Psilocybe niveotropicalis: a new species of psilocybin containing mushroom from South Florida

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ABSTRACT

Psilocybe niveotropicalis is described as a new, bluing, wood-rotting species from Florida, USA with a uniquely variable spore morphology including a high proportion of deeply apically cleft spores in hymenial mounts. Morphological features place it in Psilocybe section Stuntzae while multilocus phylogenetic analysis places it in or sister to Psilocybe section Caerulescentes (= Section Cubensae), close to P. ovoideocystidiata, P. wayanadensis, P. thaiaerugineomaculans, and P. thaiduplicatocystidiata. This new species can be distinguished by its lighter pileus coloration, fruiting body stature, distribution, highly variable and novel spore morphology, and DNA sequence (nrITS, nrLSU, rpb1, rpb2, tef1). A full macro- and microscopic description of P. niveotropicalis is provided along with photographs of fresh specimens, phylogenetic analysis, and an HPLC-UV determination of the tryptamine alkaloid composition.

Keywords: Basidiomycota, Agaricales, Hymenogastraceae, tropical mycology, 1 new taxon

INTRODUCTION

The genus Psilocybe contains mushroom forming basidiomycete fungi in the family Hymenogastraceae (Agaricales) most notable for producing the entheogenic tryptamine alkaloid psilocybin and related compounds. Species are distributed world-wide in temperate and especially tropical locations where they subsist as saprotrophs decomposing herbaceous or woody plant debris as well as herbivore dung (Guzmán 1983, 1995). Species have been cultivated and artificially distributed widely due to their psychotropic effects. For a thorough review of the evolution of psilocybin in mushrooms and their anthropocentric uses, see the following: (Bradshaw et al., 2024; Froese et al., 2016).

In April of 2019 a blueing mushroom resembling P. ovoideocystidiata Guzmán & Gaines, but much lighter in color, was observed growing outside of a security gate to a gated neighborhood
in an irrigated mulch bed in Jupiter, Florida by one of the authors (Ostuni) and Andrew Chambers. Over the next 4 years over 20 observations were made in Palm Beach County, Florida. These collections do not satisfactorily match any of the species of Psilocybe that are previously recorded from Florida: *P. cubensis* (Earle) Singer, *P. mammillata* (Murrill) A.H. Sm., *P. tampanensis* Guzmán & S.H. Pollock, and *P. caerulescens* Murrill (this last species has not been verified with a specimen) nor any other known species. This species has been provisionally referred to as “*Psilocybe niveo-tropicalis* nom. prov.” (Ostuni, 2022). In order to clarify the identity and taxonomic placement of this putative new species, molecular and microscopic investigation was performed.

**MATERIALS & METHODS**

**Collection and macromorphological examination.** Macromorphology was described from field-fresh collections using Mushroom Observer Glossary of Mycology Terms (https://mushroomobserver.org/glossary_terms). Colors are reported based on general common usage and not based on a specific color nomenclatural reference. Minimum and maximum measurement outliers are given before (minimum) or after (maximum) the reported range. Specimens were dried partially on the authors (Ostuni) dashboard and then placed in a Hamilton beach food dehydrator at approximately 130 degrees F before depositing in a fungarium. Herbarium abbreviations follow Thiers (continuously updated).

**Micromorphological examination.** For microscopic examination, thin hand sections of the basidiome were rehydrated and mounted in 5% KOH and/or Eosin Y (1:1 with 70% isopropyl alcohol). Characters are described based on Largent (1977). Measurements were made using the free micrograph processing software Piximetre 5.2 (http://ach.log.free.fr/Piximetre/) or ImageJ (Schneider et al., 2012). Spore measurements were made in face view while other characters were measured in profile view. Dimensions are given in the following format: (min outlier) min–mean–max (max outlier), N=sample size. Q (quotient)-value is the length divided by the width.

