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GLOMEROMYCOTA RECOVERED FROM CACAO SOIL

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ABSTRACT
KRAMADIBRATA, K. 2009. *Glomeromycota* recovered from cacao soil. *Reinwardtia* 12(5): 357–371. — Glomeromycotan fungi were studied from several cacao plantations in Indonesia (Java and Bali) and Ecuador. The identity of 28 species of *Glomeromycota* associated with cacao is presented.

Key words: *Glomeromycota*, cacao, Java, Bali and Ecuador

ABSTRAK
KRAMADIBRATA, K. 2009. *Glomeromycota* yang berasosiasi dengan tanaman kakao. *Reinwardtia* 12(5): 357–371. — Disajikan pertelaan 28 jenis *Glomeromycota* yang berasosiasi dengan tanaman kakao di beberapa perkebunan kakao di Indonesia (Jawa, Bali) dan Ekuador.

Kata kunci: *Glomeromycota*, kakao, Jawa, Bali dan Ekuador

INTRODUCTION

Cacao (*Theobroma cacao* L.) occurs naturally in the Amazon Basin, but is now a tropical crop of considerable economic importance. It is believed that the wild cacao was transported by human activity from the Amazon Basin, to Central and Mesoamerica and established as two different populations separated by the Panama Isthmus. These two isolated populations are sometimes considered as subspecies, which become the basis of 'Criollo' and 'Forastero' cacao. In the 16th century the Criollo type spread from Mexico to Carribean islands and parts of South America and it was also taken to the Phillipines in about 1600 by the Spanish. From the Philippines it was later taken to Sulawesi and Java and then spread to Ambon in the Mollucas (Wood, 1985). Cultivation of Forastero began in the 18th century and it replaced the Criollo type which was dominant in the 16th and 17th centuries in Brazil and Ecuador. In Ecuador, the cacao planted was the Nacional type, which is peculiar to Ecuador and is believed to be derived from wild trees chosen for seed when plants were first established as a crop. Ecuador was the largest producer in the 19th century for almost 100 years from the mid 19th to the early 20th centuries.

Cacao is a characteristic crop of the humid tropical zone. It requires well distributed rainfall in the region of 2000 mm annually and an average temperature of 25–26ºC. Cacao is now an important crop mainly in the South American tropics, West Africa, Malaysia and Indonesia. The root system comprises a tap root which goes down to a depth of 1 m to 1.5 m and a mass of lateral feeder roots, usually mycorrhizal, most of which lie in the top 20 cm of soil and maybe extend to several metres from the trunk.

Members of the fungal phylum *Glomeromycota* produces arbuscular mycorrhiza in most land plants, *T. cacao* being amongst them. The identity of glomeromycotan fungi associated with cacao roots and rhizosphere soils was reported from Costa Rica by Janos (1975), Janos & Trappe (1982), and Malaysia (Nadarajah, 1980). These two countries yielded different species. Janos (1975) reported *Sclerocystis dussii* and *Acaulospora* sp.; the latter was eventually described as *Acaulospora foveata* Trappe & Janos. The Malaysian worker, Nadarajah (1980) reported *Sclerocystis* sp., *Acaulospora* sp., *Gigaspora* sp., *Glomus fasciculatus*, *G. macrocarpum* and *G. geosporum* as associated with cacao. A grammatical error in the epithets of species in the genus *Glomus* was corrected by Walker (1982) and consequently the epithet endings were changed from the erroneous masculine to the correct neuter. The changes are listed in Walker (1982) and later species epithets have been published with the correct neuter gender. *Glomus macrocarpus* var. *geosporus* was raised to species status as *G. geosporum* Walker (Walker, 1982). *Glomus fasciculatum* has been erroneously used for describing different taxa based on misidentification. This led Walker & Koske (1987) to

redefine this species from examination of Thaxter's sporocarpic material from the Farlow Herbarium and other specimens from different parts of the world. Almeida & Schenck (1990) revised the genera *Sclerocystis* and transferred five out six species into *Glomus*. Morton & Redecker (2001) erected two families of *Glomales*, *Archaeosporaceae* and *Paraglomaceae*, with two new genera *Archaeospora* and *Paraglomus*, based on concordant molecular and morphological characters. Later Walker & Schüßler (Schüßler *et al*., 2001), erected a new phylum, *Glomeromycota* based on natural relationship for the arbuscular mycorrhizal and related fungi.

The aim of this study is to investigate the species of *Glomeromycota* associated with cacao in several cacao plantations and small scale cacao plantation in Indonesia (Java and Bali) and Ecuador.

MATERIAL AND METHODS

Field sampling of soils under cacao plant

Soil samples were collected during the field trip from April to May 1987. Approximately 2–4 kg of soil from cacao plantations and small cacao farms throughout Java and Bali, was excavated from around each cacao tree. The soil was a combination of four sub-samples from four points at 0–15 cm depth, 40–50 cm from the tree trunk, using a small trowel. Soil samples were taken to the laboratory in Bogor where spore extraction by centrifugation and sugar-floatation (Walker *et al.* 1982) was carried out as soon as possible after the arrival of the soil. Other samples were air dried for later spore extraction by the same method. Extracted spores in water were transferred to vials of 10% formalin to make up formaldehyde for storage pending identification.

About 100 g of soil from each sample was separated, stored and taken to Britain for pot culture in order to multiply the number of glomeromycotan spores, based on Gilmore's method (1968).

A similar technique was employed to collect samples in March to May 1983 from cacao plantations and other field crops in Ecuador by Dr. J.N. Hedger. One sample (approx. 1 kg) was taken at 10 cm depth about 40 cm from the base of a single wild cacao tree in the Amazon area of Ecuador and from agricultural soils and greenhouse experiments in Ecuador. Spores were retrieved by wet sieving and decanting (Gerdemann & Nicolson, 1963) and the extracts, stored in FAA, were subsequently transported to Britain for detailed examination.

RESULTS AND DISCUSSION

Twenty eight species in five genera were found in the surveys, 24 species and five genera from Indonesia and 13 species and four genera from Ecuador. Some of the species fitted the species descriptions well, whereas with others, there were some differences. The latter are indicated by a query before their names in the following descriptions.

1. ACAULOSPORA FOVEATA Trappe & Janos, Mycotaxon 15: 515-518. 1982.

Spores were yellowish brown to reddish brown, globose to subglobose, 165–260 x 185–290 µm. The surface was covered with round to oblong sometimes irregular depressions 4–8 x 4–12 µm, 1–3 µm deep with curved bottoms, separated by ridges 4–10 µm deep with curved bottoms, separated by ridges 4–10 µm wide. The wall composed of three walls. A sporiferous saccule was not observed in any of the collections made during the study. Spore wall structure is of three wall groups.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK258, KK260, KK279, KK286, KK294*. Banjar County, XIII State Plantation Company, Putrapinggan Plantation, *KK359, KK376, KK389.* Malang County, Sumberpucung Subdistrict, Peniwen village, *KK191*. ECUADOR: Los Rios Province, Estacion Experiment Tropical (EET) Pichilingue, INIAP, from cacao greenhouse experiments, originally from cacao soil, Retrocruce cacao/non sterile, *RCC/NS, KK30.*

The spores from Java were smaller (165–260 x 185–290 µm) than the measurements in the original description (185–310(410) x 215–350(–480) µm) (Trappe & Janos in Janos & Trappe, 1982). However *A. foveata* described from Colombia by Schenck *et al*. (1984) also differed in size compared to the measurements of Trappe & Janos (1982) *i.e.* (135–)250(300) µm. The spore colour of the Javan material was similar to the description of young spores in Trappe & Janos (1982) and spores with a darker colour were never found (mature spores in the original description are said to be reddish brown to brown). One specimen from Ecuador, from non-pasteurised soil in greenhouse experiment, Retrocruce cacao, RCC/NS, appeared to be different from *A. foveata*,

but was inadequate for further determination. It was globose, 200 µm in diameter and differed in having a dark brown wall with bigger irregular pits 14–16 µm in diameter separated by wider ridges, 8–10 µm in diameter. This specimen has been placed as (?) *A. foveata* because of its general resemblance to that species.

