

SPECIES OF *GEASTRUM* (BASIDIOMYCOTINA: GEASTRACEAE) FROM MEXICOEVANGELINA PÉREZ-SILVA¹, TEÓFILO HERRERA¹ & MARTÍN ESQUEDA-VALLE²¹Laboratorio de Micología, Instituto de Biología, UNAM. Apartado Postal 70-233, México, D.F., 04510.²Centro de Investigación en Alimentación y Desarrollo A.C., Apartado Postal 1735, Hermosillo, Sonora, 83000.

ABSTRACT

There are some publications on *Geastrum* from Mexico but not enough to integrate a monograph for the country. The present contribution lists the habitat and distribution of the species in Mexico and some outstanding aspects of their ecological relations. Scanning electron microscopy studies have been done to get more information on the fine structure of capillitium and spores of the Mexican specimens. The species reported herein are: *G. campestre*, *G. coronatum*, *G. fimbriatum*, *G. floriforme*, *G. fornicatum*, *G. javanicum*, *G. lageniforme*, *G. minimum*, *G. pectinatum*, *G. quadrifidum*, *G. saccatum*, *G. schweinitzii*, *G. triplex*, and *G. xerophilum*. Some aspects of their ethnomycological importance taken from the literature are indicated.

Key words: *Geastrum*, Gasteromycetes, taxonomy, distribution, ecological notes.

RESUMEN

ESPECIES DE *GEASTRUM* (BASIDIOMYCOTINA: GEASTRACEAE) EN MÉXICO. *Rev. Mex. Mic.* 15: pp-pp (1999). Se indican las especies del género *Geastrum* que han sido registradas de México, así como algunos datos sobre su morfología, hábitat y distribución. Se describen las características de las esporas y del capilicio de las especies estudiadas con base en observaciones en el microscopio electrónico de barrido. Las especies consideradas son: *G. campestre*, *G. coronatum*, *G. fimbriatum*, *G. floriforme*, *G. fornicatum*, *G. javanicum*, *G. lageniforme*, *G. minimum*, *G. pectinatum*, *G. quadrifidum*, *G. saccatum*, *G. schweinitzii*, *G. triplex* y *G. xerophilum*. Se indican algunos aspectos sobre su importancia etnomicológica con base en una revisión bibliográfica.

Palabras clave: *Geastrum*, Gasteromycetes, taxonomía, distribución, notas ecológicas.

Introduction

There are important publications dealing with the species of *Geastrum* from many regions of the world, most of them useful for the identification of the Mexican species. Some of these are: Lloyd (1902, 1907), Longnecker (1927), Coker & Couch (1928), Cunningham (1942), Long & Stouffer (1948), Smith (1951), Cejp *et al.* (1958), Dissing & Lange (1961), Dissing (1962a,b), Ponce de León (1968), and Sunhede (1989). The species of *Geastrum* have been cited frequently in publications on the macromycetes of Mexico (Herrera, 1964; Salcedo & Herrera, 1966; Guzmán & Herrera, 1969, 1973; Pérez-Silva, 1974; Guzmán, 1977; Frutis & Guzmán, 1983; Martínez-Alfaro *et al.*, 1983; Acosta & Guzmán, 1984; Esqueda-Valle *et al.*, 1990, 1995; Ochoa-Morales, 1993; Pérez-Silva *et al.*, 1994). Even though there are few papers treating specially on the genus in this country (Herrera, 1957; Pérez-Silva, 1974). Remarks on the taxonomic characters are indicated in the

present paper specially for the spores and capillitium observed under the SEM. The importance of the genus is briefly discussed. Data on distribution of the species of *Geastrum* in Mexico are included. The species are in alphabetical order and a key to them is presented.

Materials and methods

Dry specimens from several Mexican herbaria and fresh specimens were studied under conventional optical microscopes (OM), and under the scanning electron microscope (SEM). Fragments of gleba on the surface of adhesive tape strips were disposed on special cylinders or sample holders covered under vacuum conditions with a 300 Å gold or aluminium layer using an ionizer Jeol FG-100, and observed under a Jeol JSH-35C SEM.

Key to the mexican species of *Geastrum*

- | | | |
|----|---|------------------------|
| 1 | Mycelium subiculose, spread on the substratum. | 2 |
| 1 | Mycelium not subiculose | 3 |
| 2 | Surface layer of exoperidium velutinous splitting into 2 fibrous persistent layers | <i>G. javanicum</i> |
| 2 | Surface layer of exoperidium not splitting into 2 fibrous persistent layers | <i>G. schweinitzii</i> |
| 3 | Exoperidium surface covered with a mycelial layer intermixed with debris | 4 |
| 3 | Exoperidium surface attached only at the base of the gastrocarp | 10 |
| 4 | Peristome sulcate | 12 |
| 4 | Peristome not sulcate ± even | 5 |
| 5 | Spore sac sessile | 6 |
| 5 | Spore sac distinctly stalked | 7 |
| 6 | Basidiocarps hygrosopic | <i>G. floriforme</i> |
| 6 | Basidiocarps not hygrosopic | <i>G. fimbriatum</i> |
| 7 | Exoperidium fornicate | 8 |
| 7 | Exoperidium not fornicate, pseudofornicate or fornicate | 9 |
| 8 | Peristome determinate; spores 5-6 µm | <i>G. quadrifidum</i> |
| 8 | Peristome indeterminate; spores 3.5-5 µm | <i>G. fornicatum</i> |
| 9 | Peristome surrounded by a groove, exoperidium pseudofornicate | <i>G. coronatum</i> |
| 9 | Peristome not surrounded by a groove, exoperidium fornicate or not | <i>G. minimum</i> |
| 10 | Exoperidium surface felted, hyphae clampless; gastrocarp mainly saccate | <i>G. saccatum</i> |
| 10 | Exoperidium surface not felted, hyphae clamped; gastrocarp saccate, planar or arched | 11 |
| 11 | Gastrocarp 5-12 cm wide, subsaccate, usually with a pseudoparenchymatous collar beneath the endoperidium. | <i>G. triplex</i> |
| 11 | Gastrocarp 2-7 cm wide, saccate, usually without a pseudoparenchymatous collar beneath the endoperidium. | <i>G. lageniforme</i> |
| 12 | Exoperidium hygrosopic | <i>G. campestre</i> |
| 12 | Exoperidium not hygrosopic | 13 |
| 13 | Spore sac sessile, endoperidium surface furfuraceous | <i>G. xerophilum</i> |
| 13 | Spore sac stalked, endoperidium surface not furfuraceous | <i>G. pectinatum</i> |

Species description

Geastrum campestre (Morg.) Stanek, *Fl.*, **CSR**, **B-1**: 463, 1958.

= *Geaster campestris* Morg. *Amer. Nat.* **21**: 1026, 1887.

= *G. berkeleyi* Masee, *Am. Bot.* **4**: 79, 1891.

= *G. pseudomamosum* Henn., *Hedwigia* **39**: 54, 1900.

= *G. asper* Lloyd, *Geastrae* **18**, 1902.

Fig. 1.

Macroscopic characters: Gastrocarp 1.5-4 cm wide when expanded. Exoperidium splitting about the middle into 6-12 hygrosopic, equal, acute rays, spreading out when wet, involute or sometimes revolute when dry, frequently folding over or under the endoperidial sac. Mycelial layer persistent, covered with debris and umbilicate at the base. Fibrous layer thin, adherent, gray or whitish. Fleshy layer yellowish gray to dark brown, in old specimens frequently rimose, but continuous in young

specimens. Endoperidial sac subglobose or depressed globose, subsessile to short-pedicellate, whitish gray or yellowish brown, covered with minute and dense wart-like granules. Peristome small, conical, concolorous or often dark brown, acute or blunt, strongly sulcate in a well delimited zone. Gleba dark brown. Columella small, subspherical, persistent.

Microscopic characters: Spores globose, verrucose, 5-7 µm in diameter including ornamentation, chestnut brown, often with a stump of pedicel (Fig. 1). Capillitium threads 3-5 µm diam, pale yellowish, with thick walls, frequently tapering at the ends, scarcely branched, some of them flexuous.

Habit and habitat: Gregarious, in sandy soil with cow dung under *Prosopis juliflora*, and in tropical forest.

Distribution: Sonora: Hermosillo municipality, in a urban zone near a cattle barn, leg. M. Esqueda & R.E. Villegas (07.V.1993) CESUES 1580. San Javier municipality, Km 137 Hermosillo - Yécora road, leg.

A. Armenta, A. Núñez & R. Santos (02.VI.1996) CESUES 2754.

Gastrum coronatum Pers. **Syn. Meth. Fung.**, p. 132, 1801

= *G. multifidum* DC. **Fl. Fr.** 2: 267, 1805.

= *G. limbatum* Fr. **Syst. Mycol.** 3: 15-16, 1829.

= *G. atratum* Smarda, **Ces. Mykol.** 1: 71, 1947 (as *Geaster*).

Fig. 2.

Macroscopic characters: Gastrocarp 2.5-8 cm wide when expanded, mostly 3-5 cm. Exoperidium splitting to about the middle into 4-10 acute, unequal rays, not hygroscopic but sometimes involute or partially revolute. Mycelial layer incrustated with debris, eventually loosening from the fibrous layer remaining as a thin cup. Fibrous layer grayish white, papery. Fleshy layer whitish gray to dark brown, 3-4 mm thick. Endoperidial sac stalked, globose, subglobose, ovoid or subellipsoid, papyraceous, with a marginal rim or collar at the base (apophysis), dark brown or purplish, with a hoary sheen on the surface due to many glistening minute particles. Peristome flat or conical, more or less distinctly outlined by a groove paler than the remainder of the endoperidium. Gleba grayish to dark brown. Columella of varying shape, generally columnar, persistent or almost obsolete.

Microscopic characters: Spores spherical, 4-5 μm diam.; hilar appendage conspicuous, hollow, with radial ridges which are mixed with the ornamentation of the spore in the basal region. Episorium with or without coalescent processes 1 μm high; the surface between these processes with some bridge like connections and several granulations and scales, providing a pulverulent surface (Fig. 2). Capillitial hyphae 4-5 μm wide, smooth but often with remains of gleba.

Habit and habitat: Solitary, terrestrial, in mixed and tropical forest, and grasslands. 120-2900 m alt.

Distribution: **Chihuahua:** Guachóchic, Cabóráchi municipality, leg. E. Pérez-Silva *et al.* (25.VIII.1980) MEXU 16309. **Distrito Federal:** Desierto de los Leones, Cerro Tlapanco, leg. T. Herrera & M. Ruiz O. (16.II.1958) MEXU 1051, 23984. La Venta - La Marquesa, leg. M. Ruiz O. (13.VII.1958) MEXU 840. Milpa Alta, Cerro Tochuca, leg. T. Herrera & O. Sánchez (29.VII.1956) MEXU 1804. Cerro Cabezas, leg. T. Herrera, B. Lowy & M. Ruiz O. (01.VII.1962) MEXU 1403. Iztapalapa, Cerro de la Estrella, leg. T. Herrera & O. Sánchez (12.VIII.1956) MEXU 5778.