**PCR and DNA Sequencing.** Dried material of the holotype was sent to ALVALab (Oviedo, Spain) for DNA extraction, PCR, and sequencing. Sequences of the nrITS (nuclear ribosomal Internal Transcribed Spacer) region were generated using ITS1F and ITS4 (Gardes & Bruns, 1993; White et al., 1990) primers but could not be clearly aligned because of the presence of multiple indels recovered so reanalysis with ITS1+2 and ITS3+4 primers (White et al., 1990) to amplify ITS1 and ITS2 regions separately were performed. For the nrLSU (nuclear ribosomal Large Subunit), LR0R and LR5 primers (Vilgalys & Hester, 1990) were used. For rpb2 (RNA polymerase II gene, second largest subunit) the primers 6F2 and 7R2 were used (Denton et al., 1998; Liu et al., 1999). For rpb1 (RNA polymerase II gene, largest subunit), RPB1AF (Stiller & Hall, 1997) and RPB1Cr was initially used but ultimately R1f_int+Int2_1r and r1_intc_rev+RPB1Cr (Matheny et al., 2002; Frøslev et al., 2005) provided better results. The tefl
gene partial sequence was amplified using 983F and 1567R primers (Rehner & Buckley, 2005) which yielded forward and reverse sequences with multiple indels. These indels were manually corrected in Ugene (Okonechnikov et al., 2012) to generate a consensus sequence with minimal degenerate nucleotides where possible. Additional paratype ITS sequences were generated by Mycota Labs, The Ohio Mushroom DNA Lab, and Mike Zwolinski (Sporeworks) following the methods outlined in (Russell, 2023; Canan et al., 2024).

**Phylogenetic Analysis.** All sequences (excluding environmental sources and genomes) belonging to the genus *Psilocybe* were downloaded from GenBank (Sayers et al., 2023) on 12/1/2023 and organized by taxon and specimen voucher. Sequences generated in the study were included to populate the dataset. Each region was aligned using MAFFT v. 7 (Katoh & Standley, 2013) in UGENE (Okonechnikov et al., 2012) and preliminarily analyzed using a maximum likelihood phylogenetic analysis in raxML GUI 2.0 (Edler et al., 2021) using RAxML-NG (Kozlov et al., 2019). Based on these preliminary results, misidentified, misclassified, low quality (high proportion of polymorphic sites or highly gappy), and duplicate (from the same specimen) sequences were excluded from the dataset. For the final analysis, a curated dataset of only sequences that clustered most closely with *Psilocybe* section *Caerulescentes* Singer and select representatives from other clades with multilocus coverage were included in the final dataset (Supplementary File 1). Each region was aligned separately as above, and then concatenated (Supplementary File 2). The best-fit model was selected and assigned to each partition (codon positions and introns analyzed separately) using ModelTest-ng v0.1.7 (Darriba et al., 2020) based on AICc (Supplementary File 3). The concatenated, partitioned dataset was analyzed from 20 random starting trees with transfer bootstrap estimation using the autoMRE option to determine the number of bootstrap samples required. Phylogenies were visualized, annotated, and edited in FigTree (Rambaut 2023).

**HPLC analysis of fruiting bodies for tryptamine alkaloids.** Fruit bodies of *P. niveotropicalis* from mushroomobserver.org/518275 (herein abbreviated “MO”) were collected with care to minimize trauma induced enzymatic degradation of tryptamine alkaloids. Fruit bodies were dehydrated at 43 °C for 24 hours, and stored whole, in darkness at -18 °C, in an Argon purged glass jar packed with color indicating silica gel prior to analysis. Samples retrieved from cold storage were acclimated to ambient temperatures before opening the container. Five fruit bodies were homogenized independently to a fine powder using a mortar and pestle. Approximately 30 mg of each homogenate was weighed into a 2 mL centrifuge tube and extracted following the method described by Dorner et al. (2022). One mL of methanol was added to the tube and sonicated in a sonicator bath for 10 minutes. The contents of the tube were spun down at 16,000 x g for five minutes and the supernatant was collected. A second extraction of the fungal pellet was performed, same as the first. The second extract’s supernatant was combined with the first and a third extraction of the fungal pellet was performed, with the supernatant combined with the first two. The pooled extracts were filtered to 0.2 µm using a PTFE syringe filter before transferring into amber glass autosampler vials. HPLC analysis was performed on each of the five extractions
on an Agilent 1260 equipped with an Agilent 1290 DAD. The separation, determination, and quantitation methods follow those previously described in Miller et. al. 2023.

**TAXONOMY**

*Psilocybe niveotropicalis* Ostuni, Rockefeller, J. Jacobs & Birkebak, sp. nov., MycoBank MB# 852387, Figures 1–3

Etymology: From the Latin *niveo* (adjective) in reference to the consistent light color of the pileus and *tropicalis* (adjective) in reference to its tropical distribution.

Common Name: Over the past four years *P. niveotropicalis* has captured the attention of the amateur community which has resulted in the use of the common name “niveo” or “niveos” in short to refer to this species.

