s treatment. (a–e) Bars = 1 cm. (f–h) Bars = 2 cm. Photos by Drewinski MP.

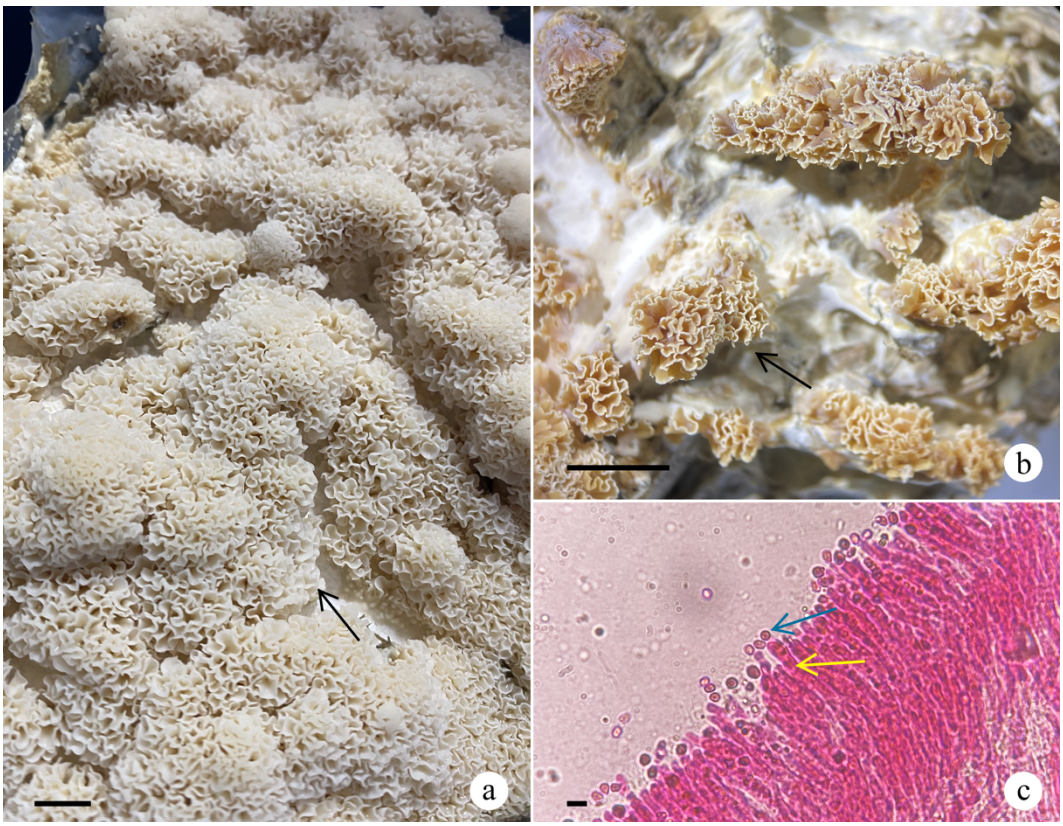

Figure 5 – *Irpex rosettiformis* wild strain CCIBt4369. (a) Development of the fertile structure adhered to the substrate. (b) The same structure, after dehydrating, seen in stereo microscope. (c) Section of the basidiomata structure showing basidia (yellow arrow) and basidiospores (blue arrow). (a–b) Bars = 1 cm. (c) Bar = 20 µm. Photos by Drewinski MP.

Table 3 Nutritional and mineral composition of cultivated wild strains of *Irpex rosettiformis*.

Component		**CCIBt4369 (A/s)**	**CCIBt4706 (A/s)**
Nutrient constituent	Dry matter (%)	98.00	96.22
	Moisture (%)	2.00	3.78
	Ash (%)	8.9	6.10
	Crude protein (%)	18.89	25.63
	Crude fat (%)	10.09	10.28
	Crude fiber (%)	27.61	22.68
	Carbohydrates (%)	60.12	54.21
Macroelements	P (mg/kg)	10,800	12,500
	K (mg/kg)	33,500	33,500
	Ca (mg/kg)	200	800
	Mg (mg/kg)	2,300	2,600
Microelements	Cu (mg/kg)	12	19
	Fe (mg/kg)	80	53
	Mn (mg/kg)	18	24
	Zn (mg/kg)	61	60

A/s: environment A and scratching for primordia induction treatment. Values expressed on dry matter. Protein conversion factor N × 4.38.

The constituents of the substrates pre-cultivation and after 60 days of growth of the two wild strains of *I. rosettiformis* were characterized and the results obtained are presented in Table 4. The C/N ratio of the initial substrate was 93:1 and changed to 79:1 and 89:1 after cultivation of wild strains CCIBt4369 and CCIBt4706, respectively. A decrease in the values of humidity, pH, and content of elements Ca, B, Mn, and Zn, and an increase in the values of electrical conductivity and elements P, K, Mg, S, and Cu were found in post-cultivation substrates. For Fe element, it was found a decrease in the content in the post-cultivation substrate of the wild strain CCIBt4706, and an increase in the post-cultivation substrate of the wild strain CCIBt4369.

