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An emendation of *Scleroderma*, new records, and review of the known species in Mexico

Una emendación de *Scleroderma*, nuevos registros y revisión de las especies conocidas en México

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Abstract. An emendation of the generic description of *Scleroderma* is proposed to consider the membranaceous veil like, or granulose patches, both on the base of the globose basidiome or on the upper part of the stipe, formed by the growth of the basidiome, which breaks the exoperidium. *Veligaster* previously segregated by this character, is a synonym. Guzmán's classification of the genus in 3 sections is followed, however due to the change of the type of the genus for *S. verrucosum*, Sect. *Aculeatispora* is now a synonym of Sect. *Scleroderma,* and *S. citrinum* that was in Sect. *Scleroderma* is now in a new section named *Reticulatae*. A review of the 21 Mexican species of *Scleroderma* is presented, 14 of these are accepted. The most common species in the country is *S. nitidum* in the tropical and subtropical forests. New localities from Mexico and foreign countries are discussed in *S. bermudense*, *S. bovista*, *S. citrinum*, *S. hypogaeum*, *S. michiganense, S. polyrhizum*, and *S. pseudostipitatum*. On the other hand, it is discussed that *S. sinnamariense* seems absent in Mexico, because it was confused with *S. bermudense.*

Key words. gasteromycetes, *Veligaster*, membranaceous patches, new records.

Resumen. Se presenta una emendación del género *Scleroderma* para considerar los parches membranáceos o granulosos en el exoperidio, presentes en la base de la porción globosa del basidioma y en la parte apical del estípite. Éstos se forman por el desgarramiento en el crecimiento del basidioma, pero no habían sido tomados en cuenta antes. *Veligaster*, previamente segregado por este carácter es sinónimo. Se sigue la clasificación en secciones propuesta por Guzmán en 1970, pero debido al cambio de la especie tipo del género, ahora *S. verrucosum*, la sec. *Aculeatispora* es sinónima de la sec. *Scleroderma,* y *S. citrinum*, antes en la sec. *Scleroderma*, se acomoda en la sección ahora nombrada *Reticulatae*. Se revisaron las 21 especies de *Scleroderma* citadas de México, de las que se reconocen 14. La especie más común en el país es *S. nitidum*, que se desarrolla en bosques tropicales y subtropicales. Se registran *S. bermudense*, *S. bovista*, *S. citrinum*, *S. hypogaeum*, *S. michiganense*, *S. polyrhizum* y *S. pseudostipitatum* de nuevas localidades, incluso del extranjero. Se discute que *S. sinnamariense* parece ausente en México, debido a que los registros de ella corresponden a *S. bermudense.*

Palabras clave: gasteromycetes, *Veligaster*, parches membranáceos, nuevos registros.

Introduction

Since Guzmán (1970)'s world monograph on the genus *Scleroderma*, few new observations have been published in Mexico, except the review by Guzmán-Dávalos and Guzmán (1985) on the species of Jalisco, where it was discussed *S. bovista* and *S. polyrhizum*. Later, Guzmán and Tapia (1995) described *S. mexicana* and recorded *S. pseudostipitatum*, both as *Veligaster*. Cortés-Pérez (2011) reviewed the genus in Veracruz. Moreover, there are several records on previously known species, many did not checked yet, as those of Herrera et al. (1989, 2005), Pérez-Silva et al. (1992, 1994), Esqueda-Valle et al. (1995, 2000, 2011), Nava-Mora and Valenzuela (1997), Díaz-Barriga et al. (1998), Quiñones-Martínez and Garza-Ocañas (2003), Herrera and Pérez-Silva (2004), Pardavé-Díaz et al. (2006), Moreno et al. (2010), and Canseco-Zorrilla (2011), among others.

Important works on *Scleroderma* after Guzmán (1970)'s monograph were reviewed, as those from North, Central and South America, Africa, Europe and Asia by Demoulin and Malençon (1970), Demoulin and Dring (1971, 1975), Jeppson (1979, 1986, 1998), Beaton and Weste (1982), Calonge (1982, 1998), Kobayasi (1986), Rifai (1987), Coccia et al. (1990), Sims et al. (1995, 1997, 1999), Grgurinovic (1997), Guzmán and Ovrebo

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(2000), Macchione (2000), Kasuya et al. (2002), Poumart (2003), Guzmán et al. (2004), Watling and Sims (2004), Calonge et al. (1997, 2005), Liu et al. (2005), Gurgel et al. (2008), Guzmán and Ramírez-Guillén (2010), Cortez et al. (2011), Guzmán and Piepenbring (2011), Alfredo et al. (2012), and Nouhra et al. (2012). New species described in those papers are: *S. congolense* Demoulin et Dring and *S. schmitzii* Demoulin et Dring from Africa; *S. cyaneoperidiatum* Watling et K.P. Sims, *S. hakkodense* Kobayasi, and *S. xanthochroum* Watling et K.P. Sims from Asia; *S. mayama* Grgur., and *S. paradoxum* G.W. Beaton from Australia; *S. meridionale* Demoulin et Malençon from Mediterranean area; *S. franceschii* Macchione, and *S. septentrionale* Jeppson from Europa; and *S. minutispora* Baseia, Alfredo et Cortez from Brazil, and *S. patagonicum* Nouhra et Hernández-Caffot from Argentina. The present paper can be considered an introduction to the second edition of the monograph on the genus *Scleroderma*.

Materials and methods

Microscopic observations were made from hand sections of the dry basidiome, mounted in 5% aqueous KOH solution, plain or mixed with 1% Congo red solution, after the material being rehydrated in 96% alcohol. It was also used cotton blue in lactophenol; sometimes the material was boiled gently to prevent cells covering the basidiospores, which make difficult the study. In the size of the basidiospores, spines and reticulum are included. Exceptional dimensions are indicated in parenthesis and super-exceptional cases in a second parenthesis. In the descriptions or comments of the species, we avoid the hyphae of the peridium, because they lack in general of taxonomic importance, except in some cases. More than 300 specimens were macro- and microscopically studied, also several from other countries. For limitations on the available space, only some representative herbarium specimens are mentioned.

Descriptions

Scleroderma vs. Veligaster. Guzmán (1969) described this latter based on *Scleroderma columnare* Berk. and Broome from Ceylon (today Sri Lanka), Java and Singapore, and on *S. leptopodium* Pat. et Har. from Central Africa. The taxonomic feature to distinguish *Veligaster* was the veil-like patches on the exoperidium, both on the upper part of the stipe, and on the base of the globose basidiome. These patches are formed by the growth of the basidiome, which breaks the exoperidium, and lyses the hyphae. When dry, these patches turn blackish and granulose and are lost in some species. Guzmán and Tapia (1995) described *V. mexicanus* Guzmán et Tapia and *V. singaporensis* Guzmán et Tapia. Also they considered *Scleroderma pseudostipitatum* and *S. nitidum* as *Veligaster*. Cunningham (1942) presented *S. verrucosum* in the plate XV, fig. 2, with 2 basidiomata, which have a well developed stipe, covered in the upper part with a conspicuous veil, but he did not describe it. It seems that Cunningham' fungus is really *S. columnare*. Studying the authors Mexican specimens of *S. citrinum* and *S. verrucosum*, they found the veil-like blackish patches on the base of the sessile, globose basidiome, also on the upper part of the lacunose pseudostipe and on the globose apex. They concluded that in all the species of the genus these patches are formed by the growth of the basidiome. Then these patches have not taxonomic value. In this way *Veligaster* is a synonym of *Scleroderma*. Recent DNA studies (e.g. Sims et al., 1999; Binder and Bresinsky, 2002; Watling, 2006; Louzan et al., 2007) showed that *Veligaster columnaris* is a synonym of *Scleroderma columnare*.

Scleroderma Pers. emend Guzmán emend nov.
Scleroderma Pers., *Syn. Meth. Fung. 1*: xiv, 150, 1801.
= *Pompholyx* Corda, in Sturm., *Deutschl. Fl. (Pilze Deutschl.) III, 3(12)*: 51, 1834.
= *Phlyctospora* Corda, in Sturm., *Deutschl. Fl. (Pilze Deutschl.) III, 7(19-20)*: 51, 1841.
= *Sclerangium* Lév., *Ann Sci. Nat. Bot., sér. 3,9*:130, 1848.
= *Caloderma* Petri, *Malpighia 14*: 136, 1900.
= *Veligaster* Guzmán, *Mycologia 61*: 1117, 1969.
Generitypus: *S. verrucosum* (Bull.) Pers. (!).

After the synonymy of *Veligaster* with *Scleroderma*, which was based on the veil-like patches on the peridium which did not considered in the concept of *Scleroderma*, it is necessary to do an emendation, as follow. Those words in italics are new features or not clearly described before in the concept of the genus.

Basidiome leathery to very hard when dry, globose, subglobose, pyriform, sessile, pseudostipitate or with a well developed stipe, with a large basal compact mass of mycelium. Exoperidium thin or thick, dry, smooth, cracked, scaly or cover by small or large scales, frequently with *membranaceous veil-like or patches on the base of the globose basidiome or in the upper part of the stipe, also sometimes in the apex of the basidiome, formed by the basidiome growth which lacerates and lysis the hyphae. Endoperidium thin, with a membrane covering the gleba. Both exo- and endoperidium frequently rufescent.* Gleba subfleshy to leathery, compact, finally dusty, white, soon purple or dark grayish-brown or reddish-brown, at first with tramal plates, then with thin whitish or yellowish filaments. Dehiscence by cracking the apical part of the

basidiome, or through an irregular lacerated apical pore or stellated by tearing off all the peridium, in this latter case all the gleba is lost. Hymenium not developed. Capillitium absent. Basidiospores globose, thick-walled, yellowish-brown, echinulated, subreticulated or reticulated, when immature and subglobose, smooth, with a visible apiculus. Ornamentation meanly due to the nutrient cells (trophocysts) that cover all the surface of the young basidiospores, helping in its development; when the spores mature, these cells leave their walls on the surface of the spore (fig. 31). Basidia 4-6 (-8) spored, pyriform, sometimes claviform, thin or thick-walled, hyaline, discharging early the basidiospores in an immature stage. Odor and taste in general strong like rubber. Habitat on soil, rarely on rotten wood, *or on ferns stipes*, epigeous or hypogeous, ectomycorrhizic. Temperate, subtropical and tropical species.