Hidalgo: Km 18 Pachuca - Tulancingo road, Calnali, leg. E. Pérez-Silva *et al.* (22.VI.1988) MEXU 21134. Parque Nacional El Chico, leg. A. Muñoz (29.X.1975) MEXU 9898. Las Ventanas, leg. Fontana de la Cruz (10.IX.1970) ENCB. Km 4 Huasca - San Miguel Regla road, leg. E. Pérez-Silva *et al.* (31.V.1981) MEXU 13874. **Jalisco:** La Primavera, Km 10 to San Isidro Mazatepec, leg. B. Corres (15.IX.1973) MEXU 24033. **Michoacán:** Estación El Zamorano, leg. F. García (X.1974) ENCB. **Morelos:** Tepoztlán, Tepozteco road, leg. G. Guzmán 5462 (12.X.1966) ENCB. **Oaxaca:** Oaxaca - Cuicatlán road, La Carbonera, leg. E. Pérez-Silva *et al.* (23.VIII.1976) MEXU 10484. **Quintana Roo:** Est. Exp. San Felipe Bacalar, leg. R.E. Chio 100 (23.VIII.1980) ENCB. **San Luis Potosí:** Alvarez, leg. C.R. Orcatt s/n (I.1925) ENCB. **Sonora:** Bacoachi municipality, Km 170 Mazocahui - Cananea road, leg. M. Esqueda & J. Jiménez (27.III.1993) CESUES 1255, MEXU 23986. **State of México:** Río Frío, SE of Telapón, leg. G. Guzmán 1545 (VII.1958) ENCB. Jilotzingo municipality, Km 13 detour to Tlazala, leg. E. Pérez-Silva *et al.* (28.VII.1984) MEXU 17979. Ocuilan municipality, Barranca de Ocuilan, leg. A. Estrada (21.VIII.1981) ENCB.

Gastrum fimbriatum Fr. **Syst. Mycol.** 3: 16, 1829 (as *Geaster*).

= *G. tunicatus* Vitt. **Monogr. Lyc.** 162, 1841.

= *G. infrequens* Lloyd, **Myc. Writ.** 2: 263, 1906.

Fig. 3.

Macroscopic characters: Gastrocarp 2-5 cm wide when expanded, mostly 3-4 cm. Exoperidium more or less saccate, sometimes plane or arched at the base, splitting to about the middle into 6-10 pointed, unequal rays, not hygroscopic, but frequently involute and sometimes partially revolute. Mycelial layer felted, whitish or yellowish, naked or incrustated by debris, persisting or flaking off. Fibrous layer thin, light brown, smooth. Fleshy layer whitish at first, dark brown with age, about 1-3 mm thick, tending to become rimose. Endoperidial sac sessile, globose or subglobose, 1-3.5 cm diameter, tan to dark brown, or blackish gray, apparently smooth but covered by protruding hyphae as seen under a lens. Peristome indeterminate, sometimes lighter than the surrounding endoperidial surface, finely fibrillose, flat or

mammiform, with fimbriate margin. Gleba fuscous brown. Columella club-shaped, evident or inconspicuous.

Microscopic characters: Spores in mass brown, 3.5-4.5 μm including ornamentation, under SEM epispore 1.4 μm thick, with claviform processes which are capitate with flat tips, coalescent in small groups of two or more forming irregular ridges, the processes near the hilar appendage more or less confluent and clustering in a rosette (Fig. 3). Capillitial hyphae 1.5-2 μm wide, wall more or less rugose, with or without remains of gleba. In young spores the processes of the ornamentation are very close and often with narrow bridges among them. These processes are loose in mature spores.

Habit and habitat: Solitary or gregarious, on soil in forest of *Quercus*, *Pinus-Quercus*, *Abies religiosa-pseudotsuga* and *Pinus hartwegii*.

Distribution. **Chiapas:** Km 18 Ocozocauitla - Malpaso road, leg. Gallegos Cupril 26 (07.IX.1979) FCME 10735. **Distrito Federal:** Desierto de los Leones, leg. E. Pérez-Silva *et al.* (14.X.1988) MEXU 23936. Contreras 3d. Dinamo, leg. G. Guzmán s/n (VII.1967) ENCB. **Durango:** Bosque de Chapultepec, S of El Salto, leg. G. Guzmán & S. de la Campa 3514 (20.IX.1961) ENCB. **Hidalgo:** Parque Nacional El Chico, El Cerezo, leg. M.T. Olvera 371 (17.X.1992) ENCB, leg. G. Rodríguez 2825 (18.IX.1963) ENCB. Las Ventanas, leg. G. Guzmán 1350, 17860 (22.IX.1979) ENCB, leg. I. Frutis 205 (12.X.1980) ENCB. Pueblo Nuevo, leg. E. Pérez-Silva & R. Lamothe (8.X.1975) MEXU 10082, 10035, leg. Marcet w/n (X.1974) ENCB. **Jalisco:** La Huerta municipality, Estación de Biología Chamela, leg. A. Solís & A. Pérez-Jiménez (01.X.1977) MEXU 11944. **Michoacán:** Pátzcuaro municipality, 2 Km SW Los Tanques, leg. Guzmán 18585 (15.VIII.1980) ENCB. **Morelos:** Lagunas de Zempoala, near the lake, leg. M. Ruiz O. (10.XI.1957) MEXU 154, leg. G. Guzmán 17827 (9.IX.1979) ENCB. **Nayarit:** Tepic-Mazatlán road, leg. R. Valenzuela 2493, leg. L. Guzmán-Dávalos 999 (6.IX.1993) ENCB. Sta. María del Oro, near the lake, leg. F. González Medrano (15.IX.1964) MEXU. **Nuevo León:** Galeana municipality, Cerro del Potosí microwave station road, leg. G. Guzmán 11177 (ENCB). **Puebla:** México - Puebla Federal road, leg. L. Gamboa (5.VIII.1979) MEXU 13751. Cerro Telapón, leg. T. Herrera, M. Ruiz O. (14.XII.1958) MEXU 880. Mesa de San Diego, El Jengibre, leg. R. Cruz Cisneros

1490 (01.XI.1966) ENCB. **Sonora:** San Javier municipality, Km 137 Hermosillo - Yécora road, leg. A. Armenta, A. Núñez & R. Santos (02.VI.1996) CESUES 2754. **State of México:** Km 14 Amecameca - Tlamacas road, leg. T. Herrera (16.VIII.1969) MEXU 22574, leg. M.T. Olivera 283 (26.IX.1982) ENCB. Nexcoalango, leg. T. Herrera (9.IV.1960) MEXU 21866, leg. E. Pérez-Silva (6.IV.1967) MEXU 5418, leg. Pineda R. 110-B (17.IX.1967) ENCB. Zoquiapan zone, Est. Inv. For. Univ. Agr. Chapingo, leg. E. Ortega s/n (10.X.1980) ENCB. Rancho Viejo, leg. González Velázquez 170 (30.IX.1984) ENCB. Jilotzingo municipality: Km 13 Tlazala road, leg. E. Pérez Silva *et al.* (28.VII.1984) MEXU 17989, leg. R. Vásquez (28.XI.1982) ENCB. Km 25.5 Temascaltepec road, leg. E. Pérez Silva *et al.* (23.IX.1984) MEXU 18305, 18352. México - Toluca road, Cola de Pato, leg. T. Herrera (23.IX.1956) MEXU 3150. Sultepec road, El Capulín, leg. González Velázquez 349 (19.X.1985) ENCB. Km 29 Naucalpan - Toluca road, Las Rajas, leg. A. Pérez Patraca 65 (15.VIII.1968) ENCB. Parque Nacional Miguel Hidalgo, La Marquesa, leg. 434 (IX.1962) ENCB, leg. M. Frías 4 (8.X.1967), L.G. Guzmán 21397 (13.XII.1981) ENCB, leg. Pérez Iniestra s/n (14.VII.1968) ENCB. Chalma road, near La Marquesa, leg. G. Guzmán 7063 (15.II.1969) ENCB. **Veracruz:** Catemaco - Monte Pío road, Balzapote, leg. S. Chacón 848, Valenzuela 901 (01.I.1982) ENCB. Minatitlán municipality, Coachapa river, leg. P. Ortiz 892 (7.VIII.1977) ENCB. Coatepec municipality, Alchichica, Tuzanapan Ejido, leg. G. Guzmán 19473 (2.VII.1971) ENCB. **Zacatecas:** Km 2 Juchipila - Guadalajara road, near Santa Rosa, leg. E. Fanti 316 (27.VIII.1982) ENCB.

Geastrum floriforme (Vitt.) Cunn. **New Zealand Journ. Sci. Tech.** 23: 172, 1942.

= *Geaster floriformis* Vitt. **Mon. Lyc.**, p. 23, 1842.

= *G. delicatus* Morg. **American Nat.** 21: 1028, 1887.

= *G. spegazzinianus* De Toni, **Revisio gen. Gast.** 19, 1887.

= *G. hungaricus* Hollos, **Gast. Ung.** 64, 1904.

= *G. simulans* Lloyd, **Lyc. Austr.** 17, 1905.

= *G. sibiricus* Pilat, **Bull. Soc. Myc. Fr.** 51: 423, 1935.

Fig. 4.

Macroscopic characters: Gastrocarp 1-5 cm wide when expanded mostly 2-4 cm. Exoperidium sacculiform or plane, umbilicate or rounded at the

base, splitting to the middle or a little more into 5-10 narrow, acute, strongly hygroscopic rays which are revolute over the endoperidial sac. Mycelial layer thin, whitish, with adhering sand debris, but soon disappearing. Fibrous layer smooth, grayish brown. Fleshy layer thin, persistent, very hard and cracked in age whitish to grayish, dark brown or blackish. Endoperidial sac sessile, globose, subglobose or depressed globose, almost smooth or somewhat furfuraceous. Peristome not distinctly delimited, more or less fibrillose, the mouth naked, slightly fimbriate when old. Gleba umber or brown. Columella of varying shape, generally columnar, persistent or obsolete.

Microscopic characters: Spores spherical, 4.5-5.5 μm diam. including ornamentation, which is composed of truncate or conical warts around 0.5 μm high, some of them coalescent at the tips, as observed under SEM. Capillitial hyphae thick-walled, smooth, but often with granular remnants of the gleba, 2-4 μm wide (Fig. 4).

