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Laccaria fraterna (Cooke & Mass.: Sacc.) Pegler, 1965 (Agaricales, Basidiomycota) associated with exotic *Eucalyptus* sp. in northern Argentina and Paraguay

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Abstract
Laccaria fraterna is recorded for the first time from the Cordillera Department, Paraguay and from northern Argentina. Both macroscopic and microscopic morphological characteristics of the basidiomata are described. Photographs of fresh material are presented along with photographs of the microscopic characters. Comments regarding the distribution and taxonomy are provided.

Key words
Cordillera; Hydnangiaceae; Agaricomycetes; Fungi.

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Introduction

Laccaria Berk. and Broome is a cosmopolitan fungal genus of ecological importance due to its ectomycorrhizal associations with a wide range of conifers and angiosperms and is especially important in *Eucalyptus* plantations around the world (Kropp and Mueller 1999, Wilson et al. 2013). Formerly, this genus was placed within the families Hydnangiaceae (Kühner 1980), Laccariaceae (Jülich 1981) and Tricholomataceae (Singer 1986), respectively. In the early 1980s, Kühner (1980) included *Laccaria* in the family Hydnangiaceae within Agaricales, which contains agaricoid fungi along with mycorrhizal gasteroid species. The genera *Laccaria, Hydnangium* and *Podohydnangium* are similar in morphological characters. They all possess basidiospores with an echinulate ornamentation, which suggests a close phylogenetic relationship between them (Kropp and Mueller 1999).

Laccaria is characterized by its glabrous, radially striate and hygrophanous pileus, with a color variation ranging from brown-ferruginous, reddish brown to brown-violet. The lamellae are broad and thick, with regular hymenophoral trama. The spores are globose to amygdaliform, ornamented with warts or spines. The basidia have 2 to 4 sterigmata and lack cystidia (McNabb 1972, Tommerup et al. 1991).

Laccaria has a cosmopolitan distribution, and is distributed mainly in temperate and tropical regions (Kropp and Mueller 1999). The genus contains 75 species (Kirk et al. 2008), having been well studied in Asia, Oceania, Europe and America (McNabb 1972, Castro Cerceda and Freire 1984, Mueller and Vellinga 1986, Tommerup et

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al. 1991, Kropp and Mueller 1999, Wilson et al. 2013). In South America, 9 *Laccaria* species are recorded from Argentina (Niveiro and Albertó 2013) and 10 species are recorded from Brazil, with most records occurring within the southern states of Brazil (Giachini et al. 2004, Capelari et al. 2015). Here we report the first record of the genus *Laccaria* within Paraguay. In this paper, we describe and illustrate *Laccaria fraterna* based on recent collections made in northern Argentina and Paraguay.

Methods

The samples studied in this paper were collected in the city of Piribebuy-Pirareta, Cordillera Department, Paraguay and Cerro San Javier, Tucumán Province, Argentina,. Macroscopic data, including size, color and consistency, were described from fresh material. For structural microscopic study of dried material, rehydrated preparations were analyzed with KOH (5%) and stained with Phloxine (1%) and Congo Red (1%). For the analysis of microchemical reactions Melzer's reagent was used (Wright and Albertó 2002). Samples were observed through an optical microscope Carl Zeiss with 40× and 100× objectives with immersion oil and all the measurement were made with the oil immersion objective. The examined material was deposited at the Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Asunción Herbarium (FACEN) and at the Instituto de Botánica del Nordeste Herbarium (CTES).

Results

Laccaria fraterna (Cooke & Mass.: Sacc.) Pegler, Australian Journal of Botany 13: 332 (1965). Figures 1–4.

= *Agaricus fraternus* Cooke and Massee, Grevillea 16: 31 (1887), nom. illeg., non *A. fraternus* Lasch, Linnaea 3: 402 (1828).

= *Naucoria fraterna* Sacc., Syll. Fung. 9: 110 (1891).