Review of the taxonomic features in Scleroderma. Both macro- and microscopic features are important in the taxonomy of *Scleroderma*, although the latter, i.e. the basidiospores ornamentation and the clamp connections are the base of its classification, and the basidiospores structure and size are the key for the species determination, together with the peridium structure. Dehiscence type, presence of stipe, and peridium color are also important macroscopic features. It seems that the thickness of the basidium wall is also relevant, as well as its form, i.g. *S. texense*. Sometimes the wide of the hyphae of both endo- or exoperidium, and the thickness of their wall seem important. Presence or absence of clamps connections are very important. Chemical reactions on the peridium seem without taxonomic value, KOH stains brownish, brown, orange or reddish-brown, in a wide range of variation.

Classification of the genus and considered species. Based in the structure of the surface of the basidiospores, as well in the presence or absence of clamp connections, *Scleroderma* was divided by Guzmán (1967, 1970) in 3 sections: *Aculeatispora* Guzmán, with echinulated basidiospores and without clamps; *Sclerangium* (Lév.) Guzmán, with subreticulated basidiospores and common clamp connections; and Sect. *Scleroderma* with reticulated basidiospores and clamps. This classification had been accepted for several specialists, e.g. Phosri et al. (2009) through a phylogenetic study with molecular data stated that Guzmán's classification is natural. However, the names of 2 sections need to be changed, as stated above, because now *S. verrucosum* is the type of the genus, then it belongs to Sect. *Scleroderma* instead of *Aculeatispora*, and Sect. *Scleroderma* sensu Guzmán requires another name. We proposed here the new name *Reticulatae* Guzmán.

It is interesting to know, that Van Bambeke (1906) was the first specialist who studied the structure of the basidiospores in *Scleroderma*. He divided the genus in 2 groups, the reticulated spores group with *S. aurantium* (L.) Pers. and *S. bovista*, and that of the echinated spores without reticulum, with *S. cepa* and *S. verrucosum*. Regarding the considered species in the present paper, it is curious that *S. sinnamariense* Mont. that was reported from Mexico by Guzmán (1983, 2003) and Canseco-Zorrilla (2011) from tropical forests, seems absent. It was confused with *S. bermudense*. The same with the record of *S. stellatum* (Guzmán, 1983) which belongs to *S. bermudense*.

Key to the considered species.

1a. Basidiospores echinulated, neither subreticulated, nor reticulated. Without clamp connections (Sect. *Scleroderma*) 2
1b. Basidiospores subreticulated or reticulated. Clamp connections present (Sects. *Sclerangium* and *Reticulatae*) 8
2a. Exoperidium smooth to cracked, uniformly colored 3
2b. Exoperidium warty with small dark brown scales 5
3a. Basidiome stipitate. Peridium thin, velvety. Basidiospores (7-) 8-10 (-11) µm diam. Tropical species ..... *S. mexicana*
3b. Basidiome sessile. Peridium thin or thick, not velvety. Temperate or subtropical species 4
4a. Basidiospores (10-) 13-17 (-18) (-19) µm diam. Dehiscense by cracking the apical peridium or substelliform. Temperate species ..... *S. albidum*
4b. Basidiospores (7-) 8-13 (-14) µm diam. Dehiscense stelliform or by cracking the apical peridium. Temperate species ..... *S. cepa*
5a. Basidiome sessile or shortly stipitate. Basidiospores (9-) 10-15 (-18) µm diam. Temperate species ..... *S. areolatum*
5b. Basidiome pseudo- or stipitate 6
6a. Basidiome pseudostipitate. Basidiospores (8-) 9-12 (-14) µm

diam. Temperate or subtropical species ..... *S. verrucosum*
6b. Basidiome sessile or stipitate. Subtropical or tropical species 7
7a. Basidiospores (6-) 7-11 (-12) µm diam. Subtropical species..... *S. nitidum*
7b. Basidiospores (8.5-) 10-14 (-15) µm diam. Tropical and subtropical species..... *S. pseudostipitatum*
8a. Basidiospores subreticulated, reticulum thin and incomplete. Dehiscense stelliforme (Sect. *Sclerangium*)..... 9
8b. Basidiospores reticulated, reticulum thick, sometimes not uniform. Dehiscence by cracking the apical peridium or substelliform (Sect. *Reticulatae*) 11
9a. Small basidiome, 15-25 mm diam. Basidiospores (5-) 6-9 µm diam. In sand dunes, associate with *Coccoloba*, in the tropics ..... *S. bermudense*
9b. Large basidiome, 60-100 mm diam. Basidiospores (6-) 7-11 (-12) µm diam. On clay or sandy soils, temperate, subtropical or tropical species..... 10
10a. Peridium rough to cracked, whitish to grayish-yellow..... *S. polyrhizum*
10b. Peridium strongly scaly, whitish to yellowish or some orangish, with thick and folded scales..... *S. texense*
11a. Basidiospores up to 22 (-26) or 23 (-30) µm diam. Hypogeous or epigeous basidiomata..... 12
11b. Basidiospores up to 14 (-17) µm diam. Epigeous basidiomata 13
12a. Exoperidium smooth, slightly cracked or subscaly. Basidiospores (15-) (17-) 20-23 (-26) (-30) µm diam. Hypogeous or subhypogeous..... *S. hypogeoum*
12b. Exoperidium scaly or verrucose. Basidiospores (13-) 15-22 (-23) µm diam. Mainly epigeous ..... *S. michiganense*
13a. Exoperidium smooth to finely warty, whitish or yellowish-brown, with minute dark scales. Basidiospores with a uniform and thick reticulum..... *S. bovista*
13b. Exoperidium thick, coarsely scaly, scales in rosette in the apex or on the sides, yellowish to orange-yellowish. Basidiospores with a not uniform but thick reticulum ..... *S. citrinum*

Scleroderma albidum Pat. et Trab. emend. Guzmán, *Darwiniana 16*: 295, 1970.
= *Scleroderma albidum* Pat. et Trab., *Bull. Soc. Mycol. Fr. 15*: 57, 1899.
= *Scleroderma flavidum* Ellis et Eveh. f. *macrosporum* G. Cunn., *Trans. Proc. New Zeal. Inst. 62*: 117, 1931.
= *Scleroderma reae* Guzmán, *Ciencia (Méx.) 25*: 200, 1967 (!).
= *Scleroderma laeve* Lloyd emend. Guzmán, *Darwiniana 16*: 301, 1970 (!).
Figs. 1-3, 24-25

Basidiome (10-) 15-50 mm diam., globose or pyriform, sessile or shortly stipitate. Peridium thick, whitish to pale yellowish-brown, smooth to irregularly cracked on the apex. Dehiscence by irregular cracking on the apical peridium or substelliform. Gleba whitish to dark reddish-brown, with whitish and yellowish filaments. Context rubescent. Taste and odor like something rubber. Basidiospores (10-) 13-17 (-18) (-19) µm diam., echinulated, spines 1-2 (-3) µm high. Hyphae of endoperidium 2-17 µm wide, thin- to thick-walled. Oleiferous hyphae present in exoperidium. Clamp connections absent.

Taxonomic summary

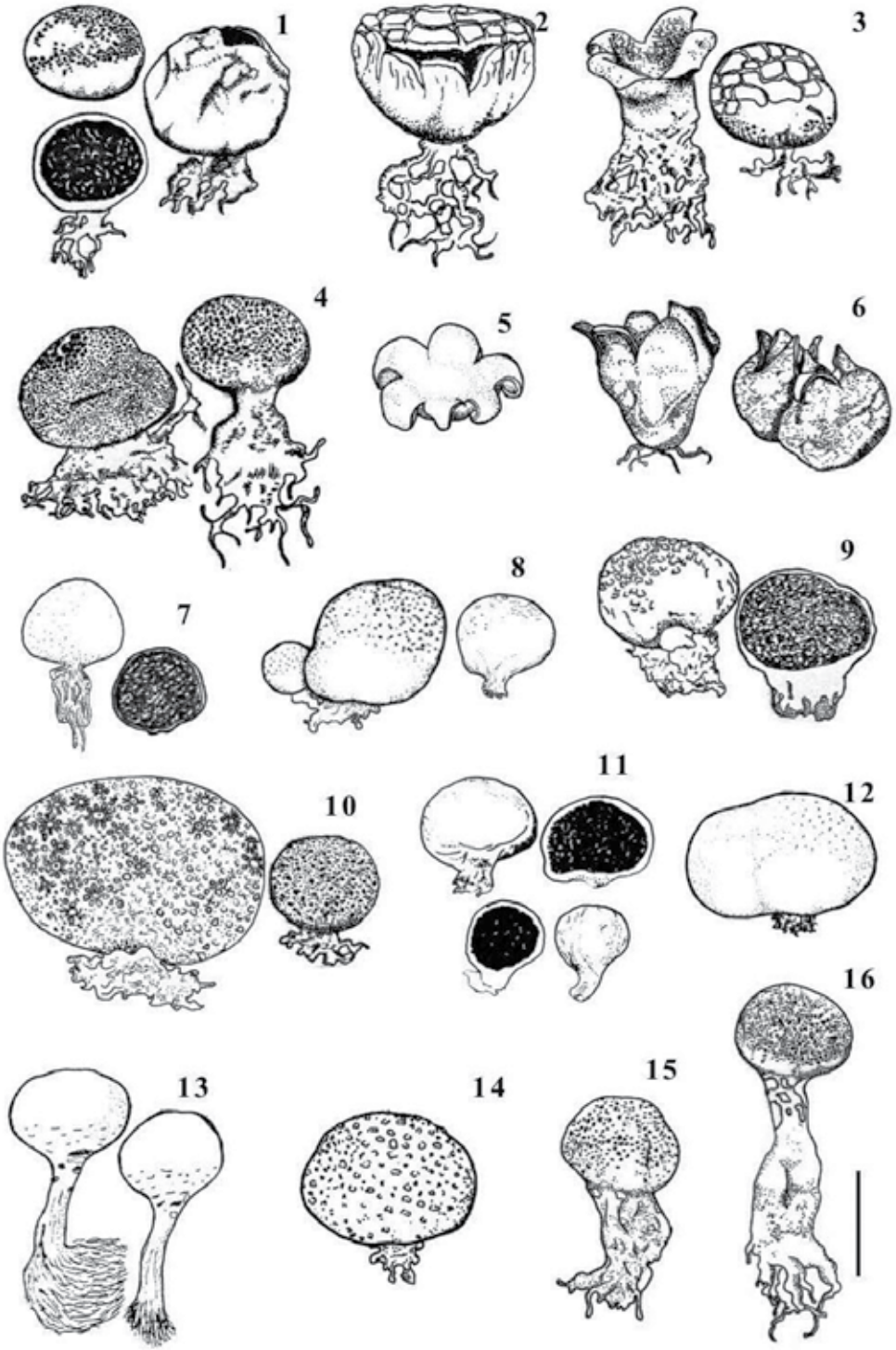
Habitat and distribution. Gregarious on soil, mainly in parks or *Eucalyptus* plantations or disturbed *Pinus-Quercus* forests. See table 1 for its distributions in Mexico. The collections from Chihuahua, Coahuila, and Durango are the first records from these regions.