Table 4 Characterization of the substrates pre-cultivation and after 60 days of growth of two wild strains of *Irpex rosettiformis*.

	pre-cultivation substrate	**post-cultivation CCIBt4369**	**post-cultivation CCIBt4706**
Moisture	68%	55%	57%
pH	6.42	4.30	4.70
EC (µS/cm)	966	2,191	1,981
%N	0.57	0.60	0.56
%C	53.5	48.0	49.9
C/N ratio	93.2	79.7	89.1
N (mg/Kg)	5,700	6,000	5,600
P (mg/Kg)	3,100	5,700	5,000
K (mg/Kg)	5,000	5,200	6,000
Ca (mg/Kg)	6,300	4,000	3,100
Mg (mg/Kg)	2,500	3,700	3,100
S (mg/Kg)	900	1,100	1,000
B (mg/Kg)	23	8	13
Cu (mg/Kg)	7	11	20
Fe (mg/Kg)	243	264	211
Mn (mg/Kg)	145	138	123
Zn (mg/Kg)	40	33	29

EC: electrical conductivity.

Discussion

The temperatures that best favoured the mycelial growth of *I. rosettiformis* were both 28 °C and 30 °C. This is the first study that evaluates the effect of different temperatures on the mycelial growth of *I. rosettiformis*. For another species of the genus, *Irpex lacteus* (Fr.) Fr., the optimum temperature for mycelial growth ranges from 25 °C to 35 °C (Capelari & Zadrazil 1997, Hwang & Song 2000, Kalpana et al. 2011, Koutrotsios & Zervakis 2014, Dong et al. 2017). Capelari & Zadrazil (1997) studied a wild strain of *I. lacteus* from Brazil and observed

that the temperature of 30 °C favoured the mycelium development of the species as well as the lignin degradation of a wheat straw substrate. Temperature is an important factor for mycelium growth in both agar media, spawn running, and also for mushroom development (Thawthong et al. 2014).

The wild strains of *I. rosettiformis* developed better in the sterile substrate based on eucalyptus sawdust. Most mushrooms require lignocellulosic substrates for growth, and different species of mushrooms require different types of substrate (Chang & Miles 2004). The use of sawdust and wood debris are very common in the cultivation of various edible species (Stamets 2000, Thawthong et al. 2014). *Irpex rosettiformis* is a wood decomposer considered saprophytic but has already been found growing on roots or around the base of living trees (Fidalgo 1963, Wright & Albertó 2006) such as *Eucalyptus* sp. (Ryvarden & Meijer 2002, Castiblanco et al. 2017). This observation suggests a possible parasitic behaviour of the species (Fidalgo 1963).

The highest BE values for both evaluated wild strains were obtained in the treatment in which the scratching technique was performed. The scratching technique (*Kinkaki* in Japanese) consists of removing the original inoculum with the aerial mycelium from the surface of the growing substrate (Yamanaka 2017, Thuy & Suzuki 2019). The technique is used to induce and synchronize primordium formation and mushroom development, increasing the biological efficiency (Thuy & Suzuki 2019). The scratching technique is common to be used for species grown in plastic bottles (Yamanaka 2017), and is used mainly for the species *Flammulina velutipes* (Curtis) (Kitamoto et al. 1993, Hiramori et al. 2017), *Pleurotus* spp. (Bao et al. 2004), *Hypsizygus marmoreus* (Peck) H. E. Bigelow (Xu et al. 2023), and *Cordyceps militaris* (L.) Fr. (Liu et al. 2018).

Irpex rosettiformis has had its taxonomic classification changed in different families and in many genera over the years, such as *Polyporus* P. Micheli ex Adans. (Fries 1830), *Thelephora* Ehrh. ex Willd. (Montagne 1843), *Polystictus* Fr. (Cooke 1886), and *Hydnopolyporus* D.A. Reid (Reid 1962), but never agreeing entirely with the fundamental characters of the genera to which it has been assigned (Fidalgo 1963). The long taxonomic history of the species is mainly due to the great variation in the morphology of basidiomata, especially in the hymenial configuration (Fidalgo 1963). Recently, Chen et al. (2021) proposed the classification of the species into the genus *Irpex*. Within *Irpex*, most species produced effused, cushion-like, or effused-reflexed basidiomata, except for one species, *I. rosettiformis*, that has been characterized by produces stipitate-pileate basidiomata (Chen et al. 2021). However, in the axenic cultivation developed in this study, we observed the formation of a

fertile short-erect structure of *I. rosettiformis*, mainly in the wild strain CCIBt4369. The substrate-adhered growth form of this species is described here for the first time.

Environmental factors as light, temperature, humidity, and gaseous components, as well as nutrient concentration in substrate, individually or in combination, influence the primordia induction and basidiomata development (Sakamoto 2018). The species *Pleurotus ostreatus,* for example, when cultivated at high temperatures produces mushrooms with pileus close to white, while at low temperatures it presents a darker color (Jhune et al. 2006). On the other hand, Sou et al. (2013) evaluated the morphological and genetic characteristics of ten crossbred strains of *Sparassis latifolia* Y.C. Dai & Zheng Wang produced under the same environmental conditions, and also observed differences in the size and color of basidiomata. Thus, in addition to environmental factors, the genetics of each strain also affects the morphological characteristics of the mushroom and production yield (Sobieralski et al. 2007, Sou et al. 2013, Oh et al. 2016).

