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Diversity of mycorrhizal fungi in Pinus caribaea forests in Poptún, Guatemala.

Diversidad de hongos micorrícicos en bosques de Pinus caribaea en Poptún, Guatemala.

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Resumen

Pinus caribaea var. *hondurensis* (Sénéc.) W. H. Barrett & Golfari es una especie mesoamericana cuyo hábitat natural en Guatemala se está reduciendo aceleradamente por deforestación, aumento de ganadería y producción de cultivos de subsistencia. Además, los hongos ectomicorrícicos asociados, fundamentales para su supervivencia, han sido muy poco estudiados. Este es un estudio descriptivo que contiene información acerca de la diversidad de hongos micorrícicos recolectados en rodales de *P. caribaea* del municipio de Poptún, Petén, durante los años 1997-1998 y 2013-2016, del uso de algunos de esos hongos como inóculo micorrícico, de identificación molecular de dos especies de *Lactarius* y de importantes aspectos etnomicológicos locales. Se encontró que existen especies endémicas, como *Boletus guatemalensis*, predominancia de boletales y russulales, diversidad fúngica semejante a la del sureste del país, poco uso de hongos comestibles silvestres y el primer registro de *Amanita persicina* (anteriormente *A. muscaria* var. *persicina*) en las tierras bajas mayas de Guatemala, con importantes aportes etnomicológicos. Aunque la diversidad debe ser mucho mayor a la encontrada, es aconsejable proseguir las recolectas, la identificación taxonómica de las especies locales y promover la conservación y reforestación con esta singular especie de pino a nivel municipal.

Palabras clave: *Boletus guatemalensis, Lactarius indigo, Amanita persicina*, especies endémicas, Neotrópico, Mesoamérica.

Abstract

Pinus caribaea var. *hondurensis* (Sénéc.) W. H. Barrett & Golfari is a Mesoamerican species whose natural habitat in Guatemala is being quickly reduced by deforestation, increase of livestock and subsistence crops. The mycorrhizal fungi associated with them, fundamental for their survival, had not been studied before. In this study it is presented a short report of the ectomycorrhizal fungi diversity collected in the stands of *P. caribaea* in the village of Poptún, Petén, between the years 1997-1998 and 2013-2016. Endemic species, such as *Boletus guatemalensis*, and predominance of boletales and russulales, were found. The fungal diversity presents more similarities to the one found in the southeast of the country, compared to the diversity of the west highlands. The first record of *Amanita persicina* (previously *A. muscaria* var. *persicina*) in the Mayan lowlands of Guatemala is reported, as well as related important ethnomycological findings. Nevertheless, it is expected higher diversity in the area, therefore, further research is recommended, regarding the taxonomic identification of the different species and the conservation and reforestation of the area with this pine species.

Keywords: *Boletus guatemalensis, Lactarius indigo, Amanita persicina*, endemic species, Neotropic, Mesoamerica.

Introduction

Pinus caribaea is the pine species with the closest natural distribution to the equator on the American continent. It is found in warm subtropical environments from Mexico to Nicaragua and some Caribbean islands. (Delgado, Piñero, Rebolledo, Jardón, & Chi, 2011; Farjon & Styles, 1997; Moura & Dvorak, 2001; Sánchez, Ingrouille, Cowan, Hamilton, & Fay, 2014). The species has been successfully introduced as a forest plantation, using mycorrhizal inoculum, in South American countries (Moura & Dvorak, 2001), southeast asia (Das & Stephan, 1982) and Africa (Moutanda, N'zada, & Kazotti, 1998; Wright, Gibson, & Barnes, 1986). Although it is a species of great forest and ecological value, the mycorrhizal component has not been studied in depth in the countries of origin. To date, only two articles about ectomycorrhizal fungi varieties related to this important forest species have been published (Flores & Simonini, 2000; Ortiz-Santana, Lodge, Baroni, & Both, 2007) and a website that shows part of the variety of macrofungi in Belize (Baroni, *s.f.*)

Between 1997 and 1998, an investigation was carried out on the diversity of these fungi in wooded pine areas in Poptún, with the support of the Guatemala Conservation Trust [FCG, by its acronym in Spanish] and the Department of Microbiology of the Faculty of Chemical Sciences and Pharmacy of the San Carlos University of Guatemala. To do this, several places in the municipality were sampled during the rainy season, where specimens (fruit bodies) were collected, which were described, identified and preserved in the Department of Microbiology. From this research, the publication of the first endemic species of the genus Boletus for Guatemala, *Boletus guatemalensis* Flores & Simonini 2000, and a new combination for another local species *Tylopilus leucomycelinus*, were achieved (Singer & M.H. Ivory) R. Flores & Simonini 2000. The collection of fungi allowed later analysis of some local strains (Culajay, 2001) and develop studies on

mycorrhizal synthesis with seedlings of *P. oocarpa* (Miranda, 2001) y *P. caribaea* (Reyes, 2004).