Habit and habitat: Solitary or in small groups, in urban areas or semiarid mountains, under *Schinus molle*, grasslands, and *Yucca filifera* (Izote).

Distribution: **Distrito Federal:** Cerro de la Estrella, Iztapalapa, leg. T. Herrera & O. Sánchez (12.VIII.1956) MEXU 1052. **Sonora:** Altar municipality, 4 Km NE Altar, leg. H. Araiza 8 (XI.1968) ENCB. San Javier municipality, Km 137 Hermosillo - Yécora road, leg. A. Armenta, A. Núñez & R. Santos (02.VI.1996) CESUES 2766. **State of México:** Huixquilucan municipality, La Herradura, leg. G. Guzmán 22 (07.VII.1968) ENCB. Km 7 N of Zumpango, leg. J. Magaña 29 (23.VII.1968) ENCB. Sierra de Guadalupe, Sta. Isabel mountain, leg. T. Herrera & O. Sánchez (23.VI.1957) MEXU 4181.

Geastrum fornicatum (Huds.) Hook. **Fl. Londinensis** 4: 575, 1821.

= *Lycoperdon fornicatum* Huds. **Fl. Anglica** 2: 502, 1762.

= *G. quadrifidum* var. *fenestratum* (Batsch) Pers. **Syn. Meth. Fung.**, p. 133, 1801.

= *G. fenestratum* (Batsch.) Lloyd, **Myc. Writings** 7: 70, 1901.

Fig. 5.

Macroscopic characters: Gastrocarp 3-10 cm high, 4-8 cm across when expanded, fornicate at maturity. Exoperidium splitting very deeply mostly into 4 rays, but sometimes 5-6 rays are formed, the rays narrow

or broad, not hygroscopic, thick and rigid with the tips attached to the margin of the mycelial cup. Mycelial layer thick, whitish or light brown, persisting in the ground as a cup. Fibrous layer thin, turning brown in old specimens when the fleshy layer has peeled off. Fleshy layer thick, dark brown and hard in age, but remaining only partially on the fibrous layer. Endoperidial sac stalked, globose, depressed globose or urceolate, 1-3 cm across, at the base often with a distinct apophysis, light gray to blackish brown, when young covered by protruding hyphae and whitish minute crystals which generally disappear with age. Peristome not well delimited, but often fibrillose or silky and lighter than the rest of the endoperidium, the mouth is frequently white, fibrillose to lacerate, even mammiform or shortly tubular. Gleba dark brown. Columella well developed or inevident, when present several-shaped, from columnar to conical, rounded or club shaped.

Microscopic characters: Spores globose, 3.5-5 μm diam., sculptured with columnar processes 0.5 μm long, scattered on the surface, leaving free areas 0.3 μm wide. The spines of immature spores are confluent. Hilar appendage 0.6 μm diam. x 0.25 μm long (Fig. 5). Capillitial hyphae thick walled, with the surface slightly rugose often partially covered by remnants of gleba, 2-6 μm wide.

Habit and habitat: Gregarious, terrestrial, in tropical forest, urban zone under *Schinus molle*, and in mezquital or grassland.

Distribution: **Hidalgo:** Km 5 SW of Huichapan, leg. J. Acosta w/n (15.IV.1978) ENCB. **Sonora:** Bacoachi municipality, Km 146 Mazocahui - Cananea road, leg. M. Esqueda & J. Jiménez (27.III.1993) CESUES 1245, MEXU 23981. Baviácora municipality, 4 Km Baviácora - Aconchi road, leg. M. Esqueda & J. Jiménez (26.III.1993) CESUES 1222, MEXU 23980. Etchojoa municipality, Agiabampo, leg. R. Hernández (11.VII.1967) MEXU 5770. **State of México:** Naucalpan municipality, Cd. Satélite, leg. E. Pérez-Silva (07.IX.1986) MEXU 22479.

Geastrum javanicum (Lév.) Ponce, **Fieldiana: Botany** 31, 1968.

= *Geaster javanicus* Lév., **Ann. Sci. Nat.** 5(3): 161, 1846.

= *G. readeri* Cook et Masee, **Grev.** 16: 73, 1888.

= *G. velutinus* Morg., **Journ. Cinn. Soc. Nat. Hist.** 18: 38, 1895.

= *G. lloydii* Bres. et Pat. in Lloyd, **Myc. Writings** 1: 50, 1901.

= *G. saccatus* var. *walkeri* Coker et Couch, **Gast. E.U.S. and Canada** 113, 1928.

Fig. 6.

Macroscopic characters: Gastrocarp up to 6-8 cm wide when expanded. Exoperidium with a prominent umbilical scar at the base, splitting to about the middle into 4-8 not hygroscopic, flat, reflexed or revolute, and pointed rays. Mycelial layer thick, velvety or tomentose, easily splitting from the fibrous layer which remains adhered to the thin fleshy layer, the latter cream-colored or light brown when fresh, later becoming darker and rimose. Endoperidial sac sessile, globose or subglobose, papyraceous, light gray or brown, smooth or minutely tomentose. Peristome conical, fibrillose, light gray or brown. Gleba dark brown. Columella generally clavate, persistent or becoming obsolete.

Microscopic characters: Spores spherical, 3-4 μm diam.; epispodium with blunt columnar processes, 0.3-0.4 μm wide x 0.5 μm high; hilar appendage short, surrounded by spines which are \pm confluent in immature spores (Fig. 6). Capillitial hyphae 2-2.5 μm diam.; surface rough with remains of gleba.

Habit and habitat: In forest of *Abies religiosa* and *Pinus sp.* from 2,700 to 3,150 m alt.

Distribution: **Chiapas:** Finca Guatimoc, E of Tapachula, leg. G. Guzmán 522 (27.IX.1956) ENCB. Revolución Mexicana - Jaltenango road, leg. B. Gracia *et al.* 2 (22.IX.1983) ENCB. **Distrito Federal:** Desierto de Los Leones, leg. T. Herrera & O. Sánchez (05.X.1952) MEXU 3138, 6217. La Venta, leg. E. Pérez-Silva & R. Lamothe (20.XI.1961) MEXU 23982, leg. G. Guzmán 11999 (29.IX.1974) ENCB, leg. M. Ruiz O. (17.VIII.1958) MEXU 861. Cerro Tlapanco, leg. T. Herrera & M. Ruiz O. (16.XI.1958) MEXU 23983. Salazar, leg. T. Herrera (14.X.1955) MEXU 22576. **Guerrero:** Guerrero municipality, Km 4.5 Carrizal - Atoyac road, leg. M. Martínez (05.X.1960) FCME 1362. **Hidalgo:** Km 26 Zacualtípan - Molango road, leg. J. Cifuentes 447 (07.VII.1980) FCME 10422. **Michoacán:** Km 180 Zitácuaro - Morelia road, leg. G. Guzmán 22583 (09.IX.1982) ENCB. Puerto Garnica, leg. G. Guzmán 22695 (10.IX.1982) ENCB. **Morelos:** Km 54 Cuernavaca - México road, leg. C. Beutelspacher (24.X.1964) MEXU 2042. **Nuevo León:** Santiago municipality, El Cerrito, leg. R. Valenzuela 529 (12.X.1981) ENCB. **State of México:** Cerro Cabezas, leg. T. Herrera & O. Sánchez (30.IX.1956) MEXU 3176, 3108, 3158, leg. T. Herrera, M. Zenteno & R. Riba (01.X.1961) MEXU 1402. Salazar, leg. T.

Herrera & M. Zenteno (13.IX.1970) MEXU 7528, leg. González Morgado (17.XI.1967) MEXU 6001. El Zarco, leg. M. Gispert de Imaz (18.VIII.1963) MEXU 1825. Isidro Fabela municipality, Km 38 Ixtlahuaca - San Mateo Nopala road, in front of Centro Ceremonial Otomí, leg. E. Pérez-Silva (21.IX.1986) MEXU 23935. Amecameca - Paso de Cortés road, leg. T. Herrera & O. Sánchez (18.XI.1956) MEXU 3096, 33166. Tlalmanalco municipality, 3 Km SW of San Rafael, leg. Velázquez- Pérez 502 (29.IX.1974) ENCB. Parque Nacional Nevado de Toluca N of Toluca, Km 21 El Capulín, leg. González-Velázquez (19.X.1985) ENCB, leg. R. Valenzuela 350 (16.IX.1984) ENCB. Lagunas de Zempoala, leg. Ruiz Torres (11.IX.1974) ENCB. **Tabasco:** Comalcalco, Finca La Luz, leg. S. García w/n (19.IX.1962) ENCB. **Veracruz:** Coyame - Catemaco road (04.IX.1970) MEXU 9380. Huatusco road, near Fortín de las Flores, leg. G. Guzmán 16314 (07.VIII.1976) ENCB. 7 Km Minatitlán -Acayucan road, leg. A. López 1007, leg. G. Guzmán 17438 (13.VII.1978) ENCB.

Geastrum lageniforme Vitt. **Monogr. Lycoperd.**, p. 16, 1842.

= *G. capense* Thümen. **Mycotheca Universalis**, No 715, 1877 (as *Geaster*).

Fig. 7.

Macroscopic characters: Gastrocarp 2-7 cm wide when expanded, mostly 3-5 cm; unexpanded onion shaped or lageniform. Exoperidium not hygroscopic, splitting deeply into 5-10 often recurved rays, generally with long and slender tips, but the base remains saccate, arched or plane. Mycelial layer persistent, yellowish brown or whitish, smooth, longitudinally cracked on the rays. Fibrous layer thin, papery, grayish white. Fleshy layer light brown to dark brown or grayish, in age partially peeling off, 1-2 mm thick. Endoperidial sac sessile, globose or subglobose, 1-2 cm diam., smooth, light brown to dark brown or grayish. Peristome well delimited, sometimes almost flat or columnar, generally conical or mammiform, delicately fibrillose, often lighter than the endoperidial surface. Gleba yellow brown to dark brown. Columella generally club-shaped.

Microscopic characters: Spores globose, 3-4 μm diam. including ornamentation which is conformed by columnar processes with free tips, \pm convex, leaving free ornamented areas between them (Fig. 7). The immature spores have coalescent columns. The surface of capillitial hyphae with remains of

gleba, sometimes devoid of them; 2.5-3 μm wide.

Habit and habitat: In mixed forest with *Abies religiosa*, *Pinus* sp., *Pinus-Quercus*, *Quercus* spp., and in coffee plantations.

