The Japanese Hallucinogenic Mushrooms *Psilocybe* and a New Synonym of *P. subcaerulipes* with Three Asiatic Species Belong to Section *Zapotecorum* (Higher Basidiomycetes)

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**ABSTRACT:** The subtropical Japanese bluing mushroom *Psilocybe subcaerulipes*, described by Hongo, has several synonyms: *P. argentipes* by Yokoyama (also from Japan), *P. taiwanensis* by Guzmán and Yang (from Taiwan), and *P. thaizapoteca* by Guzmán, Ramírez-Guillén, and Karunaratna (from Thailand). The study of the holotypes and others specimens of these mushrooms shows that they have basidiospores, pleurocystidia, cheilocystidia, and several other important taxonomic features in common, as well as habitat. Recent discussions of all Japanese hallucinogenic species of *Psilocybe* and their neurotropic effects are also considered.

**KEY WORDS:** medicinal and hallucinogenic mushrooms, neurotropic fungi, Japan, Taiwan, Thailand

**I. INTRODUCTION**

The genus *Psilocybe* s.str. (Strophariaceae, higher Basidiomycetes) has been reconsidered, and a new edition of the monograph *The Genus Psilocybe*¹ and its Suppement,² including the section on *Zapotecorum*, which will soon be published. The *Zapotecorum* differ from other mushrooms of the genus in their thin-walled subellipsoid basidiospores. The present paper discusses the new synonyms of *P. subcaerulipes*, with three Asiatic species. In addition, a summary of the neurotropic species of *Psilocybe* in Japan is presented. In this review, we are following the new concept of *Psilocybe* according to Redhead et al.,³ which was accepted by the International Nomenclature Committee.⁴ Accordingly, all of the species that now form the genus *Psilocybe* s.str. are bluing and hallucinogenic (known also as neurotropic). The non-bluing, non-hallucinogenic species now belong to the genus *Deconica* (W.G. Sm.) P. Karst.

**II. MATERIALS AND METHODS**

In the study, we reviewed the holotypes, isotypes, paratypes of authentic specimens of *Psilocybe*. The reviewed specimens are deposited in the National Museum of Nature and Science (TNS), Kunming Academy of Sciences Herbarium (HKAS), Mae Fah Laung University (MFLU), and Instituto de Ecología, A.C. (XAL). Microscopic observations of hand-cut sections of the basidiome were made and mounted in 5% solution of KOH, with or without 1% Congo red solution on the slide. The material had previously been treated with 75% alcohol for rehydration. Around 25–40 measurements of the microscopic features were recorded to know the range of the size variation of each feature. The basidiospore measurements are given as extreme values in parenthesis on the right or left of the size. The descriptions of the species contain full details of the following microscopic features: basidiospores, basidia, pleurocystidia, cheilocystidia, subhymenium, hymenophoral trama, pileipellis, subpellis, pileus trama, pileocystidia, and caulocystidia.
FIGS. 23–25: *Psilocybe subcaerulipes*, 23: holotype, from Imazaki et al.\textsuperscript{14}, 24: *P.argentipes* from Imazequi et al.\textsuperscript{23}, 25: *P. argentipes* from Yokoyama.\textsuperscript{25}
III. RESULTS

