

NEW TAXONOMICAL AND ETHNOMYCOLOGICAL OBSERVATIONS  
ON *PSILOCYBE* S.S. (FUNGI, BASIDIOMYCOTA, AGARICOMYCETIDAE,  
AGARICALES, STROPHARIACEAE) FROM MEXICO, AFRICA AND  
SPAIN

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ABSTRACT

A new emendation of *Psilocybe zapotecorum* is presented, based on a new study on the holotype and on the description of pseudocystidia, pleurocystidia and cheilocystidia, confusingly described previously. An extensive and careful review of all holotypes of synonyms, and the wide neotropical distribution is also presented. The traditions as sacred mushroom are analyzed based on a study of codices and anthropological pieces, where *P. zapotecorum* and related species as *P. muliercula* and *P. moseri* are identified. Some of the codices and anthropological pieces showed that the cult of Quetzalcóatl was related to the use of these mushrooms. The application and meaning of the words “teonanácatl” from Sahagún and “teotlaquilnanácatl” by Guzmán are reviewed. Moreover, the relationship of *P. mairei* to the prehistoric mushroom depictions at Tassili in the Sahara Desert is discussed, and the first study of authentic material of this species from Algeria is presented, from where a neotype is selected. Finally, the relationship between a prehistoric mural in Spain and *P. hispanica* is also discussed.

Key words: prehistoric murals, *Psilocybe hispanica*, *Psilocybe mairei*, *Psilocybe moseri*, *Psilocybe muliercula*, *Psilocybe zapotecorum*, Quetzalcóatl, teotlacuilnanácatl.

RESUMEN

Se presenta una nueva emendación de *Psilocybe zapotecorum*, basada en un re-estudio del holotipo y en la descripción de los pseudocistidios, pleurocistidios y queilocistidios,

antes confusamente descritos. Se discute la numerosa sinonimia de este hongo, con base en el estudio de los holotipos y su amplia distribución en el neotrópico. Se analizan sus usos tradicionales como hongos sagrados y se hace una revisión de códigos y piezas antropológicas, en donde se identifica a este hongo o sus especies afines: *P. muliercula* y *P. moseri*. Se establece una relación entre el culto de Quetzalcóatl y el uso de estos tales hongos. Se analizan las palabras “teonanácatl” de Sahagún y “teotlaquilnanácatl” de Guzmán. Se discuten las relaciones de *P. mairei* con los murales prehistóricos de Tassili en el Desierto del Sahara. Se presenta el primer estudio de materiales auténticos de *P. mairei* de Argelia, de donde se designa un neotipo. Finalmente se tratan las relaciones entre un mural prehistórico en España y *P. hispanica*.

Palabras clave: murales prehistóricos, *Psilocybe hispanica*, *Psilocybe mairei*, *Psilocybe moseri*, *Psilocybe muliercula*, *Psilocybe zapotecorum*, Quetzalcóatl, “teotlacuilnanácatl”.

## INTRODUCTION

Despite the fact that the genus *Psilocybe* (Fr.) P. Kumm. has been known since the 18th century (Guzmán, 1983), it was only at the end of the 1950's that an interest in knowing its species began, this in relation to the discovery of the hallucinogenic species in Mexico. Many important studies have been published, e.g. Heim and Wasson (1958), Singer and Smith (1958), Heim et al. (1966), Guzmán (1978a,b, 1983, 1995, 2000, 2009), Wasson (1980), Redhead et al. (2007), and Noordeloos (2011), among others. However, despite extensive research on this genus, it is surprising that several taxonomic problems still remain, and the resolution of some of these is waiting, as well as the presentation of new ethnomycological data. This is the basis of the present article. In this way, a new concept of *Psilocybe zapotecorum* is provided, as well as its numerous synonyms, with a wide neotropical distribution, and its interesting relationships with Quetzalcóatl cult in ancient traditions of Mexico. Also discussions on the identification of the mushrooms depicted in two prehistoric murals in Africa and in Spain are considered.

## MATERIAL AND METHODS

This paper is based on an intensive bibliographic review, related to the descriptions of *Psilocybe zapotecorum* under several names, by Heim, Singer and

Smith, and Guzmán, among others, as well as on the ethnomycological information on this complex. Microscopic studies of several herbarium specimens, including the holotypes of *P. zapotecorum* and related species were made. These microscopic observations were made with hand sections of the basidiome and mounted in 5% solution of KOH, with or without 1% Congo red solution on the slide, previously treated with 96% alcohol for rehydration. In this way more than 300 *exsiccata* were checked from several herbaria, including the holotypes. The name neurotropic is used for these mushrooms, instead of the common name hallucinogenic, because it is more appropriate, as it was previously discussed by the author (Guzmán, 2009).

## RESULTS

New concept of *Psilocybe zapotecorum*, its synonyms, distribution and traditions in Mesoamerica and South America (Figs. 1, 4, 9-10, 14-24, 32)

Following the new status of the genus *Psilocybe* (Fr.) P. Kumm. proposed by Redhead et al. (2007), and accepted by the International Nomenclature Committee for Fungi (Norvell, 2007), *Psilocybe* s.l. is now divided in two genera: *Psilocybe* s.s. and *Deconica* (W.G. Sm.) P. Karst. In this way, all the bluing and then neurotropic species are included in *Psilocybe* s.s., whereas the non-bluing non-neurotropic are accommodated in *Deconica*. Concerning *Psilocybe zapotecorum* R. Heim (Figs. 1, 9), this species needs revision, because it presents great variation in its macroscopic features in the color and form of the basidiome, as well as in the microscopic characters.

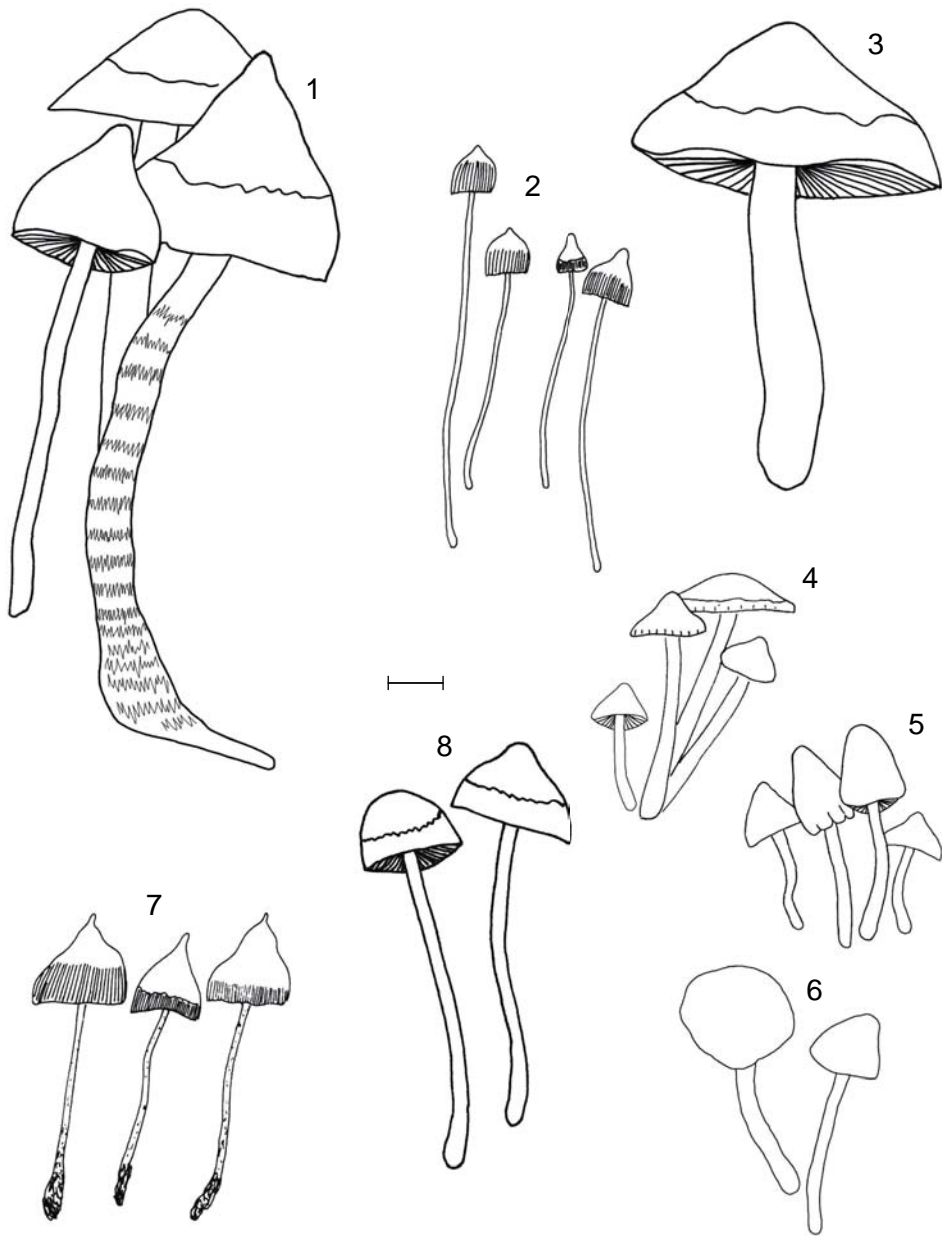
After the first descriptions of *P. zapotecorum* from the Zapotec region in Oaxaca (Mexico) by Heim (1956, 1957a), Heim and Wasson (1958), and Heim et al. (1966), as well as the publication of a color plate by Heim in Wasson (1957) and the Latin diagnosis in Heim (1957b), the identity of this mushroom was confused and several names were applied by some authors, as discussed below. First, Singer (1958) mistakenly redescribed this species based on specimens that Guzmán sent him at LIL as *P. zapotecorum* aff., gathered in 1958 from the type locality reported by Heim (1956). Guzmán's material is Guzmán 1501-A at ENCB and LIL. The habitat of this collection, as that reported by Heim (e.g. Heim, 1956; Heim and Wasson, 1958), and discussed further by Guzmán (1978a) is swampy and muddy soils. Also, those mushrooms from the type locality were identified by local Zapotec people as "corona de Cristo" (Christ crown), one of the common names of *P. zapotecorum* (Guzmán, 1997). Singer (1958) reported Guzmán's fungus as a topo-