Distribution: Distrito Federal: Contreras, 4th Dínamo, leg. A. Muñoz Rivas (13.X.1975) MEXU 11148. Desierto de los Leones, leg. E. García 192 (17.VI.1972) ENCB, leg. L. Colón 442 w/d ENCB. **Guerrero:** Tierra Colorada municipality, Km 12 Villa Guerrero - Tloyolapa road, leg. S. Capello 264 (19.IX.1981) FCME 12369. Tixtla municipality, Km 29 Chilpancingo - Tlapa road, leg. A. Anda, FCME 1302. Chichihualco municipality, Km 4.5 Atoyac road, near El Carrizal, leg. M. Martínez (05.X.1980) FCME 1361. **Hidalgo:** Parque Nacional El Chico, between Pueblo Nuevo, leg. E. Pérez-Silva (08.X.1975) MEXU 10018, leg. D. Ramos Zamora 128 (06.X.1974). Molango, Laguna Atezca, leg. J. Cifuentes 666-B (09.VIII.1980) FCME 10548. **Morelos:** Huitzilac municipality, Laguna de Quila (18.IX.1988) MEXU 24000. Lagunas de Zempoala, leg. A. Amador w/n (01.VIII.1982) ENCB. Tepoztlán, Cerro del Tepozteco, leg. E. Pérez-Silva (20.09.1962) MEXU 1063. **Michoacán:** Puerto Garnica, leg. G. Guzmán 22625 (10.IX.1982) ENCB. **Nayarit:** Km 28.5 Tepic - Mazatlán road, leg. L. Guzmán-Dávalos *et al.* 1151, M. Palacios Ríos 467, G. Rodríguez 2705, S. Santillán 419 (06.IX.1983) ENCB. **Oaxaca:** Tuxtepec, Cerro Sebastopol, leg. A. López 695 (02.VIII.1977) ENCB. **Sonora:** Yécora municipality, 3.4 km Yécora - Las Cabañas way, leg. M. Esqueda *et al.* (12.IX.1996) CESUES 3247. **State of México:** Ocuilan municipality, Barrancas de Ocuilan, leg. A. Estrada 1207 (29.IX.1984) ENCB. Nexcoalango, leg. E. Pérez-Silva 09.IV.1960) MEXU 1400. Salazar, leg. E. Vegas Rojas (13.X.1966) MEXU 22578. E. Pérez-Silva (01.X.1976) MEXU 11229. Llanos de Acopilco, leg. R. Alatorre & I. Cid del Prado (26.II.1970) MEXU 7466. Temascaltepec, leg. E. Pérez-Silva (23.IX.1962) MEXU 18352. Isidro Fabela municipality, Km 62 Protimbos, leg. E. Pérez Silva (27.VIII.1989) MEXU 22091.

Geastrum minimum Schw. **Syn. Fung. Carol.** 58, 1822

= *Geaster marginatus* Vitt. **Monogr. Lyc.** 163, 1842.

= *G. cesatii* Rabenh. **Bot. Zeit.** 9: 628, 1851.

= *G. granulatus* Fuckel, **Enumerat.** 41, 1860.

Fig. 8.

Macroscopic characters: Gastrocarp 1-4 cm wide when expanded. Exoperidium not hygrosopic,

splitting to about the middle into 5-9 acute, subequal rays which often become recurved or remain in both horizontal and vertical positions. Mycelial layer whitish brown, persistent, attached to the fibrous layer or loosening as a cup in the substratum. Fibrous layer very thin, yellowish white or grayish. Fleshly layer white, pale yellow or dark brown, in age rimose, partially peeling off, 1-2 mm thick. Endoperidial sac with a short pedicel, globose, subglobose, ovate or pear-shaped, 0.5-1 cm diam., grayish brown, generally with apophyses, smooth or minutely granulose by the presence of white crystals. Peristome well delimited, subconical, bordered by a ring, concolorous with the endoperidial surface but often darker or lighter, delicately fibrillose. Gleba ferruginose to dark brown. Columella cylindrical or club shaped, small or obsolete.

Microscopic characters: Spores in mass brown, slightly equinulated; under SEM epispore with columnar processes, 0.7 x 0.9 μm diam., radially distributed from the basal side, with a granular surface between columns; hilar appendage inconspicuous, short, 0.75 μm wide (Fig. 8). Capillitium smooth often with remains of gleba, 1.5 - 1.8 μm diam.

Habit and habitat: Solitary, terrestrial, in mixed forest.

Distribution: Distrito Federal: Mexico City, ENCB campus, leg. V. González 37 (IX.1970) ENCB. **Durango:** La Michilía, leg. L. Guzmán Dávalos 401 (18.VIII.1982) ENCB, Km 32 Cuéncame - Fresnillo road, leg. G. Rodríguez 803, 804 (26.VIII.1982) ENCB, near Luis Moya, leg. E. Fanti 284 (23.VIII.1982) ENCB. **Hidalgo:** Parque Nacional El Chico, Las Ventanas, leg. I. Mendoza 5 (09.VI.1968) ENCB. **Morelos:** Lagunas de Zempoala, leg. J. Vargas 4 (18.VI.1967) ENCB. Km 17 Cuernavaca - Yautepec road, leg. F. Juárez 5 (30.VI.1968) ENCB. **Puebla:** Km 69 México - Puebla Federal road, leg. L. Gallegos 57 (VII.1967) ENCB. **Sonora:** La Colorada municipality, Km 100 Hermosillo - Yécora road, leg. M. Esqueda *et al.* (02.VII.1997) CESUES 3296. Pitiquito municipality, La Inmaculada ranch, leg. C. Valenzuela (17.IV.1993) CESUES 1267, MEXU 23972. San Javier municipality, Km 137 Hermosillo - Yécora road, leg. M. Esqueda *et al.* (26.XI.1995) CESUES 2344a. Km 151 Hermosillo - Yécora road, leg. M. Esqueda *et al.* (14.X.1995) CESUES 2142. **State of México:** Parque Nacional Miguel Hidalgo, La Marquesa, leg. M. Alcocer 3 (16.VI.1968). Río Frio: Km 52 Federal road, leg. A. Ríos 7 (IX.1967),

leg. G. Guzmán 2437 (23.VII.1960), leg. F. Brizuela 650 (15.XI.1970) ENCB. Tlalnepantla municipality, Tenayuca, edge of Tlalnepantla river, Acueducto Ave., leg. Montellana 11 (23.VI.1968) ENCB. Toluca-Querétaro road, near El Jazmín, N of Acambay, leg. G. Guzmán 9325 (ENCB).

Geastrum pectinatum Pers. **Syn. Meth. Fung.**, p. 132, 1801

= *Geaster plicatus* Berk. **Ann. Nat. Hist.** 3: 399, 1839.

= *G. tenuipes* Berk. **Fl. Tasm.** 2: 264, 1860.

Fig. 9.

Macroscopic characters: Gastrocarp 2-10 cm wide when expanded, mostly 4-8 cm. Exoperidium not hygroscopic, splitting into 6-10 subequal, acute, expanded, incurved or recurved rays, with the central region convex above elevating the endoperidial sac. Mycelial layer persistent, well developed, strongly encrusted with debris. Fibrous layer very thin, whitish to brown or gray. Fleshy layer thin to about 1 cm thick, not rimose, grayish white to brown. Endoperidial sac globose, subglobose, depressed globose or urceolate, 1-3 cm diam., gray or brown, with a prominent slender stalk up to 1 cm long which frequently continues into a prominent often plicate or striate apophysis. Peristome generally broad conical or long and slender conical, plicate and strongly sulcate, pale to dark brown, well or indistinctly delimited from the surrounding endoperidial surface. Gleba chocolate brown. Columella well developed or rudimentary.

Microscopic characters: Spores in mass brown, finely echinulate; under SEM columnar processes can be observed, up to 0.5 μm high, with granular surface between them, radially distributed from the hilar appendage, some of the columns are confluent (Fig. 9). Pedicels very short, 1 μm wide. Capillitial hyphae 3.5 μm wide, with sculptured surface and remains of gleba.

Habit and habitat: Solitary or gregarious, terrestrial, under *Prosopis juliflora*, *Lophocereus schottii*, *Schinus molle*, *Pinus*, *Abies* and *Juniperus* forests.

Distribution: **Distrito Federal:** Viveros de Coyoacán, leg. A. Calderón (01.X.1986) MEXU 20140. Contreras, leg. A. Gómez-Flores & P. Vilchis-López (1976) MEXU 11488. **Hidalgo:** Parque Nacional El Chico, leg. Huacuja *et al.* (12.IX.1976) FCME 422. 3 Km N of Jalpa, leg. F. Brizuela 560 (12.IX.1970) ENCB. **Michoacán:** Mil Cumbres, Puerto Garnica, leg. G. Guzmán 22648 (10.IX.1982)

ENCB. **Nayarit:** Km 28.5 Tepic - Mazatlán road, leg. G. Rodríguez 2700, R.E. Santillán 417 (06.IX.1983) ENCB. **Sonora:** Baviácora municipality, 4 Km Baviácora - Aconchi road, leg. M. Esqueda & J. Jiménez (26.03.1993) CESUES 1227, MEXU 23971. Hermosillo municipality, Centro Ecológico de Sonora, leg. A. Búrquez & A. Quijada (19.XII.1990) MEXU 23585. Yécora municipality, Km 204.5 Hermosillo - Yécora road, leg. M. Esqueda *et al.* (13.IX.1996) CESUES 2951. **State of México:** Iztaccihuatl, Diamantes falls, leg. S. Toda-Watanabe (24.07.1960) MEXU 1401. Km 15 Amecameca - Tlamacas road, leg. R. Hernández, E. Pérez-Silva & E. Aguirre (08.VIII.1977) MEXU 12128, leg. T. Herrera (18.XI.1956) MEXU 1803, Km 56, leg. Piedras-Enciso (30.VI.1967) ENCB. Llano Grande, S of Telapón, leg. Pérez-Ramírez 121 (23.VI.1979) FCME 704, leg. J. Cifuentes 117 (06.VII.1979) FCME 846. Río Frío, leg. V. Peláez (06.IV.1976) FCME 425. Ciudad Satélite, leg. R. Lamothe (08.IX.1991) MEXU 23985. **Tlaxcala:** Cerro Cuatlapanga, near San Antonio Cuaxomulco, leg. E. Hernández, F. Miranda & R.T. Clausen (26.III.1949) MEXU 871.

Geastrum quadrifidum Pers. **Syn. Meth. Fung.**, p. 133.

= *Lycoperdon coronatum* Scupoli. **Flora Carniolica ed. 2, II:** 490, 1772.

Fig. 10.

Macroscopic characters: Gastrocarp small to medium or large sized, 4-7 cm high, 2-8 cm wide when expanded, splitting to beyond the middle into 4-5 rays. Exoperidium not hygroscopic, typically fornicate, with the mycelial layer whitish remaining as a conspicuous cup which holds the tips of the rays at the border, strongly encrusted with debris. Fibrous layer thin, grayish white, remaining attached to the fleshy layer which is pale brown at first, dark brown and partially peeled off in old specimens. Endoperidial sac subglobose, depressed or urceolate, 0.5-1.5 cm diam., light gray to dark brown, pruinose in young specimens, smooth in age, short stalked, usually with an apophysis above the stalk which is 1-3 mm high. Peristome well delimited, conical, mammiform or tubular, silky fibrillose, concolorous or lighter than the endoperidial surface. Gleba ferruginous or chocolate brown. Columella well developed or rudimentary.