Since earliest times, mushrooms have been treated as a special kind of food (Chang & Miles 2004). They can be considered as a functional food due to their nutritional and medicinal values (Vetter 2019). The nutritional composition of a species is affected by the genetic characteristic of the strain and by cultivation conditions, such as the type of substrate used (Chang & Miles 2004). The cultivated basidiomata of *I. rosettiformis* were found to contain a high value of crude fiber (22.68–27.61%), crude protein (18.89–25.63%), and crude fat (10.09–10.28%). The nutritional composition of *I. rosettiformis* resembles the values commonly found for other wild and commercial mushroom species (Barros et al. 2008b, Vetter 2019, Alberti et al. 2021, Silva-Neto et al. 2022). In addition to the amount of macronutrients present in mushrooms, the quality of these nutrients also is very important. The proteins of commonly cultivated mushrooms contain all the nine amino acids essential for humans, and the fat is mostly composed by unsaturated fatty acids, which are beneficial to our health (Chang & Miles 2004).

For *I. rosettiformis*, there are few but promising studies on medicinal properties. Contato et al. (2020) studied biochemical properties and effects on mitochondrial respiration of eight wild mushrooms from Brazil. The species *I. rosettiformis* (as *Hydnopolyporus fimbriatus*) was the one that presented the most significant results for the antioxidant activity and did not present characteristics of cytotoxicity. Menezes-Filho et al. (2022) evaluated the hydroethanolic extract of wild *I. rosettiformis* (as *Hydnopolyporus fimbriatus*) from Goiás state, Brazil, and found the presence of different metabolites classes with therapeutic applications. The medicinal properties of mushrooms are attributed to many bioactive metabolites present in the mycelium but especially in the basidioma, whose biological effect varies according to the molecule and the fungal species (Venturella et al. 2021).

The main mushroom producers in Brazil are located in the states of São Paulo and Paraná, and the main cultivated species are *P. ostreatus*, *Agaricus bisporus* (J.E. Lange) Imbach, and *L. edodes* (Sánchez et al. 2018). However, mushroom production is an expanding activity in Brazil, and cultivation has spread to other regions of the country. The introduction of new species and new strains could help to improve the mushroom production for the forthcoming years (Albertó 2017). To discover new industrial mushroom is important to make sure the species is edible and establish if it can readily be cultivated (Thawthong et al. 2014). The information on edibility of *I. rosettiformis* is based on ethnomycological studies, previously from traditional communities in Mexico (Villarreal & Perez-Moreno 1989) but later also in Guatemala (Flores-Arzú et al. 2012) and Brazil (Sanuma et al. 2016). In this work we record for the first time the successful cultivation of the species in sawdust-based substrate. *Irpex rosettiformis* has a potential to be introduced in the market of cultivatable mushrooms and further studies are needed to optimize its cultivation conditions and increase its productivity.