Trappe & Janos (1982) originally described this species from soils of tropical forest, cacao plantation in Costa Rica, Panama as well as grass, banana, and sugarcane in Mexico. Schenck *et al*. (1984) found it in soil from under native grass in Colombia.

This species is also reported from Java, Indonesia such as, under alang-alang in Bogor (Widiastuti & Kramadibrata, 1992), under forest trees in the slope of Mount Pangrango of the Gede Pangrango National Park (Kramadibrata, 1993), palm oil in West Java (Widiastuti & Kramadibrata, 1993), bamboo in Bogor Botanic Gardens (Setya *et al*., 1995), under forest trees in natural forest in the Mount Halimun National Park (Suciatmih & Kramadibrata, 2002), under durian in Bogor (Chairani *et al.*, 2002), and under corn in Bogor (Haerida & Kramadibrata, 2002).

2. ACAULOSPORA REHMII Sieverding & Toro, Angew Bot. 61: 217-223. 1987.

Spores were light yellow to yellow, globose to subglobose, 90–200 x 100–200 µm. The surface had evenly labyrinthine-form folds, with ridges 1–4 µm wide and 1–4.5 µm high and depressions between ridges 1–4 µm. The spore wall consisted of four components. Reaction to Melzer's reagent was negative, but such reaction may be extinguished by storage in FAA or formaldehyde solution.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK257, KK258a, KK258b, KK278.*

This taxon was originally described from Colombia. The Javan population appeared to be always lighter in colour although than the original description by Sieverding & Toro (1987) which gave a range of from yellow to black, but dark spores were never found in the samples studied here.

Spore size from Javan samples was bigger 90–200 x 100–200 µm than in the original description, (82–)112–168(–175) µm (Sieverding & Toro, 1987). The spore surface was similarly labyrinthine in form but most of the ridges in the Javan specimens were 1–4 µm narrower and shorter 1–4.5 µm than in the original description, 1–4.5 µm and 1–5 µm (Sieverding & Toro, 1987). Nevertheless, these differences do not seem sufficient to consider the Javan specimens as a different species.

The original description was of a spore type associated with cassava, beans, sorghum and a *Crotalaria* species in Colombia (Sieverding & Toro, 1987). It is also reported from Java, Indonesia under bamboo in Bogor Botanic Gardens (Setya *et al.*, 1995), under corn (Haerida & Kramadibrata, 2002), and under durian all in Bogor area (Chairani *et al*., 2002).

3. ACAULOSPORA SCROBICULATA Trappe, Mycotaxon 6: 363-366. 1977.

Spores were borne singly on a globose, to subglobose sporiferous saccule which was, 140-160 µm in diameter and formed on a wide thin-walled, hyaline hyphae, ± 50 µm diameter. Spores globose, subglobose to broadly ellipsoidal, or ovoid, light brown, 90–(130)–250 x 100–(120)–250 µm. The surface was uniformly pitted with depressions 1–1.5 x 1–3 µm, separated by ridges 2–4 µm thick with a circular, linear or y-shaped pattern. The spore attachment to the sporiferous saccule was about 15 µm in diameter. The spore wall was composed of four wall components. In Melzer's reagent components 1–3 turned a deeper yellow whilst the innermost component soon became a purple reaction but through the 'filter' of a yellow structural wall, it appears red.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK407*. Jepara County, XVIII State Plantation Company, Beji Plantation, Beji Barat, *KK218a.* Malang County, Sumber pucung Subdistrict, Peniwen village, *KK185*; Pancursari Subdistrict, Pancursari village, *KK198, KK213*. ECUADOR: Los Rios Province, EET Pichilingue, INIAP, from cacao soils, Finca San Carlos, *KK136*; Palma Chavez cacao, *KK121a*; Bosque Viejo, *KK15;* Napo Province, Napo Station of Instituto Nacional de Investigaciones, Agropecuarios, London Cocoa Trade Project – Estacion Experiment Napo (LCT-EEN), Napo *LCT-EEN136, KK130*; Napo *LCT-EEN137, KK57a*. Los Rios Province, near EET Pichilingue, INIAP, Quevedo area, from other agricultural soils, under coffee, *KK48*; under banana, *KK51a*, under grass *KK59,* under maize, *KK104 & KK149*, under rice, *KK116a*. Los Rios Province, EET Pichilingue, INIAP, from greenhouse experiments, originally from cacao soil collected in Quevedo area, Pichilingue, Finca la/non sterile *Fla/NS, KK1;* Finca la/ sterile *Fla/S, KK79;* Finca Donna Maria/non sterile *FDM/NS, KK122;* Finca Donna Maria/sterile *FDM/S, KK3;* San Carlos/non sterile

SC/NS, KK165; San Carlos/sterile *SC/S, KK157;* Retrocruce Palma/non sterile *RP2/NS, KK152,* Retrocruce Palma/sterile *RP2/S, KK13;* Retrocruce cacao/non sterile *RCC/NS, KK29;* Retrocruce cacao/sterile *RCC/S, KK103;* Cacao soil/non sterile *C/NS, KK88;* Cacao soil/sterile *C/S, KK92;* Retrocruce Palma/non sterile *RP1/NS, KK138;* Retrocruce Palma/sterile *RP1/S, KK41;* Bosque Viejo/non sterile *BV/NS, KK73;* Bosque Viejo/sterile *BV/S, KK66;* 7A EET Pichilingue hybrid cacao *7A/S, KK155;* Finca/sterile *F/S, KK154;* Santa Pricia 'Nacional' cacao/steril *SP/S, KK156;* originally from maize soil collected in Quevedo area, Retrocruce maize/non steril *RCM/NS, KK26;* Retrocruce maize/steril *RCM/S, KK71*.

Most of sporiferous saccules found were bigger 140–160 µm than the original description 100–160 µm (Trappe, 1977). Other minor differences were found perhaps reflecting the large number of spores examined in the present investigation. Javanese material had a high proportion of ovoid spores, 90–(130)–250 x 100–(120)–250 µm, the collections have extended the size range of the original description 100–240 x 100–220 µm (Trappe, 1977).

A. scrobiculata was first described from Mexico, in association with wild grasses, *Saccharum officinarum* and in rain forest. In the USA it has been found associated with maize and *Festuca viridula* and in Japan with wild grasses (Trappe, 1977). In Java, Indonesia it was reported from under alang-alang (Widiastuti & Kramadibrata, 1992), under forest trees in Mount Gede Pangrango National Park (Kramadibrata, 1993), palm oil (Widiastuti & Kramadibrata, 1993), bamboo in the Bogor Botanic Garden (Setya *et al.*, 1995), under mangosteen (Silviana *et al*., 1999), under corn (Haerida & Kramadibrata, 2002), under durian (Chairani *et al*., 2002), and under rambutan (Muliawan *et al*., 2002)

4. ACAULOSPORA TUBERCULATA Janos & Trappe, Mycotaxon 15: 515–522. 1982.

The spores were globose to subglobose, 120–280 x 120–280 µm, light yellowish brown to light brown. They had a covering of tubercules 0.5–1.5 µm tall, 1.5 µm diameter at the base, which tapered to 0.8–1 µm at the top. The hyphal attachment was ± 15 µm diameter. The wall structures comprised of three walls. Reaction to Melzer's reagent: wall 2 becoming bright brown.