Microscopic characters: Spores in mass brown, 4 μm diam. including ornamentation; under SEM

conical processes can be observed, up to 0.5 μm high; the surface between columns rugose in immature spores; verrucae confluent forming ridges; hilar appendage short (Fig. 10). Capillitial hyphae 1-2 μm wide, with sculptured surface and remains of gleba.

Habit and habitat: Terrestrial, in grasslands.

Distribution: **Chiapas:** Km 18 Ocozocuautila - Malpaso road, leg. C. Gallegos 27 (02.IX.1979) FCME 10729. **Sonora:** Arizpe municipality, Km 122 Mazocahui - Cananea road, leg. M. Esqueda & J. Jiménez (27.03.1993) CESUES 1234, MEXU 23973. Bacoachi municipality, Km 146 Mazocahui - Cananea road, leg. M. Esqueda & J. Jiménez (27.03.1993) CESUES 1246, MEXU 23974.

Geastrum saccatum (Fr.) Fischer, *Nat. Pflanz.* 2(7): 73, 1933

= *Geaster saccatus* Fr. *Syst. Myc.* 3: 16, 1829.

Fig. 11.

Macroscopic characters: Gastrocarp 2-5 cm wide when expanded. Exoperidium generally saccate, splitting to beyond the middle into 6-8 acute, subequal rays, not hygroscopic, expanded, involute, reflexed or revolute. Mycelial layer thick, free of debris, sometimes with longitudinal cracks, peeling off or persisting in age. Fibrous layer thin, grayish white. Fleshy layer thick, whitish brown in age, peeling off or persistent in old specimens. Endoperidial sac sessile, globose or subglobose, 0.6-2.5 cm, papyraceous, almost smooth, whitish or light brown. Peristome generally well delimited, mammiform or conical, in some specimens almost flat. Gleba pale to dark brown. Columella indistinct or well developed, rounded, claviform or cylindrical, light colored.

Microscopic characters: Spores spherical, 3-4 μm in diameter including the ornamentation, which consists of columnar processes 0.5-0.8 x 0.5 μm , some of them confluent when young; hilar appendage short, 0.3 μm long x 0.5-0.7 μm in diam (Fig. 11). Capillitial hyphae 1.5-3.0 μm wide, with the surface smooth or ornamented and generally with some remains of gleba.

Habit and habitat: Hypogeous early in development, emerging after development, growing in soil from tropical forest to mixed coniferous forest, solitary or gregarious. This is the most commonly found species in autumn, 1780 -3000 alt.

Distribution: **Baja California Sur:** Sierra de La Laguna, leg. J. L. León 6002 (27.IX.1992) MEXU 23781. **Coahuila:** Alazanas municipality, La Siberia,

leg. G. Guzmán 10751 (22.IX.1972) ENCB. **Chiapas:** San Cristóbal de las Casas, leg. T. Herrera & J. Trappe (16.VII.1972) MEXU 8559. **Chihuahua:** 20 Km NW of Chihuahua, leg. P. Huerta w/n (20.VIII.1972) ENCB. **Distrito Federal:** Cañada de Contreras, 4th. Dinamo, leg. M. Medina Cuatro (07.X.1974) ENCB. Sierra de Guadalupe, Sta. Isabel mountain, leg. T. Herrera & O. Sánchez (23.VI.1956) MEXU 3165. Desierto de los Leones, leg. T. Herrera (02.VIII.1957) MEXU 3074. El Zarco, leg. M. Olguín w/n (IX.1958) ENCB. Ciudad Universitaria, leg. Chavelas Hurtado (04.IX.1959) MEXU 1398. Ajusco, Monte Alegre, leg. E. Aguirre (21.IX.1990) MEXU 16016, leg. G. Guzmán 483 (20.IX.1956) ENCB. **Durango:** Zacatecas - Durango road, near Suchil, leg. G. Guzmán 3347 (16.IX.1961) ENCB. **Guerrero:** 2 Km S of Petatlán, leg. A. Guevara 96 (24.IX.1978) ENCB. Chichihualco municipality, km 4.5 El Carrizal - Atoyac road, leg. Jiménez Peña (20.IX.1980) FCME 11919, 11270, leg. M. Martínez (05.X.1980) FCME 1359. Chilapa de Álvarez municipality, km 30 Chilpancingo - Tlapa road, leg. J. Cifuentes (17.VIII.1981) FCME 1350. **Hidalgo:** Epazoyucan municipality, 2 Km N of Nopalillo, leg. I. Frutis 198 (28.IX.1980) ENCB. Parque Nacional El Chico, Llanos Grandes, leg. J. Rzedowski w/n (03.IX.1978) ENCB, leg. P. Vilchis & A. Gómez (12.IX.1976) MEXU 11891, leg. G. Guzmán 690 (16.VI.1957) ENCB. Bahía de los Enamorados, leg. G. Guzmán 17702 (02.X.1978) ENCB. Las Ventanas, leg. J. Carrillo w/n (X.1978) FCME 1353. Real del Monte -San Miguel Regla road, 1 Km SW of Huasca, leg. M. Aguilar 61, leg. A. López 67 (28.VII.1968) ENCB. Molango, Atezca lake, leg. J. Cifuentes 656b (09.VIII.1980) FCME 10548. **Jalisco:** Near Presa Casimiro Castillo, leg. D. García 448 (04.X.1970) ENCB. Km 21 Guadalajara - Zacatecas road, barranca del río Santiago, leg. S. Chacón & G. Guzmán 12362 (14.VIII.1975), leg. G. Guzmán 22014 (16.VIII.1972) ENCB. La Primavera, (27.VIII.1973) MEXU 21287. La Huerta municipality, Estación de Biología Chamela, leg. Martínez & Cervantes (04.IX.1982) MEXU 18894, 19060. **Michoacán:** Los Azufres, leg. J. Espinosa w/n (X.1976) ENCB. Km 5.5 San Pedro Jácuaro detour to Eréndira, leg. Torres Villegas (15.VIII.1987) FCME 14004. Uruapan, Zarácua falls, leg. R. Aguilar 55 (18.VIII.1977) ENCB. Pucuat, leg. R. Aguirre 11 (06.X.1977) ENCB. Ocampo municipality, El Fresno, leg. R. Aguirre 36 (04.X.1977) ENCB. Km 49 México - Morelia road, Puerto Garnica, leg. L.

- Dávalos 287 (06.IX.1981) ENCB. **Morelos:** Km 49.5 Xochimilco - Oaxtepec road, Los Robles, leg. G. Guzmán 1892 (21.IX.1980) ENCB. La Pera, México - Cuernavaca HW, leg. J. Wright & T. Herrera (21.IX.1969) MEXU 7116. Cuernavaca - Tres Marias federal road, Km 3, colonia Atlixac, leg. G. Guzmán 6964, 8475 (11.X.1970) ENCB. Lagunas de Zempoala, leg. J.L. Castro w/n (20.X.1963) ENCB. Tepoztlán, near Tepozteco way, leg. G. Guzmán 5472 (12.X.1966) ENCB, leg. E. Pérez-Silva (09.X.1960) MEXU 4550, leg. Díaz González 17 (14.VIII.1968) ENCB. Cañón de Lobos, Km 3 S of Amador Salazar, leg. G. Guzmán 1139 (12.IX.1973) ENCB. **Nayarit:** 95 miles W of Tepic, leg. R.M. Vangla 50 (25.IX.1960) ENCB. Km 28.5 Tepic - Mazatlán road, R. Valenzuela *et al.* 2492 (06.IX.1993) ENCB. **Nuevo León:** García municipality, Puerta del Chipinque - La Joya del Venado way, leg. H.N.V. 53 (08.X.1967) ENCB. San Pedro Garza municipality, near meseta de Chipinque, leg. G. Guzmán 11118a (03.VIII.1973) ENCB. **Oaxaca:** Tuxtepec, Paper Factory, C. Betancourt 133 (21.VIII.1976) ENCB. Presa de Oro, between Ojitlán - Tuxtepec, C. Betancourt 44, G. Guzmán 16189 (03.VIII.1976) ENCB. NW of Oaxaca, El Estudiante, leg. J. Solís (10.VII.1976) MEXU 11090. Jalapa de Díaz, leg. G. Guzmán 161 (03.VIII.1976) ENCB. **Puebla:** Km 3 Jilotepec - Zacapoaxtla road, leg. E. Pérez-Silva *et al.* (15.IX.1980) MEXU 16754. **Quintana Roo:** near El Cedral, Mérida - Puerto Juárez road, leg. G. Guzmán 20703, 20718 (05.XI.1981). Chunyaxché zone, Puerto Morelos - Carrillo Puerto road, leg. G. Guzmán 20585 (04.XI.1981) ENCB. Near Central Vallarta, leg. G. Guzmán 21084, leg. A. López 1804, 1818, 1897 (10.X.1981) ENCB. Km 15 Tulum - Cobá road, leg. A. López 1917 (12.XI.1981) ENCB. Santa Matilde, 1 Km to Tulum, leg. G. Guzmán 20541b, 20567 (04.XI.1981) ENCB. Km 77 Chetumal - Escárcega, leg. G. Guzmán 20898, 20978 (08.XI.1981) ENCB. Lázaro Cárdenas, between Chinquilá - Solferino, leg. G. Guzmán 20672, 20677, 20681 (05.XI.1981) ENCB. **Sinaloa:** Mazatlán - Tepic road, El Portezuelo, leg. R. Santillán 403 (06.IX.1983) ENCB. **Sonora:** Alamos municipality, Km 12 Alamos - Las Flores way, leg. M. Esqueda & R.E. Villegas (14.IX.1991) CESUES 510, MEXU 23523. Km 42 Navojoa - Alamos road, leg. M. Esqueda & R.E. Villegas (15.IX.1991) CESUES 521, MEXU 23526. Arizpe municipality, Km 122 Mazocahui - Cananea road, leg. M. Esqueda & J. Jiménez (27.III.1993) CESUES 1232, MEXU 23975. Bacoachi municipality, Km 146 Mazocahui - Cananea road, leg. M. Esqueda & J. Jiménez (27.III.1993) CESUES 1248, MEXU 23976. Nacozari municipality, Sierra de la Púrica, Coronado 14 (26.VII.1989) MEXU 22597. Yécora municipality, Mesa Grande, leg. M. Esqueda & E. Pérez-Silva (15.VIII.1991) MEXU 23524. Km 10.5 Yécora - Sahuaripa way, leg. E. Pérez-Silva & M. Esqueda (28.X.1992) MEXU 23614. Km 251 Hermosillo - Yécora road, leg. M. Esqueda *et al.* (17.II.1996) CESUES 2429. Km 258 Hermosillo - Yécora road, leg. M. Esqueda & R. Rodríguez (10.IX.1995) CESUES 1862; leg. A. Armenta, A. Núñez & R. Santos (17.II.1996) CESUES 2456. 3.2 km Yécora - Sahuaripa way, leg. E. Pérez-Silva *et al.* (12.IX.1996) CESUES 3135. 4.8 km Yécora - Sahuaripa way, leg. M. Esqueda *et al.* (12.IX.1996) CESUES 3082. 3.4 km Yécora - Las Cabañas way, leg. M. Esqueda *et al.* (12.IX.1996) CESUES 3175. **State of Mexico:** Parque Nacional Estado de Toluca, Km 21 El Capulín, Sultepec road, leg. L. Colón 472 (25.IX.1983) ENCB. Toluca - Sultepec road, leg. G. Guzmán 16496 (14.IX.1976) ENCB. Km 6 Tenancingo - Santo Desierto road, leg. González Velázquez 475 (17.VIII.1976) ENCB. Toluca - Temascaltepec, Km 7 detour to Valle de Bravo, leg. R. Valenzuela (27.II.1983) ENCB. Mesa de Nanchititla, leg. R. Hernández 2039 (10.X.1993) MEXU 11452. México - Pachuca road, San Pedro Teacalco, leg. J.L. Magaña 43 (30.VI.1964) ENCB. Popocatepetl, leg. T. Herrera (08.IX.1957) MEXU 1809. Paso de Cortés, leg. T. Herrera (08.IX.1957) MEXU 129. Cañada de Nespoyantla, leg. T. Herrera (11.X.1959) MEXU 1399. Iztaccíhuatl - Nexcoalango, leg. R. Oronoz (12.IX.1959) MEXU 6202. Km 15 Cueva del Negro, Tlamacas road, leg. I. Hernández w/n (26.IX.1982) ENCB. Barranca de Ameyalco, leg. J. Peña Cabrides 7 (w/d) ENCB. San Pedro Nexapa road, leg. G. Guzmán 1163 (17.XI.1957) ENCB, leg. G. Guzmán 4958 (17.X.1965) ENCB. Parque Nacional Miguel Hidalgo, La Marquesa, leg. G. Guzmán 21398 (13.IX.1981) ENCB, leg. E. González 413 (19.IX.1963) ENCB, leg. F. Brizuela 854 (13.XI.1971) ENCB, leg. R. Lamothe & E. Pérez-Silva (21.X.1973) MEXU 8472. Salazar, leg. R. Rodríguez Jiménez 45 (20.IV.1967) ENCB. Cerro de la Campana, leg. Ruiz Oronoz (20.X.1957) MEXU 142, leg. T. Herrera (13.X.1966) MEXU 5326, leg. M. Martínez Dorado (26.X.1964) FCME 901. 3 Km W of Salazar, leg. J. Cifuentes (06.VII.1979) FCME