*Psilocybe subcaerulipes* was described by Hongo in Japan in 1958, but it is known also by the following synonyms: *P. argentipes* by Yokoyama (also from Japan), *P. taiwanensis* by Guzmán and Yang (from Taiwan), and *P. thaizapoteca* by Guzmán et al. (from Thailand). These synonyms represent the same species based on the fact that these fungi have the same taxonomic features mac-
ro- and microscopically, such as basidiospores, pleurocystidia, and cheilocystidia, with some minor variations of no taxonomic value. Originally, the high variation of *P. subcaerulipes* was not considered by Hongo when he described this species. He did not observe pleurocystidia in *P. subcaerulipes* nor did Yokoyama with the description of *P. argentipes*. However, new studies of the holotypes of both species now show that pleurocystidia may be present, although they are uncommon. Yokoyama first recognized *P. subcaerulipes*, but later he described it with a new name, *P. argentipes*, in other collections based on minor differences among the sizes of the basidiospores: 6‒6.5 × 3.5‒4 µm in *P. subcaerulipes*, against (5‒) 6‒7.5 (‒8.5) × 4‒5 (‒5.5) µm in *P. argentipes*. Guzmán first followed this criterion of Yokoyama and recognized both species separately. However, when we recently reviewed materials from Taiwan and Thailand, we found that those materials presented conspicuous pleurocystidia and the veil well development that form an ephemeral annulus. We also observed that the form of the pileus described as subumbonate in the descriptions of Hongo and Yokoyama presented great variations. From conic to campanulate or umbonate or convex and short papillate, the pilei were also lobulated and undulating at the margin, reaching 30‒60 mm in diameter in Hongo’s description, and 50‒60 mm Yokoyama’s description.

A. Description


Pileus (10‒) 20‒50 (‒60) mm diam., conical to campanulate, subumbonate or short papillate to convex, sometimes irregularly lobulated, surface smooth, glabrous, lubricous or subviscid to dry, brown, brownish-ochraceous, brownish-red or brownish-chocolate, hygrophanous, changing to pale yellowish or orangish-brown to pale brownish, staining green-blue to blackish with age or when brushed, sometimes margin with white floccose remnant from veil. LAMELLÆ subadnexed or adnexed, shortly sinuate, grey-brown to dark violaceous-brown, edges paler or whitish. STIPE (40‒) 50‒90 (‒120) × (2‒) 4‒6 (‒8) mm, uniform, but little narrows toward the base, flexuous, whitish to pale brownish or pale orangish-brown or violaceous-purple, staining irregularly green-blue to blackish as the pileus. All of the basidiome remains almost black or blackish-chocolate or only with the stipe blackish-red in old specimens. PSEUDORHIZA as a long irregular, pyriform, thick prolongation of the stipe, although sometimes this is difficult to observe in the herbarium specimens. VEIL white, fibrillar or submembranaceous to arachnoid, that form an annulus, fragile, submembranaceous or floccose and ephemeral. CONTEXT whitish to yellowish-brown to pale yellowish or light gray. ODOR and TASTE farinaceous, taste also somewhat bitter. BLUING common in pileus, stipe and context, finally blackish. SPORE PRINT dark brown purpureous.

Basidiospores (5‒) (5.5‒) 6‒7 (‒7.5) (‒8) × (3‒) (3.5‒) 4‒4.5 (‒5) (‒5) × 3.5‒4 µm, narrowly subellipsoid, oblong-ellipsoid or with slightly angles in face-view, subellipsoid or little compressed in side-view, thin-walled, wall 0.5‒0.8 µm thickness, pallid brownish or pale yellowish-brown, with a broad truncate and plane germ pore at the apex and a short acute apiculus at the apex. Basidia (15‒) 16‒25 × (4.5‒) 5‒6 (‒6.5) µm, 4-spored, subventricose-clavate, sometimes with a middle constriction, hyaline. Pleurocystidia (11‒) 15‒20 (‒24) (‒30) (‒32) × (3‒) 4‒6 (‒7) (‒10.5) µm, polymorphous, ventricose-capitate or broadly globose, subclavate, subfuscoid to sublageniform, sometimes subcylindric or ventricose, with a short neck or with two or three necks, simple or irregularly branching, diverticulated or irregularly lobulated, with two or more lobules, hyaline, rare or common (its presence seems to depend on the place in the lamellæ or the maturity of the basidiome). Cheilocystidia (11‒) 14‒22 (‒30) (‒40) × (3‒) (4‒) 5–7
(–10) µm, like the pleurocystidia and their variation. **Subhymenium** ramose-inflated, hyaline or encrusted. **Hymenophoral trama** regular, hyphae 1.5–21 (–39) µm diam, thin- or thick-walled, up to 1 µm thickness, yellowish to yellowish-brown in mass. **Pileipellis** a layer up to 10 µm thick, subgelatinous, with hyaline to bluing hyphae, (2–) 3–5 (–8) µm diam, thin-walled. **Subpellis** little differentiated, distinguished by strongly pigmented hyphae. **Pileus trama** radial, hyphae (2–) 3–29 (–30) µm diam., thin-walled, hyaline or yellowish, but yellowish-brown in mass, some encrusted. **Pileocystidia** (8–) 10–30 (–40) × (4–) 5–7 (–10) µm, rare or common, very irregular in form, from globose, subglobose, ventricose or capitate, irregular lobulated, or little differentiated at the end of some raised hyphae on the pileus surface. **Caulocystidia** (13–) 15–38 (–46) × 4–8 (–9.5) µm, polymorphous, ventricose, clavate, apex obtuse, sublageniform, or fusoid, hyaline, frequently fasciculated, in the upper part of the stipe, uncommon. **Clamp connection** present.