The yellowish thick walled sporiferous saccule was recovered from field collections but is not described here due to the poor condition and collapsed nature of all the material examined.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK256, KK266, KK289, KK293, KK295.* Jepara County, XVIII State Plantation Company, Beji Plantation, Beji Barat, *KK225, KK226*. Bali, Jembrana County, Pekutatan Subdistrict, Puluhan village, *KK242, KK244, KK245, KK253.*

The Balian and Javan spores were always smaller, 120–280 x 120–280 µm, than the published description 255–327 x 255–340 µm (Janos & Trappe, 1982) and their colour always resembled the description of the colour of young spores in Janos & Trappe (1982) as being dark honey brown or almost reddish black but spores of this colour were never found. Leaching of pigment by long storage in 5% formalin could have occurred. Some of the spores collections also had shorter and finer tubercules (0.5–1.5 µm) compared to the original description 0.7–1.5 µm (Janos & Trappe, 1982).

A. tuberculata was originally described from Costa Rica and from the lowland tropical moist, wet forest and secondary vegetation (Janos & Trappe, 1982). In Java, Indonesia it was recorded from under forest trees in Mount Gede Pangrango National Park (Kramadibrata, 1993), under palm oil (Widiastuti & Kramadibrata, 1993), under mangosteen (Silviana *et al*., 1999), and under durian (Chairani *et al*., 2002). These specimens differed from *A. spinosa* because of the tubercular surface ornamentation. The ornamentation of *A. spinosa* consists of crowded blunt spines rather than tubercules (Walker & Trappe, 1981).

5. ACAULOSPORA WALKERI Kramad. & Hedger, Mycotaxon 37: 73-77. 1990.

Spores were globose or subglobose or reniform, pale brown or yellow-brown to brown, 140–200 x 140–200 µm. The surface was smooth. Spores were formed at about 40–80 µm distant from the neck or stalk of a hyaline sporiferous saccule, and each is separated by a globose to irregular scar 10–20 µm wide left on the spore. The wall structure consisted of four components.

Spores arising laterally from a sporiferous saccule which collapses as the spore matures. The sporiferous saccule is hyaline to white, globose to subglobose, 80–120 x 100–150 µm diameter, with a hyaline to greenish wall, 0.5–1.0 µm thick. It gives rise to a hypha ± 200 µm long, which is 10–20 µm broad near the sporiferous saccule, but which tapers to 5 µm at its tip near the spore. The sporiferous saccule itself is sometimes minutely roughened because of minute particles of soil, which appear like granules on the surface.

Reaction to Melzer's reagent were (a) fresh spores from pot cultures walls 1 and 2 do not react, the inner components become purple; (b) after prolonged storage in 5% formaldehyde, wall components 1 and 2 remain unreactive, but components 3 and 4 become brown in Melzer's, and ornamentation in component 3 become obvious.

Collection examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK277* (Holotype), *KK275, KK202, KK202a*. Banjar County, XIII State Plantation Company, Batugajah Plantation *KK322, KK323,* Pangandaran Plantation *KK144, KK340, KK345.* Jepara County, XVII State Plantation Company, Beji Tengah, *KK228.* Malang County, Pancursari Subdistrict, Pancursari village, *KK212*. Bali, Jembarana County, Pekutatan Subdistrict, Puluhan village, *KK s.n.*

All collection of spores of *A. walkeri* from cacao soils throughout Java and Bali appeared to be very similar. Most field collections from Bali lacked sporiferous saccules, but were clearly *A. walkeri*.

A. walkeri resembles the description of *A. delicata* Walker, Pfeiffer & Bloss (1986) but the spores of the latter are smaller 80–125(150) x 80–110(140) µm in A. *delicata*, compared to 140–200 x 140–200 µm in *A. walkeri* but both have a sparkling appearance. Fresh spores of *A. walkeri* are also much darker in colour than those of *A. delicata.*

6. ? GIGASPORA cf. DECIPIENS Hall & Abbott, Trans. Brit. myc. Soc. 83: 204-206. 1984.

The spores were globose, greenish yellow, sometimes hyaline, 250–320 µm diameter. The wall structure seemed to consist of three hyaline components. The bulbous suspensor was yellow to light brown, 16–20 µm in width.

Collection examined. ECUADOR: Los Rios Province, near EET Pichilingue, INIAP, Quevedo area, field sample from under cacao, San Carlos Farm, *KK134.* Other field sample, under pasture, *KK58*.

These specimens resembled *G. decipiens* Hall & Abbott, although the original description specified a larger range of spore diameters (320–490 µm as compared to 250–320 µm) and very much thicker walls compared with my specimens (7–8 µm), *vs* 20–35 µm in young spores, 34–47 µm thick in older spores (Hall & Abbott, 1984).

Since all the spores were found in poor condition, further progress with this taxon was not possible but it may represent a form of *G. decipiens* or an undescribed *Gigaspora* species with affinities with other colourless *Gigaspora* species.

This species is said by Hall & Abbott (1984) to be wide spread in Western Australia. It forms arbuscular association with kikuyu grass (*Pennisetum clandestinum*).

7. ? GIGASPORA GIGANTEA (Nicol. & Gerd.) Gerd. & Trappe, Mycologia Memoir 5: 29-30. 1974.

Endogone gigantea Nicol. & Gerd. Mycologia 60: 321. 1968.

The spores were globose to ellipsoid, with a greenish yellow to bright yellow colour after storage in FAA, 250–320 x 270–380 µm diameter. A bulbous suspensor ± 40 µm diameter was found on most spores. It had a slender hyphal connection to the base of the spore. The spore wall consisted of two components. Germ tube production was observed in a few spores through the spore wall next to the suspensor. Auxiliary cells typical of *Gigaspora* type were also found in a number of collections. Reaction to Melzer's reagent: wall 1 became yellow, wall 2 turning light yellow.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK306, KK307, KK311*; Banjar County, XIII State Plantation Company, Putrapinggan Plantation, *KK351*, Pangandaran Plantation, *KK344*. Malang County, Pancursari Subdistrict, Pancursari village, *KK213d.* ECUADOR: Los Rios Province, EET Pichilingue, INIAP, from greenhouse experiments with cacao, *RCM/NS, KK20, KK24*; Los Rios Province, near EET Pichilingue, INIAP, Quevedo area, from agricultural soil, under maize, *KK107*; under rice, *KK112, KK115*.

Gigaspora gigantea was first described as *Endogone gigantea* by Nicolson & Gerdemann (1968). The spore size of the Javan material was within the range given by the authors (183–500 x 291–812 µm) but spores falling within the upper range of these values were never found. Such large spores, would possibly have been retained in the discarded sievings on the 650 µm sieve. In their definition of this taxon Gerdemann & Trappe (1974) give spore sizes in the range 353–368 x 345–398 µm, which are closer to the Javan material but still larger. However since the number of spores of this species in the Java collections was limited it is possible that the absence of cylindrical and irregular shaped spores

giving larger dimensions, which were never seen, could account for this difference. The existence of one wall group is the main characteristic which placed this spore type in *Gigaspora* as also did the position of germ tube. Although some auxiliary cells of *Gigaspora* type were found in a field they cannot be associated with this species alone because *G. margarita* was also found in the same sample of Rajamandala.

Some Ecuadorean specimens were placed under *G. gigantean* group (*albida* or *candida*) because of the resemblance of the wall structure. They were globose to subglobose measured 180–270 μm with a greenish yellow in colour. They were found in poor condition and it will not useful to separate these material from *G. gigantea* until further collections can be examined.

G. gigantea is said by Gerdemann & Trappe (1974) to be common in Midwest of the USA and Florida. It forms arbuscular association with maize and a range of tree species (Clark, 1969). This species is also reported from Indonesia such as under bamboo (Setya *et al*., 1995), under mangosteen (Silviana *et al*., 1999) and rambutan (Muliawan *et al*., 2002).

