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Podoserpula miranda sp. nov. (Amylocorticiales, Basidiomycota) from New Caledonia

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Abstract – *Podoserpula miranda* sp. nov. (Amylocorticiales) is described from an old *Arillastrum gummifera* stand in New Caledonia.

Arillastrum / biodiversity / Craterellus / taxonomy

INTRODUCTION

The genus *Podoserpula*, usually referred to as "the Pagoda Fungus" because of its unmistakable, multi-storied fruit bodies, was first collected in Tasmania more than 150 years ago by the English botanist Berkeley. Initially described as "*Craterellus pusio*" (Berkeley *in* Hooker 1860), this unusual fungus was also discovered and redescribed from Victoria, Australia, by Cooke & Massee (1889) under the name *Craterellus multiplex*, later recombined into *Cantharellus* by Lloyd (1920). Many years later, Reid (1963), studying similar collections by R.W.G. Dennis from Venezuela, pointed out some important microscopical differences between these collections and the other members of Cantharellaceae. As a result, Reid (1. c.) described a new monospecific genus, *Podoserpula*, which he presumed to be closely related to family Coniophoraceae (Boletales), thereby distinguishing four differences.

Since then, *Podoserpula pusio* has become a very popular fungus in introductory field guides for the Australasian region, in particular New Zealand and Australia, including Tasmania (Bougher & Syme, 1998; Fuhrer & Robinson, 1992; Shepherd & Totterdell, 1988; Stevenson, 1982; Willis, 1950; Young, 1982). In more recent years, *Podoserpula* has also been recorded from Madagascar (Buyck,

1997, 2008), Guiana and Chile (S. Miller, pers. comm.), Tanzania (Buyck unpubl.) and the Falkland Islands (Watling & Eggeling, 2009).

The systematic placement of *Podoserpula* has recently been re-assessed on the basis of Australian specimens in recent phylogenetic studies (Matheny *et al.*, 2006; Binder *et al.*, 2010). The latter publications have clearly shown that this genus is neither related to Boletales, nor to Cantharellales, but belongs in Amylocorticiales, an ancient group of resupinate, pileate-stipitate or pileatesessile forms with hydnoid, merulioid or poroid hymenophores, all sharing a monomitic hyphal system with clamped hyphae and a thickening hymenium (Binder, 2010).

Given its known distribution in Tasmania, Australia and New Zealand, the presence of *Podoserpula* in New Caledonia is not surprising. Nevertheless, the discovery by the local mycological society in 2009 of a presumed new *Podoserpula* in New Caledonia created some kind of hype in the local and specialized French press (e.g. Anonymous, 2010; Ducousso *et al.*, 2009). The purpose of the present paper is to officially describe and validate this new taxon, which is already referred to as the "Barbie Pagoda" (http://www.guardian.co.uk/science/2011/oct/02/barbie-pagoda-new-to-nature) and to discuss some of its characters in our ongoing effort to document the unknown mycota of New Caledonia (Eyssartier *et al.*, 2009, 2010; Duhem & Buyck, 2011).

MATERIAL AND METHODS

The macroscopic description is based on photographs from the collectors. Studied collections are kept at the Mycological Herbarium of the National Natural History Museum, Paris (PC). The fresh specimens were photographed and tissues collected for later sequencing. The holotype specimen has been deposited in the mycological herbarium of the Natural History Museum in Paris (PC). Detailed microscopic observations and illustrations are based on thin, freehand sections that were observed in Congo red and a mixture of a 2-3% (w/v) Potassium hydroxyde solution and a 1% (w/v) aqueous Phloxine B solution. Melzer's reagent was used to check for the presence of amyloid or dextrinoid reactions, whereas Cotton blue was used to check for cyanophilic reactions. All measurements are based on 30 spores.

TAXONOMY

Podoserpula miranda sp. nov.

Mycobank: MB 802706

Etymology: derived from the latin verb "*mirare*", meaning literally "she is to be admired", referring to the extraordinary form as well as intense lilac pinkish color of this fungus.

Diagnosis: The species differs morphologically from *P. pusio*, the type and only other described species of the genus, in its generally very intense pinkishlilac color, the absence of incrustations on the hyphae of the cap surface and its geographical distribution limited to New Caledonia.