type of *P. zapotecorum*. However, Guzmán's collection is in fact *P. hoogshagenii* R. Heim (Fig. 7), a neurotropic and sacred mushroom described by Heim (Heim and Wasson, 1958) from Coatlán, in the Mixe zone, of Oaxaca, as stated Guzmán (1978a). *Psilocybe zapotecorum* and *P. hoogshagenii* are different species distinguished by macro- and microscopic features (Guzmán, 1983).

Independent of the preceding confusion, Singer and Smith (1958) described *P. candidipes* Singer & A.H. Sm. from Oaxaca as a neurotropic mushroom among the Mazatecs. Also they described in the same article *P. aggericola* Singer & A.H. Sm. from Argentina; moreover Singer determined *P. aggericola* var. *alvaradoi* Singer based on an herbarium specimen also from Argentina at BAFC. Later Heim (Heim et al., 1966) described *P. zapotecorum* f. *elongata* R. Heim from Oaxaca; Guzmán (1968) described *P. bolivarii* Guzmán from Sinaloa; Cifuentes and Guzmán (1981) described *P. barrerae* Cifuentes & Guzmán from Guerrero; and Guzmán (1982) described *P. sanctorum* Guzmán from the State of México. From Brazil, Guzmán et al. (1984) described *P. microcystidiata* Guzmán & Bononi and *P. zapotecorum* var. *ramulosum* Guzmán & Bononi. Guzmán (1999) presented an emendation of *P. barrerae*, based on new observations of the pleurocystidia (now pseudocystidia), which were not considered in the original description by Cifuentes and Guzmán (1981). Later, Guzmán (2000) described *P. subzapotecorum* Guzmán from Oaxaca, and more recently Guzmán et al. (2004) described *P. chaconii* Guzmán, Escalona & Ram.-Guill. from Veracruz. All of the above 12 names, are now merely synonyms of *P. zapotecorum* as Guzmán (1983) previously noted for *P. candidipes*, *P. aggericola* var. *aggericola*, *P. aggericola* var. *alvaradoi*, *P. zapotecorum* f. *elongata* and *P. bolivarii*. The others are proposed as synonyms here for first time.

These conclusions play an important role in the taxonomic concept of *P. zapotecorum*, and are the result of careful studies of the holotypes, where it was found that the pseudocystidia had not been previously considered, except for *P. subzapotecorum*. These pseudocystidia were mistakenly described as pleurocystidia in *P. candidipes* and *P. aggericola* by Singer and Smith (1958). Also, it was found that the form and color of the basidiome are highly variable and without taxonomic value, as well as the form and size of the cheilocystidia. All these mushrooms were compared with others of the same section *Zapotecorum* Guzmán, e.g. *P. moseri* Guzmán, *P. muliercula* Singer & A.H. Sm. and others, in order to better define the limits of *P. zapotecorum*, and the section *Zapotecorum*.

Based on the confusion discussed above in the concept of *P. zapotecorum*, a new emendation is presented.



Figs. 1-8. Important ethnomycological species of *Psilocybe* in the world. 1. *P. zapotecorum* (Mexico); 2. *P. mexicana* (Mexico); 3. *P. caerulescens* (Mexico); 4. *P. muliercula* (Mexico); 5. *P. hispanica* (Spain); 6. *P. mairei* (Africa); 7. *P. hoogshagenii* (Mexico); 8. *P. aztecorum* (Mexico). Scale bar: 1-2,4-7 = 20 mm, 3,8= 10 mm.

*Psilocybe zapotecorum* R. Heim emend. nov.

Holotype: Heim & Wasson No. J-125, August 3, 1956 (PC, isotypes ENCB, XAL)

≡ *P. zapotecorum* R. Heim, Comp. Rend. Séan. l'Acad. Sc. 242: 1393, 1956, nom. nud.

≡ *P. zapotecorum* R. Heim, Rev. Mycol. 22: 77, 1957.

≡ *P. zapotecorum* emend. Guzmán, Nova Hedwigia 29: 633, 1978.

= *P. candidipes* Singer & A.H. Sm., Mycologia 50: 141, 1958.

= *P. aggericola* Singer & A.H. Sm., Mycologia 50: 142, 1958.

= *P. zapotecorum* f. *elongata* R. Heim, Comp. Rend. Séan. l'Acad. Sc. 250: 1158, 1960, nom. nud.

= *P. aggericola* var. *alvaradoi* Singer, in BAFC, 1965, nom. nud.

= *P. bolivarii* Guzmán, Ciencia (Méx.) 26: 25, 1968.

= *P. barrerae* Cifuentes & Guzmán, Bol. Soc. Mex. Mic. 16: 52, 1981!

= *P. sanctorum* Guzmán, Bol. Soc. Mex. Mic. 17: 90, 1982!

= *P. microcystidiata* Guzmán & Bononi, Mycotaxon 19: 345, 1984!

= *P. zapotecorum* var. *ramulosum* Guzmán & Bononi, Mycotaxon 19: 346, 1984!

= *P. barrerae* Cifuentes & Guzmán emend. Guzmán, Acta Bot. Mex. 49: 43, 1999.

= *P. subzapotecorum* Guzmán, Doc. Mycol. 29 (116): 46, 2000!

= *P. pseudozapotecorum* Guzmán, Doc. Mycol. 29 (116): 47, 2000, a typographic mistake.

= *P. chaconii* Guzmán, Escalona & Ram.-Guill., Int. J. Med. Mushrooms 6: 276, 2004!