8. ? GIGASPORA MARGARITA Becker & Hall, Mycotaxon 4: 155-160. 1976.

The spore was globose, white, 300 μm in diameter. The spore wall structure comprised a single group of one wall component. The bulbous suspensor was ± 40 μm wide, hyaline with a slender hypha projecting to the base of spore. Auxiliary cells of *Gigaspora* type were also observed in this field collection.

Collection examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK 306a*.

Only one spore of this species was found. Since it resembled the description of *G. margarita*, it was placed in this taxon, although the fresh colour of spore was unknown.

Becker & Hall (1976) originally described this taxon from an agricultural field in east central of Illinois and virgin sand prairie in central Illinois and Florida. It was also found in Waikato, North Island, New Zealand and in South Africa.

9. ?GLOMUS AGGREGATUM Schenck & Smith, Mycologia 74: 79-80. 1982.

Spores were globose to subglobose or obovoid 40–80 x 40–80 μm, with a pale yellow to yellow brown colour. The wall structures comprised two walls. The spore base had a hyphal attachment which was usually straight or on occasions curved, being 5–12 μm at the site of attachment to the spore. Reaction to Melzer's reagent was negative.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK265*. Banjar County, XIII State Plantation Company, Batugajah Plantation, *KK310, KK312, KK319, KK321*, Kebun Putrapinggan, *KK396,* Pangandaran Plantation, *KK336*. Malang County, Pancursari Subdistrict, Pancursari village, *KK213a,* Sumberpucung Subdistrict, Peniwen village, *KK194.* ECUADOR: Los Rios Province, near EET Pichilingue, INIAP, Quevedo area, field sample from agricultural soil, under rice, *KK113*.

Specimens from Java and Bali were smaller 40–80 x 40–80 μm than the sizes given in the original description (50.4–)72.5(–91.2) μm when globose or (67.2–)87(–110.4) x (57.6–)72(–79.2) μm when subglobose (Schenck & Smith, 1982). The spore colour in some specimens from Java and Bali was darker, from pale yellow to yellow brown, than in the original description, hyaline to yellow, Schenck & Smith (1982). Spore colour could however have been affected by long storage in 5% formaldehyde solution. Koske (1985) also found a greater range of spore sizes and shapes than on the original description of this species (20–)40–85(–120) x (20–)40–85(–120) μm when globose or subglobose and (30–)40–120(–210) x (20–)40–90(–120) μm when irregular. The colour of Koske's specimen was also varied from very pale yellow to yellow brown to orange brown and fitted better with the colour range of my samples. However a straight hyphal attachment was by far the commonest type in my material and the curved, infundibuliform, constricted, swollen or irregular types observed by Koske were rarely seen.

The sporocarps characteristic of *G. aggregatum* were not observed, although loose aggregates of 3–10 spores were found in some collections.

Glomus aggregatum was first described from a pot culture from roots of *Citrus sinensis* x *Poncirus trifoliate* in Florida (Schenck & Smith, 1982). It has also been reported from sand dunes of the Atlantic Coast of the USA and Canada, lacustrine dunes of Lake Huron and Lake Michigan, abandoned railroad bed in Michigan, sand dunes in Hawaii and *Citrus* nursery in Florida (Koske, 1985). It has also been reported from under forest trees in Gede Pangrango National Park (Kramadibrata, 1993), under natural

forest Mount Halimun National Park (Suciatmih & Kramadibrata, 2002), under corn (Haerida & Kramadibrata, 2002), and durian (Chairani *et al.*, 2002).

10. ?GLOMUS ALBIDUM Walker & Rhodes, Mycotaxon 12: 509–514. 1981.

Spores were light yellow to yellow, globose to subglobose, 85–160 x 85–160 µm. The wall structure was of two components. The subtending hypha ± 5 µm, straight and simply attached to the spore base, without a constriction or funnel shape.

Collection examined. INDONESIA: Bali, Jembrana County, Pekutatan Subdistrict, Puluhan village, *KK251*.

The spores from Bali had persistent roughened granules on the outside thus differing somewhat from the original description but Walker (*pers. comm.*) has confirmed that this species had the general appearance of *Glomus albidum*. Bali's specimen appeared to be smaller, 85–160 x 85–160 µm, than the original description (85–)95–168(–198) x (85–)95–168(–177) µm (Walker & Rhodes, 1981) and was paler.

This species was collected from winter wheat (*Triticum aestivum*), *Bromus inermis*, *Zea mays*, *Setaria* spp. and *Populus* spp. in Iowa (Walker & Rhodes, 1981).

11. GLOMUS CONSTRICTUM Trappe, Mycotaxon 6: 361–363. 1977.

The spores were globose to subglobose, 180–200 µm, brown to dark brown and smooth. The wall structures comprised one wall. The hyphal attachment was straight then recurved, 10–16 µm diameter. The hyphal wall was yellow to yellowish brown.

Collection examined. ECUADOR: Los Rios Province, EET Pichilingue, INIAP, Quevedo area, from cacao soil, Finca San Carlos, *KK135*; Los Rios Province, EET Pichilingue, INIAP, greenhouse experiment, *RP2/S, KK10; RCM/S, KK72, BV/S, KK77*. INDONESIA: Java, Jepara County, XVII State Plantation Company, Beji Plantation, Beji Tengah, *KK219*

The spores from Ecuador were found in poor conditions and were never obtained in clusters as originally described by Trappe (1977). The spore size was within the range of 150–330 µm diameter given by Trappe. Spore colour was paler than the original description in which it was described as dark brown to black, shiny.

This species was collected from Central California and tropical rain forests of Mexico (Trappe, 1977). This species is also known from under durian in Java, Indonesia (Chairani *et al.*, 2002).

12. GLOMUS DIAPHANUM Morton & Walker, Mycotaxon 21: 433–434. 1984.

The spores were globose to subglobose, 60 x 100 µm, hyaline and smooth. The wall structures comprised two walls each with one component. The subtending hyphae straight, 4–8 µm thick. No sporocarps were found but the spores were sometimes found in loose clusters.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK300*. Malang County, Pancursari Subdistrict, Pancursari village, *KK210, KK212a.* Some spores resembling *G. diaphanum* were extracted from Jepara, XVII State Plantation Company, Beji Plantation, Beji Tengah, *KK224a, KK241*; Beji Barat, *KK237.*

The spore size from Java was within the range given in the original description (39)–74–(121) µm in West Virginia (Morton & Walker, 1984). Most of subtending hypha from Java were shorter than West Virginian specimens (5.4)–8.1–(11.2) µm. This species has been confused with spores of *Glomus occultum* under the dissecting microscope (Morton & Walker, 1984) so that during the sorting out of field material some specimens could have been misplaced under *G. occultum*, although *G. diaphanum* has a smooth spore surface (so does *G. occultum*). In West Virginia this species has been associated with corn, red clover, subterranean clover, sudan grass, tall fescue, black locust, big tooth aspen (Morton & Walker, 1984).

13. GLOMUS ETUNICATUM Becker & Gerdemann, Mycotaxon 6: 29-32. 1977.

The spores were globose 150 x 150 µm, smooth, pale yellow to yellow. The wall structure comprised two components in one group. In those specimens with intact subtending hyphae, the spore wall thickening extended up to 20 µm distally is as described Becker & Gerdemann (1977).