Selected studied specimens. Baja California, region of Ensenada, 5 km E of Agua Viva, Dec. 10, 1983, *Ayala 227* (XAL). Coahuila, Monclova Municipality, Oct. 21, 1970, *Guzmán 17421* (XAL). Chihuahua, Barranca del Cobre, S of Creel, Aug. 18-19, 2004, *Guzmán 36028* (XAL). Durango, Biosphere Reserve La Michilia, near the Biological Station, Aug. 20, 1982, *Rodríguez 647* (XAL). Jalisco, Tequila Hill, July 30, 1983, *Rodríguez 143* (IBUG). Michoacán, Zitácuaro road to Morelia, near Mil Cumbres, Aug. 18, 1989, *Guzmán 29498* (XAL). Veracruz, Xalapa, Zona Universitaria, July 30, 2010, *Cortés-Pérez 285* (XAL).

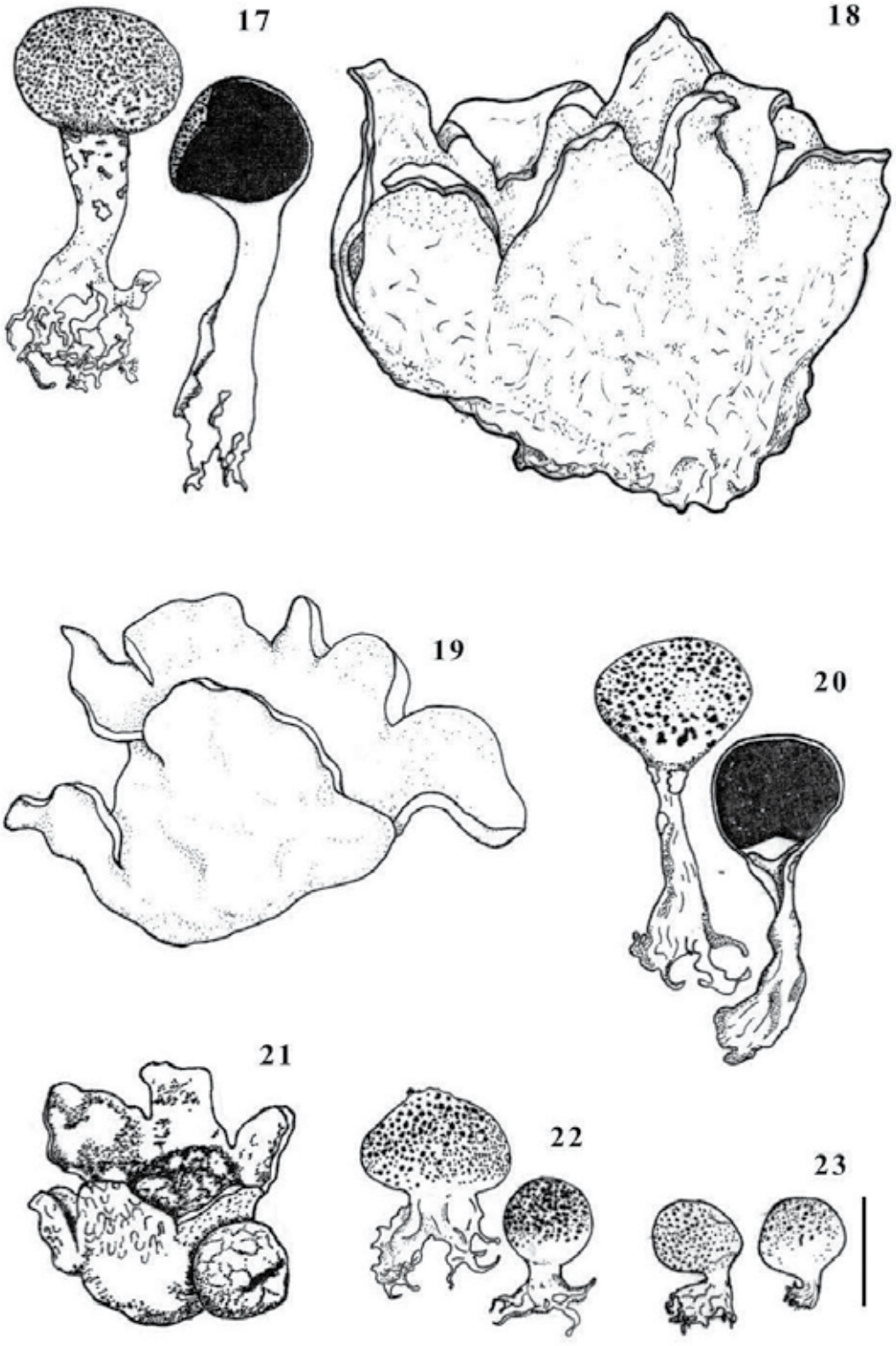
Remarks. This species was described by Patouillard and Trabut from Algeria (Patouillard, 1899). They described basidiospores 10-13 µm diam., but the type (at FH) presents basidiospores 10.5-17.5 µm diam. It seems that *S. albidum* is a southern hemispheric species, linked with *Eucalyptus*. Cortez et al. (2011) reported this species and *S. laeve* as common in Brazil below *Eucalyptus*. Here, we considered *S. laeve* and *S. reae* as synonyms because new observations on these fungi showed that there is not difference between them and *S. albidum* for the great variation of the basidiospores size, as well as the form of the basidiome.

Table 1. Species of *Scleroderma* from Mexico (in boldface valid species and new records).