Holotype: USA, Florida, Palm Beach County, Jupiter, 1 Admirals Cove Blvd, 26°54'14.5"N 80°05'38.2"W, elevation 3 m, April 7, 2019, Leg. S. Ostuni, FLAS-F-68078/MO489561.

Isotypes: TENN (accession number pending), MICH (accession number pending)

Paratypes: USA. Florida, Palm Beach County, Jupiter: MO492004 (FLAS-F-71306), MO519478 (FLAS-F-72187), MO491260 (FLAS accession number pending), MO520472 (TENN accession number pending), MO520177 (MICH accession number pending)

Phenology: Has been observed fruiting from January to mid-September excluding summer (mid-June through August).

Habit, Habitat, & Distribution: solitary, gregarious to cespitose-imbricate on dyed mulch beds, in well maintained landscaped neighborhoods typically under the shade of small shrubs. Known only from Palm Beach County, Florida.

**Pileus** (9) 20–40 (58) mm diam., hygrophanous, lubricous to subviscid, glabrous, translucent-striate near the margin, margin decurved, broadly umbonate but can be acutely umbonate when young, becomes split and irregular at maturity, white to light yellow when young, becoming medium brown or grey as the pileus dries out, with a dark blue to black or sometimes golden yellow to orange to brown or white umbo. Flesh bruising blueish. **Lamellae** adnxed, even, close to subdistant, ranging from white to rusty to light brown to dark purple brown. Bruising blue upon handling. Fluoresces raspberry red in 365 nm UV along the gill edges. **Lamellulae** present, 1-3 between each lamellum. **Stipe** (1) 2–7 (9) mm broad, 15–55 (64) mm long, central, smooth, fibrillose-striate, cylindric, equal, somewhat sub-bulbous, base sometimes hypogeous, whitish to sorrel brown, solid or hollow, with white radiating rhizomorphs at the base. Strongly bruising blue when handled. **Annulus** membraneous, white,
thick, persistent or very rarely evanescent, bluing with age. **Context** whitish to sorrel brown, bluing once cut. **Odor** lightly farinaceous. **Spore print** dark purplish-brown in color.

