NEW RECORDS OF BOLETALES (BASIDIOMYCOTA) IN A TROPICAL OAK FOREST FROM MEXICAN SOUTHEAST

NUEVOS REGISTROS DE BOLETALES (BASIDIOMYCOTA) DE UN ENCINAR TROPICAL DEL SURESTE MEXICANO

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Abstract

Background: Derived from the study of mycobiota associated with *Quercus oleoides*, tropical holm oak forests in Tabasco have been explored, finding a great diversity in numerous fungal groups, such as boletoid macromycetes.

Question: What is the diversity of Boletales mycobiota associated with tropical holm oaks of Tabasco?

Species Study: Boletales, *Quercus oleoides*

Study sites and date: municipality of Balancán in the state of Tabasco, Mexico. 2012 - 2016.

Methods: Boletoid fungi associated with *Q. oleoides* were collected according to conventional mycological techniques. A dichotomous key of the species found was made and data on their geographical distribution are included.

Results: Nine species assigned to five genera and two families were identified.

Conclusions: *Boletellus ananas*, *Boletus auripes*, *Boletus vermiculosus*, *Butyriboletus floridanus*, *Phylloporus centroamericanus*, *Porphyrellus indecicus*, *Tylopilus alboater*, *Gyroporus ballouii* and *Gyroporus castaneus* are new records for the state of Tabasco, Mexico. The distribution of these species is wider than what has been reported in the literature. This work constitutes the first study of macromycetes associated with tropical holm oaks in southeastern México.

Key words: Balanan, Boletoids, Ectomycorrhiza, Macromycetes of Tabasco.

Resumen

Antecedentes: Derivado del estudio de la micobiota asociada a *Quercus oleoides* se han explorado los encinares tropicales en Tabasco, encontrando una gran diversidad en numerosos grupos fúngicos, como los macromicetos boletoides.

Pregunta: ¿Cuál es la diversidad de la micobiota de Boletales asociada a encinares tropicales de Tabasco?

Especie de estudio: Boletales, *Quercus oleoides*

Sitio y años de estudio: Municipio de Balancán en el estado de Tabasco, México 2012 - 2016.

Métodos: Se realizaron recolectas de hongos boletoides asociados a *Q. oleoides* según las técnicas convencionales de micología para su identificación taxonómica. Se realizó una clave dicotómica de las especies encontradas y se incluyen datos sobre su distribución geográfica.

Resultados: Se identificaron nueve especies adscritas a cinco géneros y dos familias.

Conclusión: *Boletellus ananas*, *Boletus auripes*, *Boletus vermiculosus*, *Butyriboletus floridanus*, *Phylloporus centroamericanus*, *Porphyrellus indecicus*, *Tylopilus alboater*, *Gyroporus ballouii* y *Gyroporus castaneus* son nuevos registros para el estado de Tabasco, México. La distribución de estas especies es más amplia de lo que se había reportado en la literatura. Este trabajo constituye el primer estudio de macromicetos asociados a encinares tropicales del sureste de México.

Palabras clave: Balancán, Boletoides, Ectomicorizas, Macromicetos de Tabasco.

The order Boletales is one of the most diverse groups of macromycetes, including 2,173 species that belong to 19 families (Catalogue of Life 2018). These fungi present a wide variety of forms in their fruiting bodies and can be resupinate or crust-like with smooth, merulioid, or hydroid hymenophores; gasteroid (puffball-like); polypore-like, as in the unique case of *Bondarcevomyces taxi* (Bondartsev) Parmasto; and a typical mushroom form (stipe and pileus), a fleshy body and a hymenophore composed of gills (lamellae) or tubes. The configuration of tubular hymenophores is the most common of the Boletaceae family, which is referred as boletoid form (Binder & Hibbett 2006).

