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Morpho-taxonomy of synonyms: *Glomus rubiforme* and *Glomus pachycaulis* (Glomeromycota)

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Resumen

Morfotaxonomía de sinónimos: Glomus rubiforme *and* Glomus pachycaulis *(Glomeromycota).*

En este trabajo se redescriben los sinónimos *Glomus rubiforme* y *Glomus pachycaulis* para morfotaxonomía. Estas especies se citaron por primera vez en Goa, India, asociadas a plantas de *Carica papaya* L. Son especies esporocárpicas y están caracterizadas por la presencia de clamidosporas amarillas o marrones radialmente distribuidas alrededor del plexo central de la hifa. Las clamidosporas están terminalmente soportadas por hifas cortas cuya pared es más gruesa que la de la espora. La oclusión del poro se produce en la base de la espora por un engrosamiento de la pared y septo, es algo poco frecuente en las clamidiosporas. Las esporas maduras suelen presentar hifas de soporte de las esporas con un lumen estrecho que conecta el interior de la espora con la hifa.

Palabras clave: *Carica papaya*, Clamidósporas, *Glomus pachycaulis*, *Glomus rubiforme*, Morfotaxonomía.

Abstract

In the present paper, synonyms, *Glomus rubiforme* and *Glomus pachycaulis* are re-described for its morpho-taxonomy. The species *G. rubiforme* and *G. pachycaulis* are reported for the first time from Goa, India and are recorded in association with *Carica papaya* L. plants. The species are sporocarpic and are characterized by presence of yellow to brown chlamydospores radially arranged on terminal central plexus of hypha. Chlamydospores are subtended with short hypha having walls thicker than spore wall. Pore occlusion takes place at the spore base by wall thickening and septa are less frequent in the chlamydospores. Mature spores usually have a subtending hypha with a narrow lumen connecting the spore inside with the hypha.

Key words: *Carica papaya*, Chlamydospores, *Glomus pachycaulis*, *Glomus rubiforme*, Morpho-taxonomy

Introduction

Glomus rubiforme (Gerd. & Trappe) Almeida & Schenck and its synonym *Glomus pachycaulis* (Wu & Chen) Almeida & Schenck was earlier known as *Sclerocystis rubiforme* Gerdemann & Trappe and *Sclerocystis pachycaulis* Wu & Chen respectively. Sporocarps of *Glomus rubiforme* was reported from Oregon and Washington in fields and orchards and in Michigan (Gerdemann & Trappe 1974) while sporocarps of *G. pachycaulis* was reported from rhizosphere of several

plants from Central Taiwan (Wu & Chen 1986). The present paper is the first record of these synonyms from agro-based ecosystem of Goa, India. In the present paper the species are described for its morphotaxonomy.

Figura 1: Esporocarpo joven, amarillo dorado, de *Glomus pachycaulis* con clamidósporas elipsoidales terminalmente soportadas por una hifa no septada (flecha).

Figure 1: Young golden yellow sporocarp of *Glomus pachycaulis* with ellipsoidal chlamydospores borne terminally on subtending (arrow) non septate hypha(x100).

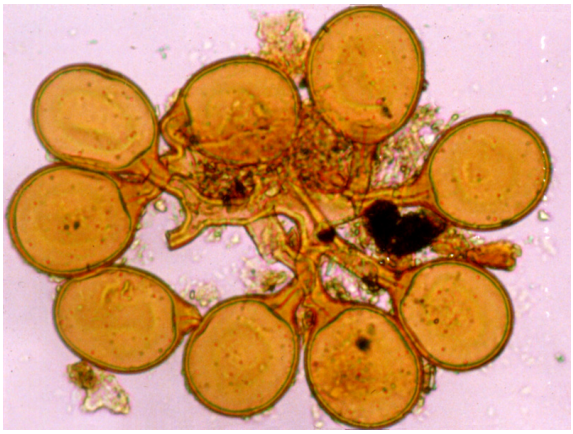

Figura 2: Esporocarpo maduro, marrón, de *Glomus rubiforme* con clamidósporas globosas radialmente distribuidas alrededor del plexo central (x400).

Figure 2: Mature old, brown sporocarp of *Glomus rubiforme* with globose chlamydospores radially arranged around the central plexus (x400).

Material and methods

Extraction of arbuscular mycorrhizal fungal spores

Spores of arbuscular mycorrhizal fungi associated with papaya plants from, Goa, India were isolated directly from rhizosphere soil samples by wet sieving and decanting method (Gerdemann & Nicolson 1963).