*Those features in italic are new addition to the concept of the species.*

Pileus (20-)40-70(-110) mm diam., polymorphic, conic to convex, convex-plane or campanulate, regular or irregular, sometimes papillate, or subumbilicate, hygrophane, yellowish pale to chocolate-brown, orangish-brown or cinnamon-brown, smooth, sublustrous, sometimes with white floccose scales from the veil at the margin. Lamellae adnexed to sinuate, whitish-brown or pale reddish-brown to dark violaceous, edges whitish. Stipe (70-)100-180(-200) x (5-)10-15(-20) mm, tapering upward, solid to hollow, fibrous, whitish to concolorous with pileus, covered by short or large, floccose, white appressed scales toward the base, frequently in multi-

annulate arrangement. Veil developed in young stages, as white, thin subarachnoid membrane, *which sometimes forms an ephemeral subannulus*. Context white and fleshy in pileus, fibrous, whitish to pale brownish or blackish in stipe. *Pseudorhiza well developed, as a long, thick cordon or as thick, pseudofleshy, piriform, white mass*. Odor and taste farinaceous. Spore print dark brown-violaceous.

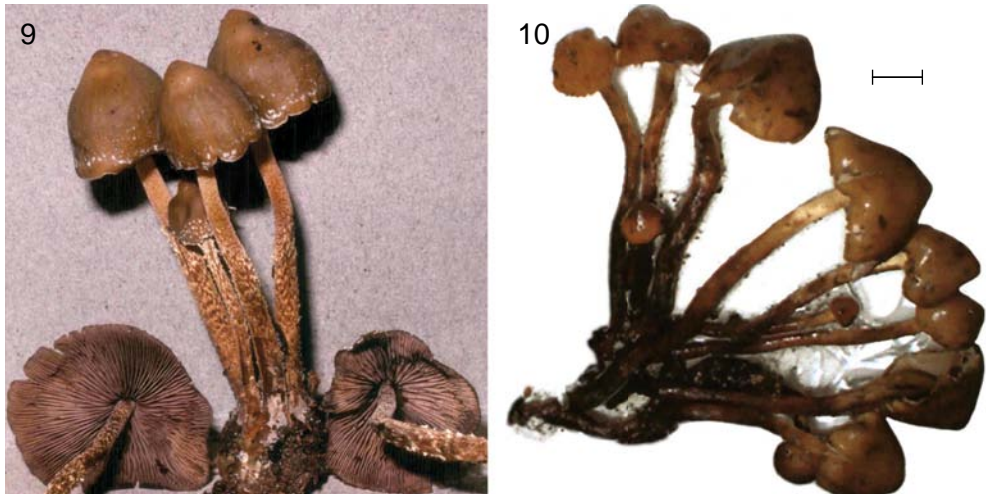
Basidiospores (5-)6-7(-8) x (3-)3.5-4.5(-5) x 3-4  $\mu\text{m}$ , narrowly subellipsoid, oblong ellipsoid or obscurely subrhomboid in face-view, subellipsoid in side-view, thin-walled, wall 0.5-0.8  $\mu\text{m}$  thick, pale to dark yellowish-brown, with a truncate germ pore, and a short and acute apiculus. Basidia (13-)(15-)(20-)22-29 x (4-)(5-) 6-7  $\mu\text{m}$ , 4-spored, clavate or subvesiculose-subcylindric, with a middle constriction, hyaline. *Pleurocystidia* (12-)15-20(-24)(-28) x (3-)4-6(-8)(-10)(-12)  $\mu\text{m}$ , *common, but difficult to find, hyaline, bottle shaped, subfusiform, subcylindric or subventricose, with a wide or narrow base, mucronate or with a short to very long neck up to 28  $\mu\text{m}$  long., sometimes sublageniform, irregularly branched. Pseudocystidia* (18-)(21-)25-33 (-40)(-56) x (6-)8-10(-16)(-17.5)  $\mu\text{m}$ , *common, grayish, polymorphous, subfusiform, subventricose, subglobose or sublageniform, branched or lobulated, sometimes submoniliform, with a narrow or wide base, which is born in the trama hymenophoral. Cheilocystidia* (14-)20-30(-40) x (4-)5-7(-8)(-10)(-20)  $\mu\text{m}$ , generally polymorphous, sublageniform or lageniform, regular or irregularly branched or lobulate, subcylindric or globose to subglobose, with a short or long neck, with a wide or narrow base, hyaline. *Pileipellis* subgelatinous, thin to thick, up to 15(-20)  $\mu\text{m}$  thick, hyphae 1.5-5  $\mu\text{m}$  wide, thin-walled, hyaline to yellowish. *Pileocystidia* 16-40 x 6-8(-10)  $\mu\text{m}$ , *ventricose-subcylindric, submoniliform or subglobose, some strangled. Pileus trama with hyphae* (1.5-)3-8  $\mu\text{m}$  wide, some globose, up to 30  $\mu\text{m}$  wide, thin-walled, hyaline to brownish, not incrustated. Subhymenium subcellular, elements 2-5  $\mu\text{m}$  wide, hyaline and incrustated with yellowish-brown pigment. Trama hymenophoral regular or subregular, hyphae 2-20(-26)  $\mu\text{m}$  wide, thin- or thick-walled, some of them inflated, hyaline, occasionally incrustated with yellowish-brown pigment. *Oleiferous hyphae* 4-7  $\mu\text{m}$  wide, *infrequent, grayish or yellowish-gray. Caulocystidia* (8-)11-25(-30)(-40) x (3.5-)7-8(-10)  $\mu\text{m}$ , *polymorphous, sublageniform, ventricose-rostrate, subglobose or pyramidal, sometimes regular or irregularly branched, hyaline, solitary or in small groups. Clamp connections present.*

This new emendation is supported mainly by the description of the pleurocystidia and pseudocystidia, as well as more details on the cheilocystidia, pileipellis and caulocystidia, and on the size and color of the basidiome, and the pseudorhiza. Concerning the distribution of *P. zapotecorum*, it is common in the Neotropics from

Mexico to Argentina, through mountainous cloud forests, at 900-2000(-3500) m elevation in the north, or in subtropical forests in flat lands at sea level in the south (e.g. Brazil and Argentina). There are records of *P. zapotecorum* from Mexico, Guatemala, Colombia, Brazil, Venezuela, Ecuador, Peru and Argentina.