Pileus 15–55 mm in diameter, ovate to hemispheric when young, then campanulate and finally plano-convex at maturity, somewhat depressed in the center with a small umbo at the disc, reddish brown towards the center, reddish orange, orange to yellow at the margin, surface dry with striations, and sometimes sulcate margin. Lamellae pinkish to coral pink, moderately distant, adnate with a decurrent tooth, margin even, 1–3 mm wide, with 2 to 6 lengths lamellulae. Stipe 30–70 × 2–5 mm, equal or slightly thickening towards the apex, central, cylindrical, hollow, reddish brown, fibrous, with small white floccules at the junction with the pileus. Context thin, fleshy, reddish orange. Taste and odor fungoid. Spore print white.

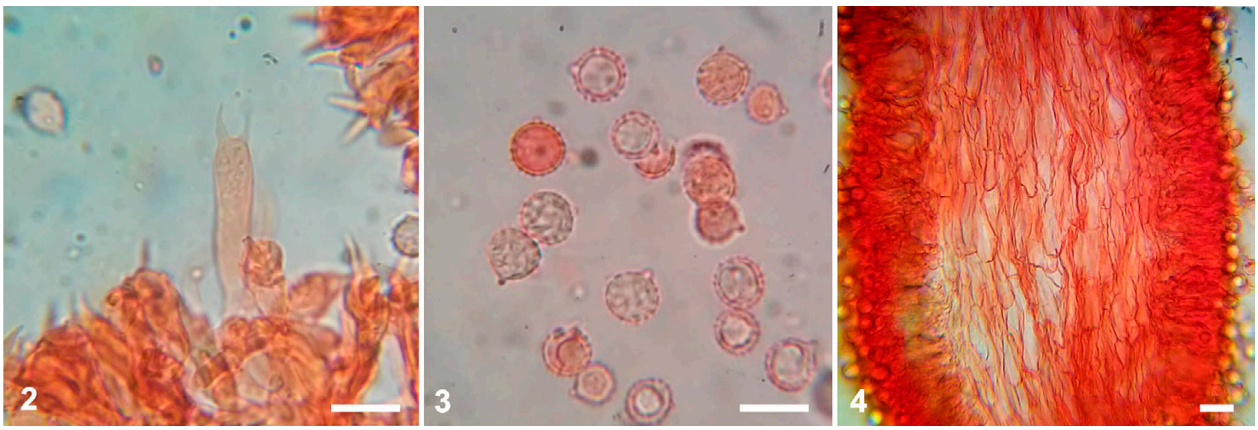
Basidiospores (7–) 8–9 (–10) × 7–9 µm; when young, appearing subglobose when viewed laterally, appearing globose in front view; hyaline; walls up to 1 µm thick, ornamented with spines 1–1.5 µm; inamyloid. Basidia (40–) 42–50 × 7–10 µm, clavate, 2-spored, thin-walled. Pleurocystidia and cheilocystidia not seen. Hymenophoral trama regular, consisting of parallel hyphae 5–15 µm in diameter, septate. Pileipellis a cutis, with repent hyphae, 5.5–15 µm in diameter, thin-walled, septate. Stipitipellis a cutis, hyphae of 4.5–10 µm in diameter, septate. Clamp-connections not seen.

Figure 1. *Laccaria fraterna* FACEN 003337, macroscopic characters. Scale = 20 mm.

Habitat. Gregarious. Associated with *Eucalyptus* sp.

Material examined. Paraguay, Cordillera Department, Piribebuy-Pirareta city, 8 July 2015, C. Mancuello and M. Campi, C.M. 001, (FACEN 003337, CTES 0568349). Argentina, Tucumán, Cerro San Javier, in *Eucalyptus* sp. plantation near the city of Universitary, N. Niveiro 2837 (CTES 0568350).