The majority of the boletoid fungi form ectomycorrhizal associations with numerous photobionts in temperate forests as well as tropical regions. These fungi are important for all forest ecosystems worldwide because they are the main recyclers of organic matter, nutrient uptake, and even nutrient transport within the forest system (Halling *et al.* 2007). This type of fungi is greatly valued as edible food for several human cultures (Carrasco-Hernández *et al.* 2010). In general, boletoid fungi are associated with conifers in temperated forest. A small number of this species have been reported in tropical regions, association to Salicaceae Myrtaceae and mainly Fabaceae (Pérez-Moreno & Read 2004), is probably due to the lack of more comprehensive studies in tropical forest.

Mexico is a world center of oaks richness and endemisms (Manos *et al.* 1999, Valencia-A 2004, Varela-Fregoso *et al.* 2017, Cavender-Bares 2018), it has been observed that there is a correspondence also of a high boletoid diversity, shown by the recent report of mycorrhizal fungi (García-Jiménez & Garza-Ocañas 2001, Chávez-Vergara *et al.* 2016, Varela-Fregoso *et al.* 2017), even though oak forests represent only

5.5 % of the vegetation cover of Mexico (López-Upton *et al.* 2011).

The natural distribution of the tropical oak *Quercus oleoides* Schltdl. *et* Cham. (Figure 1 A-B) extends from 23 °N from the state of Tamaulipas, Mexico to 10° N to the Guanacaste province of Costa Rica, including parts of Honduras, Belize, and Nicaragua (Fournier 2003; Romero-Rangel *et al.* 2015, Pérez-Mojica & Valencia-A 2017). In Tabasco, Mexico, fragments of *Q. oleoides* are found, mainly in the municipality of Balancán (Cámara *et al.* 2011, Cámara & Cappello 2013). These fragments are relicts resulting from the displacement that occurred during the most recently recorded glacial periods, these oak trees were able to adapt to the warm-humid climate conditions. Furthermore, these tropical oak forests are considered an important refuge of the flora and fauna during the Pleistocene (Prance 1982, Pennington & Sarukhán 2005). Therefore, it is imperative to continue studying the mycobiota associated with oak. Additionally, this would contribute to the understanding of the biota associated with these forests which in turn would help to develop preventive strategies, recovery and loss of this habitat.

Materials and methods

Study site. It was carried out in the municipality of Balancán in the state of Tabasco, Mexico. In this location *Q. oleoides* is found fragmented and associated with different types of vegetation, mainly grassland. This entire area corresponds to the ecogeographical unit Terraces of Balancán (Figure 2) and the Terrace subprovince, which contains structural plains dating to the Miocene period, with an elevation ranging from 0 to 50 m (Ortiz-Pérez *et al.* 2005). The climate is

Figure 1. A) *Quercus oleoides* in youth stage. B) Oak forest fragmented by livestock activities.

Figure 2. Sampling sites of oak forest in Balancán, Tabasco.

warm-subhumid (Am), and most of the rainfall occurs during the wet summer (García 2004), with 1,200-1,400 mm from May to October and 400-500 mm from November to April (INEGI 2009).

The localities mostly coincided with the ejido “El Pípila,” which contains a secondary forest where *Q. oleoides* dominates, as well as with several ranches along the Balancán-El Triunfo road, associated with grassland or pasture. In both localities, the oak vegetation is highly fragmented due to livestock grazing, as the land is largely private owned. The specific collection sites are shown in Appendix 1.

Data collection. The two collection sites of the boletoids associated with the oak vegetation are within an area of 100 m². Boletoid basidiomes were collected following conventional mycological techniques (Cifuentes *et al.* 1986, Cappello 2006). Küppers (2002) guide was used to describe the color of the basidiomes. The specimens were herborized and deposited in the UJAT Herbarium, located in the Academic Division of Biological Sciences at the Universidad Juárez Autónoma de Tabasco (UJAT), and duplicates were deposited in the Herbarium of the Faculty of Sciences (FCME), Universidad Nacional Autónoma de México (UNAM). The sites were visited in the rainy seasons during the period 2012 to 2016. Specimens previously collected, present in the Herbarium of UJAT, were also reviewed for this work. For each sample, photographs were taken in the field and during laboratory study. Description of the microscopic structures used

Largent *et al.* (1977) terminology. Specimens were observed with a Zeiss AxioStar Plus microscope using phase-contrast microscopy. Spores, basidia, and cystidia were measured using AxioVision 40 V4.7.1.0. software. For the taxonomic identification specialized bibliography was used (Smith & Thiers 1971, Montoya & Bandala 1991, García-Jiménez & Garza-Ocañas 2001, Halling *et al.* 2007, Halling *et al.* 2008, Neves & Halling 2010). The Index Fungorum (2018) was used to identify the current names use, classification, nomenclature and synonymy for the studied fungi in this work.