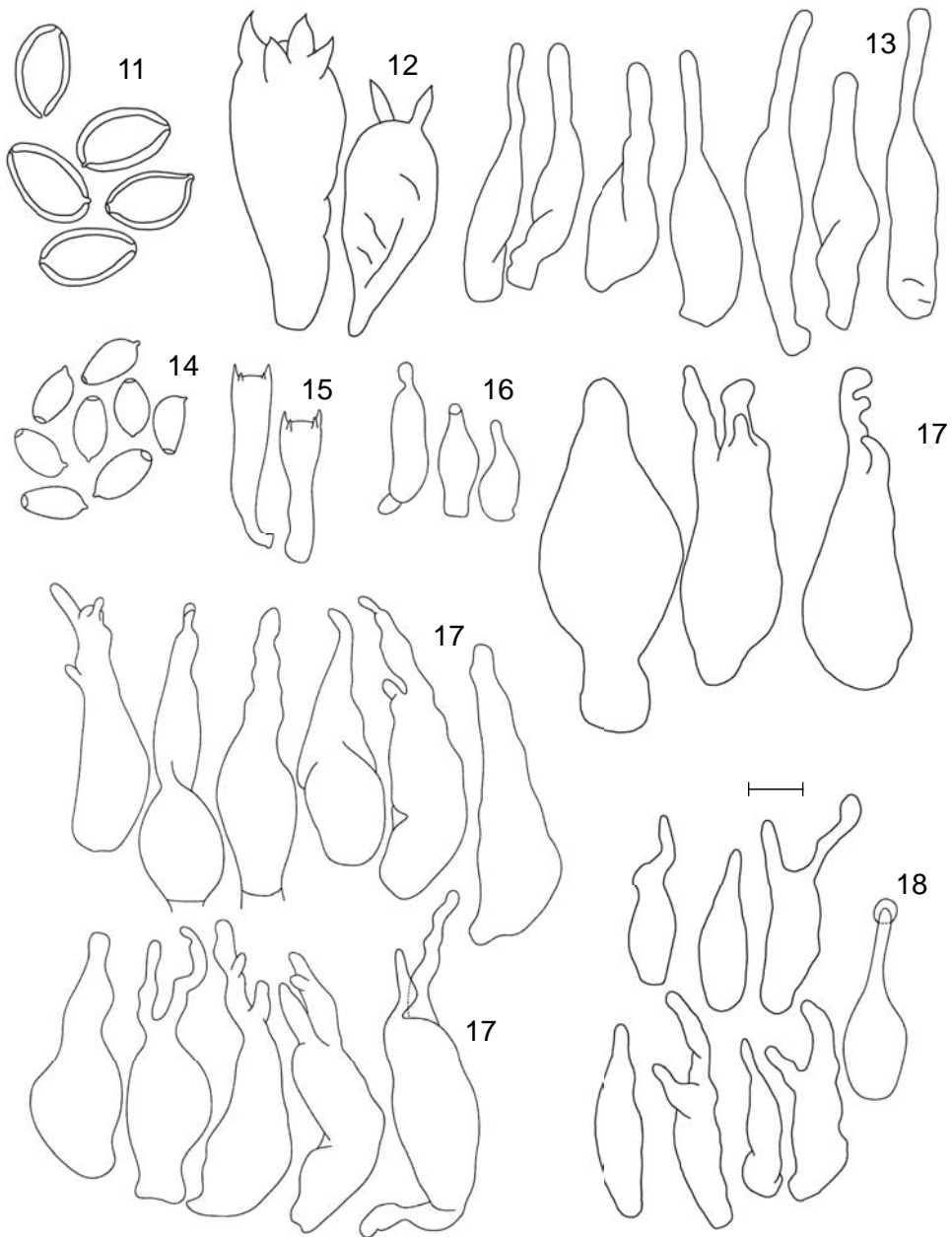
There are evidences of the traditional use of this mushroom and taxonomically close species (e.g. *P. moseri* and *P. muliercula*) from prehispanic times. These include pieces by ceramic, stone and metal from Mexico, Colombia and Peru. It is possible to find in these pieces, figures resembling *P. zapotecorum* and closely allied species, as will be discussed below. Moreover, in some codices at Mexico, such as the Magliabechiano (Fig. 32), there are possible representations of *P. zapotecorum*, *P. muliercula* and also *P. caerulescens* (Figs. 1, 3, 4, 9, 10). These two latter species have basidiome very similar to that of *P. zapotecorum*. As the latter has the widest distribution of the three, *P. zapotecorum* is considered the mushroom most represented on these anthropological figures and codices. At present, *P. zapotecorum* together with other species such as *P. caerulescens*, *P. muliercula*, *P. hoogshagenii* and *P. mexicana* are used in nocturnal ceremonies only in Mexico, among several ethnic groups.

Studying some anthropological ceramics pieces found in Mexico, especially from the Capacha culture in the State of Colima, in the Nevado de Colima region,



Figs. 9-10. Two important ethnomycological species of *Psilocybe* in Mexico. 9. *P. zapotecorum* (by Halling); 10. *P. muliercula* (by Soria). Scale bar: 9 = 20 mm, 10 = 10mm





Figs. 11-18. Microscopic features of *Psilocybe mairei* and *P. zapotecorum*. 11-13. *P. mairei*: 11. basidiospores, 12. basidia, 13. cheilocystidia. 14-18. *P. zapotecorum*: 14. basidiospores, 15. basidia, 16. pleurocystidia, 17. pseudocystidia, 18. cheilocystidia (all from the holotype). Scale bar: 4  $\mu$ m.

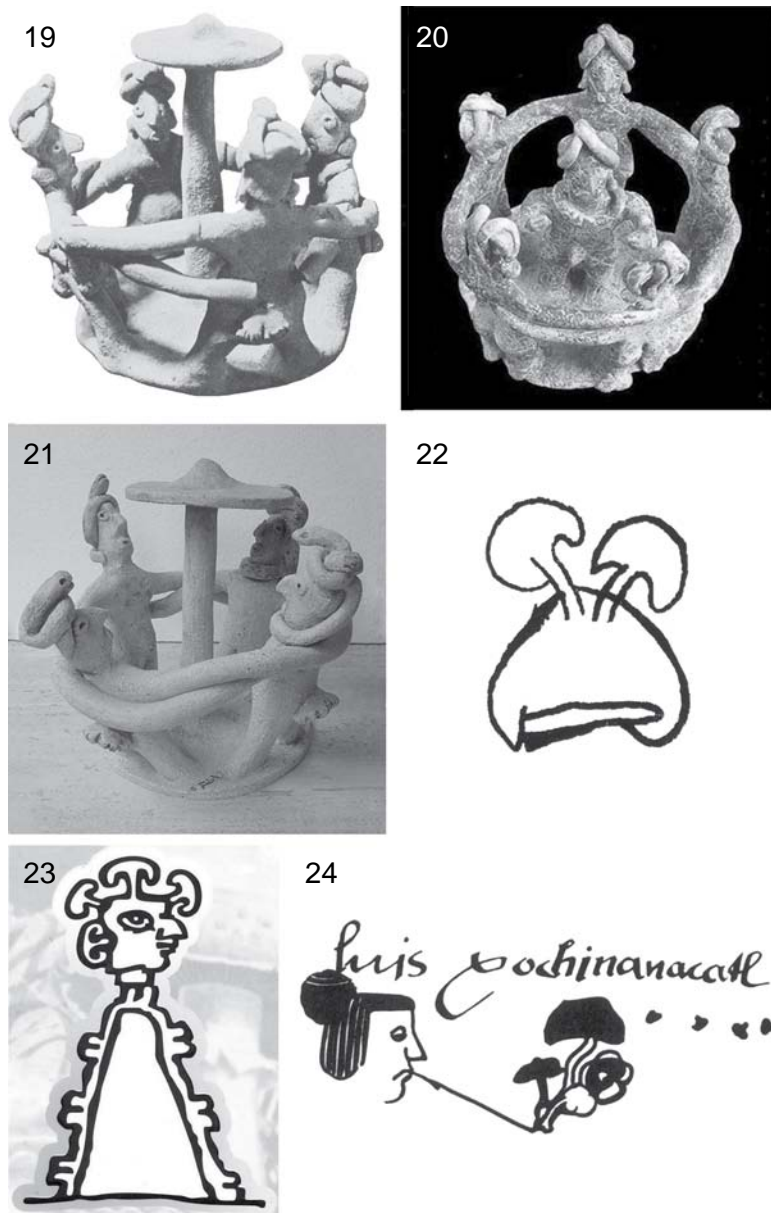
an interesting piece (Fig. 19) was found and presented for first time by Furst (1974) and later by Schultes and Hofmann (1979). It is a piece of about 15 cm tall and deposited in a private collection (Furst, 1974). They described this piece as “mushroom ceremony” and “dancing Indians”, respectively, around a long-stemmed mushroom effigy, which was suggested to be a *Psilocybe* by Furst (1974) or *P. mexicana* or a closely related species by Schultes and Hofmann (1979). However, due to the robustness of the mushroom and the thick stipe, it is probable that the species is *P. zapotecorum* (Figs. 1, 2, 9), a mushroom common in Colima region. The four personages of this piece are embracing each other, and are not really dancing. This is because their faces with their eyes out of orbit suggest that they are under the effects of neurotropic mushrooms. This is the reason that they need to embrace themselves, because under the influence of neurotropic fungi, a person can neither remain standing nor dancing. Also, in this figure we can see the effects of gigantism or dwarfism that are commonly produced by the neurotropic mushrooms.