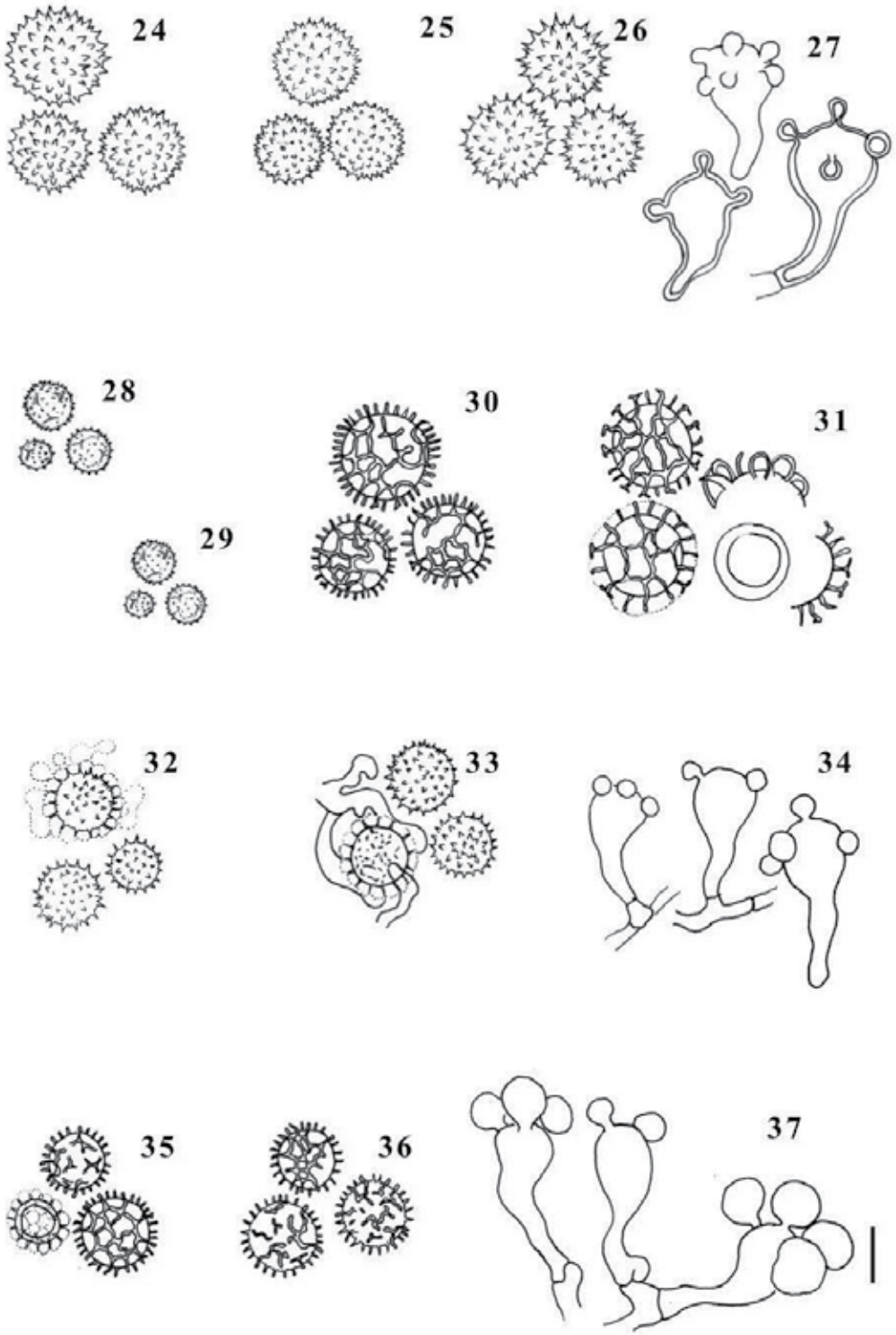
S. albidum	Aguascalientes, Coahuila, Chihuahua, Distrito Federal, Durango, Hidalgo, Jalisco, Michoacán, Morelos, Nuevo León, Quintana Roo, Sonora, State of Mexico, Veracruz (Guzmán and Herrera, 1969; Guzmán, 1970; Guzmán, 1977; Frutis and Guzmán, 1983; Guzmán-Dávalos and Guzmán, 1985; Herrera et al., 1989; Pérez-Silva et al., 1992; Esqueda-Valle et al. 2000; Pardavé-Díaz et al., 2006; Moreno et al., 2010; Cortés-Pérez, 2011).
S. arenicola	Distrito Federal, State of Mexico (Herrera, 1959).
S. areolatum	Aguascalientes, Chiapas, Chihuahua, Colima, Distrito Federal, Durango, Guerrero, Hidalgo, Jalisco, Michoacán, Morelos, Nuevo León, Oaxaca, Puebla, Quintana Roo, Sonora, State of Mexico, Tlaxcala, Veracruz (Herrera, 1959; Guzmán, 1970, 1977; Frutis and Guzmán, 1983; Guzmán-Dávalos and Guzmán, 1985; Garza et al., 1985; Urista et al., 1985; Herrera et al., 1989; Pérez-Silva et al., 1992; Cifuentes et al. 1993; Esqueda-Valle et al., 2000; Quiñones-Martínez and Garza-Ocañas, 2003; Herrera and Pérez-Silva, 2004; Moreno et al., 2010; Canseco-Zorrilla, 2011; Cortés-Pérez, 2011).
S. bermudense	Guerrero, Quintana Roo, Veracruz, Yucatán (Guzmán, 1983, 2003; Guzmán et al., 2004) (see *S. sinnamariense* and *S. stellatum*).
S. bovista	Hidalgo, Jalisco, Veracruz (Frutis and Guzmán, 1983; Guzmán-Dávalos and Guzmán, 1985; Cortés-Pérez, 2011).
S. cepa	Chihuahua, Distrito Federal, Durango, Guerrero, Hidalgo, Jalisco, Michoacán, Morelos, Nuevo León, Puebla, Sinaloa, Sonora, State of Mexico, Veracruz (Guzmán, 1970, 1977; De Ávila et al., 1980; Frutis and Guzmán, 1983; Guzmán-Dávalos and Guzmán, 1985; Urista et al., 1985; Herrera et al., 1989; Guzmán et al., 1997, Díaz-Barriga et al., 1998; Esqueda-Valle et al., 2000; 2011; Moreno et al., 2010; Cortés-Pérez, 2011).
S. citrinum	Aguascalientes, Chihuahua, Hidalgo, **Jalisco**, Michoacán, Puebla, State of Mexico, Veracruz (Fries, 1851; Guzmán, 1970, 1977; Pérez-Silva et al., 1970; Frutis and Guzmán, 1983; Herrera et al., 1989; Pardavé-Díaz et al., 2006; Cortés-Pérez, 2011).
S. fuscum	Veracruz (Guzmán et al., 1997; Cortés-Pérez, 2011). Synonym of *S. bovista*.
S. hypogaeum	Aguascalientes, **Chiapas**, Distrito Federal, Michoacán, Morelos, State of Mexico, Veracruz (Herrera, 1959; Guzmán, 1970, 1977; Guzmán et al., 1997; Díaz-Barriga et al., 1998; Pardavé-Díaz et al., 2006; Cortés-Pérez, 2011).
S. laeve	Morelos, Sonora, Veracruz (De Ávila et al., 1980; Esqueda-Valle et al. 2000; Moreno et al., 2010; Cortés-Pérez, 2011). **Now synonym of *S. albidum***.
S. mexicana	Chiapas (Guzmán and Tapia, 1995).
S. michiganense	**Jalisco**
S. nitidum	Campeche, Chiapas, Jalisco, Veracruz, **Yucatán** (Guzmán and Tapia, 1995; Fierros and Guzmán-Dávalos, 1995; Guzmán and Ovrebo, 2000; Herrera et al., 2005; Cortés-Pérez, 2011).
S. polyrhizum	**Chiapas**, Jalisco, **Michoacá**n (Guzmán-Dávalos and Guzmán, 1985).
S. pseudostipitatum	**Veracruz** (Guzmán et al., 1997; Cortés-Pérez, 2011).
S. reae	Sonora (Esqueda-Valle et al., 1995, 2000). **Now synonym of *S. albidum***.
S. sinnamariense	Oaxaca, Quintana Roo, Yucatán (Guzmán, 1983, 2003; Canseco-Zorrilla, 2011). The records from Guzmán (1983, 2003) belong to *S. bermudense*. That of Canseco-Zorrilla (2011) was not checked.
S. stellatum	Quintana Roo, Yucatán (Guzmán, 11983); Guzmán et al., 2004, these records belong to *S. bermudense*).
S. tenerum	Campeche (Herrera et al., 2005)
S. texense	Chiapas, Guerrero, Hidalgo, Jalisco, Michoacán, Morelos, Oaxaca, Puebla, Sinaloa, State of Mexico, **Veracruz** (Guzmán, 1970, 1977, 1998; Guzmán and García, 1973; Frutis and Guzmán, 1983; Guzmán-Dávalos and Guzmán, 1985; Herrera et al., 1989; Cifuentes et al., 1993; Nava-Mora and Valenzuela, 1997; Vázquez-Mendoza and Valenzuela, 2010; Canseco-Zorrilla, 2011; Cortés-Pérez, 2011).
S. verrucosum	Aguascalientes, Chiapas, Chihuahua, Guerrero, Hidalgo, Jalisco, Michoacán, Morelos, Nuevo León, Oaxaca, Puebla, San Luis Potosí, Sonora, State of Mexico, Veracruz (Guzmán, 1970, 1977; Frutis and Guzmán, 1983; Guzmán-Dávalos and Guzmán, 1985; Urista et al., 1985; Herrera et al., 1989; Cifuentes et al., 1993; Díaz-Barriga et al., 1998; Esqueda-Valle et al. 2000; Pardavé-Díaz et al., 2006; Moreno et al., 2010; Canseco-Zorrilla, 2011; Cortés-Pérez, 2011) (several records mixed with *S. nitidum*).
S. vulgare	Veracruz (Fries, 1851).



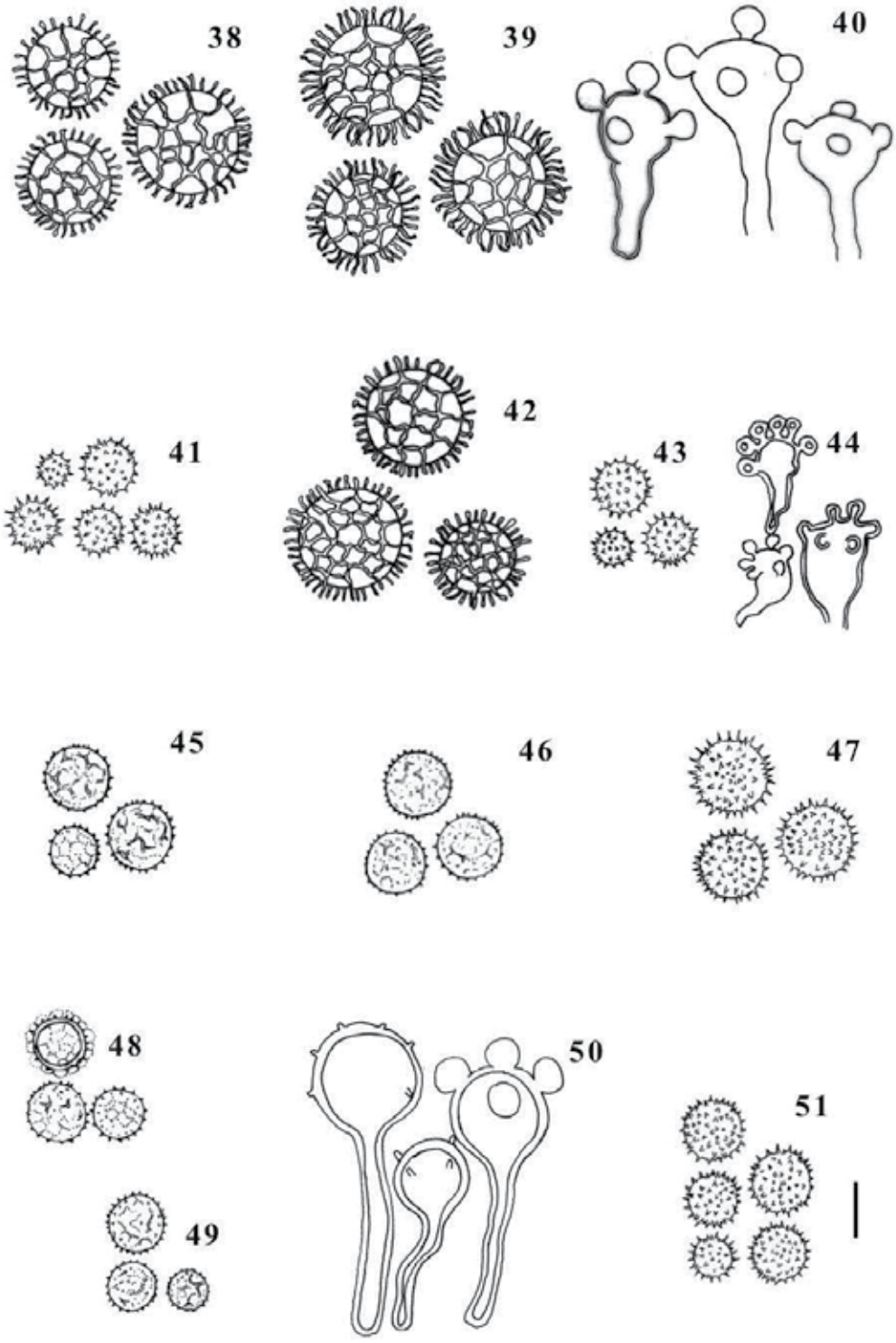
Figures 1-16. Basidiomata of several species of *Scleroderma*. 1-3, *S. albidum* (1, *Cortés Pérez 285*; 2, *Cortés Pérez 300*; 3, *Cortés-Pérez et Arias-Vergara 126*). 4, *S. areolatum* (*Cortés-Pérez 305*). 5-6, *S. bermudense* (5, *Guzmán 34475*; 6, *Guzmán 35528*). 7-8, *S. bovista* (7, *Rivera-Camacho s. n.*; 8, *Guzmán-Dávalos 9410*). 9, *S. cepa* (*Escalona 138*). 10, *S. citrinum* (*Cortés-Pérez 303*). 11-12, *S. hypogaeum* (11, *Guzmán 38484*, 12, *Guzmán 30516-B*). 13, *S. mexicana* (holotype). 14, *S. michiganensis* (*Ambriz s.n.*). 15-16, *S. nitidum* (15, *Cortés-Pérez 12*; 16, *Cortés-Pérez 391*). Scale= 20 mm.