Results

Twenty four specimens were identified at the species level, belonging to two families, seven genera, and nine species. The best-represented family was Boletaceae, with five genera and seven species, followed by the family Gyroporaceae, which was represented by *Gyroporus ballouii* and *G. castaneus* (Table 1).

Key to boletoid species from the oak forest of the Mexican southeast.

- 1a. Hymenophore tubular 2
- 1b. Hymenophore lamellate *Phylloporus centroamericanus*
- 2a. Context and hymenophore change when cutting 3
- 2b. Context and hymenophore not bruising blue when cutting 5

Table 1. Taxonomic list of the boletoid fungi found in the sampling sites.

Family	Species
Boletaceae Chevall.,	<i>Boletellus ananas</i> (M. A. Curtis) Murrill
	<i>Boletus auripes</i> Peck
	<i>Boletus vermiculosus</i> Peck
	<i>Butyriboletus floridanus</i> (Singer) G. Wu, Kuan Zhao & Zhu L. Yang
	<i>Phylloporus centroamericanus</i> Singer y L.D. Gómez
	<i>Porphyrellus indecisis</i> (Peck) E.-J. Gilbert
	<i>Tylopilus alboater</i> (Schwein.) Murrill.
Gyroporaceae Manfr. Binder & Bresinsky	<i>Gyroporus ballouii</i> (Peck) E. Horak.
	<i>Gyroporus castaneus</i> (Bull.) Quél.

- 3a. Pores reddish 4
 3b. Pores yellowish *Boletellus ananas*
 4a. Pileus vinaceous-pink, strongly reticulated reddish stipe
 Butyriboletus floridanus
 4b. Pileus brown, non reticulated non reddish stipe.
 Boletus vermiculosus
 5a. Hymenophore with greenish yellow tints
 Boletus auripes
 5b. Hymenophore without greenish yellow tints 6
 6a. Stipe hollow. *Gyroporus castaneus*
 6b. Stipe always solid 7
 7a. Pileus bright orange *Gyroporus ballouii*
 7b. Pileus brown to dark tints 8
 8a. Pileus ochraceous to pale brown. *Porphyrellus indecisis*
 8b. Pileus black to dark grayish brown . *Tylopilus alboater*

Boletellus ananas (M. A. Curtis) Murrill., Mycologia 1 (1): 10 (1909) (Figure 3-A) $\equiv$ *Boletus ananas* M. A. Curtis, Amer. J. Art Scienc. 6: 351 (1848) $\equiv$ *Suillus ananas* (M. A. Curtis) Kuntze, Revis. Gen. Pl. (Leipzig) 3(2): 535 (1898). Examined material: México. Tabasco, Balancán, Ranch Don Filemón, road Ej. El Pípila-Ej. San Elpidio, km 0.5, terrestrial, alt 30 m, tropical oak, 11/01/2015. C. E. González-Chicas 3895 (UJAT). Distribution: The distribution extends from the southeastern United States to Mexico, Costa Rica, Guyana and Colombia. Additional records have been found in Asia, New Zealand and New Caledonia, associated to different hosts (Singer *et al.* 1992, Mata 1999, Mayor *et al.* 2008, García-Jiménez 2013, Ayala-Vásquez *et al.* 2018). Taxonomic comments: This unique boletoid is easily recognizable by its pileus with notable scales, white to soft reddish in color ($Y_{60}M_{60}C_{00}$), with yellowish color ($Y_{60}M_{00}C_{00}$) hymenium, which will turn blue ($N_{50}C_{80}Y_{30}$) when touched and darken as they age. These fungi were found at the base of oak trees. Our specimen coincided with those reported by Mata (1999) and Halling & Mueller (2005), basidiospores show longitudinal and transverse striations. This fungus is also found under the *Q. oleoides* in Costa Rica. In Belize, Ortiz-Santana *et al.* (2007) reported this species with the name *Boletellus coccineus* (Sacc.) Singer. We decided to consider *B. coccineus* as synonymous to *B. ananas* as established by Halling *et al.* (2015).