Figure 1. Fruiting bodies of *Psilocybe niveotropicalis*. A) MO489561; Holotype in situ. B) MO520177; in situ. C) MO529090; photographed on black velvet. D) MO518275; with ruler for size reference. E) MO520214; young fruiting bodies. F) MO533789; showing the raspberry red 365 nm UV fluorescence. (Photography: Scott Ostuni)
**Basidiospores** Typical morphology: (7.9) 8.9–9.4–10.2 (11.0) × (6.3) 7.0–7.7–8.4 (9.4) μm, Q = (1.0) 1.1–1.2–1.4 (1.5), N = 100 (measurements from a spore deposit of MO491260), rhomboid to subrhomboid in face view, ellipsoid in side view, thick-walled, wall 0.8-1.2 μm thick, yellowish brown, with a germ pore. Spores with an irregular morphology making up ~10-20% of total spores (Holotype: 31/300, Paratype-MO424812: 56/300 in a hymenial mount), but at a much lower proportion in spore deposits (Holotype: 6/300), 6.4–9.5 × 7.0–9.1 μm, Q = 0.77–1.35, cordate to bifid or apically cleft (either equilaterally or inequilaterally) in face view, thick-walled, with one or two germ pores. **Basidia** 21.6–30.2 × 6.1–10.2 μm (holotype, N=34), 4 or 2-spored, hyaline, thin-walled, cylindric-vesiculose to subclaviform, sterigmata up to 8.22 μm. **Basidioles** 12.2–16.8 × 6.0–9.4 μm, ovate to subcylindrical, hyaline, thin walled, densely packed. **Hymenium** individual elements appearing more-or-less hyaline but distinctly pigmented light brown in masse. **Pleurocystidia** 17.2–33.4 × 7.8–12.6 μm (holotype, N=33), hyaline, thin-walled, subventricose, fusoid-ventricose, occasionally with double apices, with a rounded to obtuse, rarely broadly mucronate, apex sometimes with a subgelatinous, refractive secretion/occlusion at the apex, scattered but more abundant near lamellar edge. **Cheilocystidia** 9.3–26.2 × 5.8–11.4 μm (holotype, N=80), hyaline, thin-walled, subventricose, fusoid-ventricose, sometimes subpyriform or subovate, with a rounded to obtuse, rarely broadly mucronate, apex, sometimes with a subgelatinous, refractive secretion/occlusion, typically in clusters in an extensive sterile band. **Caulocystidia** fusoid-ventricose, thin-walled, hyaline, with a rounded to obtuse apex often with a subgelatinous secretion/occlusion at the apex, limited to the extreme apex of the stipe, scarce. **Subhymenium** a narrow zone of shorter, nearly pseudoparenchymatous, light brown in masse, tightly packed elements. **Hymenophoral trama** composed of parallel/subparallel, hyaline to very faintly pigmented in masse, thin-walled, mostly barrel-shaped cells. **Pileipellis** a cutis to an interwoven and ascending ixocutis, elements repent to ascending in more gelatinized specimens, 3.0–5.5 μm broad, hyphal elements several cells deep transitioning abruptly into the pileal trama. Terminations undifferentiated to subcapitate. Lacking distinct pileocystidia. **Pileus trama** composed of more-or-less cylindrical to barrel shaped, hyaline to faintly lightly brown in masse, thin-walled elements relatively tightly packed into a sub parallel arrangement, narrowing slightly toward the pilepellis and hymenium. **Stipe trama** composed of barrel shaped, thin-walled, hyaline elements in a parallel arrangement. **Stipitipellis** a slightly differentiated cutis of narrower, hyaline, repent hyphal elements that appear light brown in masse. **Clamp connections** present in all tissues.
Figure 2. Microscopic characters at 1000× magnification with 10 µm scale bars. A) Basidiospores, pleurocystidium and basidium. B) Basidiospores. C) Pleurocystidia, basidiospores, and basidia. D) Gill edge. E) Cheilocystidia on gill edge. (F) Caulocystidia. (Microscopy photos: Alan Rockefeller)
Figure 3. Micromorphological characters at 200× (A, scale bar = 50 µm) and 1000× (B-E, scale bar = 10 µm). A) Pileal and lamellar cross section. B) Pileipellis in cross section. C) Pileus trama. D) Lamellar trama. E) Cheilocystidia crush mount. (Microscopy photos: Alan Rockefeller)
Comments: This species differs from all closely related species by virtue of the extremely unique and previously unreported cordate to apically bifid spore morphology present in a relatively high proportion in hymenial mounts. Comparison with descriptions of closely related species reveals consistent differences (Table 1). Macroscopically, it looks strikingly like a faded *Psilocybe ovoideocystidiata* at first glance, especially when young. The much lighter pileus color as it matures as well as the graying coloration upon drying are consistently different from the former species. Microscopically, *P. niveotropicalis* lacks pigmented pseudocystidia, has broader cystidial apices, and produces broader spores. *Psilocybe subaeruginascens* is another similar species but again can be distinguished by the darker pileus color, more ellipsoid spores as well as cystidia with narrower, longer apices. The species is also phylogenetically very close to the following tropical asian species: *P. wayanadensis* K.A. Thomas, Manim. & Guzmán, *P. thaiaerugineomaculans* Guzmán, Karun. & Ram.-Guill., and *P. thaiduplicatocystidiata* Guzmán, Karun. & Ram.-Guill. *Psilocybe niveotropicalis* spores are markedly larger (especially wider) than *P. wayanadensis* in addition to the paler pileus coloration and shorter, broader stipe stature. The species can be told from the latter two species by the cystidial shape and spore dimensions. This species can easily be transplanted using stem butts or colonized wood chips to new beds of fresh wood chips. An unverified observation may be the first documented instance of *P. niveotropicalis* from Delrey Beach, Florida, but unfortunately no specimens were retained (Shroomery, 2016).

Table 1. Comparison of *P. niveotropicalis* to closely related species. Spore dimensions given in face view.