Some of the stands sampled at that time no longer exist due to a severe pine weevil pest (*Dendroctonus*) that drastically reduced local forests from 1999 to 2001, and then due to anthropogenic disturbance by notoriously increasing human population and extensive livestock farming in Poptún.

Studying the diversity of ectomycorrhizal fungi associated with P. caribaea in Petén is of utmost importance since it is an area with little known fungal endemism and with very unique ecological conditions in the Central American isthmus. On the other hand, deforestation and land use change in the area endanger species that have existed in that ecosystem for thousands of years.

Materials and Methods

Study Area

Poptún municipality is located to the south of the department of Petén, between coordinates 16 ° 19′20 ″ N, 89 ° 25′20 ″ W, with an extension of 1,716 km^2. The region was classified by Holdridge, Genke, Hatheway, Liand and Tosi (1971) within the life zone, very humid warm subtropical forest (bmhSc). It presents an average relative humidity of 90%, an average annual rainfall of 1,700 mm, with minimum temperatures ranging between 12o-16oC and maximums of 30o-36o C, and an altitude between 440 to 500 meters above sea level, with plains and hills characteristic of the area called *mogotes*, 30-50 m high (Poptún Municipality, National Council of Protected Areas, National Forest Institute, The Nature Conservancy [CONAP, INAB, TNC, for their acronym in Spanish], 2007).

The native vegetation is made up of remnants of *Pinus caribaea*, the only local conifer, which covers approximately 27% of the territory, and diversity of broadleaved forests that cover 24% of the territory. The rest is destined to extensive livestock (including pine savannas), guamiles and agriculture (Rivera, 2007). *P. caribaea* forests of Poptún are part of the buffer zone of the Maya Biosphere Reserve, according to the law of Protected Areas of Guatemala (National Council of Protected Areas [*CONAP*, by its acronym in Spanish], 2002; Rivera, 2007). Poptún's soils have an eminently forestry vocation; however, forest cover has decreased dramatically in recent years: for 2010, the loss registered was greater than 9% (*Planning and Programming Secretariat of the Presidency* [SEGEPLAN], 2013).

55% of the population of the inhabitants belong to the Q'eqchi 'ethnic group, 40% are Ladinos, and 5% are made up of the Mayan ethnic groups: Mopán, Pocomchí, Kaqchiquel, K'iche' and Achí according to data from the census of 2002 (National Statistics Institute [*INE*, by its acronym in Spanish], 2003). In Poptún, strong migration has occurred in recent years, especially from the eastern departments of Alta and Baja Verapaz, Zacapa and Chiquimula (*INE*, 2003; Peláez, 2007).

Sampling, Collection and Identification Places for Fungi.

The samplings were carried out at different points in the municipality of Poptún: Finca Ixobel, Finca Las Lajas, Finca Las Flores, forestry area of *PROCAFOR* (Regional Forest Program of Central America), forestry area of *ICAVIS* (Institute for Agroforestry and Wildlife Training), forest area of the Kaibil Training School and Special Operations of the Guatemalan Army (Kaibil School), military zone no. 23 and the Poptún municipal forest, in front of the Kaibil School.

Eight samplings were carried out during the rainy season from June to December 1997 and 1998, and subsequently an annual sampling in the rainy season from 2013 to 2016. Mixed forests (pine and broadleaf) were selected, pine stands with the least possible disturbance and new pine plantations. During the samplings, fruit bodies were found in the vicinity of pine trunks, removing grass and / or secondary vegetation, and sometimes displacing some rotting trunks. Printed photographs and photographic slides were obtained from the collections of the years 1997 and 1998 and digital photography in the later ones. During the samplings, the accompaniment of local people was requested as guides, especially those who knew about plants and who could identify fungi in the field.