Boletus auripes Peck, Rep. (Annual) New York State Mus. Nat. Hist. 50:107 (1898) (Figure 3-B). Examined material: Mexico. Tabasco, Balancán, Ranch Don Filemón, road Balancán -El Triunfo, km 8.3, terrestrial, alt 30 m, tropical oak, 20/06/2015. Cappello G.S. 3894 (UJAT); Don Filemón, road Ej. El Pípila-Ej. San Elpidio km 0.5, terrestrial, alt 30 m, tropical oak, 20/06/2015. Cappello S. G. 3893 (UJAT). Distribution: Northern America, including Canada, Florida, and New York; northern and central Mexico, and Belize; also recorded in China, Japan and Taiwan in Asia, and recently recorded in east of Russia in association with different hosts (Chen *et al.* 1997, Bessette *et al.* 2000, García-Jiménez & Garza-Ocañas 2001, Ortiz-Santana *et al.* 2007, Bulakh 2008). Taxonomic comments: This species is easily recognized by the yellowish brown-brown ($N_{20}Y_{80}M_{40}$) color of its pileus, which becomes paler with age and the lack of blue staining anywhere when bruised. This bolete have flesh yellowish-pale ($N_{00}Y_{10}M_{00}$), stipe yellow or weak yellow ($N_{00}Y_{10}M_{00}$), reticulated near the apex. The concept of *B. auripes sensu* (Singer 1947) differs from that of Ortiz-Santana *et al.* (2007) for its larger basidiospores ($11-14.9 \times 3.9-5.2 \mu\text{m}$ vs. $9.6-12.8 \times 3.2-4.8$). We found both sizes of the spores in the study area; therefore, we consider that the *B. auripes* concept is broader than what is believed.

Boletus vermiculosus Peck, Rep. (Annual) New York State Mus. Nat. Hist. 23:130 (1872) (Figure 3-D). Examined material: Mexico. Tabasco, Balancán, Ranch Don Filemón, road Balancán -El Triunfo km 8.3 terrestrial, alt 30 m, tropical oak, 16/06/2013. González-Chicas C. E. 3899 (UJAT); Ranch Don Filemón, oak Ej. El Pípila-Ej. San Elpidio km 0.5, terrestrial, alt 30 m, tropical oak, 21/03/2015. González-Chicas C. E. 3900 (UJAT); Rancho Don Filemón, Ej. El Pípila-Ej. San Elpidio km 0.5, alt 30 m, tropical oak, 20/06/2015. Cappello S. G. 3893 (UJAT). Distribution: Wide distribution from eastern Canada to Georgia and western Michigan in the United States, Guerrero in Mexico, Belize, and southern Costa Rica, always in symbiosis with trees of the genus *Quercus* (Bessette *et al.* 2000, Cifuentes *et al.* 1993, Halling & Mueller 2005, Ortiz-Santana *et al.* 2007). Taxonomic comments: This species is characterized by the reddish-brown

Figure 3. Basidiomes of the species found. A) *Boletellus ananas*, B) *Boletus auripes*, C) *Butyriboletus floridanus*, D) *Boletus vermiculosus*, E) *Gyroporus ballouii*, F) *Gyroporus castaneus*, G) *Phylloporus centroamericanus*, H) *Porphyrellus indecisis* and I) *Tylopilus alboater*.

