frontiers | Frontiers in Forests and Global Change

REVIEW
published: 23 May 2022
doi: 10.3389/ffgc.2022.813998

An Overview on the Taxonomy, Phylogenetics and Ecology of the Psychedelic Genera *Psilocybe*, *Panaeolus*, *Pluteus* and *Gymnopilus*

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Specialty section:
This article was submitted to People and Forests, a section of the journal Frontiers in Forests and Global Change

Received: *12 November 2021*
Accepted: *07 April 2022*
Published: *23 May 2022*

Citation:
Strauss D, Ghosh S, Murray Z and Gryzenhout M (2022) An Overview on the Taxonomy, Phylogenetics and Ecology of the Psychedelic Genera Psilocybe, Panaeolus, Pluteus and Gymnopilus. Front. For. Glob. Change 5:813998. doi: 10.3389/ffgc.2022.813998

Psilocybin and psilocin, two psychoactive components found in "magic mushrooms," have therapeutic potential in a number of mental health disorders without the addictiveness and overdose risks found in other mind-altering drugs, such as cocaine, methamphetamines and alcohol. Psychedelic mushrooms occur naturally, are wide distributed and easily accessible. The need for reviews and comprehensive field guides is urgent due to the recent surge of research into psychedelic mushrooms along with public interest. Psilocybin and psilocin are recorded in mushroom species of *Psilocybe, Panaeolus, Pluteus*, and *Gymnopilus*. This review discusses species identification, taxonomy and classification, available DNA sequence data and psychedelic species in *Psilocybe*, *Panaeolus, Pluteus*, and *Gymnopilus*, as well as similar looking genera that could be harmful.

Keywords: hallucinogenic mushrooms, taxonomy, phylogeny, *Psilocybe*, *Panaeolus*, *Pluteus*, *Gymnopilus*, psychedelic mushrooms

INTRODUCTION

Over 30 million people have used psychedelic substances at least once throughout their life (Krebs and Johansen, 2013). Psychedelic mushrooms, also referred to as hallucinogenic mushrooms (Nichols, 2016), are the most widely used natural hallucinogen in the world due to their wide geographical distribution and easy cultivation (Stafford, 2013). Their existence played a substantial role in defining the psychedelic era of the 1960s and 1970s, and psychedelic cultural customs remain in places where "magic mushrooms" remain legal, such as the Bahamas, Brazil, British Virgin Islands, Jamaica, Nepal, Netherlands, and Samoa (Flaherty et al., 2017; Duneman, 2021).

Many states in the United States of America have started making changes in legislations regarding the use and culturing of psychedelic mushrooms (Hartman, 2018). Popular intellectuals and entertainers advocate the positive uses of psychedelics to millions of people using podcasts and virtual videos (Kohn and Hofmann, 2010; Hartman, 2018; Rogan, 2018, 2019). Growers' guides are available (Oss and Oeric, 1991) and billionaires are also investing heavily into psychedelic research (Marlan, 2019).

Psilocybin, a serotonergic hallucinogen, is the main psychoactive substance found in psychedelic mushrooms, and alters perception and mood, and produces hallucinations in individuals who ingest them (Nichols, 2016). To date, human and animal studies have shown that psilocybin is non-addictive and has short- and long-term benefits in mood disorders, abuse disorders and chronic pain (Amsterdam et al., 2011; Carhart-Harris et al., 2016; Hanks and González-Maeso, 2016; Tyls et al., 2016; Hartman, 2018; Johnson et al., 2018; Dos Santos et al., 2019; Castellanos et al., 2020; Reiff et al., 2020).