After collecting the mushrooms, they were wrapped in waxed paper and placed in plastic baskets with adequate ventilation during sampling. Subsequently they were deposited in expanded polystyrene coolers, with ice and newspaper, for their transfer to Guatemala City. Sometimes, the fruit bodies were partially dried in a homemade dehydrator, to avoid decomposition due to the heat and humidity of the place, as well as during the transfer to the City, which on those dates took around 9-12 hours and around seven hours. In the laboratory, the fruiting bodies were described macroscopically, they were assigned a scientific name based on their characteristics (with the help of North American and European publications), then they were assigned a registration number and finally, after drying them appropriately, they were stored in plastic bags with your data at the Micoteca Rubén Mayorga Peralta-MICG.

Mycelial Cultures and Samples for Molecular Analysis.

In order to obtain local fungal strains, fungal tissue isolations were made from those specimens that presented better conditions for cultivation, using Saboreaud agar with bengal rose to decrease bacterial contamination.

With the interest of knowing better the genetic identity of the species belonging to the *Lactarius* section *Deliciosi* of Poptún, three local specimens (*Lactarius indigo, L. aff rubrilacteus* y *L. salmoneus*) deposited in the Micoteca, were analyzed to isolate their DNA and know their phylogenetic position, thanks to the support of the University of Murcia, Spain

Ethnomicological Compilation

During the samplings, personnel from the farms visited the Central American Regional Forest Program (PROCAFOR) and the Institute of Agroforestry and Wildlife Sciences (ICAVIS) and some soldiers from the area were consulted about the use of edible, medicinal and toxic mushrooms of the place. The information was registered in the field agenda.

Results

Fungal Diversity

More than 40 species belonging to 17 genera of ectomycorrhizal fungi were collected, which are mentioned in Table 1. Several were identified up to species but others as related (*aff*) to other species due to their similarity. Most belong to the Order Boletales (*Boletus, Gyroporus, Leccinum, Pisolithus, Retiboletus, Scleroderma, Suillus, Strobilomyces, Tylopilus* y *Xerocomus*) and Russulales Order (*Lactarius* y *Russula*). Figures 1 and 2 show some of the species found in Poptún.

Table 1. Ectomycorrhizal fungal species present in stands of *Pinus caribaea* in Poptún, Petén.

Ectomycorrhizal species	Period 1997-1998	Period 2013-2016
Agaricales Order		
Amanitaceae		
Amanita persicina (Dav.T.Jenkins) Tulloss & Geml	x	
A. aff bisporigena	x	
A. aff conara	x	
A. aff magniverrucata	x	
A. aff pantherina	x	
A. aff solitaria	x	x
Amanita sp.		x
Hydnangiaceae		
Laccaria aff *laccata*	x	
Inocybaceae		
Inocybe spp.	x	x
Boletales Order		
Boletaceae		
Boletus guatemalensis R. Flores & Simonini	x	
Boletus sp.	x	x
Boletellus ananas (M.A. Curtis) Murrill	x	x
Retiboletus griseus (Frost) Manfr. Binder & Bresinsky	x	x
Scleroderma polyrhizum (J.F. Gmel.) Pers.	x	
S. texense Berk.	x	x
Pisolithus arrhizus (Scop.) Rauschert	x	x
Suillus decipiens (Peck) Kuntze	x	x
Suillus aff *luteus*	x	x
Suillus spp	x	x
Strobilomyces strobilaceus (Scop.) Berk.	x	x
Tylopilus aff *felleus*	x	
T. plumbeoviolaceus T.H. Li, B. Song & Y.H. Shen	x	
T. leucomycelinus (Singer & M.H. Ivory) R. Flores & Simonini	x	x
Hymenochaetales Order		
Hymenochaetaceae		
Coltricia aff *cinnamomea*	x	x

Russulales Order		
Russulaceae		
Lactarius indigo (Schwein) Fr.	x	x
L. aff rubrilacteus	x	x
L. aff psammicola	x	x
L. piperatus (L.) Pers.	x	x
L. salmoneus Peck	x	
Russula vesicatoria Murrill	x	
R. delica Fr.	x	x
R. brevipes Peck	x	x
R. nigricans Fr.	x	x
R. aff *foetida*	x	x
Russula spp	x	x
Thelephorales Order		
Thelephoraceae		
Thelephora terrestris Ehrh.	x	x
T. aff palmata	x	x

Figura 2. a) Forest of *Pinus caribaea* in Finca *Ixobel, Poptún*; b) *Craterellus* aff. *ignicolor*; c) *Russula* aff. *foetida*; d) *Russula* aff. *brevipes*; e) *Russula* sp.; f) *Lactarius* aff *psammicola*; g) *Lactarius indigo*; h) *Thelephora palmata*.