(N₆₀Y₃₀M₈₀) color of the pores, pale brown (N₂₀Y₆₀M₃₀) color and a velvety surface of the pileus, pruinose stipe, and blue (N₈₀C₆₀Y₂₀) color of the flesh and tubes upon cutting are diagnosis characters for this species. This taxon can be confused with *Boletus vermiculosoides* A.H. Sm. and Thiers, which mainly differs for having slightly larger basidiospores (9-12 µm vs. 10-15 µm), and with *B. subgraveolens* A.H. Sm. and Thiers, which is distinguished by its unpleasant odor (of urine) after being herborized in contrast with the common fungal odor of *B. vermiculosus* (Smith & Thiers 1971). Our specimen better coincides with the concept of *B. vermiculosus* of Ortiz-Santana *et al.* (2007). In addition to the previously mentioned characteristics, an intense red coloration was observed at the base of the stipe. This peculiarity had not been mentioned for the North American concept (Smith & Thiers 1971, Bessette *et al.* 2000). Molecular analyses are needed to clarify the limits between the above-mentioned taxa.

Butyriboletus floridanus (Singer) G. Wu, Kuan Zhao and Zhu L. Yang. Fungal Diversity Res. Ser. 81:72 (2016) (Fig. 3-C). ≡ *Boletus frostii* subsp. *floridanus* Singer, Mycologia 37: 799 (1945) = *Boletus floridanus* (Singer) Murril, Lloydia 11: 23 (1948) = *Suillellus floridanus* (Singer) Murrill, Lloydia 11: 29 (1948) = *Exsudoporus floridanus* (Singer) Vizzini, Simonini & Gelardi, Index Fungorum 183: 1 (2014). Examined material: Mexico. Tabasco, Balancán, Ranch Don Filemón, road Ej. El Pipila-Ej. San Elpidio, km 0.5, terrestrial, 30 m altitud, tropical oak, 21/03/2015. *González-Chicas C. E.* 3902 (UJAT). Distribution: The United States, including Tennessee, South Carolina, and Florida; northeastern Mexico in Tamaulipas; and recently Belize always in symbiosis with trees of the genus *Quercus* (Bessette *et al.* 2000, García-Jiménez & Garza-Ocañas 2001, Ortiz-Santana *et al.* 2007). Taxonomic comments: *Butyriboletus floridanus*, is easily recognizable by the violet to red (Y₈₀M₉₀C₄₀) color of the pileus, reddish (Y₈₀M₉₀C₀₀) hymenophore and small pores (2-3/mm). Our specimen coincides with the description of Ortiz-Santana *et al.* (2007) under the name of *Boletus floridanus*.

Gyroporus ballouii (Peck) E. Horak, Malayan Forest Rec. 51: 42 (2011) (Figure 3-I) ≡ *Boletus ballouii* Peck, Bull. New York State Mus. Sci. Serv. 157: 22. (1912) [1911] = *Boletus ballouii* Peck, Bulletin of New York State Museum of Natural History 157: 22. (1912) [1911] var. *ballouii* = *Gyrodon ballouii* (Peck) Snell, Mycologia 33: 422. (1941) = *Rubinoletus ballouii* (Peck) Heinem. & Rammeloo, Bull. Jard. Bot. Natl. Belg. 53 (1/2): 295 (1983) = *Rubinoletus ballouii* (Peck) Heinem. & Rammeloo, Bull. Jard. Bot. Natl. Belg. 53 (1/2): 295 (1983) f. *ballouii* = *Rubinoletus ballouii* f. *persicinus* Watling & T.H. Li, Australian Boletes: 50 (1999) = *Rubinoletus ballouii* (Peck) Heinem. & Rammeloo, Bull. Jard. Bot. Natl. Belg. 53 (1/2): 295 (1983) var. *ballouii* = *Rubinoletus ballouii* var. *luteoporus* Heinem. & Rammeloo, Bull. Jard. Bot. Natl. Belg. 53 (1/2): 296 (1983) = *Rubinoletus ballouii* var. *viscidus* T.H. Li & Watling [as "*ballouii*"], Edinburgh J. Bot. 56(1): 145 (1999) = *Tylopilus ballouii* (Peck) Singer [as "*ballouii*"], Amer. Midl. Naturalist. 37: 104 (1947). Examined material: Mexico.