Distribution. This species is widely distributed on several continents: in the Americas, Africa (Mueller 1992), Asia (Senthilarasu 2014), Oceania (Tommerup et al. 1991, McNabb 1972, Kropp and Mueller 1999), and Europe (Malençon & Bertault 1975). In South America, *L. fraterna* is recorded from Brazilian states of Santa Catarina (Giachini et al. 2000, Giachini et al. 2004 as *L. lateritia* Malençon) and Rio Grande do Sul (Rick 1938, Rick 1961 as *Clitocybe laccata* Scop., Putzke 1994, Sobestiansky 2005), as well as from Argentina, within Buenos Aires Province (Singer and Digilio 1952, Niveiro and Albertó 2013 as *Laccaria ohiensis*). Collections described here represent the first records of this species from Paraguay and northern Argentina (Fig. 5).



Figures 2–4. *Laccaria fraterna* microscopic characters **2.** Basidia. **3.** Spores. **4.** Hymenophoral trama. Scale = 10 µm.

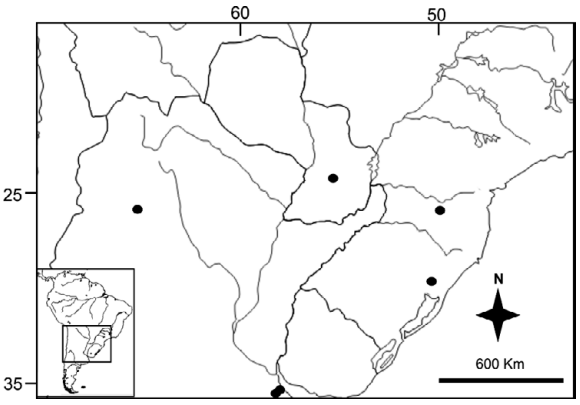


Figure 5. Distribution map of *Laccaria fraterna* in subtropical South America.

Discussion

Laccaria fraterna is characterized by its relatively small ferruginous-brown basidiomata, 2-spored basidia; globose to subglobose basidiospores smaller than 11 µm in diameter, and by lacking pleurocystidia (Mueller 1992). The morphology of basidiospores and the number of sterigmata per basidia are key characteristics used to differentiate species of *Laccaria*. However, this species has been confused with other species of *Laccaria* that are microscopically different (Mueller and Vellinga 1986, Mueller 1992). Some authors (Singer 1942, Singer 1946, Singer 1967, Singer 1969, Singer 1977; Singer and Digilio 1952, McNabb 1972, Pegler 1983) applied the name *Laccaria ohiensis* (Mont.) Singer to species of *Laccaria* with ferruginous brown color, echinate and globose spores and 2-spored basidia. However, Mueller and Vellinga (1986) and Mueller (1992) found that the type specimen of *L. ohiensis* possess exclusively tetraspored basidia, suggesting that any *Laccaria* with bisporic basidia should be treated as a separate species. According to Mueller (1992), in the Americas there are 3 species of *Laccaria* with bisporic basidia: *L. fraterna, L. pumila* Fayod and *L. tortilis* (Bolton) Cooke, which are phylogenetically related (Vizzini et al. 2011). The latter 2 species are similar to *L. fraterna* due to the presence of bisporic basidia, in addition to a few shared macroscopic characters, such as the relatively small size and the chestnut to orange color of the basidiomata. However, both *L. pumila* and *L. tortilis* have spores larger than 11 µm and are associated with Pinaceae, Fagaceae and Betulaceae. Furthermore, *L. pumila* is restricted to the Arctic and alpine zones. *Laccaria tortilis*, although widely distributed, is restricted to temperate regions (Mueller 1992). Comparatively, *L. fraterna* is found throughout the world and forms mycorrhizal associations with *Eucalyptus* sp. (McNabb 1972, Mueller and Vellinga 1986, Tommerup et al. 1991, Mueller 1992). *Laccaria proximella* Singer is another South American species similar to *L. fraterna.* Described from Chile, *L. proximella* is characterized by its flesh to brown coloration, medium-sized (20–34 mm) pileus, and the occasional presence of bisporic basidia. However, it differs clearly by the presence of 4-sterigmata basidia and the spores are markedly ellipsoid to amygdaliform (Singer and Moser 1965, Mueller 1992).

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Authors' Contributions

CM and NN collected the specimens, MC and NN identified the collections, YM, MC and CM wrote the text and made the illustration, NN made the map.

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