Psychedelic drug research will increase globally and so will the research on at least 300 species of psychedelic mushrooms, divided across *Psilocybe*, *Panaeolus*, *Pluteus, Gymnopilus* and other genera also containing psychedelic species such as *Amanita, Copelandia*, *Inocybe*, and *Pholiotina* (Guzmán et al., 1998; Metzner, 2005; Reingardiene et al., 2005; Oxford Analytica, 2021). This review provides an overview of only *Psilocybe*, *Panaeolus*, *Pluteus*, and *Gymnopilus*, their current taxonomy and ecology. Brief molecular data for species in each genus is also provided. For any party involved in research or products of research on these fungi and their metabolites and the public, identifying these often similarly looking, inconspicuous mushrooms are a challenge. The current review of these psychedelic mushrooms would be of great value to researchers, civilian scientists, medical professionals, mushroom hunters as well as the public.

IDENTIFICATION OF PSYCHEDELIC MUSHROOMS

Most professional and citizen mycologists rely on morphology for identification of mushrooms based on characteristics of the cap, stem, gills, spores, spore-bearing structures and habitats of mushrooms (Goldman and Gryzenhout, 2019). Psychedelic mushrooms are often small, indistinct, brown to white mushrooms that, usually but not always, bruise bluish to black when the tissue is cut or damaged (Guzmán, 2008). The blue stains result from an oxidative reaction when psilocybin is exposed to oxygen (Lenz et al., 2020).

Regional field guides and checklists are regularly consulted for more identification characteristics but, few dedicated guides exist to aid in the identification of psychedelic mushrooms (Gartz, 1996; Stamets, 1996). Field guides tend to use generalised descriptions of morphological characteristics which are inefficient to cover the more than 300 species of psychedelic mushrooms currently known (Stamets, 1996). For example, in South Africa, few psychedelics have been described in previous field guides and checklists (Kinge et al., 2020), with better inclusion only achieved recently (Van der Walt et al., 2020; Gryzenhout, 2021).

An additional hurdle making psychedelic mushroom identification difficult is the continuous variation in cap, stem and gill morphology (Guzmán, 2009). Expert scientific publications must frequently be consulted for the use of microscopic features. These resources are not always available or difficult to find for members of the public or others studying these mushrooms, such as law enforcement officers and medical researchers. Although available studies include increasingly more detailed descriptions of species, there is currently no up to date monograph or guide (Høiland, 1978; Guzmán et al., 2004, 2016; Borovička, 2008; Ramírez-Cruz et al., 2013a; Cortés-Pérez et al., 2021).

DNA technologies are allowing researchers to identify fungi at faster rates and higher accuracy than morphological methods (Mullineux and Hausner, 2009; Zhang et al., 2016; Badotti et al., 2017; O'Hanlon, 2018). The combination of morphological and molecular methods of identification have been used to split genera, such as was the case for *Psilocybe* and *Deconica*, and transfer species, previously thought to be psychedelic, to non-psychedelic genera (Moncalvo et al., 2002; Matheny et al., 2006; Norvell et al., 2010; Ramírez-Cruz et al., 2012). Molecular methods have been used to distinguish over 100 species in *Psilocybe*, *Panaeolus*, *Pluteus*, and *Gymnopilus* (Ma et al., 2014; Menolli et al., 2014; Khan et al., 2017; Malysheva et al., 2019).

The most frequently sequenced region of DNA used for these genera is the Internal Transcribed Spacer (ITS) region (approximately 500–800 bp), which forms a part of the ribosomal operon (Schoch et al., 2012; Badotti et al., 2017). The ITS region is used due to its efficacy at identification across fungal lineages, and represents the primary barcoding region (Schoch et al., 2012). The region is sufficiently variable to allow single nucleotide polymorphisms or more to differentiate one species from another. Wesselink (2018) used this region to convey its accuracy identification of psychedelic mushrooms in forensic settings. Other gene regions have also been used, including the translational elongation factor 1α (*TEF1*α), RNA polymerase II (rpb), large subunit ribosomal ribonucleic acid (nLSU) and small subunit ribosomal ribonucleic acid (nSSU) (Tóth et al., 2013; Meyer et al., 2019; Tekpinar and Kalmer, 2019). However, sequences of all the genes are not available for most species.