Figures 17-23. Basidiomata of several species of *Scleroderma*. 17, *S. nitidum* (*Cortés-Pérez 278*). 18-19, *S. polyrhizum* (18, *Guzmán 30516-A*; 19, *Guzmán 32145-A*). 20, *S. pseudostipitatum* (*Gándara 1345*). 21, *S. texense* (*Cortés-Pérez 674*). 22-23, *S. verrucosum* (22, *Cortés-Pérez 266*; 23, *Cortés-Pérez 276*). Scale= 20 mm.



Figures 24-37. Basidiospores and basidia of *Scleroderma*. 24-25, *S. albidum* (24, *Murrieta-Armenta 18*; 25, *Cortés-Pérez 300*). 26-27, *S. areolatum* (*Cortés-Pérez 412*). 28-29, *S. bermudense* (28, *Guzmán 35528*; 29, *Guzmán 34475*). 30-31, *S. bovista* (30, *Rivera-Camacho s.n.*; 31, type of *Phlyctophora fusca*). 32-34, *S. cepa* (32, *Escalona 138*; 33-34, *Cortés-Pérez 313*). 35-37, *S. citrinum* (35, *Cortés-Pérez 171*; 36, *Cortés-Pérez 172*; 37, *Cortés-Pérez 331*). Scale= 10 µm.



Figures 38-51. Basidiospores and basidia of *Scleroderma*. 38-40, *S. hypogaeum* (38, *Guzmán 38504*; 39-40, *Guzmán 30516*-B). 41, *S. mexicana* (holotype). 42, *S. michiganense* (*Ambriz s.n.*). 43-44, *S. nitidum* (43, *Cortés Pérez 391*; 44, *Guzmán 33885*). 45-46, *S. polyrhizum* (45, *Guzmán 24608*; 46, *Puga s.n.*). 47, *S. pseudostipitatum* (*Gándara 1345*). 48-50, *S. texense* (48, *Cortés-Pérez 757*; 49, *Cortés-Pérez 700*; 50, *Cortés-Pérez 674*). 51, *S. verrucosum* (*Guzmán 38132*). Scale= 10 µm.

Scleroderma areolatum Ehrenb., *Sylv. Mycol. Berol. (Berlin) 15*: 27, 1818.
= *Scleroderma lycoperdoides* Schwein., *Schr. Naturf. Ges. Leipzig 1*: 61, 1822.
= *Scleroderma verrucosum* s. Guzmán, *Ciencia (Méx.) 25*: 199, 1967, non Guzmán, 1970.
Figs. 4, 26-27

Basidiome 15-30 mm diam., globose or pyriform, sessile or shortly pseudostipitate. Peridium thin, membranous when mature, yellowish-brown, with distinct inherent, small, very irregularly in form, dark brown or blackish scales. Dehiscence through an irregular, lacerate apical pore. Gleba whitish to dark reddish-brown. Context strongly rubescent. Taste and odor like rubber. Basidiospores (9-) 10-15 (-18) µm diam., echinulated, spines 1-3 (-4) µm high. Basidia 16-32 x 10-14 µm, 4-6 sterigmata, pyriform, hyaline. Clamp connections absent.
Taxonomic summary
Habitat and distribution. Gregarious, caespitose or fasciculated on soil, epigeous, in *Pinus-Quercus* forests. See in table 1 the distribution in Mexico.
Selected studied specimens. Chiapas, Tapachula region, near of Rancho Nuevo, Sept. 14, 1989, *Guzmán 29563* (XAL). Chihuahua, Barranca del Cobre, near Hotel Posada Mirador, Aug. 20-23, 2004, *Guzmán 36031* (XAL). Jalisco, Zapopan Municipality, Las Agujas, Instituto de Botánica gardens, Aug. 20, 1084, *Guzmán-Dávalos 1691* (IBUG); Santa Lucía road to El Guaje, Sept. 8, 2004, *Sánchez-Jácome 1055* (XAL). Tlaxcala, Huilapan, Sept. 2007, *Bonito 32476* (XAL). Veracruz, W of Xico, Cruz Blanca road to Rusia, Sept. 5, 2010, *Cortés-Pérez 412* (XAL).
Remarks. *Scleroderma areolatum* is close to *S. verrucosum*, only the size of the basidiospores separates both species.

Scleroderma bermudense Coker, *Mycologia 31*: 624, 1939.
= *Sclerangium bermudense* (Coker) D.A. Reid, *Kew Bull. 31*: 681, 1977.
= *Sclerangium bermudense* var. *trinitense* D.A. Reid, *Kew Bull. 31*: 681, 1977.
Figs. 5-6, 28-29

Basidiome 15-20 mm diam., reaching up to 30 mm diam. in dehiscence stage, globose, sessile. Peridium thick, up to 2 mm, whitish to yellowish, yellow or brownish, stained violaceous-red when cut, covered by a loosely woven pale outer coat mixed with sand. Dehiscense stelliform, with 4-6 branches, which in mature stage remains only as a plane star, chocolate-brown or yellow, thick peridium. Gleba grayish or reddish-gray. Taste and odor not reported. Basidiospores (5-) 6-9 µm diam., subreticulated, reticulum no so well formed, spines and reticulum 0.5-1.5 µm high. Clamp connections present.
Taxonomic summary
Habitat and distribution. Gregarious and hypogeous on sand, epigeous in the dehiscence, associate with *Coccoloba*, mainly *C. uvifera* (L.) L. Common in the Caribbean region including Mexico, but also in Pacific Ocean coasts and Gulf of Mexico.
Selected studied specimens. Guerrero, Ixtapa Zihuatanejo, Jun. 16, 1999, *Guzmán 32973.* Acapulco, Sept. 26, 2003, *Guzmán 35564* (XAL). Quintana Roo, N of Leona Vicario, Ecological Reserve El Edén, Nov. 1, 2000, *Guzmán 34475* (XAL). Veracruz, near highway Veracruz to Nautla, Biological Station of La Mancha, Aug. 20, 2003, *Guzmán 35528* (XAL). Yucatán, Dzilam to Telchac, near Chabian, Oct. 28, 1984, *Guzmán 24742* (XAL).
Remarks. Scleroderma bermudense was described by Coker (1939) from Bermuda Islands below *Coccoloba uvifera*. Reid (1977) considered this fungus as *Sclerangium bermudensis* and also described *S. bermudense* var. *trinitensis* from Trinidad Island. Guzmán (1970) considered *Scleroderma bermudense* as synonym of *S. stellatum*, but later, Guzmán et al. (2004) stated that *S. stellatum* from Brazil was an independent taxon, because it presents echinulated peridium, and for this reason was also known as *Caloderma echinatum* [= *Scleroderma echinatum*]. See also table 1.

Scleroderma bovista Fr., *Syst. Mycol. 3*: 48, 1829.
= *Scleroderma vulgare* var. *macrorrhizon* Fr., *Syst. Mycol. 3*: 47, 1829.
= *Scleroderma macrorrhizon* Wallr., *Fl. Crypt. Germ., Nürnberg 2*: 404, 1833.
= *Phlyctospora fusca* Corda, *in* Sturm*, Deutschl. Fl. (Pilze Deutschl.) III, 7(19-20)*:51, 1841.
= *Scleroderma fuscum* (Corda) E. Fisch. *in* Engl. et Prantl, *Nat. Pflanzenfam. I., Ab. 1***: 336, 1900 (!).
= *Scleroderma lycoperdoides* var. *reticulatum* Coker et Couch, *Gasteromycetes East. U.S. et Canada*, p. 170, 1928.
= *Scleroderma verrucosum* subsp. *bovista* (Fr.) Šebek, *Sydowia 7*: 177, 1953.
= *Scleroderma verrucosum* var. *fascirhizum* Šebek, *Sydowia 7*: 179, 1953.
= *Scleroderma citrinum* var. *reticulatum* (Coker et Couch) Guzmán, *Ciencia (Méx.) 25*: 204, 1967.
Figs. 7-8, 30-31

Basidiome 10-45 mm diam., globose or subpiriform, sessile or with a short pseudostipe or a short fasciculated base formed by compact mycelium. Peridium thick, whitish or pale yellowish-brown to dark brown, smooth to something verrucose with dark minute scales or cracked. Dehiscence through an irregular break of the apical part. Gleba white to dark reddish-brown, with yellowish

filaments. Context rubescent. Taste and odor like rubber. Basidiospores (10-) 11-13 (-15) (-18) µm, reticulated, reticulum 1-3 (-4) µm high, thick, some spines curved as remains of the nutritive cells (fig. 31). Clamp connections present.

Taxonomic summary

Habitat and distribution. Gregarious on soil, in *Pinus* and *Quercus* forests, frequently in grasslands. See its distribution in table 1.

Selected studied specimens. Jalisco, Zapopan Municipality, Zapopan, Hospital Ángel Leaño, Sept. 13, 1992, *Fierros 13* (IBUG); Santa Lucía road to El Guaje, Sept. 8, 2004, *Guzmán-Dávalos 9410* (IBUG); La Primavera, Sept. 16, 1989, *Ayala 5* (IBUG); Ixtlahuatlán del Río, Los Trejos, Nov. 24, 1980, *Rivera-Camacho s.n.* (IBUG, XAL); Volcán de Tequila, Jul. 21, 2001, *Ponce 10* (IBUG).