However, a most important observation on this Fig. 19 which had not been noted until now either by anthropologists or other specialists, is that the headdress or hat (much like a turban of the Oriental people) of the four personages is really a snake, as too are the arms. This coincides with the fact that snakes were considered sacred animals and thus very important in the religion of several Mexican Indian cultures, such as the Nahuatl (or Aztec). For the Nahuatls, snakes represented the god Quetzalcóatl. This is also so for the Teotihuacán culture, where the representation of Quetzalcóatl is covered by many large stone snakes heads. Also Schultes (1939, 1940) observed that Quetzalcóatl is represented with mushrooms in several figures in the Vindobonensis Codex from the Mixtec culture (in Oaxaca), as discussed later by Wasson (1980). This relationship with Quetzalcóatl is possible to confirm in another figure from the same Capacha culture, found also in the Nevado de Colima region (Fig. 20). In this latter, five embraced Indians form a circle around a central personage similar to them, with the same snake hat, but also having arms as snakes, are hands as the snake heads. This piece was reported by Donitz et al. (2001) from the Museo Universitario de Arqueología at Manzanillo, but without any comments. Note that both figures (19 and 20) are very similar between them, with only one major difference, i.e., that in the second there is not any mushroom but instead at the center is an important personage with snakes, who is suggested to be Quetzalcóatl. Thus with this latter figure together with the other, it is possible to conclude that the ingestion of sacred mushrooms like psilocybes, is probably related to the cult of Quetzalcóatl. If these two figures are indeed related with Quetzalcóatl, this means that the Capacha culture was probable under the influence of the Nahuatl (the

Nahuatl empire was very large, and reached the Colima region). All these asseverations contrast with the few comments by Furst (1974), Schultes and Hofmann (1979), Donitz et al. (2001) and others, who only presented these figures as people dancing. It is important to state that the observation on the headdress in form of a snake in the personages of Fig. 19 was first made by Isabel Lasserre, who copied such figure in her clay workshop, from the picture by Schultes and Hofmann (1979), as shown in Fig. 21 made under the direction of the author of this article.

Related to the codices of several Mexican cultures, besides the Vindobonensis Codex discussed above, there is the Codex 27, which was studied by Caso (1963). In this codex, Caso found a glyph (Fig. 22) in a map made by the indians in a demand of land in Tetela region. This glyph named “Nanacatepec” is related to another codex, the Lienzo de Zacatepec No. 1 from the Mixtec culture (Fig. 23), found by Wasson (1980). The word Nanacatepec means hill of the mushrooms, and in fact, these two glyphs represent a hill. The first has two basidiomata and the second has four mushrooms on a hill shaped like an human head, all of them with a convex pileus. Tetela, the place of this first Codex, is in the State of Morelos, and probably refers to the town Tetela del Volcán, which is along the southern slope of the Popocatepetl Volcano, from where *Psilocybe angustipleurocystidiata* Guzmán was described (Guzmán, 1983), now considered a synonym of *P. muliercula* (Guzmán, unpublished data). This mushroom is an important sacred species in the region. Therefore, it is probable that the mushrooms of the two glyphs are related to their neurotropic effects. In connection with the present chapter, it is important to state that *P. muliercula* and *P. zapotecorum* are closely related species, separated only by the size of the basidiospores and basidiomata, in addition to the absence or presence of pseudocystidia. Whereas *P. muliercula* possesses large basidiospores, (6-)-7-8(-10)  $\mu\text{m}$  long, small pileus, (10-)-12-40(-50) mm diam., and lacks pseudocystidia, *P. zapotecorum* has small basidiospores, (5-)-6-7(-8)  $\mu\text{m}$ , large pileus (20-)-40-70(-110) mm and common pseudocystidia.

In the famous Codex Magliabechiano, presented by Sahagún (1530), as a part of his great work on the Nahuatl culture, there is a nice color figure (Fig. 32), reprinted by several sources, such as Wasson and Wasson (1957), Heim and Wasson (1958), Schultes (1976), Aguilar (2003), Díaz (2003), and Guzmán (2007). This figure represents the ingestion of the “teonanácatl” by Sahagún, the sacred mushroom used by the Nahuatls. In it, there is a seated Indian eating mushrooms, which supposedly he gathered from in front of him, where three basidiomata with green pileus are growing. Behind the Indian there is a giant and terrible personage who, according to the interpretation of the author, is clutching the indian by one hand, taking him to the



Figs. 19-24. Ethnomycological information on *P. zapotecorum* and *P. muliercula*. 19. Personages embracing around a mushroom, note the hat with one snake (by Furst 1974); 20. Personages embracing around another person (by Donitz et al., 2001); 21. A clay copy of Schultes and Hofmann' figure (by Lasserre); 22. Nanacatepec glyph (by Caso, 1963); 23. Zacatepec Lienzo (by Wasson, 1980); 24. Huexotzinco Lienzo (by Wasson, 1980).

world of the mushrooms. Nevertheless, as the use of these neurotropic mushrooms was forbidden by the Church in that time through the Inquisition, and because these mushrooms were considered demonic, it is probable that Sahagún asked the indians (who were tlacuiles painting the codex) to represent the devil in that ingestion of the demonic mushroom, and thus the Indians depicted that monstrous figure. For Wasson (1980) and Aguilar (2003) that personage is the Lord of the Underground or the God of Dead, respectively, both under the name of Mictlantecuhtli. Moreover, the most important observation in this Magliabechiano Codex from a mycological perspective, is the green mushroom. The green color is strongly related with the caerulescent or bluing feature of the neurotropic mushrooms. But for anthropologists the mushrooms are green, because the jade, which is green, being a very precious stone for the Indians, which they use in making several valuable figures (Wasson and Wasson, 1957). In the robustness of the basidiomata and the convex pileus, these mushrooms agree well with *P. zapotecorum* or *P. caerulescens* (Figs. 1, 3), two important sacred mushrooms in the Indian culture. Of these two species, it is more likely to represent *P. zapotecorum*, because it is more common in Mexico, and also grows in the Tetela del Volcán region discussed above, not far from the Great Tenochtitlan (now Mexico City), where Tlatelolco is located, the place of Sahagún.

With regard to the name “teonanácatl” proposed by Sahagún (1530), it is confusing that this word is not used at the present among any ethnic group in Mexico. However, this common name was extensively used in the bibliography after hallucinogenic mushrooms were rediscovered in Mexico, to appoint all the sacred mushrooms (e.g. Schultes, 1939, 1940, 1976; Wasson and Wasson 1957; Heim and Wasson, 1958; Singer and Smith, 1958; Schultes and Hofmann, 1979). Although the author could not find the use of this name in Mexico, during one of his explorations, in Necaxa, in the State of Puebla in 1959 (Guzmán, 1960), he found the application of the name “teotlaquilnanácatl”, which is very similar to that of Sahagún. This new name was obtained by Guzmán in a dialogue with some indians, when he showed them some mushrooms he gathered, such as *P. caerulescens*, *P. cubensis* and *P. zapotecorum*. The indians were at first highly surprised that a white man had sacred mushrooms in his hands; in that time it was very rare for a white man to be taking such mushrooms, as the mushrooms were a secret. After Guzmán insisted several times for the common name of the mushrooms, the indians, who were speaking Nahuatl among them, replied “teotlaquilnanácatl”. Note that “tlaquil” is a new word inserted into the middle of Sahagún is word. The Nahuatl name by Sahagún means: teo = divine or sacred, and nanácatl = mushroom. The name “tlaquil” is derived from “tlacuil” that means paint or painting. Precisely, the indians who made the

codices through drawings or paintings received the name *tlacuilos*. Thus, it is supposed that the correct name by Sahagún, and that obtained by Guzmán (1960), is “*teotlacuilnanácatl*”, which means “the sacred or divine mushroom that paints or describes through color figures”.