THE MOST IMPORTANT GENERA CONTAINING PSYCHEDELIC SPECIES

Psilocybe

Psilocybe sensu stricto is most likely the best known genus containing over 150 species distributed worldwide and represented by the type species *Psilocybe semilanceata* (**Figure 1A**; Redhead et al., 2007; Norvell et al., 2010). Mushrooms are described as little brown mushrooms (LBMs) or little white mushrooms (LWMs) (Li et al., 2014; Dalefield, 2017) with a viscid cap when moist, an dark to purplish black coloured spores (Arora, 1986) and a dark purple-brown spore print (Estrada et al., 2020). Other characteristics include a separable gelatinous pellicle, fringed whitish gill edges, and typically collyboid or mycenoid aspects (Stamets, 1996; Ramírez-Cruz et al., 2013b). The caps and stems of some species may bruise a greenish-blue, similar to that of a human bruise, when the mushroom is damaged, aged or drying indicating the presence of psychedelic compounds (Lenz et al., 2020). *Psilocybe* are regularly found in substrates such as soil, dung, wood, and mosses (Stamets, 1996).

Guzmán (1983) and Singer (1986) recognised *Psilocybe* in the Hymenogastraceae, and included non-bluing and non-psychedelic species (Redhead and Guzmán, 1985; Stamets, 1996;