<table>
<thead>
<tr>
<th>Species - Source</th>
<th>Pileus Color</th>
<th>Spores</th>
<th>Chelcocystidia</th>
<th>Pleurocystidia</th>
<th>Pseudocystidia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Length (μm)</td>
<td>Width (μm)</td>
<td>Shape</td>
<td>Apex</td>
</tr>
<tr>
<td><em>P. niveotropicalis</em> (Ostuni et al., 2020)</td>
<td>dark reddish brown to pale yellowish brown to white</td>
<td>8.9-9.8</td>
<td>6.0-6.3</td>
<td>rhomboid to subrhomboid, sometimes catenate to apically cleft</td>
<td>subventricose, fusoid-ventricose, sometimes subcylindrical or subovate</td>
</tr>
<tr>
<td><em>P. ovoideocystidiata</em> (Guzmán et al., 2003)</td>
<td>enigmatic brown to yellowish brown, dry, sometimes white</td>
<td>6.8-7.6</td>
<td>4.5-5.0</td>
<td>rhomboid to subrhomboid</td>
<td>ventricose-rostrate</td>
</tr>
<tr>
<td><em>P. thaiaerugineomaculans</em> (Guzmán &amp; thaiduplicatocystidiata) (Guzmán, Karun. &amp; Ram.-Guill., 2012)</td>
<td>enigmatic brown, olive brown, grayish green or brownish, dry, subglabrous, dull yellow-orange, brownish yellow or sterile color</td>
<td>8.7-9.8</td>
<td>6.1-6.9</td>
<td>rhomboid to subrhomboid</td>
<td>ventricose-ovariiform to subovariiform</td>
</tr>
<tr>
<td><em>P. wayanadensis</em> (Ostuni et al., 2020)</td>
<td>pale brown to brownish gray to brownish gray or brownish orange, dry, greyish brown with brownish gray to olive brownish gray, sometimes greyish yellow to greyish orange to brownish orange or light brown, pale yellow or greyish yellow</td>
<td>6.3-6.7</td>
<td>4.3-4.7</td>
<td>subrhomboid</td>
<td>subventricose, fusoid-ovariiform</td>
</tr>
<tr>
<td><em>Psilocybe niveotropicalis</em> (Shroomery, 2016)</td>
<td>dark reddish brown to pale yellowish brown to white</td>
<td>9.1-10.0</td>
<td>6.4-6.7</td>
<td>subrhomboid or subcylindrical</td>
<td>fusiform, ventricose, regular or irregularly</td>
</tr>
</tbody>
</table>

**RESULTS**

*Phylogenetic analysis.* Maximum likelihood reconstruction yielded a phylogeny with similar clades and interclade relationships as previous investigators (Ramírez-Cruz et al., 2012; Figure 4). *Psilocybe niveotropicalis* is very close to *P. thaiaerugineomaculans*, *P. thaiduplicatocystidiata*, and *P. wayanadensis* together in a clade sister to *P. ovoideocystidiata*. 

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These species make up a clade sister to Section “Cubensae” of Ramírez-Cruz et al. (2012). Section Cubensae Guzmán (1983), typified by P. cubensis, is a nomen superfluum (nomenclaturally illegitimate superfluous name; ICN art. 52.2(e); Turland et al., 2018) because of Singer’s earlier homotypic section Caerulescentes. Guzmán acknowledged this nomenclatural issue, but instead of accepting the section with priority, he states “P. subcubensis Guzmán is considered the type of the Sect. Cubensis”, which is neither nomenclaturally permissible nor is it clearly a nomenclatural act (Guzmán, 1983, p. 121). According to the rules of nomenclature, the earlier valid and legitimate name (Psilocybe section Caerulescentes) must be used for the section that includes Psilocybe cubensis. P. subaeruginascens Höhn. and P. septentrionalis (Guzmán) Guzmán are likely in this clade based on morphology, but molecular data from authoritative collections is not available at this time. Species in this clade appear to have very few nucleotide differences from other closely related species despite demonstrating consistent morphological differentiation used by previous experts to distinguish species. This is similar to what has been demonstrated for species in section Cyanescens Guzmán and stirps Serbica (Borovička et al., 2012; Borovička, 2008; respectively) suggesting that diversification may be occurring rapidly as a result of long distance dispersal, local ecological specialization, or hybridization events. Such rapid diversification can be difficult to detect using standard molecular markers due to time-dependent molecular evolutionary processes (e.g., lineage sorting, genetic drift).
Figure 4. Maximum likelihood phylogenetic reconstruction based on multilocus dataset (ITS, LSU, rpb1, rpb2 and tef1) of select species of *Psilocybe* particularly of species in section *Caerulescentes*. Transfer bootstrap values greater than 70 are given at the branch nodes. *Psilocybe niveotropicalis* is highlighted in teal.
**HPLC-UV analysis.** The HPLC method resolved tryptamine analytes from *Psilocybe niveotropicalis* (Figure 5, Table 2). Of the seven compounds screened, psilocybin was found in the highest concentrations, with an average concentration of 9.31 mg/g while psilocin, the dephosphorylated psilocybin analog, was present with an average concentration of 3.23 mg/g. Baeocystin, the desmethylamino analog of psilocybin, and the biosynthetic derivatives norpsilocin, norbaeocystin, aeruginascin, and 4-HO-tryptamine were detected at concentrations less than 1 mg/g. Partial co-elution was observed with psilocybin and norpsilocin, as well as with norbaeocystin and an unknown compound.