Figure 2. i) *Retiboletus griseus*; j) *Boletus guatemalensis*; k) *Tylopilus leucomycelinus* l) *Xerocomus* sp; m) *Tylopilus plumbeoviolaceus*; n) *Suillus aff salmoneus*; o) *Pisolithus arrhizius*; and p) *Scleroderma texense*.

During the samplings, some saprobic species were also collected, which resulted in new records for Guatemala, such as *Auricularia mesenterica* (Dicks.) Pers. and *Geastrum minimun* Schwein. The most notable species for their size were *Meripilus* sp., *Lenzites* sp. y *Chlorophyllum rachodes* (Vittad.) Vellinga; other interesting species due to their abundance and / or distribution in that area were *Agaricus* spp., *Auricularia auricula-judae* (Bull.) Quél., *Coprinus comatus* (O.F. Müll.) Pers., *Coprinus* spp., *Cotylidia aurantiaca* (Pers.) A. L. Welden, *Marasmius cladophylus* Berk., *Marasmius* spp., *Mycena* spp., *Trogia cantharelloides* (Mont.) Pat., *Neolentinus* sp., *Picnoporus sanguineus* (L.) Murrill, *Pleurotus* sp., *Psilocybe* sp., *Phaeolus schweinitzii* (Fr.) Pat., *P. tenuiculus* (P. Beauvois) Fries, *Schizophyllum commune* Fr., *Trametes versicolor* (L.) Lloyd, *Tremella reticulata* (Berk.) Farl., y *Xylaria* spp.

Species diversity by collection site

The sites with the greatest diversity of ectomycorrhizal fungi were the Finca Ixobel and the Kaibil School forest area, both with high pine density and little cattle grazing. The first specimens of *Boletus guatemalensis* were collected in Ixobel, a species with habitat apparently restricted to Guatemala (Flores & Simonini, 2000) and Belize (Ortiz-Santa et al., 2007) as well as the only specimens of *Cantharellus aff cibarius* and the largest number of fruiting bodies of *Lactarius* aff *rubrilacteus* .

In the Kaibil School, a greater diversity of bulletins was found, being *Tylopilus plumbeoviolaceus* particularly abundant, *T. leucomycelinus, Retiboletus griseus* y *Suillus aff luteus.* From this place comes the first report of *Russula vesicatoria* for the country, a species reported only in the southeastern United States and Costa Rica. Subsequently other specimens were found in Cerro Alux (Mixco, Guatemala) and in the El Trifinio reserve (Chiquimula). The first specimens of *Amanita persicina* (previously called *A. muscaria* var. *persicina*) in Guatemala were also located there.

B. guatemalensis, R. griseus and *Gyroporus castaneus* (Boletales Order) as well as abundant specimens of *Coltricia cinnamomea* and *Scleroderma polyrhizum* were found on Finca Las Flores.

Numerous specimens of *Craterellus aff ignicolor,* an American species from temperate and humid climates, were found at ICAVIS and must be analyzed at the molecular level. The only specimens of *Lactarius salmoneus* were also found together with young pine plants. In Las Lajas the predominant species were *Pisolithus* and *Scleroderma* and some degrading species such as *Picnoporus sanguineus* and other polypores.

Pisolithus arrhizius and *Scleroderma spp.*, were found at all sites, including in soils that suffered from creeping fires during the dry season. *Pisolithus* fruiting even among the bark of some pines at a height of 20 cm from the ground.

Micellar Insulations

Due to local heat and time elapsed from harvest to laboratory micellar insulation, many specimens developed larvae that destroyed fungal tissues; others decomposed (particularly the mature boletales) and others presented high bacterial and/or micro-fungal contamination in their insultation. Nevertheless, it was possible to isolate strains of *Pisolithus arrhizius, Scleroderma texense* y *Tylopilus plumbeoviolaceus.*

Phylogenetic analysis of *Lactarius*

From the three analyzed samples, the complete sequence of the ITS (Internal Transcribed Spacer) region of the nuclear rDNA of *L. indigo* and *L. aff rubrilacteus* was obtained. The *L. salmoneus* sample could not be amplified due to its poor condition. Phylogenetic diagrams showed that both species are genetically much separated from the European ones and that *L. aff rubrilacteus* from Poptún could be a new species, genetically close to *L. subpurpureus* from the USA and *L. miniatosporus* from Mexico. Details on the genetic differences of these species are found in the works of Flores (2003), Nuytinck, Miller & Verveken (2006), Flores, Díaz y Honrubia (2007), Flores & Reyna (2013).