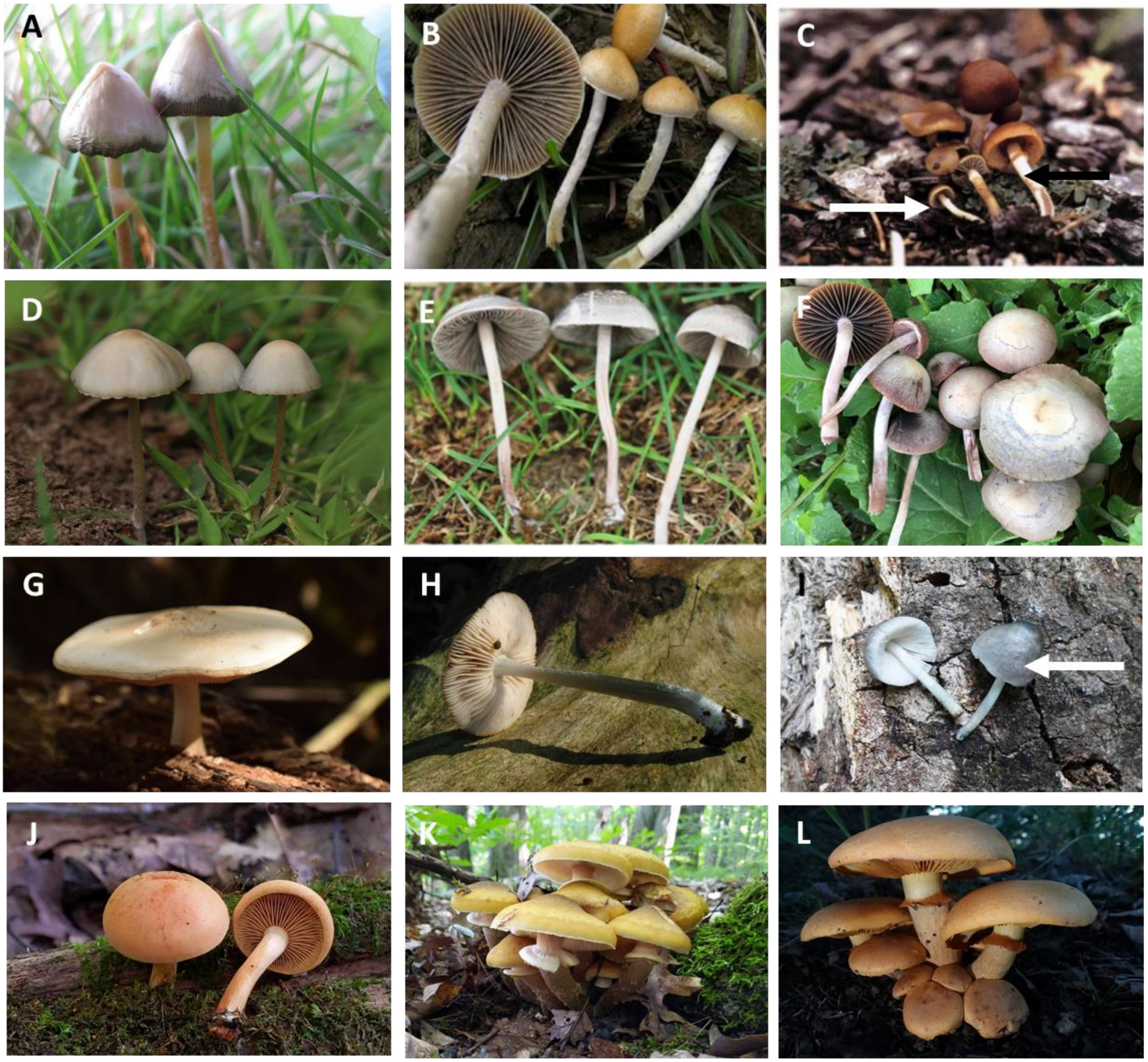

FIGURE 1 | (A) *Psilocybe semilanceata*, **(B)** *Psilocybe chuxiongensis,* **(C)** psychedelic *Psilocybe stuntzii* (white arrow), growing across a deadly poisonous mushroom, *Galerina autumnalis* (black arrow) (Stamets, 1996), **(D)** *Panaeolus cyanescens*, **(E)** the most novel species, *Panaeolus axfordii*, **(F)** unidentified *Psathyrella*, **(G)** *Pluteus cervinus*, **(H)** *Pluteus cyanopus*, and **(I)** *Pluteus salicinus*, showing bluing (white arrow), **(J)** *Gymnopilus liquiritiae*, **(K)** *Armillaria mellea*, morphologically similar to *G. spectabilis* **(L)**. Images obtained from Mushroom Observer (2021).

Guzmán, 2012). Moncalvo et al. (2002) showed the genus to be polyphyletic with psychedelic species grouping the Strophariaceae and non-psychedelic species grouping the Hymenogastraceae (Moncalvo et al., 2002; Matheny et al., 2006). Redhead et al. (2007) proposed to split the genus and conserve the name *Psilocybe* for psychedelic species, represented by the type species *Psilocybe semilanceata* (**Figure 1A**), and transfer the remaining non-psychedelic species to *Deconica,* typified by *Deconica physaloides* (Ramírez-Cruz et al., 2012). The proposal was accepted unanimously by the Nomenclature Committee for Fungi (Norvell et al., 2010). Since then more species have been transferred to *Deconica* and multiple gene regions have supported the positions of the two genera, including nLSU-rRNA, 5.8S rRNA, and rpb1 (Ramírez-Cruz et al., 2013b).

Internal classification of *Psilocybe s. str.* is largely based morphologically (Maruyama et al., 2006; Ramírez-Cruz et al., 2013b; Borovička et al., 2015). Three classifications have been proposed for the division of *Psilocybe* into subgenera (Guzmán, 1978; Singer, 1986; Noordeloos, 2011). *Psilocybe* was divided into 16 subgenera by Guzmán (1978), according to the form and structure of fruiting bodies, form and wall thickness of the spores, and absence or presence of pleuro- and cheilocystidia. Singer

(1986) placed all bluing psychedelic species in *Caerulescentes,* and distinguished six subgenera. Noordeloos (2011) assessed species on the presence of chrysocystidia, bluing and DNA sequences of the ITS, partial nLSU rDNA, and rpb1 genes, and recognised a total of three unnamed sections, that did not support previous subgenera.