Tabasco, Balancán, road Balancán -El Triunfo km 8.3, terrestrial, alt 30 m, tropical oak, 22/12/2012. *González-Chicas C. E.* 3874 (UJAT); 09/11/2012. *González-Chicas C. E.* 3873 (UJAT); 02/11/2015. *González-Chicas C. E.* 3877 (UJAT); 03/02/2013. *González-Chicas C. E.* 3875 (UJAT). Distribution: Wide distribution from the eastern United States and Tamaulipas in northeastern Mexico to Belize and Costa Rica always in symbiosis with trees of the genus *Quercus*; also recorded in Asia, in association with different hosts (Bessette *et al.* 2000, Halling *et al.* 2007, Cifuentes 2008, Osmundson & Halling 2010, García-Jiménez 2013).

Taxonomic comments: Our specimen corresponds with the concept of *Tylopilus ballouii* (Peck) Singer of Bessette *et al.* (2000) and Ortiz-Santana *et al.* (2007), although, the current name in the index Fungorum for this species is *Gyroporus ballouii*. This taxon is complex according to Halling *et al.* (2008).

Gyroporus castaneus (Bull.) Quél., Enchir. fung. (Paris): 161 (1886) (Figure 3-J). ≡ *Boletus castaneus* Bull., Herb. Fr. (Paris) 7: t. 328 (1787). = *Suillus castaneus* (Bull.) P. Karst., Bidr. Känn. Finl. Nat. Folk 37: 1 (1882). = *Suillus castaneus* (Bull.) Kuntze, Revis. Gen. Pl. 3(3): 535 (1898) = *Leucobolites castaneus* (Bull.) Beck, Z. Pilzk. 2(7): 142 (1923) = *Boletus fulvidus* Fr., Observ. Mycol. (Havniae) 2: 247 (1818). = *Boletus testaceus* Pers., Mycol. Eur. (Erlanga) 2: 137 (1825). Examined material: Mexico. Tabasco, road Balancán -El Triunfo km 8.3, terrestrial, alt 30 m, tropical oak, 20/03/2015. *González-Chicas C. E.* 3879, (UJAT); 14/11/2015 *González-Chicas C. E.* 3881 (UJAT); 20/06/2015. *Cappello G.S.* 3880 (UJAT); 27/02/2016. *Cappello S. G.* 3882 (UJAT); Rancho Don Filemón, road Ej. El Pipila-Ej. San Elpidio km 0.5, terrestrial, alt 30 m, tropical oak, 06/12/2015. *Cappello S. G.* 3883 (UJAT). Distribution: Wide distribution in Europe and North America, from eastern Canada to Florida in the United States, Mexico, Belize, and Costa Rica in association with different hosts (González-Velázquez & Valenzuela 1996, Bessette *et al.* 2000, Ortiz-Santana *et al.* 2007). Taxonomic comments: This species is easy to recognize by the chestnut-brown (N₃₀Y₅₀M₃₀) to brown (N₃₀Y₇₀M₄₀) color of its pileus, off white (N₀₀M₀₀C₀₀) hymenophore, and hollow and fragile stipe. In spite of having a wide distribution, our specimen coincides with the concept of Ortiz-Santana *et al.* (2007), with smaller basidiospores than the European-North American concept (6-8 × 3-4 µm vs. 8-13 × 5-6 µm). Davoodian *et al.* (2018) concluded that *G. castaneus* is a complex species with representatives in Europe and North America (including Central America) as well as eastern Eurasia.

Phylloporus centroamericanus Singer & L.D. Gómez, Brenesia 22: 169 (1984) (Figure 3-E). Examined material: Mexico. Tabasco, Balancán, road Balancán -El Triunfo km 8.3, terrestrial, alt 30 m, tropical oak, 02/02/2013. *González-Chicas C. E.* 3886 (UJAT); 17/06/2013. *González-Chicas C. E.* 3906 (UJAT); Rancho Don Filemón, road Ej. El Pipila-Ej. San Elpidio km 0.5, terrestrial, alt 30 m, tropical oak, 01/11/2015. *Mondragón-Sánchez A.* 3888 (UJAT); 17/06/2015. *Mondragón-Sánchez A.* 3887 (UJAT). Distribution: In southeast-