Ethnomicological Information in Field

Those who accompanied during the first years of sampling did not know or consume wild mycorrhizal fungi; However, in 2015 and 2016 there were people who mentioned the consumption of *Lactarius indigo*, which could be related to the migration of people from the southeast to Poptún. It was also found that several residents mentioned the consumption of xikin ché 'or tree ear (*Schizophillum commune*), a common saprobe fungus in the area, reported by Sommerkamp (1990).

Most of the interviewees expressed fear of consuming fungi as they were considered poisonous. Nor was any use of medicinal mushrooms detected, such as *Pisolithus*, which is used as a healing agent in other areas of the country (Mazariegos, Lara and Lara, 2014) and only a few mentioned that there are people seeking *Psilocybe*, due to its hallucinogenic properties, in paddocks with *P. caribaea* of the place.

Discussion

The list of species found in Poptún is a sample of the diversity existing in the pine forests of the area where the Boletales and Russulales orders predominate, a situation similar to that found by Quezada, Rodas and Marroquín (2016) in oak forests of Petén , and with great similarity to the tickets reported by Ortiz-Santana et al. (2007) in Belize. Many of these species are found in pine or pine-oak forests of the central and western zone of Guatemala, while others are located in the central-eastern zone of Guatemala, such as *T. leucomycelinus*, *T. plumbeoviolaceus* and *R. griseus*, and others seem to have a much more restricted habitat, such as *B. guatemalensis.*

T. leucomycelinus a striking species of orange-brown coloration that is easily confused with *T. ballouii*, was one of the most frequent species at the sampling sites. Carpophores of T. *leucomycelinus* have currently been found in Jalapa, Jutiapa and Santa Rosa (central and southeast of the country) in pine-oak forests. Osmundsen & Halling (2010), identified a very similar new species, *T. oradivensi*, in Costa Rica, so it is believed that a complex of similar species exists. *T. plumbeoviolaceus* is easily identified by the purple-violet color of the pileus and stipe as well as by its whitish hymenium; Although in North America *T. plumbeoviolaceus* is associated with oaks, in Guatemala it has been found in pine-oak forests of the central highlands and only with *P. caribaea* in Poptún. Retiboletus griseus (formerly *Boletus griseus*), is found in oak and pine-oak forests of the central and south-eastern plateau of Guatemala. Depending on the locality, rain and insolation, the fruiting bodies can be lighter to almost whitish, so it

can be confused with other species. The bitter taste and the presence of the dark reticulum are key to its identification.

The species described by Ortiz-Santana et al. (2007) and on the web page of the University of Cortland on Belize fungi, they are a good reference of the diversity of macro fungi in Poptún and even for the south-eastern zone of Guatemala where *Veloporphyrellus conicus* (Ravenel) Y.C. Li & Zhu L. Yang, *Boletellus ananas* (M.A. Curtis) Murrill, *B. auriporus* Peck, *Pulveroboletus ravenelii* (Berk. & M.A. Curtis) Murrill y *Retiboletus ornatipes* Manfr. Binder & Bresinsky. They also mention the existence of frequent species in the central part of the country as *Austroboletus gracilis* (Peck) Wolfe, *A. subflavidus* (Murrill) Wolfe, *Boletus floridanus* (Singer) Murrill, *B. rugulosiceps* B. Ortiz, T.J. Baroni & Lodge, *B. variipes* var. *fagicola* A.H. Sm. & Thiers, *Gyroporus castaneus* (Bull.) Quél., *Leccinum rugosiceps* (Peck) Singer, *Phylloporus scabripes* B. Ortiz & M.A. Neves, *Strobilomyces floccopus* (Vahl) P. Karst., *Suillus salmonicolor* (Frost) Halling, y *S. tomentosus* Singer.

Regarding Russulales, at least five species of the genus *Lactarius* were found, being the most frequent *L. indigo*, *L. piperatus*, *L.* aff *subpurpureus*, *L.* aff *psammicola* and *L. salmoneus*. Esta última, reportada para el sureste de USA, Mexico y Belize. In Guatemala it has only been found in Poptún and Jutiapa. *Lactarius* aff *psammicola* has striking yellow-orange carpophores, which can be confused with *L. deliciosus*, although the whitish latex color and the bitter, pungent flavor are sufficient to differentiate them. *L. deliciosus* has not been reported in Belize either, but it is advisable the search for the species as it is frequent in the Guatemalan highlands.