![HPLC-UV signature showing tryptamine peaks at two y-axis scales to show presence of lower concentration compounds detected.](image)

**Figure 5.** HPLC-UV signature showing tryptamine peaks at two y-axis scales to show presence of lower concentration compounds detected.

**Table 2.** Mean, minimum, and maximum concentration (in milligrams/gram by dry weight) of analyzed tryptamines and combined psilocybin associated tryptamines recovered from dried fruiting bodies of a collection made on April 14, 2023 (MO 518275, Ostuni & J. Mattucci).

<table>
<thead>
<tr>
<th>Analyte</th>
<th>mean</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psilocybin</td>
<td>9.31</td>
<td>5.30</td>
<td>14.14</td>
</tr>
<tr>
<td>Psilocin</td>
<td>3.23</td>
<td>0.70</td>
<td>5.28</td>
</tr>
<tr>
<td>Baeocystin</td>
<td>0.57</td>
<td>0.05</td>
<td>1.07</td>
</tr>
<tr>
<td>Norpsilocin</td>
<td>0.36</td>
<td>&lt;0.040</td>
<td>0.69</td>
</tr>
<tr>
<td>Norbaeocystin</td>
<td>0.19</td>
<td>&lt;0.022</td>
<td>0.42</td>
</tr>
<tr>
<td>4-HO-tryptamine</td>
<td>0.02</td>
<td>&lt;0.034</td>
<td>0.07</td>
</tr>
<tr>
<td>Aeruginascin</td>
<td>0.06</td>
<td>&lt;0.021</td>
<td>0.12</td>
</tr>
<tr>
<td>Combined</td>
<td>13.74</td>
<td>8.27</td>
<td>20.76</td>
</tr>
</tbody>
</table>
DISCUSSION

Even though fungi are well known to be poorly documented from a biodiversity standpoint, the discovery of a new species of entheogenic mushroom forming fungi is surprising given the attention given to the genus *Psilocybe*. The negative stigmatization of these fungi as federally illegal drugs may have disincentivized research into the genus. With a changing societal climate toward psychoactive tryptamine alkaloids (limited legalization, medical investigation) and the increase in citizen science participation in mycological research, it is likely that more species remain to be discovered, even in the traditionally more well studied areas like temperate North America.

The aberrant, apically cleft spore morphology is striking and has not been previously reported in the genus to our knowledge. It is currently unknown if these spores are able to germinate though it does appear that the irregular shape may prevent or decrease the likelihood of forcible spore discharge given the starkly lower proportion observed in spore deposits compared to hymenial mounts.

ACKNOWLEDGEMENTS

Pablo Alvarado of ALVALab for multi gene region sequencing of the holotype collection (FLAS-F-68078), Alexander Bradshaw, The Dentinger Lab, and The Natural History museum of Utah for providing data, the Institute of Ecology (Instituto de Ecología, UNAM) and the Guzman collection for providing the specimen of *Psilocybe wayanadensis* to Alexander Bradshaw for sequencing. Paul Stamets for additional comments on the macro morphological description. Stephen Russell (Mycota Labs), Kyle Canan (Ohio Mushroom DNA Lab) and Mike Zwolinski (Sporeworks) for DNA barcoding additional collections. Zach Guerin for helping with uploading protein coding sequences to GenBank. Dr. Matthew Smith and Benjamin Lemmond at University of Florida for allowing us to accession collections in the herbarium. Andrew Chambers, Julian Mattucci (Imperial Labs), Michael Getman, Ricky Ferris, and Anand for providing additional collections for study.

SUPPLEMENTARY FILES

Supplementary File 1 - Sequences Used

Supplementary File 2 - Alignment
https://drive.google.com/file/d/1vJNQOZF41e52YRkH6Ob6bgIAUDthWigB/view?usp=drive_link
Supplementary File 3 - Partition and Nucleotide Substitution Models
https://drive.google.com/file/d/1OJl077hZmCO0MHlEhvOM2JIi85qljUJ-/view?usp=drive_link

LITERATURE CITED