Remarks. Scleroderma bovista is an European and North American fungus, very rare in Mexico. It had been described in different ways, e.g. Coker and Couch (1928) reported the fungus s. Hollos, and described as *S. lycoperdoides* var. *reticulatum*, which is also *S. bovista*. Coker and Couch (1928) related *S. bovista* with *S. texense*, based in a collection from Lloyd. Šebek (1953, 1958) regarded *S. bovista* as *S. verrucosum* var. *bovista* and accepted *S. texense* and *S. columnare* as synonyms likewise, both that we consider here as independent species. *Scleroderma bovista* s. Dissing and Lange (1962) from Africa belongs to *S. sinnamariense. Scleroderma fuscum* by Fischer (1900) is *S. bovista*, which was described as *Phlyctospora fusca* (Corda, 1842). However, Corda's fungus was based in immature basidiomata with basidiospores completely surrounded by nutritive cells, as it was observed through the study of the holotype at K and the isotype at PC. In Mexico, *S. bovista* was recorded by Frutis and Guzmán (1983) and by Guzmán-Dávalos and Guzmán (1985). The former record was not review in the present paper, but the latter was studied, also other collections from Jalisco. It is curious the few records from Mexico of this fungus. *Scleroderma fuscum* reported by Guzmán et al. (1997) from Veracruz is *S. hypogaeum*.

Scleroderma bovista is related with *S. macrorrhizon* s. Guzmán (1967, 1970), which presents a long, lacunose pseudostipe. *Scleroderma macrorrhizon* is known as *S. meridionale* by Demoulin and Malençon (1970), and as *S. septentrionale* by Jeppson (1998). The former was described from the Mediterranean zone (Demoulin and Malençon, 1970). Later Demoulin (1974) compared *S. meridionale* with North American collections studied by Smith (1951) and Guzmán (1970) identified as S. *macrorrhizon*. Demoulin considered those specimens conspecific with *S. meridionale*, but with the Nordic European pseudostipitated forms as *S. bovista*. Also Demoulin regarded *S. vulgare* var. *macrorrhizon* (Fries, 1829) as *S. bovista* with pseudostipe. However, *S. macrorrhizon* by Wallrothio based in the study of the type by Demoulin, has not a real pseudostipe, only a mass of compact mycelium and basidiospores 10-13 µm diam., reticulated. This is the typical *S. bovista* here considered. Concerning the distribution of *S. bovista* in America, it is interesting that besides the records by Guzmán (1970) from USA (also as *S. fuscum*), it is know from Central and South America, 2 records from Costa Rica, one by Fries (1829) and other by Calonge et al. (2005). Cortez et al (2011) reported this fungus from Brazil, also as *S. fuscum*. Furthermore, Guzmán and Ramírez-Guillén (2010) reported *S. bovista* from Nepal.

Scleroderma cepa Pers., *Syn. Meth. Fung. 1*: 155, 1801.
= *Lycoperdon caepae-facie* Vaill., *Bot. Par. (Paris)*: 123, tab. 16:5-6, 1723.
= *Scleroderma flavidum* Ellis et Everh., *J. Mycol. 1(7)*: 88, 1885.
Figs. 9, 32-34

Basidiome 20-30 (-40) mm diam., but reaching up to 60 mm diam. in the dehiscence, globose or subpyrifirm, sessile or pseudostipitated. Exoperidium 1-2 mm thick, smooth to coarsely cracked, white, whitish or yellowish to orangish-yellow. Endoperidium whitish to yellowish. Dehiscence stellate, with 6-8 lobes or through an irregular cracker of the upper peridium. Gleba white to brown violaceous. Context frequently rubescent. Odor and taste sometimes like rubber. Basidiospores (7-) 8-13 (-14) µm diam., echinulated, spines 1-2 µm high. Basidia 18-25 x 8.5-10 µm, 4 sterigmata, pyriform, hyaline. Hyphae of the endoperidium 3-7 (-10) µm wide, thin-walled. Clamp connections absent.

Taxonomic summary

Habitat and distribution. Gregarious, but caespitose and fasciculated on soil, in parks and gardens, also in *Quercus*, *Pinus-Quercus* or in mesophytic forests. It is reported here for the first time from Baja California. See in table 1 the known distribution in Mexico.

Selected studied specimens. Baja California, Ensenada road to Ojos Negros, NE of Rancho Agua Viva, Feb. 29, 1984, *Ochoa 27* (XAL). Jalisco, NE of Tesistán, La Mesita, Sept. 11, 1998*, Rodríguez 2013* (IBUG). Veracruz, highway Xalapa-Veracruz, near El Lencero, Jun. 13, 2003, *Escalona 138* (XAL).

Remarks. This is a common European and North American species, known also from Australia (Cunningham, 1942). Its synonymy with *S. flavidum* was established by Guzmán (1970). However, Migliozzi and Coccia (1988), and Coccia et al. (1990) claimed that *S. cepa* is an independent species. They based their position in that in *S. cepa* the

basidiome is sessile and the dehiscence is not stelliform, besides the endoperidium presents narrow hyphae, versus *S. flavidum* which presents pseudostipitated forms, with stelliform dehiscence, and their hyphae of the endoperidium are thicker. Nevertheless, it seems that the *S. flavidum* they studied is really *S. albidum* for the size of the basidiospores, 12-16 µm diam. Calonge and Demoulin (1975), and Poumart (2003) accepted *S. flavidum* as a synonym of *S. cepa*. The color figure of Härkönen et al. (2003) and Calonge et al. (1997) as *S. verrucosum* from Tanzania, belongs to *S. cepa*, specimens which were study by Guzmán and Ramírez-Cruz in XAL.

Scleroderma citrinum Pers., *Syn. Meth. Fung. 1*: 153, 1801.
= *Scleroderma vulgare* Hornem., *Syst. Mycol. (Lundae) 3*: 46, 1829.
= *Pompholyx sapidum* Corda, *in* Sturm, *Deut. Crypt. Fl. 10-20*: 47, 1841.
Figs. 10, 35-37

Basidiome (20-) 40-80 (-100) mm diam., globose to ovoid, often apically flattened, sessile or shortly substipitate, with a compact mycelial base. Peridium 2-5 mm thick, tough, yellowish-brown to pale orangish-yellow, coarsely scaly, the scales frequently in rosette on the upper part or on the sides, also imbricate and squarrose on the sides, the exoperodium in the base of the basidiome and in the upper part of the pseudostipe breaks in submembranaceous or collapsed fragments, like patches, concolor to blackish, due to the lysing of the hyphae. Endoperidium whitish to yellowish, rubescent when cut. Dehiscence through an irregular apical breaking or substelliform, finishing as an irregular cup-like fruit body. Gleba white to dark vinaceous or purplish, compact, then dusty. Taste and odor like rubber. Basidiospores (9-) (10-) 11-14 (-17) µm diam., subreticulated to reticulated, reticulum 1-2.5 µm high. Basidia 14-30 x 7.5-10 µm, pyriform, thin-walled, hyaline, 2-4 (-6) sterigmata. Oleiferous hyphae present in both exo- and endoperidium. Clamp connections present.

Taxonomic summary

Habitat and distribution. Gregarious or caespitose, epigeous on soil or humus with mosses, sometimes on rotten wood. Common in coniferous forest or in *Pinus-Quercus* forests. See in table 1 its distribution in Mexico. The collections from Jalisco and Veracruz are the first records from these states.

Selected studied specimens. Jalisco, Tapalpa, Sept. 3, 1978, *García-Saucedo s.n.* (IBUG). Veracruz, Huayacocotla road to Viborillas, SE of Huayacocotla, Sept. 14, 2009, *Cortés-Pérez 170, 175*; Aug. 6, 2010, *Cortés-Pérez 303* (all in XAL).

Remarks. Scleroderma citrinum is one of the most common species in Europe, but infrequent in Mexico.

Scleroderma hypogaeum Zeller, *Mycologia 14*: 193, 1922.
= *Scleroderma arenicola* Zeller, *Mycologia 39*: 295, 1947, *non S. arenicola* s. Smith (1951).
= ? *Scleroderma patagonicum* Nouhra et Hernández-Caffot, *Mycologia 104*: 490, 2012.
Figs. 11-12, 38-40

Basidiome 15-30 mm diam., globose, regular or irregular, sessile or short and irregular pseudostipitate. Peridium 1-3 mm thick, smooth or finely subscaly, whitish to pale or dark yellowish-brown. Dehiscence through an irregular apical breaking or substelliform. Gleba whitish to reddish-brown. Context little rubescent. Taste and odor sometimes like rubber. Basidiospores (15-) (17-) 20-23 (-26) (-30) µm diam., reticulated, reticulum thick, reticulum and spines (1.5-) 2-4 (-5) µm high, some spines curved, as remain of the nutritive cells. Basidia 20-30 x 1-12 µm, 4 sterigmata, hyaline. Clamp connections present.

Taxonomic summary

Habitat and distribution. Gregarious in soil, hypogeous or subhypogeous, in coniferous forests, mesophytic forests with *Quercus*, and tropical forests, also probably in *Nothofagus* forests. See in table 1 its distribution in Mexico. One collection, *Guzmán 38589*, was found on the stipe of a fern tree (*Cyathea*) (see in **Discussion**).

Selected studied specimens. Chiapas, Tuxtla Gutiérrez, Botanical Garden F. Miranda, Sept. 17, 1992, *Guzmán 30516-B* (XAL). Veracruz, old road Xalapa to Coatepec, region of Zoncuantla, July 26, 2005, *Guzmán 36332* (XAL); July 2010, *Guzmán 38504* (XAL); Oct. 10, 2010, *Guzmán 38589* (XAL); July 13, 2012, *Guzmán 39174* (XAL).

Remarks. Scleroderma hypogaeum presents the bigger basidiospores in the genus. Its distribution in America is from NW of USA to Central America and probably to Patagonia. Calonge et al. (2005) reported it from Costa Rica. This species was described by Zeller (1922) from Oregon, USA, and later as *S. arenicola* by the same author (Zeller, 1947). The first record of *S. hypogaeum* from Mexico was by Herrera (1959) as *S. arenicola*, and then recorded by Guzmán (1970) as *S. hypogaeum*. *Scleroderma patagonicum* (Nouhra et al., 2012) described from Patagonia, Argentina, agrees well with *S. hypogaeum* in macro- and microscopic features, even in its hypogeous habitat; however, it was described with basidiospores (13-) 19-24 (-28) µm diam. It is necessary to study the type to confirm this synonymy, but it was impossible to get it.

Scleroderma mexicana (Guzmán et Tapia) Guzmán, *comb. nov.*
= *Veligaster mexicanus* Guzmán et Tapia, *Doc. Mycol. 25(98-100)*: 186, 1995.

