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Hysterangium (Hysterangiales, Hysterangiaceae) del norte de México

Resumen. Tres nuevas especies de *Hysterangium* (*H. quercicola*, *H. latisorum*, and *H. velatisporum*) son descritas para el norte de México. Además, una especie previamente descrita de *Hysterangium* (*H. aureum*) es registrada por primera vez para México.

Palabras clave: *Quercus*, hipogeos, pseudotrufas, falsas trufas, ectomicorriza.

Abstract. Three new species of *Hysterangium* (*H. quercicola*, *H. latisorum*, and *H. velatisporum*) are described from northern Mexico. In addition, one previously described *Hysterangium* species (*H. aureum*) is recorded for the first time from Mexico.

Key words: *Quercus*, hypogeous, pseudotruffle, sequestrate, ectomycorrhiza.

Recibido 20 de agosto 2008; aceptado 14 de diciembre 2008.

Received 20 August 2008; accepted 14 December 2008.

Introduction

The genus *Hysterangium* Vittadini can be recognized by its sequestrate habit, olive-green, gelatinous gleba, and ellipsoid, hyaline spores that usually have a loose or closely appressed, wrinkled utricle. Many *Hysterangium* species serve important roles in the equilibrium of forest ecosystems as mycorrhizal symbionts and as part of the diet (mycophagy) of small mammals, marsupials and insects (Hosaka *et al.*, 2006). *Hysterangium* has been traditionally placed into the Phallales E. Fischer (Zeller and Dodge 1929). However, recent molecular phylogenetics studies have shown that *Hysterangium* belongs to a new independent order, Hysterangiales Hosaka & Castellano alongside the Phallales, Gomphales Jülich and the Geastrales Hosaka & Castellano in the subclass Phallomycetidae Hosaka, Castellano & Spatafora (Hosaka *et al.*, 2006).

In Mexico, only one *Hysterangium* species has been reported *H. separabile* Zeller from the states of Mexico and Tamaulipas (Trappe and Guzmán, 1971; García *et al.*, 2005). Many other species from various sequestrate genera such as *Elaphomyces*, *Gautieria*, *Genea*, *Geopora*, *Glomus*, *Hydnangium*, *Hydnobolites*, *Hymenogaster*, *Leucogaster*, *Macowanites*, *Melanogaster*, *Octavianina*, *Pachyphloeus*, *Radiigera*, *Rhizopogon* and *Tuber* have been reported for the states of Nuevo Leon, Coahuila, Durango and Tamaulipas (Cázares *et al.*, 1992; Guzmán 1971; Guzmán 1988; Trappe and Guzmán 1971; Hosford and Trappe 1980; Trappe *et al.*, 1979). Recently, we examined *Hysterangium* collections from northern Mexico deposited at Oregon State University herbarium (OSC) and found three undescribed species and one *Hysterangium* species previously reported from the western United States. This paper is a contribution to the knowledge of the sequestrate mycoflora of North America.

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Materials and methods

Methods of collection and macroscopic and microscopic study were generally those of Castellano *et al.* (1989). Colors of fresh fruiting bodies were in general terms by the authors. Dried specimens were hand cut and mounted in 5% KOH for microscopic observation. Fungal collections are deposited at ITCV (Instituto Tecnológico de Cd. Victoria, Mexico) or OSC (Oregon State University) herbarium. Digitized photomicrographs of macro and microscopic characters are on file at the Forestry Sciences Laboratory, Corvallis, Oregon.

Hysterangium aureum Zeller, Mycologia 33:201–202. 1941. Figures 1, 2
= *Hysterangium stoloniferum* var. *brevisporum* Zeller, Mycologia 39:288. 1947.
= *Hysterangium affine* var. *oreades* Zeller, Mycologia 31:18–19. 1939.