This new interpretation of Sahagún’s name, as “*teotlacuilnanácatl*”, agrees well with the mean effects produced by neurotropic mushrooms, i.e. colorful figures or color hallucinations. However, the problem is why Sahagún did not hear that word? It is probable that as Guzmán heard “*teotlaquilnanácatl*”, instead of “*teotlacuilnanácatl*”, Sahagún only heard “*teonanácatl*”. But it is also probable in both cases that the indians preferred to keep in secret the knowledge of such mushrooms. It is known that Sahagún, several times was in Tlalmanalco, in the State of México and also in some parts of the State of Puebla (Álvarez, 1978; León-Portilla, 1999), in both cases close to Popocatepetl Volcano, where Sahagún was evangelizing indians and where they used, and still use at present, an important sacred mushrooms *P. aztecorum* R. Heim (Fig. 8), which they call “*apipiltzin*” (Guzmán, 1978b, 1997). Why Sahagún did not hear that important word? It is probable here the same as the case of the “*teotlaquilnanácatl*”, the indians did not provide that word “*apipiltzin*”, because they knew the use of such mushroom was forbidden by the Church. However, the mushroom from Popocatepetl, *P. aztecorum*, presents a small and narrow basidiome, contrary to those robust mushrooms of the Magliabechiano Codex. On the other hand, the locality of Necaxa, Puebla, where the name “*teotlaquilnanácatl*” was found and also *P. zapotecorum*, is not so very far from both the Popocatepetl region and Mexico City (the latter known as Tenochtitlán, as it was stated above).

Continuing with the review of the codices started above, the Matrícula de Huexotzinco (Huexotzingo, Puebla?) should be considered, in which Wasson (1980) found represented the heads of two indians with mushrooms, connected to their mouths by a line. One of them (Fig. 24) has two or three mushrooms in front of the indian head. The face of this indian looks drowsy, maybe as the result of the ingestion of neurotropic mushrooms, which could be *P. muliercula* or *P. zapotecorum*. This interpretation by the author, is based on the fact that these are two common neurotropic species in the State of Puebla. This is another representation of the neurotropic or sacred mushrooms among the indian traditions, mainly those related with the *P. zapotecorum* complex.

The Mayan pieces called “mushroom stones” (Fig. 25) are very common in Guatemala and El Salvador, although there is some anthropological debate as to their meaning (Wasson and Wasson, 1957). However, it seems that they are related to the cult of *P. zapotecorum*. This hypothesis is based on the robust mushroom



Figs. 25-28. Anthropological pieces from Central and South America. 25-27. Mayan mushroom stones: 25. First piece found, now in a Zürich Museum (by Martínez-Carrera from a Japanese copy); 26-27. Two pieces with head first related with the ingestion of hallucinogenic mushrooms (by Wasson, 1980). 28. A Peruvian piece from the Denver Museum. Note the mushrooms and the eyes out of orbit (by the Denver Museum).

that these pieces represent, like that of *P. zapotecorum*, a common species in that region. Moreover, there are two pieces (Figs. 26-27), which were studied by Wasson (1980), that have personages with their heads downward, and their eyes out of orbit. It is probable that the two personages depicted on these pieces, are under the effects of neurotropic mushrooms and that they are positioned head first because they are returning to reality, after seemingly flying or floating in space, as happens when these kinds of mushrooms are eaten.

There is another anthropological case from Central America related to the use of neurotropic mushrooms. These are some little golden pieces found in Darién, Panama, deposited in the Museo del Oro at Bogotá, Colombia (Schultes and Bright, 1979). They represent human figures (Figs. 29-30), but with two mushrooms on the head, big round earrings, and two wings growing out of both sides of the head or on the neck. According to Schultes and Bright (1979), these figures are related to the use of sacred mushrooms, and the reason that the personages have wings and big round earrings is because they fly under the effects of the mushrooms they have on the head. One of these pieces is a woman sitting (Fig. 30), with an expression of meditation. Concerning the form of the mushrooms of these figures, the author related them to *P. zapotecorum* or a closely related tropical species, which could be *P. moseri*, known from the tropics in Mexico, Colombia and Caribbean region (in unpublished papers it was concluded that *P. zapotecoantillarum* Guzmán, T.J. Baroni & Lodge from Costa Rica, *P. zapotecocaribaea* Guzmán, Ram.-Guill. & T.J. Baroni from Martinica and *P. semiangustipleurocystidiata* Guzmán, Ram.-Guill. & Torres-Torres from Colombia, are synonyms of *P. moseri*).

Related to the above golden figures, Williams (2012) found several little golden pieces similar to those from Darién, in Tumbes, in an archeological zone in Panamá, in the Western part of Canal of Panama. One of them is like that of the woman sitting with an expression of meditation described above, but with something like plane mushrooms on the head, which also seem to be plane heads of birds. Williams (2012) did not discuss this interesting figure, nor its relationship to Darién figures. Torres (2006) stated that there are other golden figures like those from Darién, in Calima and Tolima, Colombia, but he gave no further information. Another figure related to the one discussed above is a Colombian metal piece (Fig. 31), made of gold and copper, which represents a woman sitting with one mushroom in each hand. According to C.M. Torres (pers. comm. 2007) this figure belongs to Quimbaya culture and is now in a private collection at Paris. Stamets (1996, last ed., pag. 21), presented this figure without any comment. The author of the present article thinks that the mushrooms of this figure are *P. zapotecorum* or *P. moseri* based on their form.





Figs. 29-32. Important ethnomycological pieces and part of the Magliabechiano Codex. 29-30. Golden little pieces from Darién, Panama. Note the mushrooms on the head, the winds and the earrings (these latter in 30) (by Schultes and Bright, 1979); 31. A Columbian metal figure, with two mushrooms (note the eyes and the earrings) (by Torres, pers. comm.); 32. Part of Magliabechiano Codex, with the ingestion of teonanácatl. Note the green mushrooms on the left and the god of the mushrooms in the back of the Indian (by several sources).

Finally, from Peru there is an interesting Inca piece (Fig. 28), probably made of clay, which represents a personage with a mushroom on his left hand and another engraved on his hat. Moreover, the face of this person has the eyes wide out of orbit. Supposedly this figure is related to the cult and ingestion of neurotropic mushrooms, maybe the *P. zapotecorum*-complex. This seems to be the first anthropological and ethnomycological report of sacred mushrooms from Peru, although the author has

the record of three herbarium specimens (at NY) of *P. zapotecorum* from Peru gathered by Dumont (Guzmán, 1983). The Peruvian piece in Fig. 28 was in an exhibition at the Museum of Art of Denver, USA, on loan from a private collector, who after the exhibition, sold the piece to another collector in Europe. This information was kindly given to Guzmán by the Curator of the museum, M. Young-Sánchez in 2003. The piece belongs to Puccara culture, and it was found near Lake Titicaca between Peru and Bolivia. Another report from Peru is a brief account by early Jesuit missionaries, that the Yurimaguas Indians eat some mushrooms that grow on trees to get drunk (Heim and Wasson, 1958; Schultes, 1972; Furst, 1974). Supposedly those mushrooms are *P. yungensis* Singer & A.H. Sm., a species described from Bolivia and common in Mexico (Singer and Smith, 1958; Guzmán, 1983), but absolutely distinct from the *P. zapotecorum*-complex by its macro- and microscopic features, as well as its lignicolous habitat.

*Psilocybe mairei* in a prehistoric mural from Africa (Figs. 6, 11-13, 33-37)

The famous post-paleolithic murals depicting mushrooms that are found on walls of caves in Tassili (Atlas Mountains), in the Sahara Desert (Samorini, 2001) (Fig. 33), are related with *Psilocybe mairei* Singer. This supposition has been made by Guzmán several times in his lectures since the 1990's of the last century and recently by Akers et al. (2011) in a Guzmán's communication in that paper. Guzmán's observation is based on the fact that *P. mairei* (as *Hypholoma cyanescens* R. Maire, see below) was described from Algeria in a semixerophytic habitat, as that of those mushroom depictions at Tassili. These murals were discovered by Lhote (1968) between 1939-1940, as Babos† from Budapest informed to Guzmán by letter in 1973. Lhote, who did not consider the depicted mushrooms, stated that these murals are evidence of secret sanctuaries, 7,000 to 9,000 years old. Keenan (2005) discussed that the work of Lhote was unfortunately perfunctory, because the Lhote team damaged many depictions. However, the Tassili murals, as shown by Samorini (2001), are the oldest prehistoric evidence for the use of sacred mushrooms by man.