1089, leg. F. Cuevas (06.IX.1968) MEXU 6264. Zoquiapan zone, Est. Inv. For. Univ. Agro. de Chapingo, leg. F. Santoyo 28 (10.X.1980) ENCB. Tlalmanalco, Cerro El Mirador, leg. X. Madrigal w/n (05.X.1966) ENCB. Villa del Carbón road, W of Cahuacán, leg. G. Guzmán 3950 (09.VIII.1963) ENCB. Naucalpan municipality, Los Remedios, leg. T. Herrera (07.X.1956) MEXU 3145. Jilotzingo municipality, Km 13 detour to Tlazala, leg. E. Pérez-Silva *et al.* (28.VII.1984) MEXU 17953. Llano Grande, near Río Frio, leg. E. Pérez-Silva (VIII.1968) MEXU 22579, leg. G. Guzmán 7984 (27.VII.1970) ENCB. Las Delicias, leg. G. Méndez w/n (03.IX.1976) ENCB. **Tamaulipas:** 12 Km S of Bustamante, leg. J. Solís (25.V.1976) MEXU 10971. **Tlaxcala:** Parque Nacional La Malinche, San Isidro Buen Suceso municipality, San Pablo del Monte, leg. González Fuentes 473 (14.IX.1983) ENCB. Calpulalpan - Apizaco, leg. T. Herrera (05.IX.1961) MEXU 5769. **Veracruz:** Km 2 Jalapa - Coatepec road, F.J. Clavijero Botanical Garden, leg. G. Guzmán 19306 (06.VII.1981) ENCB. W of Martinica, Banderilla, leg. A. López 556 (03.VI.1976) ENCB, leg. G. Guzmán 16377 (10.VIII.1976) ENCB. Catemaco, Arroyo Agrio, leg. F. Ventura 5892 (18.VIII.1972) ENCB. Coyame road, leg. T. Herrera (10.VII.1972) MEXU 9117, leg. C. León (10.VII.1985) MEXU 19803. Catecamo - Limaxtla, leg. T. Herrera & M. Ortega (12.VII.1964) MEXU 1843. Acayucan road, between Los Mangos - J.D. Covarrubias, leg. T. Herrera (12.VII.1972) MEXU 9215. Acayucan - Minatitlán deviation to Chinameca, San Pedro Soteapa, leg. J. Pérez Ortiz 207 (15.VIII.1976) ENCB. Tierra Blanca, leg. R. Hernández (01.VIII.1972) MEXU 9379.

Geastrum schweinitzii (Berk. et Curt.) Zeller, *Mycologia* 40: 649, 1948.

= *G. mirabile* Mont. *Ann. Sci. Nat.* 4: 139, 1855.

= *Coilomyces schweinitzii* Berk. et Curt., *Journ. Acad. Nat. Sci. Phil.* 2: 297, 1853.

= *Geaster lignicola* Berk., *Journ. Linn. Soc. Bot.* 18: 386, 1881.

= *G. caespitosus* Lloyd, *Myc. Writ.* 2: 315, 1907.

Fig. 12.

Macroscopic characters: Gastrocarp 1.0-2.2 cm wide when expanded. Exoperidium saccate, splitting to about the middle into 6-7 not hygroscopic rays which are straight and upright rather than reflexed or inflexed. Mycelial layer thick, whitish, light yellow or brown, tomentose. Fibrous layer tightly adhering

to the fleshy layer which is thin, dark brown, persistent, often cracking in aged specimens. Endoperidial sac sessile, 0.5-1.0 cm thick, globose or subglobose, grayish brown or whitish gray, smooth or delicately felted. Peristome more or less conical, fimbriate, not sulcate, with a well delimited ring. Gleba light to dark brown. Columella generally not well developed.

Microscopic characters: Spores spherical, with prominent projections confluent in small groups and with many tiny granules among them (Fig. 12). Capillitium flexuose, 1.25 μ m diam., ornamented with numerous scales.

Habit and habitat: Gregarious or caespitose on wood fragments in tropical forests.

Distribution: **Guerrero:** Puerto Marqués, leg. W. López Forment (20.I.1981) MEXU 17420. **Jalisco:** La Huerta municipality, Estación de Biología Chamela, leg. A. Pérez Jiménez & A. Solís (01.X.1977) MEXU 11965. **Oaxaca:** around Presa Miguel Alemán, leg. R. Hernández (01.VIII.1972) MEXU 9378. Tuxtepec - Palomares road, near to El Mirador ranch, leg. P. Ortiz 715 (26.VII.1977) ENCB. **Sonora:** Yécora municipality, Km 251 Hermosillo - Yécora road, leg. M. Esqueda *et al.* (15.III.1996) CESUES 2533. **Tabasco:** Huimanguillo municipality, Km 8 SW of Cárdenas, leg. S. Chacón 409 (14.IX.1982) ENCB. **Veracruz:** Totutla municipality, El Mirador, leg. F. Ventura 7001 (23.IX.1972) MEXU 9568, ENCB.

Geastrum triplex (Jungh.) Fischer in Engler and Prantl, *Nat. Pflanzenf.* 2(7a): 73, 1933.

= *Geaster triplex* Jungh., *Tijdschr. Natvurl. Gesch. Physiol.* 7: 287, 1840.

= *G. michelianus* W.G. Smith, *Gard. Chron.* 608, 1873.

= *G. kalchbrenneri* Hazsl. *Verhandl. Zool. Bot. Ges. Wien.* 26: 76, 1876.

G. pillotii Roze, *Bull. Soc. Myc. Fr.* 4: 34, 1888.

Fig. 13.

Macroscopic characters: Gastrocarp up to 5-12 cm wide when expanded. Exoperidium splitting to about the middle into 4-9, usually 5-7, not hygroscopic, equal or subequal, acuminate rays which are flat, convex, revolute or often involute under the spore sac. Mycelial layer persistent, adhering small amount of debris, often cracking radially into light brown or yellowish strips, with a central umbilical scar. Fibrous layer thin, firmly adhered to the fleshy layer which is thick, whitish, yellowish gray or brown,

generally splitting around the base of the endoperidial sac into a typical cup or collar. Endoperidial sac sessile, globose or subglobose, 2-5 cm across, smooth, pale gray to brown. Peristome conical or mammiform, well delimited by a paler radially fibrillose area. Gleba dark brown in mature specimens. Columella generally well developed, subglobose or club-shaped.

Microscopic characters: Spores brown in mass, uniguttulate; as seen under SEM, ornamented with columnar processes, 0.5 μm high x 0.3 μm wide, connected by bridges; spines frequently confluent in groups of 2 or 3 (Fig. 13). Capillitium with sculptured surface, 1.5 - 2 μm wide.

Habit and habitat: Solitary or gregarious on the ground in tropical forest at 50 m alt., or more frequently found under conifer and mixed woods, 800-3200 m alt., especially in autumn.