Identification of arbuscular mycorrhizal fungi

Diagnostic slides containing intact and crushed sporocarps and spores of arbuscular mycorrhizal fungi were prepared in polyvinyl alcohol lactoglycerol (Koske and Tessier 1983). Spore morphology and wall characteristics were considered for the identification of arbuscular mycorrhizal fungi and these characteristics were ascertained using compound microscope, Leica WILD MP 3 and Nikon E 800. Arbuscular mycorrhizal fungi were identified to species level using bibliographies provided by Schenck and Perez (1990).

Results

Glomus rubiforme (Gerd. & Trappe) Almeida & Schenck.

=*Sclerocystis pachycaulis* Wu & Chen.

=*Sclerocsystis indica* Bhattacharjee , Mukherji & Misra.

Sporocarps, yellow to golden yellow in youth (Fig. 1) and brown at maturity (Fig.2), globose to subglobose, 375-675 x 80-180 µm consisting of terminal chlamydospores radially arranged on a central plexus of a hyphae (Figs. 1 & 2). Peridium unknown. Chlamydospores yellow to golden yellow in youth (Fig. 3) becoming brown at maturity (Fig. 4), globose, obvoid, ellipsoid, sometimes irregular, 27-125 x 29-87 (-110) µm.

Chlamydospore's outer spore wall , hyaline, evanescent, 0.5-3.0 µm thick, frequently absent in mature spores. Inner wall yellow to brown, laminated 3-7.6 µm thick upto 13.5 µm at the spore base. Individual spores at times partially enclosed in a thin network of tightly oppressed hypha (Fig. 3). Chlamydospores subtended with short hypha having walls thicker than spore wall (Figs. 2, 3 & 4).

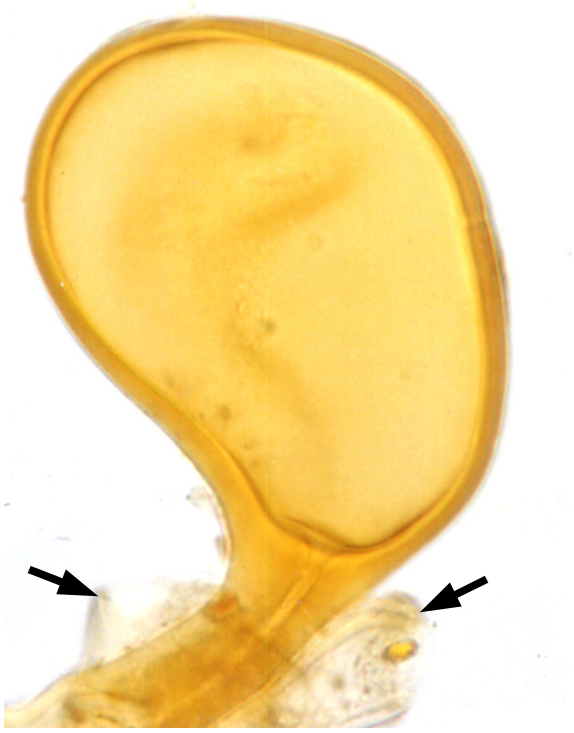

Figura 3: Espora joven amarilla dorada de *Glomus pachycaulis* con hifa corta de pared má gruesa que la de la espora (x1000). [*Obsérvese que las esporas están parcialmante encerradas en una delgada red de hifas apretadas (flechas). Así mismo, obsérvese el lumen de las hifas].

Figure 3: A golden yellow young spore of *Glomus pachycaulis* with short hypha with walls thicker than the spore wall. (x1000). [*Note individual spores partially enclosed in a thin network of tightly oppressed hypha (arrows). Also note the lumen in the hypha].

Subtending hypha upto 28 µm at spore base x with small pore opening or occluded by wall thickening (Figs. 3 & 4) less frequently with two thin septa or one septum of variable thickness. The subtending hyphal wall highly thickens with spore age due to the addition of sublayers to the inner surface of its laminate layer 2. This causes mature spores to usually have a subtending hypha with a narrow lumen connecting the spore inside with the hypha (Figs. 2, 3 & 4). The lumen in most mature spores is occluded by 1-3 thick septa. Young sporocarps usually contain spores with subtending hyphae without septa. Spores often perforated at maturity (Figs. 2 & 4).