The name *Psilocybe mairei* is based on a fungus from Algeria described by Maire (1928) as *Hypholoma cyanescens*, that Malençon (1942) later redescribed from the same locality. Kühner and Romagnesi (1953) considered this species as *Geophila cyanescens* (R. Maire) Kühner & Romagnesi. Subsequently Singer and Smith (1958) studied this fungus and related it to a species described from Argentina, *Psilocybe collybioides* Singer & A.H. Sm., because both mushrooms share taxonomic features and their semi-sterile conditions. However, Singer and Smith (1958) stated that

Maire's fungus is different from the European *P. cyanescens* Wakef., although some authors, e.g. Krieglsteiner (1984) and Babos (1997), considered *P. cyanescens* as a synonym of Maire's mushroom. Malençon and Bertault (1970) redescribed Maire's fungus as *Geophila cyanescens* from Morocco, and later Singer (1973) reported this species as *Psilocybe mairei*, to separate it from *P. collybioides*. The habitat of *Psilocybe mairei* in Algeria and Morocco is soil or small pieces of rotten wood, under *Abies*, *Cedrus*, *Pinus* or *Quercus* according to Maire (1928), Malençon (1942), Singer and Smith (1958) and Malençon and Bertault (1970). It seems that in the past the Sahara Desert was covered by green vegetation composed of those trees, as well as *Cupressus*, which was reported by Samorini (2001) from Tassili Mountains. The above information, supports the hypothesis that *P. mairei* was growing in the Tassili region, and is the species represented on the murals for its neurotropic effects.

Guzmán in 2005 studied the type of *Psilocybe mairei*, which he found after several searches through different herbaria. Singer and Smith (1958), Malençon and Bertault (1970), Singer (1973), Guzmán (1983), Krieglsteiner (1984) and Babos (1997) did not study the type, despite all of them discussing *P. mairei*. The type was found in LRZA (in the Laboratoire de Recherche sur les Zones Arides, at the University of Algeria), first through help from Malençon by a letter in 1973, and then with the support of Bouhired, who sent Guzmán all the Maire's collections at LRZA. This type was first looked for in AL (University of Algeria), NCY (Nancy, France), MPU (Montpellier) and PC (Paris). The Maire material sent by Bouhired consist of a collection of five little bottles:

1. *Hypholoma caerulescens*, number missing, from Atlas of Blida, east of Algeria, December 1<sup>st</sup>. 1922. Second number 1831a.
2. *H. hydrophilum*, number 5824, from Akfadou, east of Algeria, October 1918. Second number 1831b.
3. *Hypholoma* sp., number 41241, Alma, east of Algeria, November 25, 1940. Second number 1831c.
4. *Psilocybe duleris*, number missing, Bainem, Algeria, February 29, 1926. Second number 1834.
5. *P. gemnophila*, number missing, Calvados, dunes of France. Date missing, only 1910. Second number 1834.

All of this material was preserved in alcohol, in the above-mentioned bottles. LRZA also sent to Guzmán color pictures of all the basidiomata removed from the bottles, one of them No. 4 in the list above now broken. After a careful study of

Maire's fungi from LRZA, it was possible to determine the first collection as the authentic material of *Hypholoma cyanescens*, now *Psilocybe mairei*, as it will be discussed below. The second collection of Maire's fungi is *Hypholoma* sp. with true chrysocystidia, and thin-walled basidiospores, subellipsoid in face-view. The third collection appears to represent a species of *Psathyrella*, with a pileipellis as hymenoderm. Collection 4 appears to be a rare *Deconica*, with basidiospores subellipsoid in face-view, and with a very narrow germ pore. Finally collection 5 is another rare *Deconica* with smaller basidiospores, subellipsoid, thin-walled and with a very narrow germ pore.

The material of *P. mairei* (Figs. 6, 11-13), as *Hypholoma caerulescens*, collection 1 (see above) presents three small basidiomata, with *pileus* convex, smooth, 8-20 mm diam., yellowish-brown; *lamellae* whitish brown, subadnexed; *stipe* cylindrical, 23-35 x 3-4 mm, same color that the pileus; *basidiospores* very scarce, 8.5-10.5 x 5-6.5  $\mu\text{m}$ , subellipsoid both in face- and side-view, thick-walled, wall up to 1  $\mu\text{m}$ , yellowish-brown, with a germ pore; *basidia* 29-32 x 7-11  $\mu\text{m}$ , 2- or 4-spored, ventricose-fusoid, hyaline, many collapsed; *pleurocystidia* not observed; *cheilocystidia* 22-34(-36) x (4-)4.5-7  $\mu\text{m}$ , hyaline, sublageniform, some with a long and subcylindric base, but with a long neck; *ixocutis* 100  $\mu\text{m}$  thick, with hyphae 3-4  $\mu\text{m}$ , hyaline; *pileus trama* probably radial, hyphae 8-15  $\mu\text{m}$  wide, thin-walled, some of them subglobose, all of them hyaline to pale yellowish; *subhymenium* subcellular, with elements 2-4  $\mu\text{m}$  wide, hyaline and thin-walled; *trama hymenophoral* regular, with hyphae 6-22  $\mu\text{m}$ , hyaline; and *clamp connections* present.

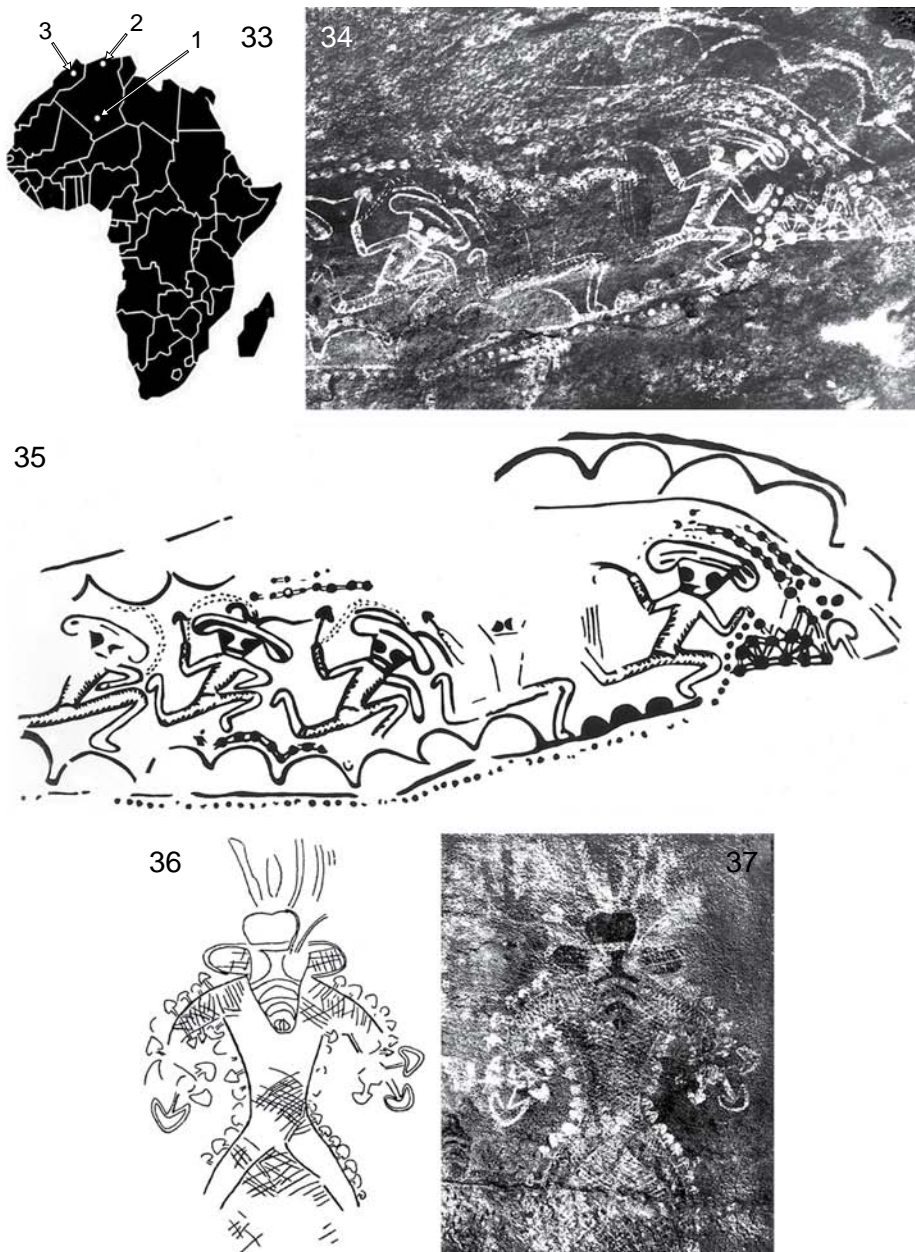
Maire's (1928) original description of *Hypholoma cyanescens* was translated to English by Singer and Smith (1958), but they did not mention the first herbarium name of this fungus, *H. caerulescens*. Both Maire's and Singer and Smith's descriptions, considered basidiospores scarce, 10-12(-20) x 5.5-6.5  $\mu\text{m}$ , ellipsoid, fusco-brown, thick-walled, pleurocystidia none or rare, similar to cheilocystidia, and cheilocystidia 30-40 x 6-8  $\mu\text{m}$ , fusiform, with long neck. This fungus was found in Atlas of Blida and La Chr ea, Algeria, Oct. 24, 1912, below *Cedrus*. Maire cited in his description another three collections from the same locality, gathered Oct. 31, 1915, Dec. 1<sup>st</sup>, 1922 and Nov. 28, 1926. All of them substerile and considered here as paratypes. The above collection from Maire, 24, 1912 seems to be lost. The LRZA collection No. 1831a, identified as *Hypholoma caerulescens*, is considered as neotype of both *Hypholoma cyanescens* and *Psilocybe mairei* (!), in spite of some difference in the size of the basidiospores described by Maire (1928), but this difference is due to the fact that the basidiospores are very scarce in this fungus, and