Collections examined. INDONESIA: Java, Bogor, Indonesian Spice and Medicinal Crops Research Institute, *KK178*. ECUADOR: Napo Province, Napo Station of Instituto Nacional de Investigaciones, Agropecuarios, London Trade Project – Estacion Ex-

periment Napo (LCT-EEN), field collections from cacao soils, Napo *LCT-EEN136, KK31*; Napo *LCT-EEN137, KK56;* Paloma Chavez *EETP, KK118.* Quevedo area, near EET Pichilingue, INIAP, field collection from agricultural soil, under maize, *KK111;* Los Rios Province, EET Pichilingue, INIAP, greenhouse experiment, *FDM/S, KK125; C/NS, KK87.*

Spores of *G. etunicatum* from Ecuador were generally in poor condition, although the spore size, 150 x 150 μm compared to 68–144(162) μm, and colour resembled the original description (Becker & Gerdemann, 1977). The spores from Ecuador only possessed one hyphal attachment, although two attachments were observed in some of the collection on which Becker & Gerdemann (1977) used in their description.

Glomus etunicatum was described by Becker & Gerdemann (1977) from prairie in Illinois and agricultural fields in Missouri, Florida and Illinois associated with roots of *Andropogon scoparius* and *Zea mays*. This species is also known from under natural forest trees in Mount Halimun National Park (Suciatmih & Kramadibrata, 2002), under corn (Haerida & Kramadibrata, 2002), under durian (Chairani *et al*., 2002), under rambutan (Muliawan *et al*., 2002), under mangosteen (Silviana *et al*., 1999), and bamboo in Bogor Botanic Garden (Setya *et al*., 1995).

14. GLOMUS FASCICULATUM (Thaxter *sensu* Gerd.) Gerd. & Trappe, Mycologia Memoir 5: 51–53. 1974.

Endogone macrocarpa f. *media* Tul. & Tul., Fungi Hypogaei :192. 1851.

Endogone fasciculate Thaxter, Proc. Amer. Acad. Arts Sci 57. 308–309. 1922. emend. Gerdemann, Mycologia 57: 562–575. 1965.

Endogone arenacea Thaxter, Proc. Am. Acad. Arts Sci. 57: 317. 1922.

Rhizophagites butleri Rosend., Bull.Torrey Bot. Club 70: 131. 1943.

Spores were globose, 90–120 x 90–120 μm, sometimes found in loose aggregations or singly. The colour varied from pale yellow to pale yellow brown. Wall structures comprised three components. The subtending hypha was paler than the spore, straight, 5–15 μm diameter.

Collections examined. INDONESIA: Java, Jepara County, XVII State Plantation Company, Beji Plantation, Beji Tengah, *KK223, KK224*. ECUADOR: Los Rios Province, EET Pichilingue, INIAP, greenhouse experiment, *C/S, KK94; SC/S, KK158*.

Glomus fasciculatum is a widespread species but many records are probably erroneous identifications as pointed out by Walker & Koske (1987) who amended the description given by Gerdemann & Trappe (1974). Sporocarps were not found in field collections but spores sizes were within the range of the emended description of Walker & Koske in 1987 (50–)60–95(–149)x 55–90(–149) μm. However, the Indonesian and Ecuadorean spores were never smaller than 90 μm or larger than 120 μm. Most spores were rather pale yellow-brown even after preservation in FAA. The brown or red colour mentioned as a possible affect of FAA storage by Walker & Koske (1987) was not seen.

Spores determined as *Glomus fasciculatum* have been described from collections made through the temperate and tropical zones (Gerdemann & Trappe, 1974; Walker & Koske, 1987) with a wide variety of vegetation. This species has been also reported associated with bamboo in Bogor Botanic Garden (Setya *et al*., 1995), under mangosteen (Silviana *et al*., 1999), under durian (Chairani *et al.,* 2002), and under rambutan (Muliawan *et al*., 2002).

15. ?GLOMUS FUEGIANUM (Spegazzini) Trappe & Gerd., Mycologia Memoir 5: 58. 1974.

Endogone fuegiana Spegazzini, Ann. Soc. Sci. Argentina 29: 125. 1887.

The spores of this species were characteristically found in clusters. Spores globose to subglobose, 80–100 x 76–120 μm and had a dark brown or reddish brown to black colour. The wall structures comprised two components. The hyphal attachment was concolourous the spores and 25-30 μm diameter. The spores attached to a single hyphal system, developing in close clusters or groups.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK280, KK288.* Banjar County, XIII State Plantation Company, Batugajah Plantation, *KK315, KK316, KK320,* Putrapinggan Plantation, *KK362, KK363*. Jepara County, XVII State Plantation Company, Beji Plantation, Beji Tengah, *KK218, KK220.* Malang County, Pancursari Subdistrict, Pancursari village, *KK197, KK202, KK204, KK208, KK209, KK209a.*

Thaxter (1922) described this species from a type specimen collected from Staten Island, Straits of Magellan by Spegazzini in 1887. The type specimen spores 80 x 65 μm diameter, reddish brown in colour. The specimens from Java were

bigger than the original description and the spores described by Godfrey (1957) and Hall (1977), but had similar 'spore groups' or a distinct pattern of spore aggregates. Since the type specimen was not examined, for the present the specimen from Java are provisionally placed in *G. fuegianum*. Some of Javan specimens were also darker than those described by Thaxter. Hall (1977) gives a radically different definition of *G. fuegianum*, defining two walls, whereas McGee & Trappe (2002) redefined the species from Australia and indicated that the wall structures comprised three components.

The known distribution of this species has been extended to England and the spores associated with yew trees mostly when ground vegetation was sparse or lacking (Godfrey, 1957) and forest trees in New Zealand (Hall, 1977). This species is also found under alang-alang, corn and cacao in Bogor (Widiastuti & Kramadibrata, 1992), and palm oil in West Java (Widiastuti & Kramadibrata, 1993).

16. GLOMUS GEOSPORUM (Nicolson & Gerdemann) Walker, Mycotaxon 15:56–59. 1982.

Endogone macrocarpa (Tul. & Tul.) Tul. & Tul. var. *geospora* Nicol. & Gerd., Mycologia 60: 318–319. 1968.

Glomus macrocarpus var. *geosporus* (Nicol. & Gerd.) Gerd. & Trappe, Mycologia Memoir 5: 55–56. 1974.

The spores were globose to subglobose, 100–280 µm diameter. They were smooth and shiny and had a dark yellow-brown to dark red-brown colour. The wall structures comprised three components. The subtending hyphae were straight, 10–20 µm diameter with a yellow to dark yellow-brown wall. Reaction to Melzer's reagent was negative.

Collection examined. ECUADOR: Napo Province, Napo Station of Instituto Nacional de Investigaciones, Agropecuarios, London Trade Project – Estacion Experiment Napo (LCT-EEN), field sample from cacao soils, Napo *LCT-EEN136, KK129*; Quevedo area, near EET Pichilingue, INIAP, from agricultural soils, under maize, *KK110*; Los Rios Province, EET Pichilingue, INIAP, from greenhouse experiments under cacao, *FDM/S, KK2; FDM/NS, KK124; RCC/S, KK101; C/NS, KK89; C/S, KK95; BV/NS, KK74; RCM/S, KK70; RP1/NS, KK144; RP1/S, KK36.*

The spore colour of Ecuadorean specimens resembled the description in Walker (1982) of mature spores of *G. geosporum*. Walker (1982) described young spores as being light yellow-brown and transparent to translucent. Such spores were found in the Ecuadorean samples. Ecuadorean specimens had spore sizes within the description of *G. geosporum* (100–280 µm *vs* 110–290) µm and always had straight subtending hypha although Walker (1982) also found recurved subtending hypha.

G. geosporum has been found in Scotland, UK (Nicolson & Gerdemann, 1968), in the Pacific Northwest, USA (Gerdemann & Trappe, 1974) in association with herbaceous plants and tree species. Walker (1982) also found it in Iowa, Georgia, Arizona USA, Mexico, The Netherlands and Great Britain, Thaper & Khan (1973) also reported in India, Hall (1977) and Hayman (1978) also found it in New Zealand.