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Supplementary material

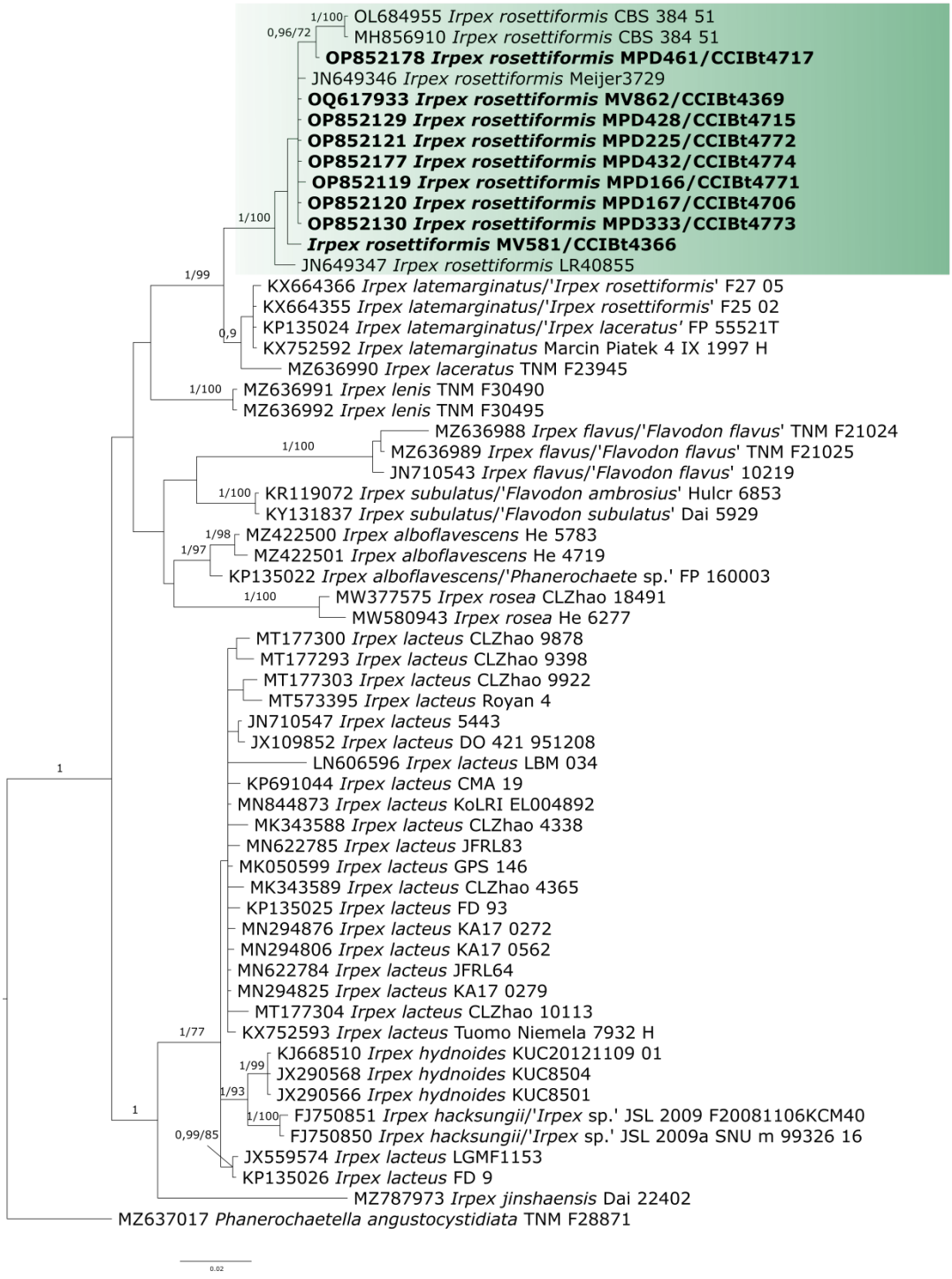

Figure 1 –Bayesian Inference (BI) tree of *Irpex* based on ITS data. Branches are labeled with BI posterior probability (higher than 0.9), and Maximum Likelihood bootstrap (higher than 70%). The sequences generated in this work are in bold. The highlight represents the clade of species *Irpex rosettiformis*.

Considerações pessoais sobre o desenvolvimento da pesquisa

Os cogumelos comestíveis silvestres são um importante produto florestal não madeireiro pouco utilizado no Brasil. Nos últimos anos, o interesse dos brasileiros pelos cogumelos comestíveis silvestres vem crescendo, e a publicação de guias de espécies em português e materiais de divulgação científica, principalmente na internet, tem facilitado o acesso às informações sobre a nossa funga. Além disso, algumas iniciativas de turismo micológico também estão surgindo no país, principalmente no sul e sudeste, impulsionando o consumo de espécies silvestres. Entretanto, é necessário tomar muito cuidado ao consumir cogumelos silvestres e também na escolha do profissional que facilita essas vivências, pois muitas espécies podem ser facilmente confundidas com outras por pessoas pouco experientes. Vale lembrar que o Brasil não possui um forte conhecimento tradicional relacionado ao consumo de cogumelos silvestres. Também é importante salientar que a coleta de cogumelos comestíveis silvestres deve ser feita apenas em áreas autorizadas, seja pelo proprietário em locais particulares, ou pelos órgãos competentes (ICMBio, IBAMA, Secretarias do meio ambiente municipais ou estaduais) em locais de preservação.

Durante a realização deste trabalho, muita coisa deu errada, mas também muita coisa deu certo. Dessa forma, seguem algumas considerações e dicas para futuros estudos sobre domesticação e cultivo de cogumelos silvestres.

Quando falamos em isolamento micelial de espécies silvestres, a pergunta sempre é: Como obter sucesso no isolamento? A minha resposta é: não sei. Algumas vezes tem tudo para dar certo, mas dá errado, e outras vezes tem tudo pra dar errado, mas dá certo. É difícil encontrar o erro. As minhas dicas são: para evitar muita contaminação provinda do ambiente, sempre tentar isolar num lugar protegido de vento e, se possível, usando mais de uma lamparina; limpar muito bem com álcool 70 % a bancada e os materiais que serão utilizados; usar pinça para os cogumelos mais macios e bisturi para os cogumelos mais fibrosos; inocular mais do que um fragmento de cada espécime, e tentar pegar os fragmentos de locais diferentes do contexto do píleo e do estipe. A condição do basidioma também conta muito. Se o cogumelo estiver muito comido, com muitos bichos, velho ou muito encharcado, a chance do sucesso no isolamento é bem menor. Não vale a pena desperdiçar placa com meio de cultura (um recurso valioso em campo) tentando isolar material ruim. Se a placa começar a contaminar muito, repicar o pedaço isolado para uma nova placa e, claro, acompanhar o crescimento diariamente, esperando o micélio crescer do pedaço inoculado com paciência e amor.

Para a manutenção das culturas, a dica é preservar o micélio do isolado assim que limpar a placa. Para a preservação, fazer pelo menos três réplicas do método escolhido e preservar de

diferentes formas e em diferentes temperaturas. Algumas cepas morrem se preservadas na geladeira.

Infelizmente algumas cepas acabaram morrendo pelo meio do caminho. A pandemia da Covid-19 acabou selecionando várias cepas. Acabamos perdendo muitos isolados, pois tivemos que ficar muito tempo longe do laboratório, exatamente quando iríamos fazer a preservação do micélio e depósito na coleção de culturas. Cada indivíduo é único e é muito triste perder a cepa daquela coleta linda, daquela espécie rara, ou mesmo aquela cepa que já tínhamos dados do experimento *in vitro*. O consolo é que ao mesmo tempo em que perdemos algumas cepas, a cada nova coleta conseguimos outras.

Conclusões

O Brasil é um país megadiverso. Na nossa pesquisa, um esforço colaborativo enorme de revisão de registro de espécies para o Brasil, nós reunimos informações sobre a ocorrência de 408 espécies de cogumelos comestíveis silvestres para o país. Destas, 349 espécies podem ser consumidas com segurança e 59 espécies necessitam de algum preparo/atenção para o consumo adequado. Segundo a nossa classificação, menos de um quarto delas (apenas 83 espécies) possuem registros robustos de ocorrência, baseados em sequências de DNA ou em tipos nomenclaturais (BEM1 e BEM2). Os dados obtidos reforçam a necessidade de estudos futuros para confirmar a identificação das outras 325 espécies comestíveis reportadas para o Brasil, pois várias espécies que entraram na lista foram registradas apenas uma ou poucas vezes, ou representam espécies com distribuição possivelmente restrita a outras áreas do globo e que não ocorrem na região Neotropical. São necessários estudos futuros tanto para confirmação da identidade dessas espécies e dos locais onde elas ocorrem, assim como das novas espécies que ainda precisam ser descritas e que podem representar um novo recurso alimentar. Para isso, são necessários estudos não só de taxonomia e sistemática, mas também de ecologia e etnomicologia.