The genus *Russula* locally produces abundant fruiting bodies of reddish, whitish-pink and beige color, with thin, thin and very fragile pellets, but they could not be determined until species due to their complexity.

Interestingly, Poptún fungi resemble those in eastern and southeastern Guatemala, where higher ambient temperatures are found than in the central and western highlands. However, between Poptún and Jutiapa there is a complex geographical barrier made up of Lake Izabal, Sierra de las Minas and dry-thorny forest. It is probable that the fungi of both areas have a common origin and that they have been separated by the geological changes (floods and emersions) that the national territory suffered during the last geological era (Eocene-Pliocene), as well as by the co-migration of species from eastern North America mentioned by Halling and Mueller (2002), in their studies on agaricals and boletals in Costa Rica.

It is necessary to add that several of the species named in Table 1 were initially identified with names of European and Mexican species, as they were the references in the late 1990s. However, today many species of fungi in Mesoamerica must be reviewed and even reclassified, as they differ in their microscopic structures (spores, basidia, cystids, cuticles) and especially genetically, as has happened with *A. persicina*, previously considered a variety of *A. muscaria* (Tulloss et al., 2015). Regarding this species, it is important to point out its finding in Poptún in 1997, although it was not published in its time. This has been cited only in the eastern part of the USA (Tulloss et al., 2015) and recently in Belize (T. Baroni, personal communication, November 20th, 2016).

In Guatemala, *A. muscaria* is found in pine forests above 2000 m.a.s.l. while *A. persicina* in *P. caribaea* forests of Poptún and Belize, around 400-500 m.a.s.l. The ethnomicological-biochemical aspect of this species is very interesting and has been little studied in Guatemala, so some observations are made. Lowy (1972), identified as *A. muscaria* a hieroglyph in the Madrid codex, and interpreted that it was used by a character who commits self-sacrifice, possibly under the hallucinogenic effects of the fungus (Torres, 1994). Later, Lowy (1977) mentioned that, in the surroundings of Cobán, people of the K'ekchi 'ethnic group knew *A. muscaria* by the name of *rocox aj tza* (devil's fungi). Taking into account the altitudinal distribution of both species and the difference in color from red to orange-yellowish, it is probable that the Cobán fungus is *A. persicina* and that this species also produces hallucinogenic and / or toxic effects in those who consume it. On the other hand, for years it has been maintained that the Madrid or Tro-Cortesian Codex was written in Yucatan, based on language; however, *P. caribaea* does not exist in Yucatan and *A. persicina* is a mycorrhizal pine symbiont, suggesting that this codex was possibly written in a Maya region with the presence of *Pinus*. Coe and Kerr, cited by García (2000), speculate the provenance of the Madrid Code around Tayasal (a city located on Lake Petén Itzá), where *P. caribaea* is native. Another possibility is that the fruiting bodies of *A. persicina* were collected in what is currently Petén and Belize and carried it to the western zone of Yucatan, Mexico, where Thompson, (cited in Ayala 2006), believes that this codex may have been written. If it were *A. muscaria*, it had to be obtained in forests of the Mexican or Guatemalan highlands with the highest altitude. The origin dilemma has not been Clarified yet, but Ayala (2006) indicates that it may be a copy of the Dresden codex, with modifications, intended for a particular unidentified Mayan population.

As for edible mushrooms, consumption was found to be minimal, with *L. indigo* being the only one recognized by some people who migrated from mountainous regions in eastern Guatemala to Poptún. However, some people mentioned the consumption of *S. commune* and its local name, xikin ché, which was previously reported by Sommerkamp (1990). The poor knowledge of the inhabitants about the diversity of edible species and their use, make the department of Petén be considered as a microphobic region, in relation to western Guatemala, where there is a long tradition of consumption and knowledge of more than 80 edible species (Bran, Morales, Cáceres, & Flores, 2003; Flores, Comandini & Rinaldi, 2011; Morales, Bran, & Cáceres 2010).

Considering the fungal endemism in the area, the different distribution patterns in the country, the pressure suffered by the *P. caribaea* forests in Petén and the historical-social importance of the area, it is recommended to continue with studies of fungal diversity, promote the ecological restoration with local species, encourage the reforestation of pine forests using native fungi that favor their growth and resistance to drought, as well as deepen the phylogenetic and biochemical analysis of local species to know not only their correct taxonomic identity, but also to investigate other utilities.

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