17. ?GLOMUS INVERMAIUM Hall, Trans. Br. mycol. Soc. 68: 345–346. 1977.

Spores were singly sometimes loose aggregates, globose to subglobose, 60–130 x 60–120 µm, yellowish brown to brown and the spore wall smooth, with one wall group. The hyphal attachment 5–6 µm, up to 8–16 µm thick near the spore base, yellowish brown to brown.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK270*. Banjar County, XIII State Plantation Company, Putrapinggan Plantation, *KK399.* Other specimens which resembled *G. invermaium*, Malang County, Sumberpucung Subdistrict, Peniwen village, *KK193*. Jepara County, VXII State Plantation Company, Beji Plantation, Beji Barat, *KK235*. Bali, Jembrana County, Pekutatan Subdistrict, Puluhan village, *KK243*. Banjar, XIII State Plantation Company, Putrapinggan Plantation, *KK352, KK361, KK390, KK395.*

Sporocarps of this species were never found in field collections but the spores resembled Hall's description (1977) of the New Zealand material in having two wall components in one group. The spores from Indonesia appeared to be bigger than those from New Zealand which were 50–75 µm. The hyphal attachment was also thinner than those the original description (6–13 µm).

This species associated with *Trifolium repens* and was described from New Zealand (Hall, 1977).

18. GLOMUS MICROAGGREGATUM Koske, Gemma & Olexia, Mycotaxon 26: 125-127.1986.

Spores of this species were usually free, in clusters, hyaline to smooth pale yellow to

brownish yellow, globose to subglobose, 30–50 x 30–40 µm in diameter. The sole wall group consisted of just one component. The hyphal attachment straight, 2–3 µm wide at the spore base. Reaction to Melzer's reagent was negative.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK269*. Banjar County, XIII State Plantation Company, Putrapinggan Plantation, *KK369a, KK380, KK386, KK388, KK397*. Other material from Java which resembled *G. microaggregatum* were from Jepara County, XVII State Plantation Company, Beji Plantation, Beji Tengah, *KK222*.

The Javan spores fell within the size range of the description of *Glomus microaggregatum* by Koske *et al.* (1986). However, they were always found free, and not, as mentioned by Koske *et al*. (1986), inside dead spores of other species of arbuscular fungi. A minor differences were the uniformly of the size of the Indonesian spores and the fact that the spore surface was always smooth. Koske *et al*. (1986) also mentioned that hyphal attachment of this spore maybe straight or infundibuliform. Most specimens collected from Java had a straight hyphal attachment. Many of the Javan specimens resembled *G. aggregatum* and were difficult to differentiate from it because of their pale yellow to brownish yellow and size (30–50 x 30–40 µm) which overlapped with small specimens of *G. aggregatum*. However, the spore wall structures of these two species is distinct and enabled them to be separated on the basis of the unit wall occurring on *G. aggregatum* and not on *G. microaggregatum*.

This taxon was described by Koske *et al*. (1986) from field collections from dune systems in California, Hawaii, Michigan and the Atlantic coast of the USA. It has been found associated with roots of sand dune plants.

19. ?GLOMUS MICROCARPUM Tul. & Tul., Giorn. Bot. Ital. 2: 63. 1845.

Endogone microcarpa (Tul. & Tul.) Tul. & Tul., Fungi Hypogaei :182. 1851.

Endogone neglecta Rodway, Proc. Roy. Soc. Tasmania 1917: 107. 1918.

The spores were found as loose aggregates. Spores globose, or subglobose, yellow and 25–40 x 30–50 µm. The spore wall appeared smooth and consisted of one wall layer. The subtending hypha 4–8 µm wide near the spore base and was light yellow. Reaction to Melzer's reagent was negative.

Collections examined. INDONESIA: Java, Banjar County, XIII State Plantation Company, Putra pinggan Plantation, *KK355, KK360.* Bali, Jembrana County, Pekutatan Subdistrict, Puluhan village, *KK250.*

Sporocarps of this species were never found in either Java and Balian collections. Some spores from Java and Bali were smaller than the description of the lectotype given by Berch & Fortin (1984) in their reexamination of material collected by Tulasne brothers in 1884, 25–40 x 30–50 µm compared to (30–)40(–45) x (30–)35(–40) µm (Berch & Fortin, 1984). Walker (*pers. comm.*) reported that this species produces quite large very dense sporocarps and always a rapid blood red reaction to Melzer's reagent, and consequently it is advisable to treat this determination as very provisional.

Thaxter (1922) described spore collections of this species from Aldecroft Creek, Los Gatos, California without any root associations. Gerdemann & Trappe (1974) mentioned the association with a range of plants in pot cultures for example *Fragaria* sp., *Geum* sp., *Phleum pretense*, *Rubus spectabilis*, *Taxus brevifolia*, *Thuja plicata*, and *Zea mays*. They cite records in the USA from Idaho, California and Michigan. It was originally collected by Tulasne brothers from the Bois de Boulogne Paris, France and Vincennes, France in 1844 and by Broome from Italy in 1846. It was also recorded from Tasmania by Rodway in 1918 (as *Endogone neglecta*) in Gerdemann & Trappe (1974).

20. GLOMUS MOSSEAE (Nicol. & Gerd.) Gerd. & Trappe, Mycologia Memoir 5: 40-41. 1974.

Endogone mosseae Nicol. & Gerd., Mycologia 60: 314–315. 1968.

Spores were 110–300 µm x 150–290 µm, globose to ovoid, yellow to light brown. The wall structures comprised two components. The subtending hyphae were straight, 20–30 µm near the spore base, usually with a curved septum and had a yellow to light brown colour.

Collections examined. ECUADOR: Los Rios Province, near EET Pichilingue, INIAP, Quevedo area, from agricultural soil, under maize 2, *EETP, KK148*.

Note: This spore material and other specimens from Ecuador resembled *G. mosseae* but they were parasitized by other fungi making complete identification difficult.

Sporocarpic specimens were never found. A feature of the original description is the wide range of spore sizes, 60–320 µm (Nicolson & Gerdemann, 1968) but later Gerdemann & Trappe (1974) redefined the size range of spore collections examined as 105–310 x 110–305 µm. The colour of spores from Ecuador resembled material from Scotland and Kent (UK), Illinois (USA) and Germany (Nicolson & Gerdemann, 1968) and also spores collected in the Pacific Northwest, Hawaii, Australia, New Zealand and Pakistan (Gerdemann & Trappe, 1974). Both Nicolson & Gerdemann (1968) and Gerdemann & Trappe (1974) mention a distinct form of this species with a large funnel shaped base found in the USA and Australia. However, no Ecuadorean material was found with a pronounced funnel-shaped base.

Gerdemann & Trappe (1974) quote a wide range of plant taxa assumed to have associations with *G. mosseae* in the Pacific Northwest of USA. It appears to be a wide spread in other parts of the world *i.e*. UK (Nicolson & Gerdemann, 1968) and Australia (Mosse & Bowen, 1968).

21. GLOMUS MULTICAULIS Gerdemann & Bakshi, Trans. Brit. mycol. Soc. 66: 340–343. 1976.

The spores were very distinct owing to their multiple hyphal attachments. Spores ellipsoidal, subangular to subglobose, brown to dark brown, 136–210 x 114–210 µm. One to three hyphal attachments occurred at opposite ends of the spore. The spore surface ornamented with darker rounded projections 1–3.5 µm long in bands over the spore surface orientated at 90º to the spore axis. These bands were connected by axial ridges 2–3 µm in length which were of a lighter colour than the projections. The spore wall structures comprised one component. The subtending hyphae were straight or recurved, 10–30 µm in diameter, yellowish brown to brown. There was no reaction to Melzer's reagent.