Morphological characteristics of *Psilocybe* species often include bluing, indicative of the presence of psilocybin, for example, recently described in *Psilocybe chuxiongensis*, *Psi. cinnamomea*, *Psi. thaiaerugineomaculans*, *Psi. thaicordispora*, *Psi. thaiduplicatocystidiata*, and *Psi. thaizapoteca* (Guzmán et al., 2012; Li et al., 2014; Ma et al., 2014). Psilocybin can be accurately measured in bluing species using physico-chemical methods (Passie et al., 2002). Thirty-three and 55 species of *Psilocybe* have been shown to be positive for psilocybin using physico-chemical methods (Wurst et al., 2002; Andersson et al., 2009). Allen (2012) reported 146 species that either had bluing reactions or confirmed the presence of psilocybin and psilocin using physico-chemical methods.

Phylogenetics of gene sequences have described the newest species of *Psilocybe.* Li et al. (2014) and Ma et al. (2014) described *Psilocybe chuxiongensis* (**Figure 1B**) and *Psilocybe cinnamomea* from China based on the ITS, nrLSU, rpb2, and tef1-α genes. In Thailand, *Psi. thaiduplicatocystidiata* and *Psi. thaiaerugineomaculans* were described using the ITS and nLSU sequences (Ma et al., 2016), similarly to *Psi. angulospora* from Taiwan (Wang and Tzean, 2015). Eighty one species of *Psilocybe* have genome sequence data available, including *Psi. tampanensis*, *Psi. azurescens*, *Psi. galindoi*, *Psi. cubensis*, *Psi.* cf. *subviscida*, and *Psi. cyanescens* (McKernan et al., 2021; NCBI, 2021).

No toxic or lethal *Psilocybe* species are known. However, there are several poisonous species in *Conocybe*, *Galerina*, and *Inocybe* that could be lethal and appear morphologically similar to *Psilocybe* (Stamets, 1996; **Figure 1C**). For example, *Galerina autumnalis* looks similar to *Psilocybe stuntzii* (**Figure 1C**), and results in sharp abdominal pain, violent vomiting, liver and kidney failure leading to possible death in 7 to 10 days if consumed accidentally (Stamets, 1996).

Panaeolus

Panaeolus contains between 15 (He et al., 2019), 20 (Ola'h, 1969) and 29 species (Gerhardt, 1996) species worldwide and is represented by the type species *Panaeolus papilionaceus* (Quélet, 1872; Gerhardt, 1996). They are characterised as LBMs with small, greyish, brown or blackish, conical- or bell-shaped caps, elongated slender stalks, attached gills and a dark brown to purple-brown to black spore print (Rumack and Spoerke, 1994; Gerhardt, 1996; Stamets, 1996; He et al., 2019). The most conspicuous characteristic is the gills that become mottled with shades of grey and black while the spores mature (Rumack and Spoerke, 1994). Microscopic characteristics include spores with an apical germ pore and a cellular pileipellis (Quel, 1872; Quélet, 1872). *Panaeolus* are coprophilic and frequently reported in livestock droppings, including horse, cow, buffalo and elephant dung (Ediriweera et al., 2015; Wang and Tzean, 2015). Non-coprophilic species, such as *Panaeolus bisporus*, grow in grassy areas (Senn-Irlet et al., 1999).

The family relationships of *Panaeolus* remain complex. The genus was formerly recognised by Singer (1949) in the Coprinaceae, but then transferred to the Strophariaceae based on basidiospore pigmentation and the presence of chrysocystidia (Kuihner, 1980) and DNA sequences of the nLSU (Hopple and Vilgalys, 1999). He et al. (2019) and Wijayawardene et al. (2020) placed *Panaeolus* in *incertae sedis*, a taxonomic group reserved for taxons where broader relationships are unknown or undefined. However, recent DNA sequence data placed the genus in Galeropsidaceae (Kalichman et al., 2020).