consequently none of the Maire's, Singer & Smith's and Guzmán's description show a real average. Also it is interesting to observe that Malençon's description on *H. cyanescens* from Morocco (Malençon, 1942), agrees well with that of Maire's description. However, Malençon (1942) considered the stipe 50-70 x 3-3 mm, basidiospores (11-)11.2-13(-13.5) x 5.5-7 µm and basidia 30-35 µm long.

All the above information on the probable identification of the prehistoric mushrooms depicted at Tassili, contrasts with the previous few and vague references about their identification. Besides the assessment by Guzmán in his lectures, and in Akers et al. (2011) as stated above, there is a brief comment by Stamets (1996), who supposed that Tassili's mushroom is *P. mairei*; however he didn't provide further information on its source. Samorini (2001), who explored Tassili region (Figs. 33-37), did not identify the mushroom. He only supposed that those mushrooms depicted on the walls are related with some psychotropic species such as *Panaeolus* or *Psilocybe*, because of their small size in both murals from Tin-Tazarift (Figs. 34-35) and Matalém-Amazar (Figs. 36-37). The latter depicts is a shaman wearing a mask, and with his entire body covered by mushrooms, including the arms, hands and legs, in an ecstatic state. It is probable that all these depicted mushrooms have some action upon the mind of those people. Samorini supposed that the mushrooms are associated with the dung of some mammals and for this reason he thought that maybe *P. cubensis* is the probable species of mushroom depicted, because some mushrooms of the shaman have some bluish color. However, this color may be a result of oxidation of the original color of the mural. It is therefore considered that *P. mairei* is the mushroom illustrated in these murals. In this way, this is the first known neurotropic species use by man during prehistoric times.

#### *Psilocybe hispanica* in a prehistoric mural in Spain (Figs. 5, 38-39)

There are several prehistoric painted rock walls in caves and shelters through Spain, mainly in the Province of Cuenca, as discussed Alonso (1983), Fernández-Miranda and Moure (1977), and Martínez-Perello and Díaz-Andreu (1992) among others. Fungi are not considered in any of these works, except in Akers et al. (2011), which will be discussed below. In the rest of the world the only prehistoric murals linked with the mushrooms are in Africa as discussed above, and in Siberia, where some petroglyphs have been found that are related to shamanistic practices using *Amanita muscaria* (L.: Fr.) Pers. (Dikov, 1971). The Spanish mural that is reviewed here, and previously discussed by Akers et al. (2011), is the first case of a prehistoric mural in Europe related to mushrooms. The relationship of this mural to mushrooms was proposed



Figs. 33-37. Tassili prehistorical murals. 33. Situation of Tassili in the Sahara Desert in Africa (1), Algeria (2) and Morocco (3); 34-35. Running men in a Tassili mural (above the original, below a copy) (from Samorini, 2001); 36-37. A shaman covered by mushrooms (original on the right, a copy on the left) (by Samorini, 2001).



Fig. 38-39. Spanish prehistoric mural depicting mushrooms (those of the arrow). 38. photograph by A. Piper; 39. A digital tracing by J. F. Ruiz (both by Akers et al., 2011).

first by Piper in a personal communication to Guzmán in 2010 for the identification the mushrooms depicted. Guzmán identified those mushrooms as *Psilocybe hispanica* Guzmán, a species described by him from the Pyrenees (Guzmán, 2000), as noted by Akers et al. (2011), based on personal communication by Guzmán in that paper.

The Spanish mural is in the Selva Pascuala region, in the municipality of Villar del Humo, province of Cuenca, in the central-eastern part of the country. This is a mountainous region at 1,000 m elevation, covered by *Pinus* forests. It is located about 270 km from Huesca, in the Pyrenees region. The mural is on the wall of a rock shelter, and represents a hunting scene featuring several primitive men with bows and arrows. The animals in the mural are bulls and deer, and on the right side of the mural, near the middle, is a row of 13 basidiomata. These mushrooms possess a convex, conical to subumbonate pileus, and a straight to sinuous stipe, which relates them closely to *Psilocybe hispanica*, a neurotropical fungus used recreationally by young people in the Pyrenees region, close to Huesca (Guzmán, 2000), as late commented by Guzmán and Castro (2003) and Fernández-Sasia (2006). This species grows on horse dung in subalpine meadows, at 2300 m elevation. It is very probable that the mushrooms depicted at the Selva Pascuala shelter are associated with the dung of bulls and deer, and were used in shamanistic traditions due to their neurotropic action and for the important place which they have on the mural, as discussed by Akers et al. (2011).

It is interesting to compare the habitat of this fungus with that of *P. aztecorum*, a species mentioned in the first part of the present work. This mushroom was described by Heim, based on specimens purchased from indians in a town at the Volcán Popocatepetl, and Guzmán (1978b) later found in a *Pinus* forests in that volcano and also in other mountainous regions, all of them between 2800-4000 m elevation. This demonstrates the great altitudinal range of this fungus, as it is observed also in *P. hispanica*. On the other hand, the fimicolous habitat of this latter, relates the species to *P. coprophila*, *P. cubensis* and *P. semilanceata*. The latter grows on meadows with rich soil and sheep, while *P. coprophila* occurs on dung of many kinds of herbivorous mammals, including horses. However, this latter mushroom is not neurotropic neither bluing (now considered as *Deconica*), and *P. cubensis*, a strongly bluing neurotropic fungus, which also grows on dung of many kinds of herbivorous mammals, it is found only in the tropics and subtropics (it is pantropical). Also *P. hispanica* possess a pileus different in form from all those species, because it is not acutely papillate as in *P. semilanceata*, neither convex as *P. coprophila*, nor subumbonate as *P. cubensis*. It is therefore asserted, that the identification of the mushrooms depicted in the Selva Pascuala region as *P. hispanica* is correct. Regarding the relationship of the depicted mushroom to shamanistic practices, it is the case that besides the row of painted mush-



rooms has a special and important place in the mural, and that in two of the basidiomata the stipe presents a bifurcated base, which could lend to anthropomorphic interpretation as legs. Also all these little figures here and on other murals were originally interpreted as schematized human beings by Alonso (1983) and others.

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