Figs. 13, 41

Basidiome 10-26 mm diam., globose and stipitated, with the stipe 12-18 x 2-5 mm (all the sizes from dry specimens). Peridium thin, 1 mm thick, smooth to somewhat velvety, slightly areolate toward the base of the globose basidiome, pale yellowish to yellowish-brown, with vinaceous color stains. The upper part of the stipe and the base of the globose basidiome breaking into conspicuous dark reddish to blackish veil-like membranaceous patches, formed by lysis of the exoperidium hyphae. Endoperidium whitish. Dehiscence by cracking the apex peridium. Gleba fleshy to dusty, blackish-brown or grayish-violet. Context rubescent. Taste and odor unknown. Basidiospores (7-) 8-10 (-11) µm diam., echinulated, spines 0.8-1.5 µm high. Oleiferous hyphae present. Clamp connections absent.

Taxonomic summary

Habitat and distribution. Gregarious on soil, in a tropical rain forest. Known only from the type locality.

Selected studied specimens. Chiapas, road Ocozocuautla to Apic-Pac (Malpasado Dam), Laguna Bélgica Ecological Park, Oct. 12, 1992, *Palacios et Cabrera 2112* (isotype, XAL).

Remarks. Scleroderma mexicana is close related with *S. columnare* from Malaysia, but differs in the size of the basidiospores, (8-) 10-12 (-13) µm, with spines 1-4 µm high in that species (Guzmán, 1969). Also it is close to *S. pseudostipitatum*, even in the basidiospores size, but that presents the exoperidium verrucose-scaly like *S. areolatum* or *S. verrucosum*.

Scleroderma michiganense (Guzmán) Guzmán, *Darwiniana 16:* 356, 1970.

= *Scleroderma hypogaeum* var. *michiganense* Guzmán, *Ciencia (Méx.) 25:* 206, 1967.

Figs. 14, 42

Basidioma (20-) 30-40 (-60) (-80) mm diam., globose or pyriform, sessile or shortly pseudostipitate. Peridium thick, whitish to orangish-brown, verrucose-scaly with small, irregular plane or granulose scales, concolor or more brownish. Dehiscence unknown, probably by an irregular peridium cracking. Gleba white to dark brown, with thin brownish filaments. Basidiospores (13-) 15-22 (-23) µm diam., reticulated, spines and reticulum 0.8-2.5 µm high. Clamp connections present.

Taxonomic summary

Habitat and distribution. Gregarious on soil, in *Pinus* forests.

Selected studied specimens. Jalisco, Nevado de Colima, alt. 3000m, breach to Canadian Foundation, Nov. 7, 1992, *Ambriz s.n.* (IBUG).

Remarks. Here is presented the first record of *S. michiganense* in Mexico, which was only known from the NE of USA (Guzmán, 1970). The verrucose to scaly peridium and the little small basidiospores, separate this species from *S. hypogaeum*.

Scleroderma nitidum Berk., *Hooker's J. Bot. Kew Gard. Misc. 6*: 173, 1854.

= *Scleroderma tenerum* Berk. et M.A. Curtis, *in* Berkeley, *J. Linn. Soc., Bot. 10(46)*: 346, 1869.

= *Veligaster nitidus* (Berk.) Guzmán et Tapia, *Doc. Mycol. 25(98-100)*: 188, 1995.

Figs. 15-17, 43-44

Basidiome (15-) 20-25 (-30) mm diam., globose, sessile or sharply stipitate. Peridium thin, verrucose-scaly as in *S. areolatum* and *S. verrucosum*, and with the same color, intensely rubescent, mainly in the endoperdium to vinaceous-red. Stipe 20-40 (-50) x 0.5-20 mm, tough, cylindric, on upper part with irregular membranaceous veil-like or granulose, hyaline to blackish patches, as those described for *S. mexicana.* Dehiscence like in *S. areolatum* and *S. verrucosum*. Gleba whitish to dark purpuraceous or grayish-brown, with whitish or yellowish filaments. Taste and odor intensely like rubber. Basidiospores (6-) 7-11 (-12) (-13) µm diam., echinulated, spines 0.5-2 (-2.5) µm high. Basidia 13-19 (-20) x 6-10 µm, pyriform, thin- or thick-walled, with 4 or 6 sterigmata. Oleiferous hyphae sometimes present in both exo- and endoperidium. Clamp connections absent.

Taxonomic summary

Habitat and distribution. Gregarious, caespitose or fasciculated on soil, in tropical and subtropical forests, these later with *Quercus*. Pantropical. See table 1 for its distribution on Mexico.

Selected studied specimens. Jalisco, Sierra de Manantlán, Puerto del Escobedo, road to Las Cabañas, Aug. 30, 1995, *Sánchez-Jácome 750* (IBUG). VERACRUZ, Coatepec, near of Hacienda El Trianón, July 29, 2010*, Cortés-Pérez 278* (XAL); Zoncuantla, Mpio. Coatepec, July 30, 2006, *Guzmán 36516* (XAL). Yucatán, road Mérida to Telchac, 5 km SW of Conkal, Aug. 5, 1983, *Guzmán 23592* (XAL).

Remarks. Scleroderma nitidum had been interpreted in different ways since it was described by Berkeley (1854) from Nepal. Guzmán (1967) first considered this species as an independent taxon, but Guzmán (1970) synonymized it with *S. verrucosum*. The pseudostipe with submembranous blackish patches described above, were the main feature to consider this fungus as *Veligaster* by Guzmán and Tapia (1995). The type of *S. nitidum* at K comprises sessile and stipitate basidiomata, with basidiospores (8-) 9-11 (-13) µm diam., and it was collected in the eastern of Nepal, at 3000 m elevation. Guzmán and Ramírez-Guillén (2010) studied a Nepal's collection, found by Guzmán in a subtropical forest with *Quercus*, in Dhulikhel, also in the eastern of

that country, but at 1000 m elevation, with basidiospores (7-) 8-11 (-12) diam. The synonymization of *S. nitidum* with *S. tenerum*, a Cuban fungus, is without discussion, as stated by Guzmán and Tapia (1995) based in the study of the type at K, which has basidiospores (7-) 9-11 (-12) µm diam.

Scleroderma polyrhizum (J.F. Gmel.) Pers., *Syn. Meth. Fung. 1*: 156, 1801.
= *Lycoperdon polyrhizum* J.F. Gmel., *Syst. Nat., Edn 13, 2*: 1464, 1792.
= *Scleroderma geaster* Fr., *Syst. Mycol. 3*: 46, 1829.
= *Sclerangium polyrhizon* (J.F. Gmel.) Lév., *Ann. Sci. Nat., Bot., sér. 3, 9*: 130, 1848.
Figs. 18-19, 45-46

Basidiome 60-100 diam., globose, regular or irregularly, sessile. Peridium thick, 2-10 mm, smooth to rough or cracked, with cottony and fibrous mycelium and adhering soil, whitish to grayish yellow. Endoperidium whitish, probably rubescent. Dehiscence stelliform, with several recurved, thick lobes. Gleba grayish-brown to violaceous-brown, covered by a thin, cottony, white to dark brown membrane. Taste and odor probably like rubber. Basidiospores (6-) 7-11 (-12) µm diam., subreticulated, spines and reticulum 0.5-1 µm high. Basidia not observed. Clamp connections present.
Taxonomic summary
Habitat and distribution. Solitary or gregarious on soil, mainly sandy-clay soils, hypogeous when immature to epigeous in the dehiscence. Growing in *Quercus-Pinus* forests, also in tropical forests. See table 1.
Selected studied specimens. Chiapas, Tuxtla Gutiérrez, Botanical Garden F. Miranda, Sept. 17, 1992, *Guzmán 30516-A* (XAL). Jalisco, Concepción de Buenos Aires Municipality, 1975, *Puga s.n.* (IBUG, XAL). Michoacán, 6 km SW of Pátzcuaro, Joya de Navas, Aug. 15, 1997, *Guzmán 32145-A* (XAL).
Remarks. A common species in Europe, North of Africa and USA, but rare in Mexico, where it is only known from Chiapas, Jalisco (very common in this state, as reported Guzmán-Dávalos and Guzmán, 1985) and Michoacán. The records from Chiapas and Michoacán are new and it is presented the first report of this species in a tropical habitat. Some materials from Jalisco present larger basidiospores, (7-) 8-13 (-14) µm, which approach to *S. floridanum* Guzmán (1967, 1970), with basidiospores (9-) 10-13 (-16) µm diam. Probably *S. floridanum* grows in Mexico, but new studies are necessary in that species.

Scleroderma pseudostipitatum Petch, *Ann. R. Bot. Gards. Peradeniya 7*: 76, 1919.
= *Veligaster pseudostipitatus* (Petch) Guzmán et Tapia, *Doc. Mycol. 25(98-100)*: 191, 1995.
Figs. 20, 47

Basidiome aprox. 30 mm diam., globose but stipitate. Stipe about 45 x 10 mm (size based only in one Mexican specimen), well formed, solid. Peridium thin, 1 mm thick, rubescent, verrucose-scaly like that of *Scleroderma nitidum* and *S. verrucosum*, with submembranous, veil-like, blackish patches in the base of the globose basidiome and in the upper part of the stipe, as described in *S. mexicana*. Endoperidium rubescent. Gleba whitish to dark purpuraceous or grayish-brown, with whitish or yellowish filaments. Taste and odor intensely like rubber. Basidiospores (8.5-) 10-14 (-15) µm diam., echinulated, spines 1-2 (2.5) µm high. Clamp connections absent.
Taxonomic summary
Habitat and distribution. Gregarious on soil, in subtropical (mesophytic) forests with *Quercus* and *Fagus*. See table 1 for its Mexican distribution.
Selected studied specimens. Veracruz, Acatlán Volcano, outer slope of the volcano crater, July 13, 2005, *Gándara 1345* (XAL).
Remarks. Scleroderma pseudostipitatum is very close to *S. nitidum*, but it separates for the bigger basidiospores. It is also related with the pseudostipitated forms of *S. verrucosum*, which present the same size of basidiospores, but the stipe in *S. verrucosum* is not well formed because it is an aggregation of mycelium in a lacunose pseudostipe. The material reported by Guzmán et al. (1997) from Zoncuantla region in Veracruz as *S. pseudostipitatum* for its lacunose pseudostipe, it is now considered as *S. verrucosum*. In this way we are reporting here, together with Cortés-Pérez (2011) *S. pseudostipitatum* for the first time from Mexico. It is curious that the studied material, *Gándara 1345* (XAL) was found in a relict of a *Fagus grandifolia* var. *mexicana* (Martínez) Little. *Scleroderma pseudostipitatum* was only known from the type locality on Sri Lanka (Ceylon) by Petch (type at BPI and K studied by Guzmán, 1970).