Para auxiliar na identificação dos espécimes coletados, tanto das cepas isoladas quanto de alguns basidiomas, foram geradas 156 novas sequências de DNA de 39 espécies pertencentes a 28 gêneros. Para as espécies *Boletus edulis*, *Clavulinopsis laeticolor*, *Cookeina colensoi*, *Cookeina tricholoma*, *Cookeina venezuelae*, *Cymatoderma dendriticum*, *Laccaria lateritia*, *Lactarius hepaticus*, *Lentinus concavus*, *Lepista sordida*, *Macrocybe titans*, *Oudemansiella cubensis*, *Pseudofistulina radicata*, *Ripartitella brasiliensis*, *Russula parazurea* e *Tremella fuciformis* foram geradas as primeiras sequências de ITS de espécimes coletados no Brasil. Com base nas novas sequências, as espécies *Lactarius hepaticus* e *Russula parazurea* são um novo registro para o Brasil. Além disso, 15 espécies são novos registros para os estados: Maranhão (*Auricularia tremellosa*), Tocantins (*Pleurotus djamor*), Mato Grosso do Sul (*P. djamor),* Espírito Santo (*Lae. gilbertsonii* e *Oudemansiella platensis*), Rio de Janeiro (*L. sordida*, *Phillipsia dominguensis* e *T. fuciformis*), Rio Grande do Norte (*M. titans*)., São Paulo (*B. edulis*, *Cantharellus guyanensis*, *C. venezuelae*, *C. tricholoma*, *La. hepaticus*, *Le. concavus, O. platensis*, *R. parazurea*), e Paraná (*O. platensis*).

Os cogumelos representam uma importante fase do ciclo de vida de um fungo, e esse recurso é limitado e altamente influenciado pelas condições ambientais. Dessa forma, estudos sobre a domesticação e cultivo de espécies comestíveis são importantes para garantir o fornecimento desse alimento. Nós estudamos o potencial de cultivo de quatro espécies coletadas

na Mata Atlântica: *A. cornea*, *A. fuscosuccinea*, *I. rosettiformis* e *L. gilbertsonii*. Dentre todas as espécies avaliadas, as cepas de *I. rosettiformis* foram as que primeiro colonizaram a placa, levando seis dias. Tanto para os dados de crescimento quanto de biomassa, os melhores valores foram obtidos na temperatura de 28 °C e 30°C. Ambas as espécies *A. fuscosuccinea* e *L. gilbertsonii* completaram a colonização da placa em sete dias. Para *A. fuscosuccinea* a melhor temperatura para crescimento e produção de biomassa micelial foi 30°C, enquanto que para *L. gilbertsonii*, o crescimento do micélio foi mais rápido a 30°C, porém quanto à produção de biomassa micelial não houve diferença entre 25°C e 30°C. Assim como para *A. fuscosuccinea*, para *A. cornea* a melhor temperatura de crescimento e biomassa foi 30°C, levando 12 dias para completar o crescimento no meio de cultura.

Nos experimentos com dois tipos de substratos: o JunCao pasteurizado e o a base de serragem de eucalipto estéril, todas as cepas avaliadas se desenvolveram muito melhor no substrato estéril de serragem. Dentre todas as espécies avaliadas, *L. gilbertsonii* foi a que cresceu mais rápido na serragem. As cepas CCIBt4710 e CCIBt4718 levaram 11 e 12 dias, respectivamente, para completar a colonização do substrato nos potes. A espécie *A. cornea* foi a segunda a terminar a colonização do substrato a base de serragem, levando 16 dias. Dentre todas as espécies avaliadas no substrato JunCao, a *A. cornea* foi a que teve melhor desempenho, apesar de ainda ser inferior ao desempenho na serragem de eucalipto. Para *I. rosettiformis* o micélio também se desenvolveu melhor na serragem de eucalipto, e a colonização do substrato foi completa entre 18 e 20 dias após a inoculação. Dentre as espécies avaliadas, a última a colonizar totalmente o substrato foi a *A. fuscosuccinea*, completando o crescimento em 21 e 22 dias no substrato a base de serragem. Assim como para *I. rosettiformis* e *L. gilbertsonii*, a formulação utilizada de substrato pasteurizado JunCao não favoreceu o desenvolvimento do micélio. Assim, o substrato escolhido para o teste em blocos foi o a base de serragem de eucalipto estéril.

No experimento em blocos de 2,5 Kg de serragem, as cepas CCIBt4710 e CCIBt4718 da espécie *L. gilbertsonii* foram as primeiras a colonizar o substrato, levando 9–11 dias. Após 30 dias da inoculação, induzimos os primórdios para produção dos basidiomas, mas não obtivemos sucesso. O micélio continuou a crescer na maioria dos métodos, mas não foi observada a produção de primórdios. Aqui, registramos o sucesso no cultivo de basidiomas de três espécies silvestres: *A. fuscosuccinea*, *A. cornea* e *I. rosettiformis*.