Dried basidiomata 1–4 cm in diam, globose, subglobose or irregularly lobed, white when fresh, slowly bruising pale red-brown, golden brown to dark golden brown when dried, surface more or less glabrous, without adherent soil particles, KOH on peridium nonreactive or pale olive-yellow, FeSO₄ pale blue-green. Gleba pale green, olive to dark gray-green; locules small, elongate, empty. Rhizomorphs usually absent, when present numerous, small, attached to base, concolorous with peridium. Columella gelatinous, dendroid, narrow, hyaline to opaque. Odor sweet, fruity. Taste not recorded.

Peridium not easily separable from gleba, a single layer 325–450 µm thick, of hyaline, thin-walled, parenchyma-like 50–75 µm in diam, no distinct filamentous layer between parenchyma-like cells and gleba, clamp connections absent.

Trama 150–250 µm, of hyaline, occasionally collapsed compactly interwoven or occasionally parallel

hyphae 1–3 µm in diam in a gelatinized matrix, clamp connections absent. Basidia hyaline, cylindrical, 12–15 x ±4 µm, 4- or 6-spored.

Spores smooth, 11–12.5 (–15) x 4–5 µm, ellipsoid; apex acuminate, base sometimes slightly pedicellate; spore wall less than 0.5 µm thick; utricle closely appressed, slightly wrinkled, mostly on young spores; in KOH hyaline singly, pale green in mass.

Etymology: referring to the golden yellow to brown color of the dried sporocarp.

Habit, habitat and season: Hypogeous, under *Pinus teocote* and *P. rudis*; May, June, October and November.

Collections examined: Oregon: Linn Co., Trout Creek Recreational Area, 21 May 1936, *S. Zeller 8480*, (Holotype OSC). Mexico: Coahuila, Arteaga, La Siberia, camino al puerto de los gringos, 24 June 1984, *García 4042* (OSC); Agua Blanca, 27 August 1983, *Cázares 71* (OSC); Nuevo León, Santiago, Camotera, 26 May 1984, *García 3822* (OSC); Zaragoza, La Encantada, 18 October 1985, *Cázares 137* (OSC); Tamaulipas, Miquihuana, 11 Nov. 2006, *Guevara 887* (ITCV, OSC).

Discussion: *Hysterangium aureum* is characterized by the combination of its single peridial layer of parenchyma-like cells, small spores without a distinct utricle. *Hysterangium aureum* of North America is similar to *H. affine* of the Southern Hemisphere but differs its thicker peridium and generally shorter spores which possess a closely appressed utricle. *Hysterangium aureum* is common at higher elevations in the Great Basin region of western North America where it is associated with a number of different species of Pinaceae. It is also similar in spore size and peridial structure to *H. crassipariete* but *H. crassipariete* is associated with *Nothofagus dombeyi* (Castellano and Muchovej, 1996).

Hysterangium latissporum sp. nov. Castellano, Cázares & Guevara
Figures 3, 4

Peridium 200–250 µm *crassum facile secedens*, *album ubi contusum brunneolescens*, *stratis duobus*; *epicutis* 190–240 µm *crassa pseudoparenchymatica cellulis* (5-) 10–15 (–50) µm *latis fibulae absens*; *subcutis* 15–30 µm *crassa*, *hyphis intertextis*, *fibulatis*. *Gleba atroolivacea*, *columella plus minusve truncata*. *Sporae verruculosae*, (15-) 18–22 x 7–9 µm, *fusiformes*, *utriculo distincto*, *incohaerenti*, *rugoso*, *plerumque circa 1 µm crasso*.

Holotypus hic designatus: Mexico, Nuevo Leon, Santiago, Cercado, 22 Oct. 1988, *Cázares-Trappe 11014* (ITCV, isotype OSC).

Basidiomata up to 15 mm in diam, globose to subglobose, white when fresh, bruising pale brown, pale brown when dried. Gleba dark green-olive, locules small, empty. Rhizomorph single, distinct, white when fresh, pale brown when dried. Columella poorly developed, more or less truncate, penetrating less than half way into the gleba, gray-translucent. Odor not recorded. Taste not recorded.