Discussion

Currently the *G. rubiforme* has two synonyms viz., *Glomus pachycaulis* (Wu & Chen) Almeida & Schenck and *Glomus indica* (Bhattacharjee, Mukherji & Misra) Almeida & Schenck (Almeida & Schenck 1990). *G. rubiforme* has chlamydospores with evanescent outerwall, absent, in most mature spore and small pore open, occluded by wall thickening or less frequently by one or two septa near the base. These spores appeared to be identical to *G. pachycaulis* where most spores have evanescent outer wall and short subtending hypha with wall normally thicker than spore wall. *G. indica* also has spores with two layered wall arranged around a central plexus of hyphae and small pore occluded by wall thickening and less frequently by one or two septa as *G. rubiforme* (Almeida & Schenck 1990). Therefore *G. pachycaulis* (Wu & Chen) Almeida & Schenck and *G. indica* (Bhattacharjee, Mukherji & Misra) Almeida & Schenck are considered synonyms of *G. rubiforme* (Almeida & Schenck, 1990). Sporocarps of *G. rubiformis* are considered primitive, since they 1) lack peridium 2) produce sporocarps from a simple, broad, thick-walled plexal cell and 3) and produce smaller spores.

G. rubiforme probably is a widely distributed fungus in the world. Its occurrence has been reported in Florida, Michigan, New York, Oregon and Washington of the U.S.A. (Gerdemann & Trappe 1974, Miller et al. 1985, Nicolson & Schenck 1979), in Canada (Dalpé 1989, Dalpé et al. 1986, Hamel et al. 1994), Brazil (Grandi & Trufem 1991, Grandi et al. 1987), Colombia (Sieverding 1989), Cameroon (Musoko et al. 1994), India (Bhattacharjee et al. 1980, Ragupathy & Mahadevan 1993), Taiwan (Wu 1993, Wu & Chen 1986) and New Zealand (Hall 1977, Johnson 1977, Mosse & Bowen 1968). In Poland, *Glomus rubiforme* has been found in many soils coming from different physiographic regions (Blaszkowski et al. 1998, 2002, Tadych & Blaszkowski 2000a, b). The soils represented both cultivated and uncultivated sites, the later including forests, heaps, maritime and inland dunes.

Conclusion

Thus in conclusion, the two synonyms *G. rubiforme* and *G. pachycaulis* are sporocarpic and characterized by yellow to brown chlamydospores radially arranged on terminal central plexus of hypha. Chlamydospores are subtended with short hypha having walls thicker than spore wall. Pore occlusion takes place at the spore base by wall

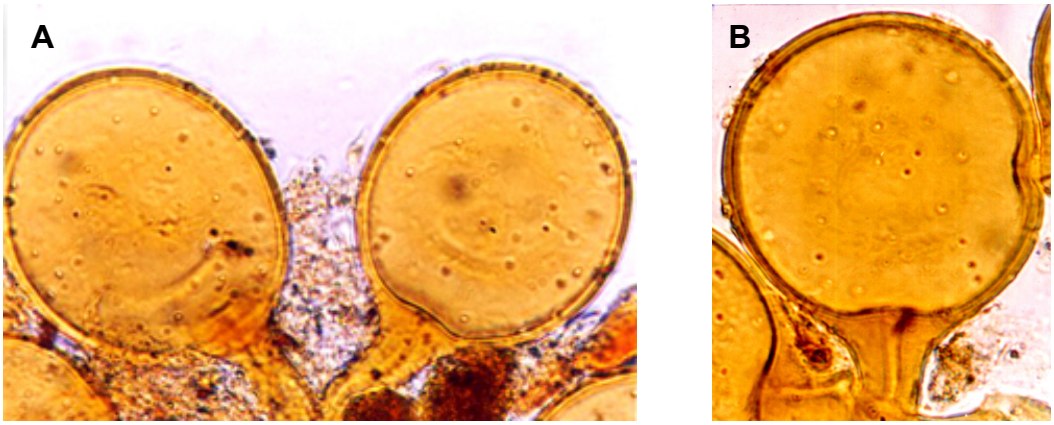

Figura 4: **A:** Esporocarpo aplastado de *Glomus rubiforme* con clamidosporas sustentadas terminalmente por hifas cortas de paredes más gruesas que las de la espora (x 1000). **B:** Espora aislada (x 1000). [Obsérvese las preforaciones en las esporas y el lumen de la hifa]

Figure 4: **A:** Crushed brown sporocarp of *Glomus rubiforme* with globose chlamydospores subtended by short hypha with walls thicker than the spore wall (x 1000). **B:** A single globose spore (x 1000). [Note the perforations in the spores and the lumen in the hypha]

thickening and septa are less frequent in the spores. Mature spores usually have a subtending hypha with a narrow lumen connecting the spore inside with the hypha. The species were recorded for the first time in Goa, India in association with *Carica papaya* plants in agro-based ecosystem.

References

Almeida RT & Schenck NC. 1990. A revision of the genus Sclerocystis (Glomaceae, Glomales). Mycologia 82:703-714.