ern Mexico and Costa Rica, always in symbiosis with trees of the genus *Quercus* (Montoya & Bandala 1991, Neves & Halling 2010). Taxonomic comments: Our specimen coincides with the concepts of Singer & Gómez (1984) and Neves & Halling (2010). It is distinguishable from other species of the genus by the reddish-brown ($Y_{70}M_{80}C_{20}$) tones of the pileus. Furthermore, the pileus surface reacted to NH_4OH , producing a blue ($Y_{00}M_{40}C_{99}$) color. Basidiospores were of $9-14 \times 4-5 \mu m$ and had very conspicuous cystidia ($45-100 \times 10-20 \mu m$) with thick walls ($2-4 \mu m$).

Porphyrellus indecisis (Peck) E.-J. Gilbert, Les Livres du Mycologue Tome I-IV, Tom. III: Les Bolets: 99 (1931). (Figure 3-H). $\equiv$ *Boletus indecisis* Peck, Rep. (Annual) New York State Mus. Nat. Hist. 41:76 (1888). = *Tylopilus indecisis* (Peck) Murril, Mycologia 1(1): 15 (1909) = *Tylopilus indecisis* (Peck) Murril, Mycologia 1(1): 15 (1909) var. *indecisis* = *Tylopilus indecisis* var. *subpunctipes* (Peck) Wolfe, Sydowia 34: 211 (1981) = *Boletus subpunctipes* Peck, Bull. New York State Mus. Nat. Hist. 116: 19 (1907). = *Tylopilus subpunctipes* (Peck) A.H. Sm. and Thiers, Boletes of Michigan (Ann Arbor): 119 (1971). Examined material: Mexico. Tabasco, Balancán, Ranch Don Filemón, road Ej. El Pipila-Ej. San Elpidio km 0.5, terrestrial, alt 30 m, tropical oak, 09/10/2014. Cappello G.S. 3891 (UJAT); 02/12/2015. Cappello G.S. 3892 (UJAT). Distribution: From New York to western California in United States; also recorded in Guerrero in Mexico, always in symbiosis with trees of the genus *Quercus* (Thiers 1975, Bessette *et al.* 2000, Cifuentes 2008).

Taxonomic comments: When mature, the rosy ($N_{00}M_{10}C_{00}$) color of the pore surface turns brown ($N_{60}Y_{30}M_{40}$) upon contact. Flesh is soft and remains white ($N_{00}M_{00}C_{00}$) upon being cut. Apex of the stipe slightly reticulated and off-white ($N_{00}M_{00}C_{00}$) in color, placing our specimen in the “*indecisis*” lineage according to Smith & Thiers (1971). The absence of globular pigment in the hyphae of the cuticle, as observed during reaction with Meltzer’s reagent, defines our specimen as *Tylopilus indecisis* (Peck) Murrill (currently named *Porphyrellus indecisis*), coinciding with the specimens presented by Smith & Thiers (1971).

Tylopilus alboater (Schwein.) Murrill., Mycologia 1 (1): 16 (1909) (Figure 3-F) $\equiv$ *Boletus alboater* Schwein., Schriften der Naturforschenden Gesellschaft zu Leipzig 1: 95 (1822). = *Porphyrellus alboater* (Schwein.) E.-J. Gilbert, Les livres du Mycologue Tome I-IV, Tom. III: Les Bolets: 99 (1931). Examined material: Mexico. Tabasco, Balancán, road Balancán -El Triunfo km 8.3, terrestrial, alt 30 m, tropical oak, 03/02/2013. González-Chicas C. E. 3897 (UJAT); 08/11/2012. González-Chicas C. E. 3896 (UJAT); Ranch Don Filemón, road Ej. El Pipila-Ej. San Elpidio km 0.5, terrestrial, alt 30 m, tropical oak, 01/11/2015. González-Chicas C. E. 3898 (UJAT). Distribution: Quebec in Canada, eastern United States, and eastern Mexico in Tamaulipas. Also recorded in China, Japan, Taiwan and Thailand in Asia in association with different hosts (Zhishu *et al.* 1993, Bessette *et al.* 2000, Seehanan *et al.* 2007, García-Jiménez 2013). Taxo-

nomic comments: Corresponds with the concept of Smith & Thiers (1971) with respect to basidiospores ($9-11 \times 3-4 \mu m$) and microchemical reactions. *Tylopilus griseocarnus* Wolfe and Halling is very similar yet has gray flesh. In comparison, *T. alboater* has white flesh, similar to our specimen.