A espécie *A. cornea* levou 17–21 dias para completar a colonização dos blocos. Assim que abertos, já nos primeiros dias, os primórdios começaram a aparecer, principalmente nos blocos cultivados na câmara climática. Apesar disso, a primeira colheita e a maior eficiência biológica foi obtida nos blocos cultivados na estufa rústica e com indução a partir de abertura

dos pacotes. Dentre as três espécies que foram produzidas nos blocos, os maiores valores de produtividade foram obtidos de *A. cornea*. Os valores de eficiência biológica variaram de 41,53 % a 46,30 % nos tratamentos da câmara climática e 92,31 % a 106,90 % nos tratamento da estufa rústica.

Aqui, registramos o primeiro cultivo exitoso da espécie *I. rosettiformis*. As duas cepas avaliadas completaram a colonização do bloco entre 25–31 dias. O desenvolvimento dos primórdios foi observado antes nos tratamentos em que foi feita a indução por meio da remoção do micélio da superfície do bloco. Os basidiomas cresceram por toda superfície do bloco de cultivo. As primeiras colheitas foram feitas dos blocos cultivados na estufa rústica. Os maiores valores de eficiência biológica (29,47 % e 30,01 %) foram obtidos da cepa CCIBt4706 e dos tratamentos na estufa rústica. De forma inversa, na câmara climática, os tratamentos com a cepa CCIBt4706 obtiveram os valores mais baixos de eficiência biológica (6,25 % e 12,37 %). A cepa CCIBt4369 obteve um desempenho mais constante, com valores de eficiência biológica entre 18,49 % a 21,20 % nos quatro tratamentos. A cepa CCIBt4369, de forma especial, exibiu uma morfologia bastante diferente em alguns momentos do cultivo, produzindo uma estrutura fértil bastante aderida ao substrato, característica nunca observada para a espécie, que a pouco passou a integrar o gênero *Irpex*, conhecido por conter espécies ressupinadas.

Para *A. fuscosuccinea*, o micélio da cepa CCIBt2381 cresceu com bastante vigor no bloco de cultivo, finalizando o crescimento micelial em 25–27 dias. Entretando, após a abertura dos pacotes, os primórdios só surgiram depois de 21 dias. A outra cepa avaliada, CCIBt4753, demorou 28–34 dias para crescer por todo o substrato, e, apesar do micélio não estar totalmente uniforme pelo bloco, os primórdios apareceram 14–27 dias após a abertura dos pacotes, crescendo principalmente na metade inferior dos blocos. Apesar da obtenção de basidiomas, não foi possível a obtenção dos valores de produtividade e eficiência biológica.

Em relação ao valor de fibra bruta, proteína bruta e cinzas, a espécie *I. rosettiformis* foi a que apresentou os maiores valores: 22,68 % e 27,61 % de fibras, 18,89 % e 25,63% de proteína bruta, e 6,10 % a 8,90% de cinzas. Quanto aos lipídios totais, os valores mais baixos foram encontrados para *A. fuscosuccinea* (0,82 % e 0,91 %). Para as outras espécies os valores foram mais altos, chegando a 10,19 % para *A. cornea*, e 10,09% e 10,28% para *I. rosettiformis*. Dentre os macro e microelementos avaliados nos basidiomas produzidos, os mais abundantes foram potássio: 20.800 mg/Kg nas amostras de *A. cornea* e 33.500 mg/Kg nas amostras de *I. rosettiformis*; e fósforo: 4.900 mg/Kg nas amostras de *A. cornea*, 10.800 mg/Kg e 12.500 mg/Kg nas amostras de *I. rosettiformis*. A composição nutricional e mineral dos cogumelos produzidos corrobora com os valores já conhecidos para espécies silvestres e cultivadas.

Os resultados deste trabalho demonstraram o sucesso no cultivo de três espécies silvestres da Mata Atlântica, utilizando métodos já conhecidos para o cultivo de espécies comerciais. Foi possível obter cogumelos em uma estrutura simples de cultivo, sem climatização, ou seja, as espécies silvestres cultivadas aqui não necessitaram de uma estrutura altamente especializada para se desenvolver, o que pode tornar a prática de cultivo mais fácil para os produtores e mais acessível para os consumidores. Estudos futuros com diferentes tipos de substratos e com outras cepas são necessários para aperfeiçoar a produção dessas espécies e aumentar ainda mais a produtividade. Além disso, o trabalho colaborativo com *chefs* de cozinha e ações de divulgação científica são fundamentais para a inclusão dessas espécies pouco conhecidas no setor gastronômico e no mercado nacional de cogumelos.

Além da importância dos cogumelos comestíveis silvestres como alimento, eles também possuem uma grande relevância ecológica, sociocultural, econômica, medicinal e biotecnológica. Os cogumelos comestíveis silvestres podem promover a sustentabilidade da floresta e a conservação da biodiversidade, pois agregam valor à floresta em pé e podem aumentar o incentivo à proteção das áreas naturais.

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Anexo 1. Tabela com materiais estudados.