Bhattacharjee M, Mukerji KG & Misra S. 1980. Studies on Indian Endogonaceae. III. Further records. Acta Botanica Indica 8: 99-102.

Blaszkowski J, Madej T & Tadych M. 1998. Glomus rubiforme (Glomales, Zygomycetes), an arbuscular mycorrhizal fungus new to the mycota of Poland. Acta Mycologia (33): 255-263.

Blaszkowski J, Tadych M & Madej T. 2002. Arbuscular mycorrhizal fungi (Glomales, Zygomycota) of the Bledowska Desert, Poland. Acta Soc. Bot. Pol. (71): 71-85.

Dalpé Y. 1989. Inventaire et repartition de la flore endomycorhizienne de dunes et de rivages maritimes du Quebec, du Nouveau-Brunswick et de la Nouvelle-Ecosse. Naturaliste can. Rev. Ecol. Syst. 116: 219-236.

Dalpé Y, Granger RL & Furlan V. 1986. Abondance relative et diversite des Endogonacees dans un sol de verger du Quebec. Canadian Journal of Botany 64: 912-917.

Gerdemann JW & Trappe JM.1974. The Endogonaceae in the Pacific Northwest. Mycological Memoir 5: 1-76.

Gerdemann JW & Nicolson TH. 1963. Spores of mycorrhizal Endogone species extracted from soil wet sieving and decanting. Transactions of British Mycological Society 46: 235-244.

Grandi RAP & Trufem SFB. 1991. Fungos micorrizocos vesiculo-arbusculares em Marantaceae cultivadas no Instituto de Botânica, Säo Paulo, SP. Revta Brasilica Botonica (14): 89-95.

Grandi RAP, Trufem SFB & Komesu ST. 1987. Fungos micorrizocos em quatro espécies de Marantaceae. P. I. In: Reuniâo Brasileira sobre Micorrhizas, Säo Paulo, SP.

Hall IR. 1977. Species and mycorrhizal infections of New Zealand Endogonaceae. Transactions of British Mycological Society 68: 341-356.

Hamel C, Dalpé Y, Lapierre C, Simard RR & Smith DI. 1994. Composition of the vesicular-arbuscular mycorrhizal fungi population in an old meadow as affected by pH, phosphorus and soil disturbance. Agriculture Ecosystems Environment 49: 223-231.

Johnson PN. 1977. Mycorrhizal Endogonaceae in a New Zealand forest. New Phytologist 78: 161-170.

Koske RE, Tessier B. 1983. A convinient permenat slide mounting medium. Mycological Society of America Newsletter 34: 59.

Miller DD, Domoto PA & Walker C. 1985. Mycorrhizal fungi at eighteen apple rootstock plantings in the United States. New Phytologist 100: 379-391.

Mosse B & Bowen GD. 1968. The distribution of Endogone spores in some Australian and New Zealand soils, and in an experimental field soil at Rothamsted. Transactions of British Mycological Society 51: 485-492.

Musoko M, Last FT & Mason PA. 1994. Populations of spores of vesicular-arbuscular mycorrhizal fungi in undisturbed soils of secondary semideciduous moist tropical forest in Cameroon. Forest Ecology Management 63: 359-377.

Nicolson TH & Schenck NC. 1979. Endogonaceous mycorrhizal endophytes in Florida. Mycologia 71:178-198.

Ragupathy S & Mahadevan A. 1993. Distribution of vesicular-arbuscular mycorrhizae in the plants and rhizosphere soils of the tropical plains, Tamil Nadu, India. Mycorrhiza 3: 123-136.

Schenck NC & Perez Y. 1990. Manual for identification of VA Mycorrhizal fungi. In : Schenck NC & Perez Y, eds., INVAM, University of Florida, Gainesville.USA. 241.

Sieverding E. 1989. Ecology of VAM fungi in tropical agrosystems. Agriculture Ecosystems and Environment 29: 369-390.

Tadych M & Blaszkowski J. 2000a. Arbuscular fungi and mycorrhizae (Glomales) of the Slowinski National Park, Poland. Mycotaxon 74: 463-483.

Tadych M & Blaszkowski J. 2000b. Arbuscular mycorrhizal fungi of the Brda river valley in the Tuchola Forests. Acta Mycologica 35:3-23.

Wu CG & Chen ZC. 1986. The Endogonaceae of Taiwan: I. A preliminary investigation on Endogonaceae of bamboo vegetation at Chi-Tou areas. Central Taiwan. Taiwania 31: 65-88.

Wu CG. 1993. Glomales of Taiwan: IV. A monograph of Sclerocystis (Glomaceae). Mycotaxon 49: 327-349.