Discussion

When comparing our results with previous studies from Neotropics and North America (Smith & Thiers 1971, Bessette *et al.* 2000, Lodge *et al.* 2002, Halling & Mueller 2005, Ortiz-Santana *et al.* 2007, Henkel *et al.* 2012, García-Jiménez 2013), we found a great resemblance to the North American boletoid species. This is likely due to the distribution of the genus *Quercus* in the study area. Additionally, the observed coincidence of these species to others from Belize and Costa Rica is due to the distribution of *Q. oleoides* in both countries.

According to the literature, the geographical distribution of the species studied, three groups are distinguished. The first group is composed of two species (*B. floridanus* and *P. centroamericanus*) and presents a distribution restricted to the southeastern United States, the mixed forests along the eastern coast of Mexico, Belize, and Costa Rica. The second group is also formed by two species (*B. vermiculosus* and *P. indecisis*) and has a more northern distribution up to eastern Canada and across the United States, in both Georgia and the west in California. The distribution then extends toward Mexico with records in the state of Guerrero, and also to Belize and Costa Rica. Finally, group three is formed by five species (*B. ananas*, *B. auripes*, *T. alboater*, *G. ballouii*, and *G. castaneus*) with a wide distribution across the American continent and reported also in Europe, Asia, and Oceania. The wide distribution of group three, according to Halling *et al.* (2008), could be the result of the historical distribution developed during the original Pangaea continent, about 300 million years ago. Along with their phytobionts, these species could have begun to diversify as the continental masses of Laurasia and Gondwana detached from each other. Then, uncovered portions of land could have functioned as “bridges” between the continental masses, resulting in a convergence of species between these supercontinents. Several examples are found in Central America in the Western Hemisphere and the Malaysian archipelago located at the Wallace Line in the Eastern Hemisphere (Matheny & Bougher 2006). Both areas are connected as part of what was once Laurasia (North America and Asia) with Gondwana (South America and Oceania) (Heckman *et al.* 2001). For this reason, these taxa likely form large species complexes. Therefore, they should be further clarified. A more comprehensive taxonomy is required that integrates molecular, chemotaxonomic, morphological and ecological characters.

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Appendix 1: Coordinate and tropical boletoid species

Degrees and Decimal Minutes			
LATITUDE	LONGITUDE	NAME	SPECIES
17°52.09083'	091°31.43317'	Carretera Balancán -El Triunfo km 8.3 Sitio 1	<i>G. ballouii</i> , <i>B. auripes</i>
17°52.16600'	091°31.48967'	Carretera Balancán -El Triunfo km 8.3 Sitio 2	<i>P. centroamericanus</i> , <i>T. alboater</i>
17°57.48500'	091°35.46383'	Rancho Don Filemón, camino Ej. El Pipila-Ej. San Elpidio km 0.5 Sitio 1	<i>G. ballouii</i> , <i>B. auripes</i>
17°57.58817'	091°34.96667'	Rancho Don Filemón, camino Ej. El Pipila-Ej. San Elpidio km 0.5 Sitio 2	<i>P. centroamericanus</i> , <i>B. floridanus</i> , <i>B. vermiculosus</i>
17°57.52550'	091°35.05733'	Rancho Don Filemón, camino Ej. El Pipila-Ej. San Elpidio km 0.5 Sitio 3	<i>P. indecisis</i> , <i>T. alboater</i> , <i>B. ananas</i>
17°57.29567'	091°35.60017'	Rancho Don Filemón, camino Ej. El Pipila-Ej. San Elpidio km 0.5 Sitio 4	<i>G. castaneus</i> , <i>P. indecisis</i> , <i>B. vermiculosus</i> , <i>B. floridanus</i>