Figs 1-15

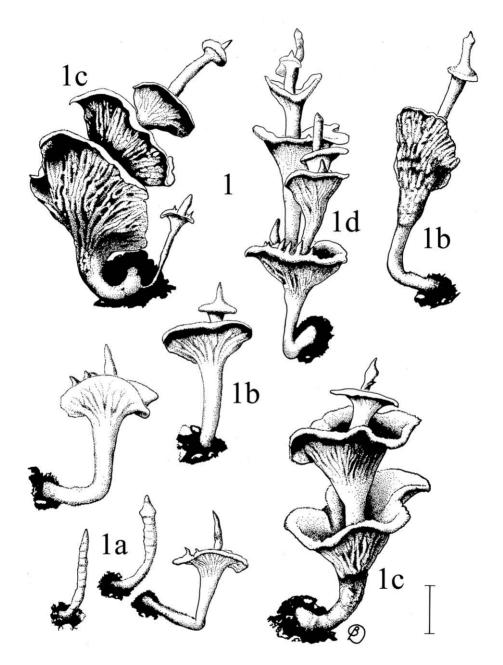
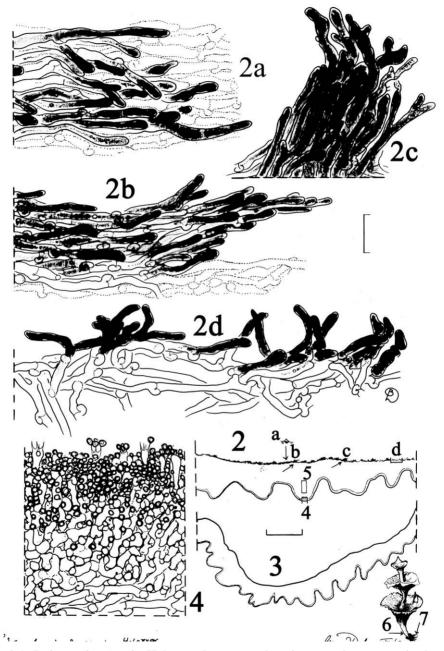
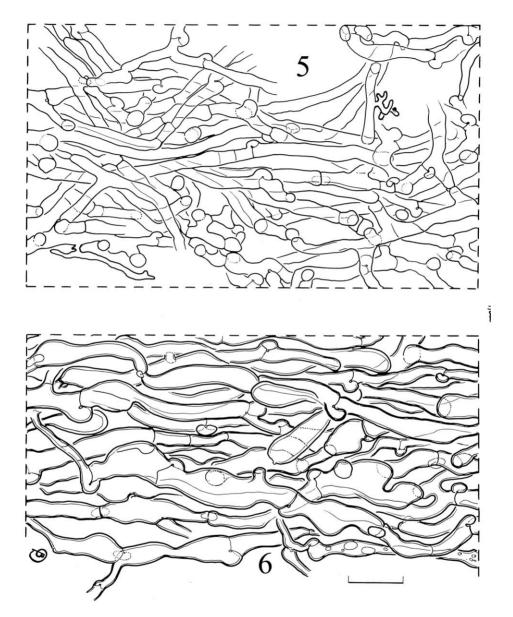


Fig. 1. *Podoserpula miranda*, Holotype. 1. basidiomata in different stages of development. 1a. young; 1b. first cap is formed and the main axis is protruding; 1c. fruit body with 3 successive caps; 1d. fruit body with secondary axes formed near the pileus margins. (Drawings B. Duhem; scale bar = 1 cm).



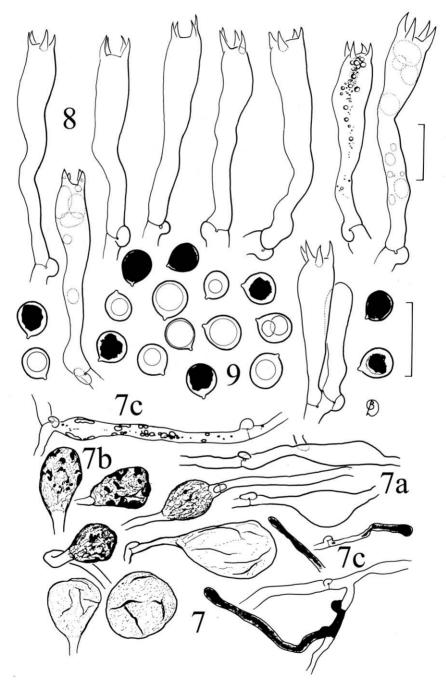
Figs 2-4. *Podoserpula miranda*, Holotype. **2.** transversal section near the cap margin showing 2 details (2a-c) of the pileipellis with terminal hyphae that are filled with olivaceous droplets. **2a.** fragments of appressed terminal hyphae seen from above. **2b.** detail of some ascending hyphal terminations in lateral view. **2c-d.** fascicle of emerging hyphal tips. **3.** transversal section of the cap from cap surface to hymenophore. **4.** detail of subhymenium and hymenium showing the general structure with trapped spores. (Drawings B. Duhem; scale bar = 10 μ m).