Táxon	N° coletor	SP	FIFUNGI	GenBank	CCIBt
Auricularia cornea	MPD290	512745	-	-	-
Auricularia cornea	MPD353	528755	-	OQ617344	-
Auricularia cornea	MPD434	528769	-	OQ617345	-
Auricularia cornea	MPD594	528779	-	OP852118	4755
Auricularia cornea	s.n.(cultivo CCIBt4755)	528789	-	-	-
Auricularia fuscosuccinea	-	-	-	OP851766	2381
Auricularia fuscosuccinea	MPD158	513097	-	OP851758	4745
Auricularia fuscosuccinea	MPD226	-	8	OQ892124	-
Auricularia fuscosuccinea	MPD227	528741	-	OQ617346	-
Auricularia fuscosuccinea	MPD230	528742	-	OQ617347	-
Auricularia fuscosuccinea	MPD278	528786	-	OQ617349	-
Auricularia fuscosuccinea	MPD294	512746	-	-	-
Auricularia fuscosuccinea	MPD351	513098	-	OP851770	4747
Auricularia fuscosuccinea	MPD416	528787	-	OQ617348	-
Auricularia fuscosuccinea	MPD455	513099	2	OP851752	4748
Auricularia fuscosuccinea	MPD497	513100	-	OP851764	4749
Auricularia fuscosuccinea	MPD500	528777	-	OQ617350	-
Auricularia fuscosuccinea	MPD527	513101	3	OP851753	4751
Auricularia fuscosuccinea	MPD539	513102	4	OP851755	4752
Auricularia fuscosuccinea	MPD576	513103	5	OP851768	4753
Auricularia fuscosuccinea	MPD576.C (cultivo CCIBt4753)	-	6	-	-
Auricularia fuscosuccinea	MPD586	528778	-	OQ617351	-
Auricularia fuscosuccinea	MPD600	513104	-	OP851800	4756
Auricularia fuscosuccinea	MPD608	-	52	-	-
Auricularia fuscosuccinea	MPD609	513105	-	OP851757	4757
Auricularia fuscosuccinea	MPD614	513106	-	OP851754	4758
Auricularia fuscosuccinea	MPD618	528780	-	OQ617352	-
Auricularia sp.	MPD474	-	9	-	-
Auricularia tremellosa	MP357	-	-	OQ617353	-
Cookeina colensoi	MPD409	528763	-	OQ621659	-
Cookeina tricholoma	B6MIC166	528782	-	OQ617354	-
Cookeina tricholoma	MPD347	528754	-	OQ621662	-
Cookeina tricholoma	MPD705	-	148	-	-
Cookeina tricholoma	MPD706	-	149	-	-
Cookeina venezuelae	MPD211	528738	-	OQ621661	-
Cookeina venezuelae	MPD214	528739	-	OQ621656	-
Cookeina venezuelae	MPD408	528762	-	OQ621658	-
Coprinus comatus	MPD273	528749	-	OR166782	-
Coprinus comatus	MPD440	528771	-	OQ617445	-
Cymatoderma dendriticum	MPD364	528756	-	OQ98260	-
Favolus brasiliensis	MPD465	528774	-	OQ617891	-
Favolus brasiliensis	MPD516	-	154	-	-
Favolus brasiliensis	MPD517	-	155	-	-
Favolus radiatifibrilosus	MPD579	-	101	-	-

Favolus rugulosus	MPD240	528743	-	OQ617926	-
Irpex rosettiformis	MPD166	512771	-	OP852119	4771
Irpex rosettiformis	MPD167	512772	-	OP852120	4706
Irpex rosettiformis	MPD188	512773	-	OQ617929	-
Irpex rosettiformis	MPD189	512774	-	-	-
Irpex rosettiformis	MPD225	512775	-	OP852121	4772
Irpex rosettiformis	MPD333	512776	-	OP852130	4773
Irpex rosettiformis	MPD372	512777	-	-	-
Irpex rosettiformis	MPD428	512778	-	OP852129	4715
Irpex rosettiformis	MPD432	512779	-	OP852177	4774
Irpex rosettiformis	MPD450	512780	-	-	-
Irpex rosettiformis	MPD461	512781	-	OP852178	4717
Irpex rosettiformis	MPD548	512782	-	-	-
Irpex rosettiformis	MPD622	512783	-	-	-
Irpex rosettiformis	MPD623	512784	-	-	-
Irpex rosettiformis	MPD644	512785	-	-	-
Irpex rosettiformis	MPD645	512786	-	-	-
Irpex rosettiformis	MPD646	512787	-	-	-
Irpex rosettiformis	MPD674	512788	-	-	-
Irpex rosettiformis	MPD676	512789	-	-	-
Irpex rosettiformis	MPD678	512790	-	-	-
Irpex rosettiformis	MV581	466786	-	xxx	4366
Irpex rosettiformis	MV862	466793	-	OQ617933	4369
Irpex rosettiformis	s.n. (cultivo CCIBt4706)	528790	-	-	-
Irpex rosettiformis	s.n.(cultivo CCIBt4369)	528791	-	-	-
Laetiporus gilbertsonii	MPD285	512739	-	-	-
Laetiporus gilbertsonii	MPD300	512740	-	OP851756	4709
Laetiporus gilbertsonii	MPD306	512741	-	OP851769	4710
Laetiporus gilbertsonii	MPD466	513107	7	OP851767	4718
Lentinula raphanica	MPD286	512743	-	-	-
Lentinus berteroi	B6MIC11	528783	-	OQ617948	4702
Lentinus berteroi	MPD248	528746	-	OQ618181	-
Lentinus berteroi	MPD367	528757	-	OQ617947	4713
Lentinus concavus	MPD168	-	10	-	-
Lentinus concavus	MPD193	528736	-	OQ628490	4708
Lentinus concavus	MPD328	-	16	-	-
Lentinus concavus	MPD374	-	18	-	-
Lentinus concavus	MPD385	-	19	-	-
Lentinus crinitus	MPD429	-	22	-	-
Lepista sordida	MPD279	528750	-	OQ618185	-
Macrocybe titans	MPD439	528770	-	OQ618189	-
Marasmius magnus	MPD520	-	24	-	-
Oudemansiella cubensis	MPD176	-	12	-	-
Oudemansiella cubensis	MPD221	-	306	-	-
Oudemansiella cubensis	MPD244	-	305	-	-
Oudemansiella cubensis	MPD246	-	307	-	-