Distribution: **Chiapas:** Km 18 Ocozocauatla - Malpaso road, Parque Laguna Bélgica, leg. Espinosa-Vázquez (02.IX.1979) FCME 10550, leg. Ocampo Genoveva (04.IX.1979) FCME 10545. **Distrito Federal:** Desierto de los Leones, leg. O Sánchez (30.IX.1957) MEXU 139, leg. R. Lamothe & E. Pérez-Silva (20.XI.1961) MEXU 4986, leg. G. Guzmán 12018 (29.XI.1974) ENCB. Near Ajusco, leg. S. Sánchez 5 (18.X.1970) ENCB, leg. E. Pérez-Silva *et al.* (25.IX.1977) FCME 716. Cerro Tlapanco, leg. T. Herrera & M. Ruiz Oronoz (16.XI.1958) MEXU 871. **Guerrero:** Chichihualco municipality, Km 4.5 El Carrizal - Atoyac, leg. V. Linares (02.VIII.1980; 20.IX.1980) FCME 11917, 12284, leg. Alpizar Valfré (20.IX.1984) FCME 12268, leg. M. Martínez (05.X.1980) FCME 1334. **Hidalgo:** Parque Nacional El Chico, leg. R. Hernández (09.XI.1975) MEXU 12828. Piedra Blanca, 4 km near to Zacuáltipan, leg. A. Delgado (26.VIII.1978) FCME 424. Las Ventanas, leg. E. Cerrato (15.IX.1974) ENCB, leg. G. Guzmán 1348, 4875 (27.X.1957) ENCB, leg. S. Acosta (18.VI.1981) ENCB. **Jalisco:** Nevado de Colima road, leg. G. Guzmán 509 (20.XI.1990) ENCB, leg. D. García (12.X.1971) MEXU 24034. **Michoacán:** Ciudad Hidalgo municipality, Parque Nacional Cerro Garnica, leg. H. Mendoza *et al.* (08.IX.1983) FCME 11775, 11357, 11341. Pontezuelos, Km 220 Toluca - Morelia road, leg. J. Cifuentes (14.IX.1983) FCME 1582. Angangeo: Llano de las Papas, leg. E. Pérez-Silva *et al.* (02.XI.1981) MEXU 18907. Km 80 Zitácuaro - Toluca road, leg. E. Pérez-Silva *et al.* (02.IX.1983) MEXU 17801. Km 49 Puerto Garnica,

leg. L. Dávalos 286 (06.IX.1981) ENCB. **Morelos:** Cerro Zempoala, leg. T. Herrera & O. Ruiz (04.I.1959) MEXU 884. Laguna de Quila, leg. A. Calderón *et al.* (10.VIII.1986) MEXU 20429, leg. C. León (VIII.1985) MEXU 22531. Curva La Pera, leg. S. Gabriel Montes 42 (21.IX.1969) ENCB. Jiutepec municipality, El Texcal, leg. D. Portugal 1276 (07.IX.1980) ENCB. **Oaxaca:** Ixtlán de Juárez - La Esperanza road, Llano de las Flores, leg. G. Betancourt 250 (15.IX.1976) ENCB. Llano Verde, 12 Km SE of Ixtlán de Juárez, leg. G. Guzmán 15 (05.VI.1970) ENCB. **Sonora:** Yécora municipality, Km 258 Hermosillo - Yécora, leg. M. Esqueda *et al.* (26.XI.1995) CESUES 2311; (17.II.1996) CESUES 2454; (13.IX.1996) CESUES 3042. 3.2 km Yécora - Sahuaripa way, leg. M. Esqueda *et al.* (17.II.1996) CESUES 2394. 4.8 km Yécora - Sahuaripa way, leg. E. Pérez-Silva *et al.* (12.IX.1996) CESUES 3079. **State of México:** Cerro Cabezas, leg. T. Herrera (30.IX.1956) MEXU 102, 17467, 3104, 3203. Paso de Cortés, leg. T. Herrera (08.IX.1957) MEXU 135. Nexcoalango, leg. E. Pérez-Silva & R. Lamothe (06.VIII.1967) MEXU 5531. Salazar, Cerro Tabaquillo, leg. Soc. Mex. Mic. (19.IX.1981) MEXU 22573, leg. Ayala Lobatón (13.VII.1965) MEXU 2707, leg. F. Cuevas (06.IX.1968) MEXU 6266. El Potrero, leg. E. Pérez-Silva *et al.* (01.IX.1976) MEXU 11219. Jocotitlán, leg. E. Pérez-Silva *et al.* (20.IX.1980) MEXU 16219. Texcoco, leg. M. Bonilla (25.X.1964) FCME 426. Cerro de Santa Catarina, Sierra Tláloc, leg. T. Herrera (25.VIII.1957) MEXU 3198. La Marquesa - Chalma, leg. Vázquez-Hurtado 38 (01.XI.1970) ENCB. El Potrero, La Marquesa - Tenancingo road, leg. González-Velásquez 512 (17.VIII.1986) ENCB. 5 Km of Salazar, leg. M. Vila & M.E. Senties (22.IX.1986) MEXU 20475. Isidro Fabela municipality, leg. Pineda R. 110-A (17.IX.1967) ENCB. Km 38 Ixtlahuaca - Sn. Mateo Nopala road, near Centro Ceremonial Otomí, leg. E. Pérez-Silva (21.IX.1986) MEXU 20384. Km 70 Toluca - Zitácuaro Hw., leg. E. Pérez-Silva *et al.* (02.XI.1981) MEXU 19683. 6 Km W of San Francisco Chimalpa road, leg. Muñoz Sevilla 68 (X.1970) ENCB. Amecameca - Tlamacas road, Barranca de Ameyalco, leg. E. García 360 (1972), leg. Peña. Llano Grande, leg. L. Varela 89-A (27.IX.1975) ENCB. San Rafael, leg. G. Guzmán (12.VI.1978) ENCB. Cabriales w/d. ENCB. 15 Km SW of Zinacantepec, leg. M. Guazin 6 (ENCB). Amecameca - Tlamacas road, leg. J. Cifuentes *et al.* (23.X.1965) FCME 910, leg. G. Guzmán 1162

(17.IX.1957) ENCB, leg. I. Paden 1071 (23.IX.1975) ENCB. Parque Nacional Miguel Hidalgo, La Marquesa, leg. G. Guzmán 487 (14.XI.1964) ENCB. Parque Nacional Llano Grande, Cañada of Río Frío, leg. G. Guzmán (08.IX.1962) ENCB, leg. S. Acosta 89 (X.1977) ENCB. Naucalpan - Toluca road, Puerto Guarda, leg. N. Aragón 43 (04.VIII.1968) ENCB. Deviation to Villa Alpina, La Glorieta, leg. A. González-Velázquez 966, leg. R. Nava 367 (25.IX.1966) ENCB. **Veracruz:** San Andrés Tuxtla municipality, Balzapote, leg. J. Cifuentes (VII.1979) FCME 11166, leg. S. Chacón 839 (1.IX.1982) ENCB.

Geastrum xerophilum (Long) Ponce, **Fieldiana: Botany** 31: 323, 1968

= *Geaster xerophilus* Long, **Mycologia** 34: 13, 1942
= *G. pluriosteus* Long et Stouffer, **Mycologia** 40: 553, 1948.

Fig. 14.

Macroscopic characters: Gastrocarp 1-4 cm wide when expanded, with a prominent basal mycelial cord. Exoperidium splitting to about the middle into 8-10 not hygroscopic, unequal, pliable, subacute or truncate rays becoming involute around the endoperidial sac. Mycelial layer adnate, thin, covered by persistent sand grains, with a big umbilical scar at the base. Fibrous layer thin, adherent. Fleshy layer yellowish white or brown, eventually rimose. Endoperidial sac subsessile or with a short pedicel, depressed globose, 1-2 cm across, light brown, yellowish gray or whitish, minutely furfuraceous. Peristome concolorous, small, conic, unequally sulcate, without a surrounding groove. Gleba light or dark brown. Columella cylindrical, persistent.

Microscopic characters: Spores globose to slightly elliptical, 4-5 μm diam., coarsely verrucose under light microscope; under SEM dentate-conical verrucose spores can be observed; pedicels very short, up to 0.5 μm long, hollow (Fig. 14). Capillitium stout or flexuose, 2-3.5 μm diam., smooth, frequently with remains of gleba.

Habit and habitat: Solitary or in small groups, in open sandy areas of semi-arid locations with *Larrea tridentata*, *Fouquieria* sp. and *Cercidium* sp.; in *Quercus* forest, and under the shadow of *Olneya tesota*.

Distribution: **Morelos:** Tepetlixca municipality, Amecameca-Cuautla road, near Tepetlixca, leg. G. Guzmán 12072, (23.VI.1975) ENCB. **Sonora:** Hermosillo municipality, Hermosillo-Bahía de Kino

road, 36 North St., leg. G. Yáñez (05.II.1994) CESUES 1598; MEXU 23937. La Colorada municipality, Las Palomas ranch, leg. A. Aparicio, (15.II.1992) CESUES 1995; MEXU 24315. Km 100 Hermosillo - Yécora road, leg. M. Esqueda *et al.* (17.III.1996) CESUES 2616.

Discussion

The identification of the genus *Geastrum* is easy, but its determination and nomenclature at species level is often difficult and the separation between closely related taxa is not always easy. This is the case of *G. campestre* (Morg.) Stanek with the endoperidial sac pedicelled, and *G. drummondii* (Berk.) Cunn. with the endoperidial sac sessile. The intermediate forms are so many that these closely related taxa can not be always sharply separated. This situation can explain the long list of synonyms of some species and the change of the valid names, even of well known species such as *G. triplex* (Jungh.) Fisch. and *G. velutinum* (Morg.) Fisch. which are considered by some authors as conspecific with *G. indicum* (Koltz.) Rauschert and *G. javanicum* (Lév.) Ponce, respectively (Ponce de León, 1968). A world monograph of the genus is needed to avoid such confusions, considering new taxonomic approaches such as the cladistic, and including developmental culture, comparative molecular biology and SEM characters. This task will probably take a long time, meanwhile, small taxonomic contributions, as the present paper should be considered, as useful to increase the knowledge of the genus. *Geastrum* is a widely distributed genus in Mexico, often well represented in wet forests, but also frequent in dry regions. Several species such as *G. campestre* (Morg.) Stanek, *G. fornicatum* (Hud.) Hook., *G. minimum* Schw., *G. pectinatum* Pers., *G. saccatum* (Fr.) Fischer were found in urban zones. The genus includes species which possibly form mycorrhizae such as *G. triplex* and *G. quadrifidum* (Garza-Ocañas, 1986) although their importance in nature is not well known. This could be the basis for further studies. On the other hand, Kreisel (1969) considered that all the Geastraceae are saprophytes.

The species of *Geastrum* are not edible and there are few reports on their uses. Mata (1987) provided information about the employment of *G. triplex* against diarrhea, asthma, "evil eye" ("mal de ojo"), and to dry the navel of the newborn. Guzmán (1994a,b) reports the same uses for *G. saccatum* and

other related species such as *G. fimbriatum* which also are used to cure wounds by applying the apical part of the toadstool.