Figs 5-6. *Podoserpula miranda*, Holotype. **5.** hyphae of the hymenophore context. **6.** hyphae near the basis of the main axis. (Drawings B. Duhem; scale bar = $10 \mu m$).

Holotypus: FRANCE (French Overseas Dept.). New Caledonia (Pacific Ocean). Forêt des Géants, 14 June 2009, on soil near *Arillastrum gummiferum* (Myrtaceae), M. Ducousso 09.614 (PC 0086035)

Fruit bodies gregarious, less than 10 cm high, nearly concolorous when fresh and producing up to five or six superimposed pilei when mature. Early



Figs 7-9. *Podoserpula miranda*, Holotype. **7.** small mycelial cord from the stipe base with vesiculose elements. **7a.** formation of a vesicle through successive inflations of the hypha. **7b.** terminal vesicles. **7c.** short terminal ramifications with ochraceous olivaceous droplets. **8.** basidia. **9.** spores. (Drawings B. Duhem; scale bar = $10 \mu m$).

development starting with the formation and elongation of the subcylindrical main axis ending in a sharply pointed apex, then developing upward a number of successive, subapical thickenings that will grow unilaterally to nearly concentrically into more or less (semi)circular, thin-fleshed pilei of rapidly decreasing diameter. Pilei growing upward and outward, forming a series of funnel-shaped structures around the elongating axis, with the outer margin remaining longtime inrolled; upper surface more or less smooth, cottony-pubescent, dull, very pale pinkish to near white, sometimes developing olivaceous tints around the main axis, soft and flexible, full-grown caps sometimes developing series of secondary stipe-like outgrowths or initials near their margin. **Hymenophore** strongly decurrent on the main axis and abruptly stopping, densely wrinkled over the entire surface from blunt, radiating and forking veins or ridges (reminiscent of *Cantharellus*), becoming sometimes more nodulose near the main axis, vividly pinkish lilac (13-14A2-3). Main axis finely pruinose to pubescent, subcylindrical, continuous, often bent in the basal part, covered by a whitish tomentum on the lower portion which m ay develop into a limited mycelial mat on contact with the soil humus, solid. Flesh soft, fibrous, whitish pink, but developing distinct ochreyellowish to almost ferruginous tints when too old or injured. Taste mild. Smell of radish. Spore print white. Exsiccatum very brittle and fragile, surfaces of axis and caps near-white with faint pinkish hues and olivaceous tints towards the cap center, strongly contrasting with the intensely pink hymenophores.

Spores globose, $3.5-5(5.5) \mu m$ diam., to subglobose, $3.5-5(5.5) \times (3)$ 3.3-4.6 µm, with firm wall, dextrinoid, cyanophilous, containing one large, hyaline lipid drop, sometimes with yellowish-olivaceous contents (Fig. 9). Basidia 26-40 \times 5-6.5 µm, four-spored, clavate, often flexuose in their lower part and clamped at the base (Fig. 8). Cystidia or gloeocystidia absent. Hyphal structure monomitic, generative hyphae hyaline, regularly clamped and producing large to sometimes ampullaceous clamps that are wider than the hyphal diam. **Subhymenium** narrow and dense, pseudoparenchymatous, enclosing numerous trapped spores. Pilei**pellis** well-differentiated, some extremities adhering together in fascicles or trichoids and with yellowish-olivaceous, vacuolar contents and yellowish granular inclusions but without zebroid, incrusting pigments typically found in *Podoserpula* collections from Australia (Fig. 2a-d). **Context** dense, but with dispersed, loosely arranged to lacunar areas, especially toward the cap margin, composed of 2-8 µm wide, ramified, radially oriented hyphae, locally inflated up to 20 µm, developing also numerous, clampless, secondary septa and some short dendroid ramifications. Stipe formed of axially oriented, $(1.3)3-8.5 \mu m$ wide hyphae, more rigid from distinctly thickened, hyaline and smooth to minutely granular walls. Mycelial cords at the stipe base with intercalary or terminal cells enclosing vellow-ochre to olivaceous granules in KOH + Phloxine (Fig. 7c) and dispersed, more inflated cells or piriform vesicles up to $40 \times 26 \,\mu\text{m}$, with slightly rugulose walls (Figs 7a, b).