Oudemansiella cubensis	MPD315	528751	-	OQ621660	-
Oudemansiella cubensis	MPD319	528753	310	OQ621664	-
Oudemansiella cubensis	MPD371	-	17	-	-
Oudemansiella cubensis	MPD386	-	20	-	-
Oudemansiella cubensis	MPD393	528758	-	OQ621663	-
Oudemansiella cubensis	MPD698	-	139	-	-
Oudemansiella platensis	B6MICIFSP18	-	-	OQ621665	-
Oudemansiella platensis	MPD157	528732	302	OQ618200	-
Oudemansiella platensis	MPD203	-	13	-	-
Oudemansiella platensis	MPD215	-	14	-	-
Oudemansiella platensis	MPD223	528740	-	OQ618201	-
Oudemansiella platensis	MPD245	-	304	-	-
Oudemansiella platensis	MPD292	512742	309	OQ618202	-
Oudemansiella platensis	MPD301	512744	-	OQ618203	-
Oudemansiella platensis	MPD392	-	21	-	-
Oudemansiella platensis	MPD407	528761	-	OQ618208	-
Oudemansiella platensis	MPD415	528766	-	OQ618206	-
Oudemansiella platensis	MPD433	528768	-	OQ618209	-
Oudemansiella platensis	MPD697	-	138	-	-
Oudemansiella platensis	Osp1	-	-	OQ618211	-
Oudemansiella platensis	Osp2	-	-	OQ618212	-
Panus strigellus	B6MIC28	528784	-	OQ618220	-
Panus velutinus	NMJ260	-	-	OQ626166	-
Pleurotus albidus	MPD161	-	-	OQ621706	-
Pleurotus albidus	MPD454	528773	-	OQ621737	4716
Pleurotus albidus	MPD530	-	28	-	-
Pleurotus djamor	FCNM3	528785	-	OQ621747	-
Pleurotus djamor	MP364	-	-	OQ623170	-
Pleurotus djamor	MPD198	-	-	OQ623169	-
Pleurotus djamor	MPD233	-	-	OQ623174	-
Pleurotus djamor	MPD238	-	-	OQ623172	-
Pleurotus djamor	MPD241	528744	-	OQ621766	-
Pleurotus djamor	MPD243	528745	-	OQ623171	-
Pleurotus djamor	MPD249	528747	-	OQ625112	-
Pleurotus djamor	MPD255	528748	-	OQ623828	-
Pleurotus djamor	MPD311	-	15	-	-
Pleurotus djamor	MPD476	528775	-	OQ623829	-
Pleurotus djamor	MPD478	528776	-	OQ623833	4719
Pleurotus djamor	MPD479	-	23	-	-
Pleurotus djamor	MPD523	-	25	-	-
Pleurotus djamor	MPD533	-	30	-	-
Pleurotus djamor	MPD704	-	147	-	-
Pleurotus magnificus	MPD186	512760	11	-	-
Pleurotus magnificus	MPD635	512761	-	-	-
Pleurotus pulmonarius	MPD160	-	-	OQ624889	4703
Pleurotus pulmonarius	MPD163	528733	-	OQ624891	4704
Pleurotus pulmonarius	MPD165	528734	-	OQ624890	4705
Pleurotus pulmonarius	MPD183	-	-	OQ624936	4707

Pleurotus pulmonarius	MPD185	528735	-	OQ624935	-
Pleurotus pulmonarius	MPD400	528759	-	OQ624955	-
Pleurotus pulmonarius	MPD404	528760	-	OQ624958	-
Pleurotus pulmonarius	MPD410	528764	-	OQ624959	-
Pleurotus pulmonarius	MPD411	528765	-	OQ625280	-
Pleurotus pulmonarius	MPD424	528767	-	OQ625253	4714
Polyporus sp.	MPD670	512762	-	-	-
Polyporus sp.	MPD671	512763	-	-	-
Polyporus sp.	MPD672	512764	-	-	-
Polyporus tricholoma	MPD331	499064	-	-	4711
Polyporus tricholoma	MPD348	499068		-	4712
Polyporus tricholoma	MPD700	-	141	-	-
Polyporus tricholoma	MPD703	-	146	-	-
Pseudofistulina radicata	MPD442	528772	-	OQ626163	-
Ripartitella brasiliensis	MPD696	528781	-	OQ916920	-
Trechispora thelephora	MPD197	528737	-	OQ626164	-
Trechispora thelephora	MPD525	-	26	-	-
Trechispora thelephora	MPD529	-	27	-	-
Trechispora thelephora	MPD532	-	29	-	-
Tremella fuciformis	MPD317	528752	-	OQ625283	-
Tremella fuciformis	MPD693	-	119	-	-
Volvariella bombycina	MPD235	-	274	OQ626161	-
Volvariella bombycina	MPD458	528788	-	OQ626165	-

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