At least 13 species of *Panaeolus* are bluing and potentially psychedelic including *Panaeolus africanus, Pan. ater, Pan. castaneifolius, Pan. fimicola, Pan. microspores, Pan. moellerianus, Pan. olivaceus*, *Pan. papilionaceus, Pan. retirugis, Pan. rubricaulis, Pan. sphinctrinus, Pan. Subbalteatus*, and *Pan. venezolanus* (Guzmán et al., 1998). Currently, *Pan. cyanescens* is the most well-known psychoactive representative (**Figure 1D**; Badham, 1984) and contains high levels of psilocybin, that are even higher than those found in *Psilocybe* species (Musshoff et al., 2000; Maruyama et al., 2003). *Pan. axfordii* is the most recent novel species that has also been reported to have psychedelic properties (**Figure 1E**; Hu et al., 2020).

The ITS region has been used in descriptions of various species, such as *Panaeolus axfordii*, *Pan. antillarum, Pan. sphinctrinus, Pan. acuminatus*, *Pan. antillarum*, *Pan. campanulatus*, *Pan. retirugis*, *Pan. rickenii*, *Pan. semiovatus*, *Pan. alcis*, *Pan. bisporus*, *Pan. foenisecii*, *Pan. plantaginiformis, Pan. desertorum, Pan. papilionaceus, Pan. cambodginiensis*, *Pan. subbalteatus*, *Pan. campanulatus*, and *Pan. retirugis* (Maruyama et al., 2006; Sette et al., 2010; Razaq et al., 2012; Osmundson et al., 2013; Ma, 2014; Ediriweera et al., 2015; Wang and Tzean, 2015; Boy et al., 2016; Malysheva et al., 2019; Hu et al., 2020). *Pan. subbalteatus* has a sequence available for the elongation factor subunit 1α gene region (Li et al., 2019), and *Pan. acuminatus* for the nLSU region (Moncalvo et al., 2002). *Pan. papilionaceus* and *Pan. cyanescens* have genome sequences available (NCBI, 2021).

Panaeolus is similar in morphology to *Psathyrella*, which is frequently found on wood or lignin-enriched soils and can be distinguished from *Panaeolus* by a brittle white stipe (**Figure 1F**; Kaur et al., 2014). An additional characteristic for identification involve the fading of spore colour in concentrated sulphuric acid. For example, *Psathyrella* present fading spores while *Panaeolus* spores will not be effected (Kaur et al., 2014). *Panaeolina* is morphologically similar but distinguished by having ornamented spores and dark brown gills, in comparison to smooth basidiospores and mottled greyish-black gills in *Panaeolus* (Kaur et al., 2014; Kalichman et al., 2020). There are no recorded fatal species of *Panaeolus*, *Psathyrella* or *Panaeolina*, but *Panaeolus subbalteatus*, and *Panaeolus retirugishas* have been reported as poisonous (Watling, 1977; Chen et al., 2014; Li et al., 2019).

Pluteus

Pluteus is a large genus of at least 500 species and is typified by *Pluteus cervinus* (**Figure 1G**; Kirk et al., 2008; Justo et al., 2011b; Wijayawardene et al., 2020). Species include small, brown- or white-capped mushrooms (1 to 15 cm across) that start conical or convex, flattening out to a typical mushroom shape with many caps having a raised central umbo (Iliffe, 2010). Furthermore, the genus is characterised by free lamellae and the absence of an annulus and volva (Menolli et al., 2010). Microscopic characteristics include smooth and round ellipsoid spores, that produce a pink spore print, and the presence of pleurocystidia and inverse hymenophoral trama (Hosen et al., 2019). Since the transfer of *Chamaeota mammillatus* to *Pluteus* using morphological and DNA sequences, the description of the genus also includes species with a partial veil (Minnis et al., 2006; Minnis, 2008; Menolli et al., 2010). *Pluteus* species are common in tropical habitats and grow almost exclusively on well-decayed wood (Justo et al., 2011b; Desjardin and Perry, 2018).