DISCUSSION

During the mediatic hype that followed the discovery of *Podoserpula* in New Caledonia, some of the arguments that were used to justify the recognition of a new species seemed a bit weak or at least unsubstantiated. The first argument, evoking differences in general architecture between *P. pusio* and *P. miranda*, might be correct when comparing with the South-American variety *austro*-

americana Reid, but not in the case of New Zealand, Australia or Madagascar, where *P. pusio* has an identical general architecture as *P. miranda*. Secondly, the color cited for *P. pusio* as being entirely cream, cream ochraceous to yellowish orange for the whole fruit body, ignores the fact that collections of *P. pusio* from Australia, New Zealand, as well as from Madagascar, can also develop distinctly pink hymenophores, even if of lesser intensity compared to *P. miranda* and the original description of the type variety explicitly opposes the pink hymenophore to the color of the pilei and central axis. One could even hypothesize that the highly metallic New Caledonian soils could influence pigment expression and that one is confronted here with a color form of a species.

Whereas the claimed ectomycorrhizal association between *P. miranda* and the endemic Arillastrum gummiferum (Brongn. & Gris) Pancher ex Baill. (Myrtaeae) would benefit from hard proof, the precise trophic status of *P. pusio* was never elucidated, notwithstanding the affirmation by Ducousso et al. (2009) that the latter is a decomposer of dead wood. It is indeed so that *Podoserpula* is typically reported from very humus-rich, strongly mossy or grassy places with decaying wood, but these are mostly (always?) situated in typically ectotroph forests or plantations (ectomycorrhizal *Ericaceae* and *Pinaceae* in the Falklands, ectomycorrhizal Sarcolaenaceae and Phyllantaceae in Madagascar, ectomycorrhizal *Pinaceae*, eucalypts and *Melaleuca* in Australia, ectomycorrhizal *Caesalpi*naceae in Guiana and now ectomycorrhizal Arillastrum in New Caledonia...). The senior author has never found *Podoserpula* outside typical ectotroph habitats in Madagascar, although Podoserpula is a regularly fruiting species, which is collected almost every year. Similar humus rich habitats have been reported for ectomycorrhizal species from other parts of the tropics (Eyssartier & Buyck, 1999; Henkel et al., 2000). To our knowledge, data on unequivocal ectomycorrhizal root structures is not yet available for *Podoserpula*, but one of us (MD) has found mycelium of *P. miranda* (verified later by sequencing of ITS showing 100% similarity with fruit bodies) in contact with *Arillastrum* roots underneath the fruit bodies. Microscopic observation of cross sections of these roots demonstrated the existence of a fungal sheath and, in some cases, the penetration of hyphae between the rhizodermic cells of the root, as in the case of a Hartig net. Whether these structures represent functional ectomycorrhizas, or not, needs further study. Although the saprotrophy-ectotrophy transition was described as reversible (Hibbett & Donoghue, 2000), the existence of a genus with only 2 species, one ectomycorrhizal and the other saprotrophic, seems unlikely. Nevertheless, intrageneric changes in trophic behaviour have been substantiated for large genera, such as Amanita, with the phylogenetically older and saprotrophic Amanita thiersii clade (Wolfe et al., 2012).

Notwithstanding the aforementioned reservations, preliminary sequence data for ribosomal and protein coding genes (Buyck & Hofstetter, unpubl.) clearly show that the New Caledonian specimens are different from *Podoserpula* on other continents. A forthcoming multigene phylogenetic analysis of *Podoserpula* (Buyck *et al.*, in prep.) may shed more light on the interesting history of this enigmatic genus.

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