Peridium readily separable, turning red-brown when cut in cross-section, 200–250 µm thick, two-layered; overlain with scattered, slightly encrusted, clamped, golden brown hyphae. Epicutis 190–240 µm thick, of hyaline, thin-walled, irregular to globose, parenchyma-like cells (5-) 10–15 (–50) µm in diam, clamp connections absent; subcutis somewhat indistinct, 15–30 µm thick, of hyaline to pale brown, coarse, irregularly-shaped, almost wiggly, interwoven hyphae, 1–3 µm in diam, occasional interspersed inflated cells up to 5 µm, clamp connections present.

Trama 40–150 µm thick, of hyaline, gelatinized, loose to compact, interwoven hyphae, 3–5 µm in diam in a gelatinized matrix, clamp connections absent. Subhymenium cellular. Basidia hyaline, 40–50 x 7–8 µm, 2–4-spored, clamp connections present. Basidioles hyaline, 30–

40 x 8–10 µm.

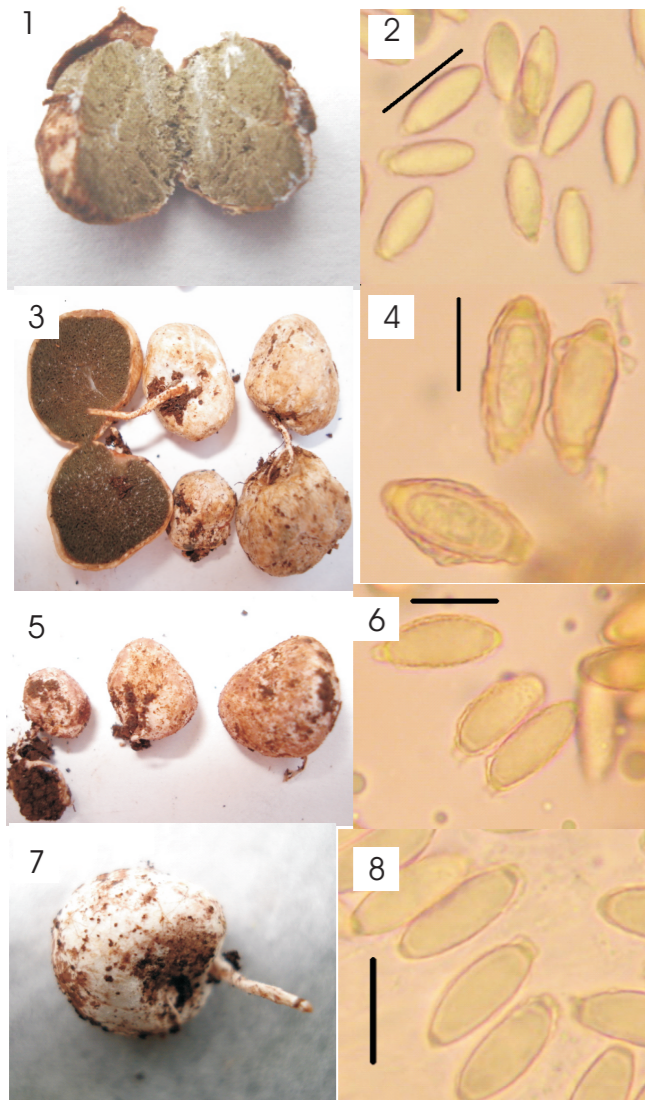
Spores minutely verrucose, (15-) 18–22 (–25) x 7–9 µm, fusiform; apex papillate and somewhat thickened, base distinctly pedicellate or occasionally claw-shaped in cross-section, up to 2 µm long; wall 1–2 µm thick; utricle distinct, loose, wrinkled, usually about 1 µm thick but occasionally up to 2 µm thick; in KOH pale olive singly, dark olive in mass.

Etymology: referring to the width of the spores.