Pluteus is part of the *Pluteaceae* family (Wijayawardene et al., 2020). Morphologically the genus is divided into the subgenera *Pluteus, Hispidoderma* and *Celluloderma* (Singer, 1958; Shaffer and Singer, 1976). Subgenus *Pluteus* possesses metuloid pleurocystidia, a pilepellis as a cutis; *Hispidoderma* have non-metuloid pleurocystidia and a pileipellis composed of elongated elements organised as a cutis, and an hymeniderm or a trichoderm; and *Celluloderma* have non-metuloid pleurocystidia and a pileipellis composed of short, clavate or spheropedunculate elements organised as an hymeniderm, with transitions to an epithelium (Singer, 1958; Shaffer and Singer, 1976). This division of *Pluteus* was supported with DNA sequences of the nLSU, nSSU and ITS regions (Shaffer and Singer, 1976; Justo et al., 2011a).

Pluteus includes a few species that are psilocybin producing. These include *Pluteus atricapillus*, *Plu. cyanopus*, *Plu. glaucus*, *Plu. nigroviridis*, *Plu. salicinus*, and *Plu. villosus* (**Figures 1H,I**; Saupe, 1981; Guzmán et al., 1998; Allen, 2012). Psychoactive tryptamines have been found in *Plu. atricapillus*, *Plu. glaucus, Plu. nigroviridis*, and *Plu. salicinus* (Gartz, 1987; Wurst et al., 2002; Stríbrný et al., 2003; Andersson et al., 2009).

Many widely distributed species of *Pluteus* have available DNA sequence data (Rodriguez et al., 2008; Justo et al., 2014; Araujo and Sampaio-Maia, 2018; Hosen et al., 2019; Ševčíková et al., 2021). Eight species were sequenced for ITS data including *Plu. brunneocrinitus, Plu. cebolinhae, Plu. crinitus, Plu. halonatus, Plu. hispidulopsis, Plu. karstedtiae, Plu. Necopinatus*, and *Plu. paucicystidiatus* (Menolli et al., 2015) and a further 12 species were sequenced for the ITS and *tef1* gene regions (Justo et al., 2014). Recently, *Plu. squarrous* (Hosen et al., 2019), and *Plu. cervinus* (Ishaq et al., 2021) have been sequenced for the ITS region. *Pluteus hubregtseorum* was described using both the nrITS and EF1- α genes (Ševčíková et al., 2021). One genome has been published of *Pluteus cervinus* (Araujo and Sampaio-Maia, 2018).

No toxic species in *Pluteus* are known (Halling et al., 1987). The genus is known for edible species, including *Pluteus cervinus* (Halling et al., 1987; Ishaq et al., 2021). Confusion with members from the Rhodophyllaceae is possible due to the Pluteaceae family sharing pink spores, attached gills, spores that are angular in outline and a regular to irregular gill trama (Halling et al., 1987).

Gymnopilus

Gymnopilus contains over 200 species world-wide and has a psychedelic type species, namely *Gymnopilus liquiritiae* (**Figure 1J**; Karsten, 1879; Wurst et al., 2002; Kalichman et al., 2020). The genus is characterised by dry, reddish-brown to rusty orange or yellow fruiting bodies that are medium to large and have a well-developed veil (Stamets, 1996). Microscopic characteristics include spores with verrucose to rugulose ornamentation, no germ pore, and dextrinoid walls, and spore prints are a rusty brown (Holec, 2005). *Gymnopilus* typically include lignicolous species that grow on wood as well as grassy areas with decomposing wood (Guzmán-Dávalos et al., 2003).

In traditional classifications, *Gymnopilus* was placed in the Cortinariaceae based on the ornamentation and lack of germinal pores of the basidiospores (Shaffer and Singer, 1976). However, based on the presence of styryl-pyrones, bis-noryangonin and hispidin the genus was transferred to the Strophariaceae (Kuihner, 1980; Rees et al., 2004; Holec, 2005). Based on DNA sequence comparisons *Gymnopilus* is currently characterised under the Hymenogastraceae (Kalichman et al., 2020).