Collections examined. INDONESIA: Java, Banjar County, XIII State Plantation Company, *KK372, KK373*. Jepara County, XVII State Plantation Company, Beji Plantation, Beji Tengah, *KK214*. Malang County, Sumber pucung Subdistrict, Peniwen village, *KK195*. Pancursari Subdistrict, Pancursari village, *KK 203, KK207a, KK213b, KK401*. Jember County, Kaliwining Experimental Station, *KK238, KK239*.

The Javan material differed in a number of aspects from the original description of *G. multicaulis*. The size of spores from Java was smaller, 136–210 x 114–210 µm compared to Indian specimens, 149–249 x 124–162 µm Gerdemann & Bakshi (1976). Most spores from Javan specimens tended to have a lighter brown colour rather than the dark brown described by Gerdemann & Bakshi (1976). The triangular spores mentioned by these authors were never seen. The spore wall appeared to be thicker in the Javan spores. The spore ornamentation had slightly shorter projections and was found to be more complex in structure. Although 2 or 3 spores were often found grouped in field collections sporocarps were not found. Gerdemann & Bakshi (1976) did not mention the existence of sporocarps.

This species was described from a demonstration forest, Uttar Pradesh, India, and appears to be associated with a range of Angiosperms and Gymnosperm tree species (Gerdemann & Bakshi, 1976). This species has been reported from Mount Gede Pangrango National Park, Java, Indonesia, associated with forest trees (Kramadibrata, 1993).

22. GLOMUS RUBIFORME (Gerd. & Trappe) Almeida & Schenck, Mycologia, 82: 709–710. 1990

Sclerocystis pachycaulis Wu & Chen, Taiwania 31 :74–75. 1986

Sclerocystis rubiformis Gerd. & Trappe, Mycologia Memoir 5: 60–63. 1974

Loose aggregates of spores, yellow to yellowish brown, spores were encountered with spores arranged around a central branching system (plexus). Individual spores smooth, obovoid to ellipsoid measuring 30–60 x 40–90 µm. The walls consisted of one group. The hyphal attachments were 7–15 µm broad with the same colour as the spore wall.

Collections examined. INDONESIA: Java, Banjar County, XIII State Plantation Company, Putrapinggan Plantation, *KK346, KK350, KK357a, KK368, KK360, KK387, KK398*; Pangandaran Plantation, *KK329*; Batugajah Plantation, *KK317, KK318*. Jepara County, XVIII State Plantation Company, Beji Plantation, Beji Timur, *KK403*.

Sporocarps were never found, but the loose aggregates were considered to be sufficiently similar, together with spore size and colour, to the original description, to make the classification as *G. rubiforme* possible. Wu & Chen (1968) described this species from Experimental Forest in

Taiwan where it was associated with the root of Pteridophytes and Angiosperms. Almeida & Schenck (1990) revised the genus *Sclerocystis*, and they maintained the genus with one species, i.e. *S. coremioides*, while five other *Sclerocystis* species were moved to the genus *Glomus*, including *G. rubiforme*). This species has also been reported from Java, Indonesia such as under alang-alang, corn and cacao in Bogor (Widiastuti & Kramadibrata 1992), under forest trees in Gede Pangrango National Park (Kramadibrata, 1993), under palm oil (Widiastuti & Kramadibrata, 1993), under bamboo in Bogor Botanic Gardens (Setya *et al.*, 1995), under mangosteen (Silviana *et al*., 1999) and under durian (Chairani, 2002).

23. GLOMUS SINUOSUM (Gerd. & Bakshi) Almeida & Schenck, Mycologia 82: 710–711. 1990.

Sclerocystis sinuosa Gerd. & Bakshi, Trans. Br. mycol. Soc. 66: 343. 1976

Sclerocystis pakistanica Iqbal & Bushra. Trans. mycol. Soc. Japan. 21: 59–60. 1980.

Sporocarps brown, 300–450 µm, spores subglobose to oblong, with a peridium, composed of thick walled, sinuous hyphae ± 20 µm thick making irregular patterns. Within the peridium the spores obovate, ellipsoidal, diverging from a central plexus of hyphae arranged in a single layer, 80–120 x 65–85 µm. Wall thickness was variable but two walls in one group. The spore wall was always thicker at the spore base. The hyphal attachment was very short.

Collections examined. INDONESIA: Java, Jepara County, XVII State Plantation Company, Beji Plantation, Beji Tengah, *KK240*, Beji Barat, *KK237a.* Jember County, Kaliwining Experimental Station, *KK237b, KK237c, KK405*.

Sporocarps from Java, 300–450 µm, were bigger than those described from India 48–412 µm (Gerdemann & Bakshi, 1976). However, the pattern of the peridium closely resembled the Indian specimens. The spores from Java were also bigger 80–120 x 65–85 µm compared to 45–118 x 30–80 µm (Gerdemann & Bakshi, 1976). It has also been reported from under forest trees in Gede Pangrango National Park (Kramadibrata, 1993), and under palm oil (Widiastuti & Kramadibrata, 1993).

24. GLOMUS TORTUOSUM Schenck & Smith, Mycologia 74: 82. 1982.

The spores of this taxon were easily recognized by the mantle of sinuous hyphae (peridium) closely appressed to the spore. The yellow to dull brown spores were globose to subglobose, 150–260 µm diameter. The wall structures comprised a single laminated component. Hyphal attachments were absent from the specimen examined.

Collections examined. ECUADOR: Quevedo area, near EET Pichilingue, INIAP, from cacao soil, Finca San Carlos, *KK135* (mixed collection with *G. constrictum*). Los Rios Province, EET Pichilingue, INIAP, cacao greenhouse experiment: *RCC/NS, KK31, KK32* (both mixed with *G. geosporum* and *G. mosseae*), *RCC/S, KK102*.

Although *G. tortuosum* spores collected from Ecuador were in poor condition they appear very similar to the description of Schenck & Smith (1982) with the exception that the mantle covering the spore was thinner 4–5 µm *vs* 4–10 µm. Both the original Floridan description and the Ecuadorean spores had a laminated wall.

25. ?PARAGLOMUS OCCULTUM (Walker) Morton & Redecker, Mycologia 93: 190. 2001.

Glomus occultum Walker, Mycotaxon 15 :50. 1982.

The spores usually found singly, ovoid to globose to subglobose, 30–90 x 40–90 µm, usually hyaline to white. The spore wall structure comprised two components in one group. The subtending hyphae usually axial in position less frequently lateral to the spore axis, some were closed by a distal septum.

Collections examined. INDONESIA: Java, Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK282, KK283, KK301*. Malang County, Pancursari Subdistrict, Pancursari village, *KK211*.

Spore size from Java was slightly bigger 30–90 x 40–90 µm than the original description 15–100 x 20–120 µm (Walker, 1982).

This species was described from Iowa, USA, associated with grasses and poplars, in the Netherlands in a polder and reclaimed coal mining spoils in Yorkshire, England (Walker, 1982).

Recently, studies on molecular phylogenetic of *G. occultum* showed that morphological characters alone are not sufficient to describe this species, hence the element of taxonomic doubt expressed here. *Glomus occultum* and *G. brasilianum* were transferred into *Paraglomus*

based on molecular analyses and a new family *Paraglomeraceae* was erected (Morton & Redecker, 2001).

26. SCUTELLOSPORA CALOSPORA (Nicol.& Gerd.) Walker & Sanders, Mycotaxon 27: 180. 1986.

Endogone calospora Nicol. & Gerd., Mycologia 60: 332. 1968.

Gigaspora calospora (Nicol. & Gerd.) Gerd. & Trappe, Mycologia Memoir 5: 28–29. 1974.