Habit, habitat and season: Hypogeous, associated with *Quercus canbyii*, *Q. rysophylla*, and other *Quercus* spp. in mixed forests; March, October, and November.

Collections examined: Mexico, Michoacan, Hidalgo, Los Azufres, 11 Oct. 1988, M. Amaranthus, *Trappe 11006, 11011* (both OSC); Tamaulipas, torre de la microondas Las Mulas, 11 Nov. 2006, *Guevara 894* (ITCV, OSC); Tamaulipas, El Madroño, along road from Victoria to Tula, 20 Oct. 1988, R. Young, *Trappe 11009* (OSC); Nuevo León, Santiago, El Salto, 20 Aug. 1983, *García 3023* (OSC); USA: Arizona, Graham Co., Coronado National Forest, Noon Creek campground, 14 March 1995, *J. States, AHF684* (OSC); Arizona, Apache Co., Chiricahua Mountains, 17 March 1992, *States, AHF564* (OSC).

Discussion: The long, wide spores (15-) 18–22 (–25) x 7–9 µm of *Hysterangium latissporum* easily distinguish it from most other *Hysterangium* species. *Hysterangium epiroticum* Pacioni from Europe has longer spores but also a three-layered, thicker peridium. *Hysterangium fragile* Vittadini also from Europe has long spores but *H. fragile* spores are narrower and its peridium is much thicker. *Hysterangium crassirhachis* has much smaller spores and the outer peridial layer is only approximately 25 µm thick (Zeller and Dodge 1929). *Hysterangium youngii* from New Zealand has long spores (18–20 (–22) µm), but they are minutely to moderately verrucose and sporocarps are associated with podocarp-broadleaf forest (Castellano and Beaver, 1994).



Figures 1-8. Basidiomata and basidiospores of *Hysterangium* species. 1-2 *Hysterangium aureum* 3-4. *Hysterangium latisporum* 5-6. *Hysterangium quercicola* 7-8. *Hysterangium velatisporum*, bar = 10 μ m.

Hysterangium quercicola sp. nov. Castellano, Cázares & Guevara

Figures 5, 6

Peridium 350-529 μ m *crassum*, *facile secedens*, *album*, *ubi contusum olivaceobrunnescens*, *stratis duobus*, *epicutis* 300-470 μ m *crassa pseudoparenchymatica cellulis* 5-40 (-80) μ m *latis*, *fibulae absens*; *subcutis* 50-199 μ m *crassa*, *hyphis intertextis*, *fibulae absens*. *Gleba atroviridis*, *columella*

dendroidea Sporae verruculosae (17-) 18-19 (-20) x (6-) 7-8 (-9) μ m *fusiformes*, *utriculo distincto incohaerenti rugoso*, *usque ad 2 μ m crasso*.

Holotypus hic designatus: Mexico, Tamaulipas, El Madroño, km 19 carr. Cd. Victoria-Tula, 24 Sept. 1985, *García 4804* (ITCV, isotype OSC).

Basidiomata up to 18 x 12 mm in diam, globose to subglobose, with a basal depression, white when fresh, bruising olive-brown, pale brown when dried, surface smooth, KOH on peridium pale brown, FeSO₄ dark olive to black. Gleba dark green to olive, locules small to large, irregularly shaped, empty. Rhizomorph single, stout, concolorous to peridium, attached at base. Columella gelatinous, thin, dendroid, gray translucent. Odor not recorded. Taste not recorded.

Peridium easily separable from gleba, 350-520 μ m thick, two-layered; overlain by evanescent, thin layer of golden brown, smooth, thin-walled, clamped, loosely interwoven hyphae up to 8 μ m in diam, epicutis 300-470 μ m thick, of hyaline, thin-walled, parenchyma-like, inflated cells 5-40 (-80) μ m in diam, with scattered interwoven hyphae, clamp connections absent; subcutis 50-100 μ m thick, of hyaline, thin-walled, periclinal to interwoven hyphae, 2-5 μ m in diam, clamp connections absent.