**B. Habitat and Distribution**

Gregarious or caespitose, on litter, clay, or sandy soil, frequently in muddy or eroded soils, naked or covered by mosses or grasses, in subtropical raining mountainous forests, with *Cryptomeria*, *Taiwania*, *Pinus* and other trees. Known only from Japan, China (Taiwan), and Thailand.


**IV. DISCUSSION**

*Psilocybe subcaerulipes* belongs to the section **Zapotecorum**¹ due to its subellipsoid thin-walled basidiospores. *P. subcaerulipes* from *P. zapotecorum* R. Heim emend. Guzmán in the absence of brownish or grayish pseudocystidia, common in that species, that is spread between Mexico and Argentina. It is close to the Mexican species *P. mulliercula* Singer et A.H. Sm.,¹⁰ which differs only by the bigger basidiospores, (6–) 7–9 (‒10) × (3.5–) 4–5 (–6) × 3.5–4.5 (‒5) µm, as well as in the poor veil development and distribution. *Psilocybe mulliercula* is only known from Mexico and Colombia, in temperate coniferous (*Pinus* and *Abies*) forests, although sometimes it occurs in the ecological boundary with subtropical humid forests. Recently, Ramírez-Cruz, Guzmán and Guzmán-Dávalos¹¹ discussed *P. taiwanensis* as a close species of *P. thaizapoteca* from Thailand and confirmed that they belong to the section *Zapotecorum*. The only differences among them are the persistent annulus in *P. taiwanensis* and the strongly branched cheilocystidia in the latter, which we consider variations of the species.

It is interesting to observe that both *P. mulliercula* and *P. zapotecorum* are important sacred mushrooms in Mexico¹ for their hallucinogenic properties. *Psilocybe subcaerulipes* is a hallucinogenic mushroom, and its peer can be found with traditional uses long ago in Japan, China, and Thailand among some religious or shamanic applications. Recently, Guzmán received a letter from Gary Price, who has lived in China for many years, saying that in the southwest of that country, the ethnic group Yi has an indigenous culture on hallucinogenic mushrooms that they named “ma-yu”
Another hallucinogenic *Psilocybe* in Japan, in addition to *P. subcaerulipes*, is *Stropharia caeruleascens* Imai,\(^1\) which that author changed later to *S. venenata* Imai due to nomenclature problems.\(^1\) However, Singer and Smith in 1958\(^10\) considered Imai’s mushroom as a synonym of the *Psilocybe subaeruginascens* Höhnen species originally described from Java. Later, Guzmán,\(^1\) in the description of *P. subaeruginascens*, considered *P. aeruginomaculans* (Höhn) Singer et A.H. Sm. as synonym, but he did not accept Imai’s *Stropharia venenata* as a synonym because he followed Imazeki and Hongo,\(^1\) who considered Imai’s fungus as *Psilocybe venenata* (Imai) Imaz. et Hongo. Also, Guzmán divided *P. subaeruginascens* into var. *subaeruginascens* and *P. subaeruginascens* var. *septentrionalis* Guzmán: the former from Japan and Java and the latter only from Japan. Guzmán\(^3\) considered this latter Japanese species as *P. septentrionalis* (Guzmán) Guzmán. On the other hand, *P. fasciata* Hongo from Japan,\(^22\) was considered by Guzmán\(^1\) as conspecific with *P. venenata*. Moreover, in 1988, Imazakiet al.\(^23\) described *P. argentiopes*, *P. fasciata*, and *P. subaeruginascens* in a color plate as common species in Japan.