The spores were globose, 150 x 150 µm and oblong, 100–160 x 165–250 µm. They had a pale yellow or greenish yellow colour. The spore wall comprised two wall groups. Most spores were found with a bulbous suspensor cell, concolorous with spore wall, 33–40 µm broad.

Collection examined. INDONESIA: Java, Banjar County, XIII State Plantation Company, Putrapinggan Plantation, *KK394*. ECUADOR: Quevedo area, near EET Pichilingue, INIAP, field collections from agricultural soils, under grass, *KK62, KK63, KK64*; under banana, *KK51a*; under maize, *KK106*. Los Rios Province, EET Pichilingue, INIAP, greenhouse experiment with cacao, *F/S, KK154; RCM/NS, KK27.*

Spores from Java never exceeded 250 µm in diameter although in the original description, Nicolson & Gerdemann (1968) mentioned an average of 126 x 190 µm, with a maximum of 111 x 511 µm, and later Walker & Sanders (1986) gave a range of 114–285(–511) x 110–412 (–511) µm. They also discussed the range of colour forms in this taxon within which the present material also fell.

This species was originally described from Scotland and has also been recorded from Illinois (Nicolson & Gerdemann, 1968) and the Oregon and Washington Coast associated with herbaceous and tree species (Gerdemann & Trappe, 1974).

Koske & Walker (1986) redefined this taxon from specimens collected from Midlothian, Scotland in pot culture with *Trifolium repens* plants which had been inoculated with a single spore from under grass. This taxon therefore seem to be widespread in the Northern temperate zone. In Indonesia it has been reported from under bamboo in Bogor Botanic Gardens (Setya *et al.*, 1995), and under corn (Haerida & Kramadibrata, 2002) all in Java.

27. SCUTELLOSPORA FULGIDA Koske & Walker, Mycotaxon 27 :221-224. 1986

The spore resembling *S. fulgida* globose to subglobose, smooth hyaline to pale straw, 150–200 x 170–270 µm. The wall structure comprised three components. Bulbous bases seen in some material, were yellowish brown 30–40 µm broad with a wall thickness 1–2 µm and had a projection towards the spore base. Reaction to Melzer's reagent: wall 1 and 2 became reddish brown, wall 3 became brown.

Collections examined. INDONESIA: Java, Jepara, XVII State Plantation Company, Beji Plantation, Beji Timur, *KK233*. Malang County, Sumberpucung Subdistrict, Peniwen village, *KK187, KK192*. Bali, Jembrana County, Pekutatan Subdistrict, Puluhan village, *KK246*. ECUADOR: Quevedo area, near EET Pichilingue, INIAP, from agricultural soil: under maize (1), *KK105*; under maize (2), *KK151*. Los Rios Province, EET Pichillingue, INIAP, from greenhouse experiment with cacao, *RP1/NS, KK143.*

The spores had a similar size range, 150–200 x 170–270 µm, to the original description 100–240 x 160–245 µm (Koske & Walker, 1986). Spore colour from fresh specimens was never examined, a point of difference to Koske & Walker (1986), but the wall structures resembled their specimens. Many spores were in too poor condition to examine properly but one good specimen, *KK187* from Peniwen, Malang, Java, was typical of *S. fulgida*. Other characters such as the germination shield were not present.

This species was originally described from sand dunes on the eastern North American seaboard, associated with root zones of *Ammophila brevigulata*, *Solidago sempervirens* and *Uniola paniculata* but not proven to be mycorrhizal (Koske & Walker, 1986).

28. ?SCUTELLOSPORA PELLUCIDA (Nicol. & Schenck) Walker & Sanders, Mycotaxon: 27: 181. 1986.

Gigaspora pellucida Nicol. & Schenck, Mycologia 71: 189–198. 1979.

Spore singly, globose to ellipsoid or even irregular, hyaline to pale grey, 160–240 x 150–350 µm. The spore smooth and comprised six walls. A suspensor-like cell found on some spores, hyaline, ± 40 µm wide.

Collections examined. INDONESIA: Java, Malang County, Sumberpucung Subdistrict, Peniwen village, *KK186*. Cianjur County, XII State Plantation Company, Rajamandala Plantation, *KK287*. Banjar County, XIII State Plantation Company, Batugajah Plantation,

KK309, KK311. ECUADOR: Quevedo area, near EET Pichilingue, INIAP, from cacao soils, Bosque Viejo, *KK18*; from other agricultural soils, under pasture, *KK60*; under maize, *KK104*. Los Rios Province, EET Pichillingue, INIAP, from greenhouse experiment: *Fla/NS, KK169; F/S, KK154; RCC/NS, KK29; RCM/NS, KK23; RP1/NS, KK141 & KK142*.

The size of *S. pellucida* spores from Java, 160–240 x 150–350 µm was close to those given in the literature, 58–212 µm globose spores or 107–183 x 145–241(–328) µm irregularly shaped spores (Nicolson & Schenck, 1979) or 58–183(–250) x 58–241(–410) µm (Koske & Walker, 1986).

These specimens also resembling *S. gilmorei* such as the character of hyaline spore and the wall structure comprising six components. The size of the spore also overlap with *S. gilmorei*.

Koske & Walker (1986) redescribed this species after Walker & Sanders (1986) separated *Scutellospora* from *Gigaspora s.l.* on the basis of membranous walls. It proved the most difficult to identify since it had 3 groups of walls and most specimens collected from Java were in rather poor condition for wall examination. However, they possessed the general features of *S. pellucida*, such as irregular shape and ellipsoid shape, and at least two group of walls could be seen in most specimens. The fresh colour of specimens from Java has never been examined and most specimens appeared hyaline or rather pale grey after long storage in FAA or 5% Formalin solution.

The species was first isolated in the USA from cultivated soils in north and central Florida (Nicolson & Schenck, 1979) later Koske & Walker (1986) redescribed it from Florida, sand dunes in California, Massachusetts, New Jersey, Rhode Island, South Carolina and Virginia and also a pot culture from mine site in West Virginia, USA.

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Utrecht, 27 March 2008

DEPOSITION OF NEW SCIENTIFIC NAMES OF FUNGI IN MYCOBANK

To: Journal Editors

Dear Colleagues

In order to place fungal nomenclature on a sound basis and take advantage of online databases, the International Mycological Association (IMA), which constitutes the IUBS Section for General Mycology, has assumed responsibility for MycoBank. At present around 1,400 new scientific names for fungi are introduced each year, dispersed through a multitude of scientific journals, and a timely method of co-ordinating information on these names has become essential.

MycoBank was initiated by the Centraalbureau voor Schimmelcultures of the Royal Academy of Science of The Netherlands in 2004. It is a database in which all newly described fungi and new names of fungi can be deposited and stored along with key nomenclatural and descriptive material. Each name is checked against a nomenclatural database (Index Fungorum) and is given a unique reference number. Several leading mycological journals (e.g. *Fungal Diversity, Mycological Research, Mycotaxon, Studies in Mycology*) have made the prior deposition of new names in MycoBank a requirement for publication. The deposition numbers are cited when names are published in the journals in a parallel manner to the way GenBank numbers are used. As with GenBank, MycoBank will never apply any form of censorship.

MycoBank has been enthusiastically embraced by mycologists and, while the process is voluntary at present, proposals to make it mandatory after the next International Mycological and International Botanical Congresses in 2010–2011 are in process.

In the interests of scientific communication, the International Mycological Association would like you to consider making the deposition of new names of fungi in MycoBank a requirement for acceptance for publication in the journal you edit.

Thank you for your attention

PWCrous

Pedro W Crous
President, IMA

The IMA would value feedback, both positive and negative, if you have any concerns that could be addressed.
For further information on MycoBank (www.MycoBank.org) and the members of its Scientific Advisory Board, consult the IMA website (www.IMA-mycology.org).