Scleroderma texense Berk., *London J. Bot. 4:* 308, 1845.
= *Scleroderma patens* Lloyd, *Mycol. Writ. 2, Letter 22*: 275, 1906.
= *Scleroderma australe* var. *imbricatum* G. Cunn., *Proc. R. Soc. N.S.W. 56*: 282, 1931.
= *Scleroderma furfurellum* Zeller, *Mycologia 39*: 296, 1947.
Figs. 21, 48-50

Basidiome very similar to *Scleroderma polyrhizum*, except that the exoperidium is more yellowish or some orangish, strongly scaly in the adult stages, with large folded thick scales. Endoperidium rubescent. Gleba surrounded by a thin cottony and white layer. Taste and odor intensely like rubber. Basidiospores (6-) 7-11 (-12) µm, subreticulated , spines and reticulum up to 0.8 µm

high. Exoperidium with thick-walled or solid hyphae. Endoperidium with thin-walled hypae. Basidia (36-) 40-55 (-60) (-75) x (12-) 13-17 µm, 4- to 6- sterigmata, hyaline, claviform or subglobose, thick-walled, with a long narrow base. Clamp connections present.

Taxonomic summary

Habitat and distribution. Hypogeous to epigeous in soil, mainly orangish-red clay soils, in *Pinus-Quercus* forests in transition with tropical vegetation. Known from the SE of USA to Mexico and Guatemala, also in the Caribbean region, Africa, Southern Asia and Australia (Guzmán, 1970). Calonge (1982) reported this species from Spain as a rare fungus. We are recording *S. texense* for the first time from Veracruz, together with Cortés-Pérez (2011). See Mexican distribution in table 1.

Selected studied specimens. Jalisco, near of San Sebastián del Oeste, Sept. 12, 1987, *Guzmán-Dávalos 4018* (IBUG). State of Mexico, Valle de Bravo, Oct. 7, 2000, *Guzmán 34363* (XAL). Veracruz, region of Teocelo, Oct. 15, 2011, *Cortés-Pérez 757* (XAL).

Remarks. This is one of the most common species in Mexico in the subtropical regions with *Pinus* and *Quercus*. Several authors (e.g. Lloyd, 1905, in Lloyd 1898-1926) considered *S. texense* as a synonym of *S. polyrhizum*, others as Coker and Couch (1928), regarded *S. texense* as a synonym of *S. bovista*, without any argument. Šebek (1953) synonymized *S. texense* with *S. verrucosum*, together with *S. columnare*. The study of the type of *S. texense* at K (Guzmán, 1970), corroborated that it is a well-defined independent species.

Scleroderma verrucosum (Bull.) Pers., *Syn. Meth. Fung. 1*: 154, 1801.

= *Lycoperdon verrucosum* Bull., *Hist. Champ. France (Paris) 1*: 24, 1791.

= *S. verrucosum* s. Guzmán, *Darwiniana 16*: 276, 1970 p.p., non *S. verrucosum* s. Guzmán, *Ciencia (Méx.) 25*: 199, 1967.

Figs. 22-23, 51

Basidiome (20-) 25-30 (-45) mm diam., globose, shortly pseudostipitate. Peridium thin, membranaceous when mature, yellowish-brown, covered with small dark brown or blackish scales. Pseudostipe short, up to 15 mm long, solid, pale brownish, frequently lacunose, up 30 mm long, whitish to pale brownish. Basidiospores (8-) 9-12 (-14) µm, echinulate, with spines 0.5-2 µm high. Clamp connections absent. Other features as those in *S. nitidum* and *S. areolatum*.

Taxonomic summary

Habitat and distribution. Gregarious, sometimes fasciculated, epigeous on soil, in *Pinus-Quercus* or cloudy forests. Common in Europa and North America. See table 1 for the Mexican distribution.

Selected studied specimens. Jalisco, Zapopan Municipality, Santa Lucía road to El Guaje, Sept. 8, 2004, *Sánchez-Jácome 1078* (IBUG). PUEBLA, Techacapán Hill, Sept. 24, 1989, *Bandala 1794* (XAL). Veracruz, old road Xalapa to Coatepec, region of Zoncuantla, Oct. 1, 2008, *Guzmán 38095*; Jun. 21, 2009, *Guzmán 38132* (XAL).

Remarks. Scleroderma verrucosum is one of the most reported species in the genus, in part for its abundance, but also because several times specimens of *S. areolatum* and *S. nitidum* are erroneously determined. Smith (1951) mixed *S. verrucosum* with *S. lycoperdoides*, which is a synonym of *S. areolatum*. He described basidiospores (8-) 10-15 (-18) µm diam.

Discussion

Ecological observations and distribution. All species of *Scleroderma* have gregarious basidiomata, although sometimes they are caespitose or fasciculose. They are hypogeous or subhypogeous in immature stages to epigeous in the maturity where the basidiospores are expelled. However, some species, as *S. areolatum, S. cepa, S. citrinum* and *S. bovista* are epigeous even in the immature states. They grow on soil or sand, in this latter case in *S. bermudense* and *S. polyrhizum*, also in *S. hypogaeum* which is common in forests soils. *Scleroderma* is typical ectomycorrhizic with several trees or shrubs as *Abies, Betula*, *Coccoloba, Eucalyptus, Nothofagus*, *Pinus*, *Populus*, and *Quercus.* The tropical and subtropical species of *Scleroderma* as *S. columnare, S. hypogaeum, S. mexicana,* and *S. sinnamariense* are associated with Caesalpinaceae, Dipterocarpaceae, or Phyllanthaceae trees, among others. Some species as *S. citrinum* are apparently saprobes until they are able to find a suitable host (Sims et al., 1997; Giachini et al., 2000; Gurgel et al., 2008; Sanon et al., 2009). It is interesting to observe that one collection of *S. hypogaeum* was found in Veracruz (Zoncuantla) growing on the stipe of a tree fern [*Cyathea arborea* (L.) Sm.], at more than 1 m up the soil level, and *S. nitidum* several times inside of old flower clay vases in a garden forest with *Quercus*, which show the large extension of the mycelium. *Xerocomus parasiticus* (Bull.) Quél. is frequently reported in Europe as a parasitic fungus on *Scleroderma citrinum*; however, this case is unknown in Mexico. Guzmán (1970) reported a specimen of *S. floridanum* parasited with *Hypomyces chrysospermus* Tul. et C. Tul. We are recording now a *S. verrucosum* specimen (*Guzmán 38095*) parasited by an immature asexual state of *Hypomyces*.

Phylogenetic analyses in Scleroderma. One of the earlier works on the phylogenetic analyses on *Scleroderma* is that

by Hibbett et al. (1997), followed by Hibbett and Binder (2002), Binder and Hibbett (2006), and Louzan et al. (2007), which considered *Scleroderma* belong to Boletales together with other sclerodermataceous fungi, based mainly in ribosomal DNA (rDNA) sequences or in sequences of the mitochondrial protein genes (Kretzer and Bruns, 1999). Sims et al. (1999) studied the culture features (morphology and growth rate), isozyme variation, and rDNA restriction fragment length polymorphisms (RFLPs) in *S. citrinum*, *S. columnare*, *S. sinnamariense*, and *S. verrucosum* from Malaysia, Philippines, and Indonesia. Sanon et al. (2009) analyzes molecularly tropical sclerodermas. Phosri et al. (2009) made a phylogenetic study using the rDNA internal transcribed spacer (ITS) with *S. areolatum*, *S. bovista*, *S. cepa*, *S. citrinum*, *S. michiganense*, *S. polyrhizum*, *S. septentrionale*, *S. sinnamariense*, and *S. verrucosum* from the USA, Europe and Thailand, where they found that Guzmán's (1967, 1970) classification on 3 sections on the genus is natural.

Some ethnomycological observations. It seems that *Scleroderma* has not ethnomycological importance in Mexico, although sometimes basidiomata with dusty gleba, as *S. areolatum*, *S, nitidum*, and *S. verrucosum,* which people mixed with *Lycoperdon* spp., *Bovista* spp. and *Calvatia* spp. are used to stop the bleed from wounds. Guzmán (1997) reported the common names "zitlananácatl malo" and "jicamo real de venado" for *S. texense* and *S. verrucosum*, respectively, both as poisonous. Also he considered the name "papas de la tierra" for all the species. People in general considered all the species of *Scleroderma* as poisonous. However, De Ávila et al. (1980) reported *S. laeve* as edible in Morelos, but Cifuentes et al. (1993) stated that all species in Guerrero are toxic. Christensen et al. (2008) in a confused report, considered *S. sinnamariense*, *S. polyrhizum*, and *S. verrucosum* as edible in Nepal. Šebek (1953) reported young stages of *Scleroderma* used to adulterated truffles. McIlvaine and Murrill (cited by Stevenson and Benjamin, 1961) stated that the species of *Scleroderma*, specifically *S. aurantium*, are edible. There is the curious use of *Scleroderma* sp. (probably *S. cepa*, see discussion in that), in Tanzania, according to Härkönen et al. (2003), to avoid bees' stings, when collecting honey from honeycombs. The fungus is attached to a stick, set on fire and then pushed into a honeycomb. The smoke sedates the bees, so that honeycomb can be removed. Stevenson and Benjamin (1961) described a case of poisoning in the USA, where after eating *S. cepa*, stomach pains, nauseas, and muscular paralysis were presented, but after the person vomited he felt well. Also Guzmán through A.H. Smith got a communication of a poisoning event by *Scleroderma* in Canada observed by R.F. Cain. The Canadian specimen was determined by Guzmán as *S. cepa*. Coccia et al. (1990) considered that *S. citrinum* is poisonous. The only poisoning case by *Scleroderma* known in Mexico is by Ott et al. (1975) in San Miguel del Progreso, Oax., when they were experimenting on some narcotic lycoperdaceous fungi, and a person of the team ate *S. verrucosum*, who produced a poisoning with stomach pain and vomit.

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