In summary, we considered *P. subcaerulipes* from Japan with its three new synonyms, *P. subaeruginascens*, *P. septentrionalis*, and *P. venenata*, although it is necessary to perform a new review of all the holotypes of these taxa to resolve the disagreements between Singer and Smith\(^10\) and Guzmán.\(^1\)

Regarding the hallucinogenic properties of these Japanese species, Imai in 1932,\(^12\) as observed Singer and Smith,\(^10\) described intoxication with *Stropharia venenata*. Imai\(^12\) discussed the case of three persons who ate cooked that mushroom in 1929; the effects were feverish with the impression of drunkenness, limbs almost paralyzed, delirium, pupils dilated to a medium size, and hallucinations. After some time, these people recovered to normal. On the other hand, Yokoyama\(^9\) with *P. subcaerulipes* performed an experiment in 1973 with three students and himself. Each person ate 5 or 6 basidiomata fresh and then ate them cooked. Thirty minutes after eating the mushrooms, three of the four subjects (one felt nothing) felt paralyzed in their limbs, sweated profusely, then reported color hallucinations. Some of them vomited. The effects lasted around 5 hours. Three of these people recovered well, but one needed to go to a hospital during the experiment for nervous problems. Also, another person in this group drank wine, but Yokoyama did not comment on this. The mushrooms they ate were the specimen Yokoyama 1323, which is part of the holotype of *P. argentiopes*.\(^6\)

The symptoms produced by the hallucinogenic species of *Psilocybe* in Japan are the same as those of the Mexican hallucinogenic psilocybes, described Guzmán in 1999\(^1\) and Singer in 1978.\(^16\) Interestingly, Imai’s\(^1\) observations in 1929 of the effects produced by the hallucinogenic psilocybes were the first report from Japan. Reports from Cooke in 1902–1906\(^17\) and Sowerby in 1883,\(^18\) both from England (the latter in 1799) precede this report, however. Notably, these English and Japanese cases preceded the studies by and experiences of Wasson and others in Mexico between 1956 and 1957.\(^1\)\(^15\) Recently, Yokoyama\(^20\) reviewed the 10 *Psilocybe* species of reported from Japan. However, confusion remained in the identification of hallucinogenic psilocybes. Yokoyama\(^20\) and Stamets\(^24\) also considered the non-bluing mushrooms as hallucinogenic: *P. coprophila* (Bull.: Fr.) P. Kumm., *P. lonchophorus* (Berk et Broome) E. Horak, *P. merdaria* (Fr.) Ricken, and *P. montana* (Pers.: Fr.) P. Kumm. They were considered to belong to *Deconica*, following Redhead et al.\(^3\) Yokoyama\(^20\) and Stamets\(^24\) considered the following mushrooms to be hallucinogenic species: *P. argentiopes*, *P. fasciata*, *P. subaeruginascens*, and *P. venenata*, as well as *P. cubensis* (Earle) Singer, a pantropical species, and others. The trade and use of hallucinogenic psilocybes in Japan was recently discussed by Matsushima et al.\(^21\) despite the fact that these mushrooms are forbidden by legislation. In addition, Mushi et al.\(^26\) Osaku and Fukiharu,\(^27\) and Nagasawa et al.,\(^28\) have discussed the importance of *P. argentiopes* in Japan.
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