Trama 95-285 μ m thick, whit hyaline, gelatinized, compactly interwoven hyphae 2-3 μ m in diam, clamp connections absent. Basidia mostly collapsed, hyaline, 50-70 x 7-10 μ m, 1-, 2-, or 4-spored.

Spores minutely verrucose, (17-) 18-19 (-20) x (6-) 7-8 (-9) μ m, fusoid; apex papillate and thickened, base distinctly pedicellate; spore wall less than 0.5 μ m thick; utricule distinct, loose, wrinkled, up to 2 μ m thick; in KOH pale olive singly, yellow-brown in mass.

Etymology: referring to its association with *Quercus* spp.

Habit, habitat and season: Hypogeous, associated

with *Quercus gambellii* and other *Quercus* sp.; March through June, September and November.

Collections examined: Mexico: Tamaulipas: Cd. Victoria, EL Madroño, km 19 carr. Cd. Victoria-Tula, 24 Sept. 1985, *García 4802, 4803* and *García s/n*; Tamaulipas, torre de microondas Las Mulas, 11 Nov. 2006, *Guevara 886* (ITCV, OSC). USA: California, Riverside Co., Skinner Lake, 22 April 1995, *Jumponnen* and *Trappe 15434* (OSC); Riverside Co., north fork of the San Jacinto River, 3 June 1983, *Trappe 7352* (OSC); same data except Alvin meadow, *Trappe 7344* (OSC); San Bernardino Co., San Bernardino National Forest, Fern Basin, 17 March 1984, *S. Berch, Trappe 7972* (OSC); same data *Watling & Dinoff, Trappe 17631a* (OSC); Arizona, Coconino Co., Lake Mary, 28 April 1982, *Trappe 6727* (OSC); Navajo Co., Lukachukai, Buffalo Pass, 22 May 1985, *States AHF432* (OSC).

Discussion: *Hysterangium quercicola* is similar in macroscopic characteristics of the sporocarps to *H. stoloniferum* var. *americana* Fitzpatrick from northeastern United States and *H. neotunicatum* Castellano & Beever from New Zealand (Castellano and Beever 1994) but *H. quercicola* has much larger spores.

Hysterangium velatisporum sp. nov. Castellano, Cázares & Guevara

Figures 7, 8

Peridium 190-400 μ m *crassum*, *album*, *ubi contusum brunneolescens vel parum violascens*, *stratis duobus*: *epicutis* 150-260 μ m *crassa pseudoparenchymatica cellulis* 5-30 μ m *latis et hyphis nonnullis usque ad 60 μ m latis inflatis*, *fibulae absens*; *subcutis* 40 μ m *crassa*, *hyphis intertextis*, *fibulae absens*. *Gleba pallide viridis*, *columella dendroide*. *Sporae verruculosae*, 15-17 x 5-6 μ m, *ellipsoideae*, *utriculo adpresso rugoso usque ad 1 μ m crasso*.

Holotypus hic designatus: Mexico, Coahuila, Arteaga, Las Carolinas, 20 June 1985, *Cázares 155* (ITCV,

isotype OSC).

Basidiomata up to 20 mm in diam, globose to subglobose, white when fresh, bruising pale brown to slightly violet, pale brown when dried. KOH on peridium olive-brown, FeSO₄ dark olive. Gleba pale green, locules small, empty. Rhizomorph single, small, white when fresh, pale brown when dried. Columella dendroid, white and translucent. Odor not recorded. Taste not recorded.

Peridium 190-400 μ m thick, two-layered; epicutis 150-260 μ m thick, of hyaline, thin-walled, parenchyma-like cells, 5-30 μ m in diam, with some periclinal to somewhat interwoven inflated cells up to 60 μ m, clamp connections absent; subcutis 40 μ m thick, of hyaline, thin-walled, interwoven hyphae 2-3 μ m in diam, clamp connections absent.