Acknowledgments

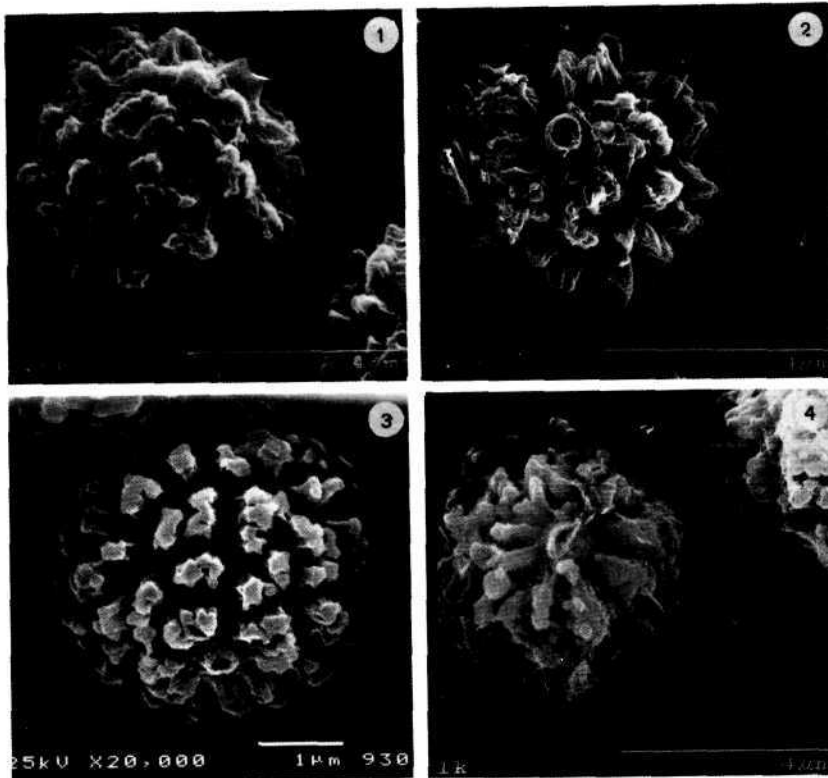
The authors acknowledge the financial support of the DGAPA project IN2038951, IN203895 (UNAM), and the SNI grants to E. Pérez-Silva and T. Herrera. The help of Jacqueline Cañetas, Pedro Mexia (Instituto de Física), Margarita Reyes (Instituto de Geología), and Sara Fuentes (Instituto de Biología) was very important in taking SEM photomicrographs. We are very grateful to them and also to Felipe Villegas (IB, UNAM), all from UNAM, for the valuable technical assistance. We also thank the curators of the herbaria CESUES, ENCB, FCME and MEXU for the loan of specimens of *Geastrum*. The critical revision of the paper by F. D. Calonge (Real Jardín Botánico de Madrid, España), and F. Chiang (IBUNAM); the comments of J. Cifuentes (Facultad de Ciencias, UNAM) is also appreciated.

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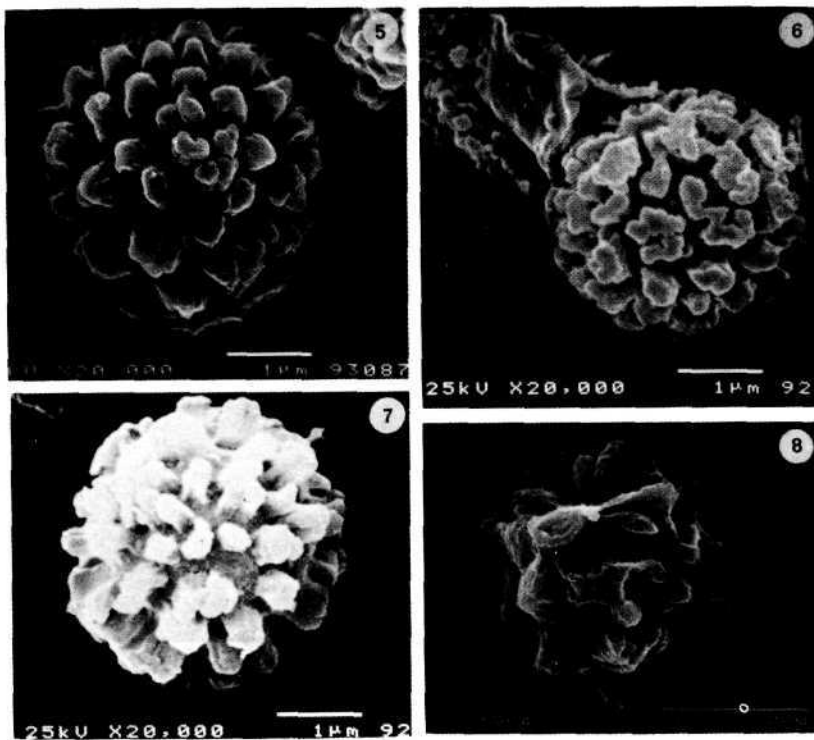
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Recibido: 16 de julio, 1999. Aceptado: 18 de octubre, 1999.

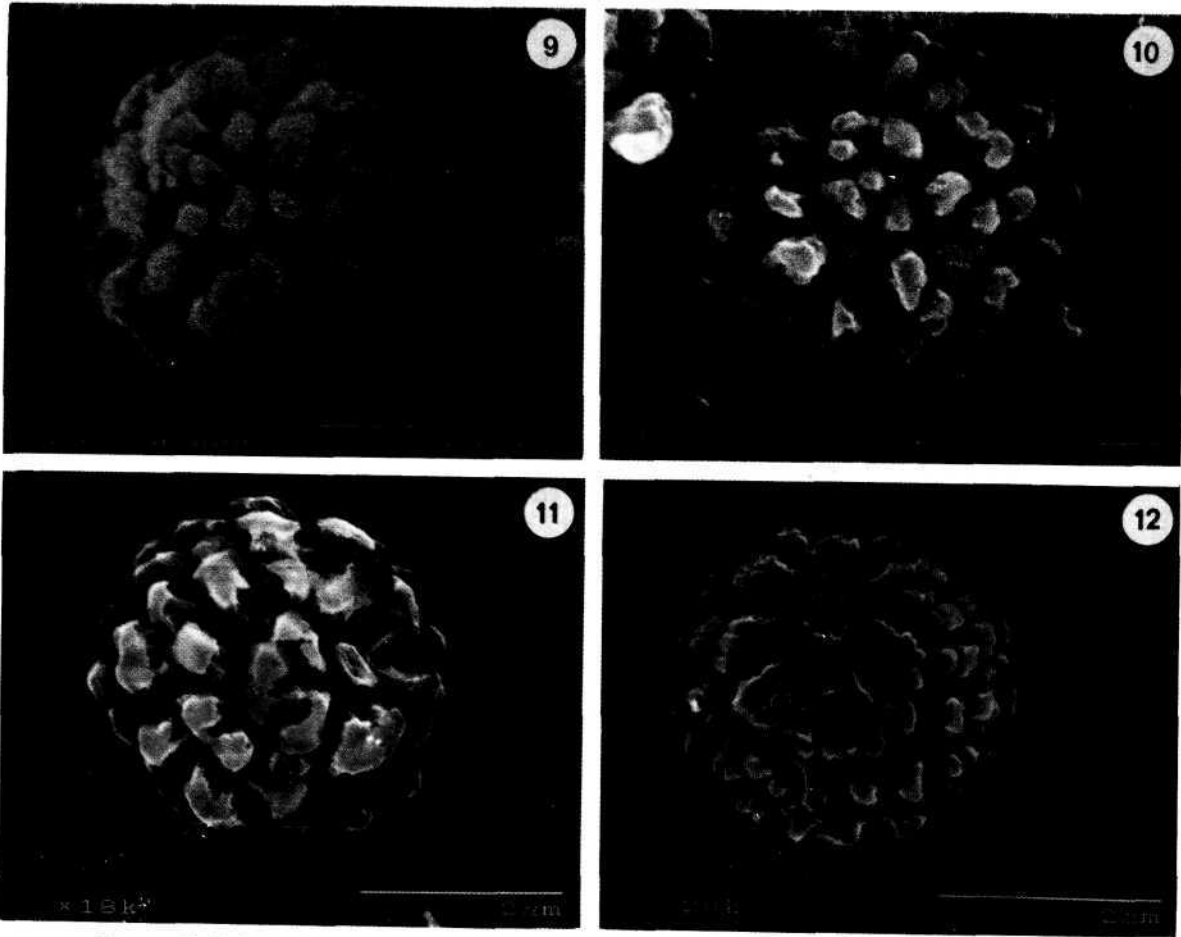
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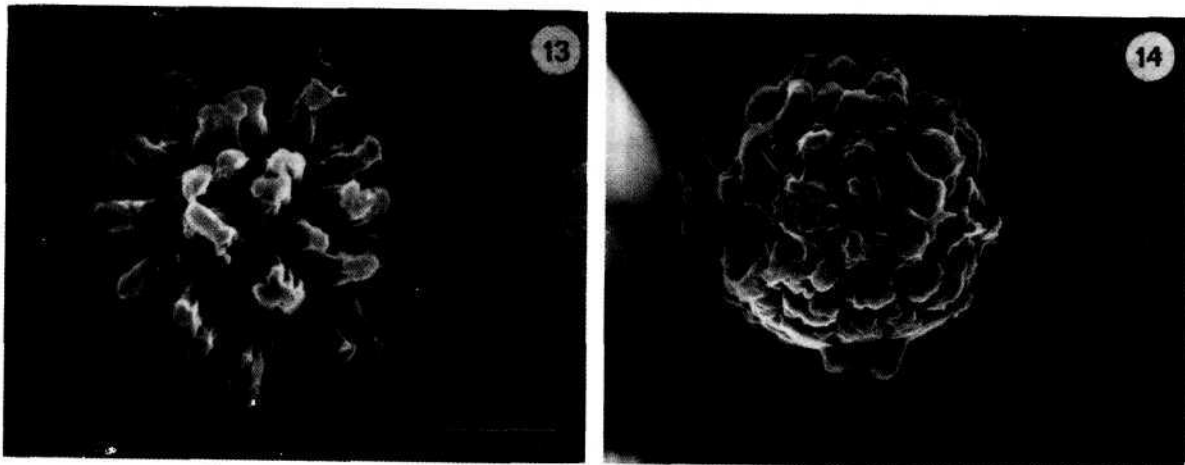
Figures. 1-4. SEM photomicrographs of spores. 1: *G. campestre* 2: *G. coronatum* 3: *G. fimbriatum* 4: *G. floriforme*.



Figures. 5-8. SEM photomicrographs of spores. 5: *G. fornicatum*, 6: *G. javanicum*, 7: *G. lageniforme*, 8: *G. minimum*.



Figures. 9-12. SEM photomicrographs of spores. 9: *G. pectinatum*. 10: *G. quadrifidum*. 11: *G. saccatum*. 12: *G. schweinitzii*.



Figures. 13-14. SEM photomicrographs of spores. 13: *G. triplex*. 14: *G. xerophilum*.