Gymnopilus is subdivided into sections *Annulati*, which has a membranous partial veil, and *Gymnopilus*, which lacks a veil (Guzmán-Dávalos et al., 2003). Phylogenetic analyses based on DNA sequences does not support the subdivision (Guzmán-Dávalos et al., 2003). The ITS regions divided 38 taxa into five well supported clades, called spectabilis-imperialis, nevadensis-penetrans, aeruginosus-luteofolius, lepidotus-subearlei and an unnamed clade formed by *G. underwoodii*, *G. validipes*, and *G. flavidellus* (Guzmán-Dávalos et al., 2003). LSU sequence data confirmed the genus to be monophyletic (Moncalvo et al., 2002).

Novel species of *Gymnopilus* were characterised using the ITS region, which include *G. minisporus, G. turficola*, and *G. dunensis* (Khan et al., 2017; Liu and Bau, 2019; Bashir et al., 2020) and *G. swaticus* using the ITS and LSU regions (Khan et al., 2017). In a study of sequestrate fungi in the Cortinariaceae using the ITS region, three species of *Gymnopilus* (*G. sapineus*, *G. penetrans*, and *G. spectabilis*) were used as an outgroup (Peintner et al., 2001). Thomas et al. (2002) included five species of *Gymnopilus* (*G. aeruginosus*, *G. penetrans*, *G. picreus*, *G. sapineus*, and *G. spectabilis*) in a study describing *Anamika*, a genus of Cortinariaceae, using both the ITS and LSU gene regions. The mitochondrial genome of *G. junonius*, a psychedelic species, has been sequenced (Cho et al., 2021) and the genome of *G. junonus* and *G. dilepsis* is available (NCBI, 2021).

Psilocybin and psilocin are commonly found in *Gymnopilus* species (Andersson et al., 2009). At least 16 species of *Gymnopilus* are considered psychedelic, including *G. cyanopalmicola, G. palmicola, G. igniculus*, *G. validipes*, *G. aeruginosus*, *G. braendlei, G. intermedius, G. lateritius, G. liquiritiae, G. luteoviridis*, *G. luteus*, *G. purpuratus, G. sapineus*, *G. spectabilis, G. subpurpuratus, G. validipes,* and *G. viridans* (Hatfield and Valdes, 1978; Guzmán et al., 1998; Holec et al., 2003; Guzmán-Dávalos and Herrera, 2006). Other tryptamine compounds such as serotonin is also commonly found in *Gymnopilus* species, suggesting that the genus has species with possible undiscovered tryptamines.

Gymnopilus is morphologically similar to *Armillaria*, and frequently found in similar substrates, such as grassy areas and decomposing wood (**Figures 1K,L**; Rees et al., 1999; Spring et al., 2016). *Gymnopilus spectabilis*, a known psychedelic mushroom, looks alike to *Armillaria mellea*, an edible mushroom (Spring et al., 2016) and accidental ingestions of *G. spectabilis* in place of *A. mellea* have been recorded (Roper, 2003). *Galerina* is also morphology similar to *Gymnopilus* and a possible synonymous genus (Landry, 2016; Kalichman et al., 2020). Species of *Armillaria*, *Galerina*, and *Gymnopilus* (such as *Gymnopilus junonius*, and *Gymnopilus spectabilis*) (**Figure 1L**) have been reported as poisonous (Maeta et al., 2008; Konno, 2009; Chen et al., 2014; Lee et al., 2020).

CONCLUSION

As the medicinal value of psychedelic species increases, the importance of accurate species identification of psilocybin containing species runs parallel. Up to date taxonomic monographs are also needed for each of the genera containing psychoactive species. Where mostly ITS sequence data is available, more genes should be added for phylogenetics, and numerous more species remain to be sequenced. With the foundation already laid, future research on these increasingly important fungi should be easily accomplished.

AUTHOR CONTRIBUTIONS

DS researched and wrote the manuscript. SG, ZM, and MG supervised and edited. All authors contributed to the article and approved the submitted version.

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