Trama 75-400 μ m thick, of hyaline, nongelatinized to gelatinized, interwoven hyphae, 3-6 μ m in diam, clamp connections absent. Hymenial elements, branched, nongelatinized. Subhymenium cellular. Basidia hyaline, 20-35 x 7-9 μ m, 2-6-spored, clamp connections present.

Spores minutely verrucose, 15-17 x 5-6 μ m, ellipsoid; apex blunt to slightly acuminate, base truncate, pedicellate; spore wall less than 0.5 μ m thick; utricule appressed, wrinkled, up to 1 μ m thick; in KOH pale olive singly, olive in mass.

Etymology: referring to the distinct wrinkled utricule covering the spore.

Habit, habitat and season: Hypogeous, associated with over story *Pinus* sp. and *Quercus* sp. understory; June, September and November.

Collections examined: Mexico: Tamaulipas, torre de microondas Las Mulas, 11 Nov. 2006, *Guevara 893* (ITCV, OSC); Querétaro, approx. 5 km south of El Doctor, 23 Sept. 1996, *Castellano & Trappe 19283* (OSC); Coahuila, Arteaga, La Siberia, 23 Sept. 1980, *García 3001* (OSC).

Discussion: The combination of a rather thin peridium (190-400 μ m thick), an outer peridial layer with

inflated cells of 5-30 (60) μm thickness, a thin subcutis (40 μm thick) of interwoven hyphae, and rather stout spores (15-17 x 5-6 μm) separate this species from all other *Hysterangium* species. *Hysterangium coriaceum* from Europe and *Hysterangium separabile* from northwestern USA have a similar peridial structure but much smaller spores.

Acknowledgement

We thank DGEST (Dirección General de Educación Superior Tecnológica) for economic support of this research.

References

- Castellano, M.A., J.M. Trappe, Z. Maser, C. Maser, 1989. Keys to spores of the genera of hypogeous fungi of North Temperate forests with special reference to animal mycophagy. Mad River Press: Eureka, California.
- Cázares, E., J. García, J. Castillo, J.M. Trappe, 1992. Hypogeous fungi from northern México. *Mycologia* 84: 341-359.
- García, J., Y. Ramírez, S. Castillo, A. Moreno, 2005. Micofagia por roedores en los bosques templados de Tamaulipas. *Biodiversidad Tamaulipeca* 1: 232-236.
- Guzmán, G., 1971. Notas sobre los generos *Radiigera* y *Mesophelliopsis* en México. *Boletín Sociedad Mexicana de Micología* 5: 7-11.
- Guzmán, G., 1988. Dos nuevas especies de *Macowanites* en México. *Revista Mexicana de Micología* 4: 115-121.
- Hosaka, K., S.T. Bates, R.E. Beever, M.A. Castellano, W. Colgan III, L.S. Dominguez, E.R. Nouhra, J. Geml, A.J. Giachini, S.R. Kenney, N.B. Simpson, J.W. Spatafora, J.M. Trappe, 2006. Molecular phylogenetics of the gomphoid-phalloid fungi with an establishment of the new subclass Phallomycetidae and two new orders. *Mycologia* 98: 949-959.
- Hosford, D.R., J. M. Trappe, 1980. Taxonomic studies on the genus *Rhizopogon*, II. Notes and new records of species from Mexico and Caribbean countries. *Boletín Sociedad Mexicana de Micología* 14: 3-15.
- Trappe, J., G. Guzmán, 1971. Notes on some hypogeous fungi from Mexico. *Mycologia* 63: 317-345.
- Trappe, J.M., G. Guzmán, C. Vazquez Salinas, 1979. Observaciones sobre la identificación, distribución y uso de los hongos del género *Elaphomyces* en México. *Boletín Sociedad Mexicana de Micología* 13: 145-150.
- Zeller, S. M., C.W. Dodge, 1929. *Hysterangium* in North America. *Annales of the Missouri Botanical Garden* 16: 83-123.