

# *Sarcodon atroviridis* sensu lato, a stipitate hydroid from Amazonian campinarana, Roraima, Brazil

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**Abstract:** *Sarcodon atroviridis* sensu lato has a rich nomenclatural history as a result of its variable morphology. Here we discuss the species most plastic morphological characters as well as its ecology and distribution, and we report it for the first time from the State of Roraima, Brazil. Color images of the basidiomata, complete descriptions and microscopic images are also provided.

**Key words:** Agaricomycetes, Bankeraceae, Neotropics, taxonomy, Thelephorales

The genus *Sarcodon* Qué. ex P. Karst. (Bankeraceae) includes generally stipitate basidiomes, white spines which are pallid when young to dark brown with age; context fleshy, brittle, rarely zonate, never duplex; hyphae with or without clamp connections; basidiospores subglobose, tuberculate and brownish (Karsten 1881; Vizzini et al. 2012; Baird et al. 2013).

*Sarcodon atroviridis* (Morgan) Banker has a rich nomenclatural history. Described originally from North American material by Morgan (1895) as *Hydnum* L., the genus was changed to *Sarcodon* by Banker (1906). Subsequently, Peck (1906) described *H. blackfordae* Peck, which was also transferred to *Sarcodon* by Banker (1906). Baker and Dale (1951) described *Hydnum bambusinum* (R.E.D. Baker & W.T. Dale) Maas Geest. from Trinidad. More recently, Baird and Khan (1986) listed all names cited above as synonyms of *Sarcodon atroviridis* (Baird et al. 2013). In South America, Bononi (1981) reported this species as occurring in Bolivia, Trinidad and Tobago and Brazil from the states of Mato Grosso, Rio de Janeiro, São Paulo and Rio Grande do Sul. Singer et al. (1983) considered *Sarcodon atroviridis* as “rather variable in shape and color and usually somewhat darker than described with an ample area of distribution in the Americas, in the Amazonas region where it seems to be restricted to ectotrophic forests (campina and campinarana forest) and seems to form ectomycorrhiza with leguminous trees.”

Here we report *Sarcodon atroviridis* sensu lato in the Amazonian basin, from the state of Roraima, and we discuss the morphology and distribution of this species in its wide sense.

*Sarcodon atroviridis* basidiome was collected in the Viruá National Park, Caracaraí, Roraima state, Brazil, along a trail (01°28'05" N, 061°00'32" W, alt. 62.7 m) of campinarana (white sands) forest, characterized by the sandy mixed with clay soil, composed mostly by Melastomataceae, Clusiaceae, Myrtaceae, Malpighiaceae, Leguminosae-Papilionoideae and Mimosoideae (Gribel et al. 2009).

The description of the macroscopic features is based on fresh material. Microscopic-features description is based on dried specimens, rehydrated in water or 3% KOH for spore dimensions, and then mounted in Congo red to observe the hymenium and pileipellis, and in water for pigment localization. Twenty-five spores were measured including tubercles. Extreme measurements are indicated within parentheses. The following abbreviations are used: L (W) = average length (width) with standard deviation of the basidiospores measured; Q = spore quotient (length/width ratio); Qm = average spore quotient (Wartchow 2012). References to color codes follow Online Auction Color (2004) – OAC and Kupperts (1979).

Materials for scanning electron microscope (SEM) were dried and metalized with gold and observed at LEO 435VP with SE1 detector, EHT of 15–20 kV.

***Sarcodon atroviridis*** (Morgan) Banker, Mem. Torrey Bot. Club 12: 148. 1906.

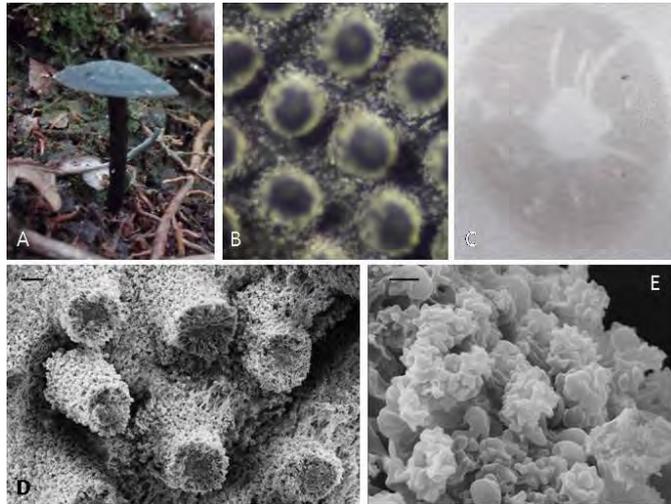
≡ *Hydnum atroviridis* Morgan, J. Cincinnati Soc. Nat. Hist. 18: 38. 1895.

≡ *Phaeodon atroviridis* (Morgan) Earle, Pl. Life Alabama: 205. 1901.

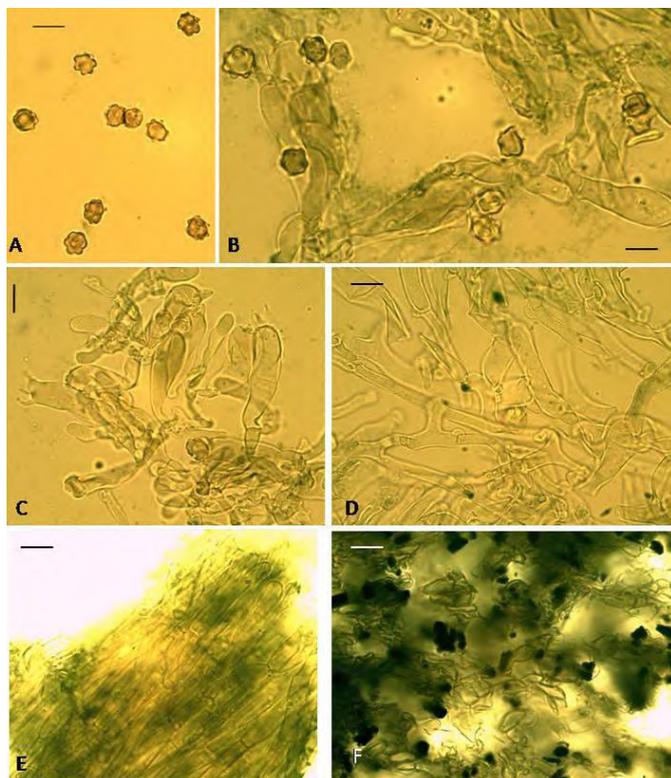
Remaining synonyms (sensu Baird & Khan 1986): = *Hydnum blackfordae* Peck, Bull. Torrey Bot. Club 33: 218. 1906; ≡ *Sarcodon blackfordae* (Peck) Banker, Mem. Torrey

Bot. Club 12: 142. 1906; = *Sarcodon fumosus* Banker, Mycologia 5: 16. 1913; ≡ *Hydnum fumosum* (Banker) Sacc., Syll. Fung. 23: 468. 1925; = *Hydnum bambusinum* R.E.D. Baker & W.T. Dale, Mycol. Papers 33: 76. 1951; ≡ *Sarcodon bambusinus* (R.E.D. Baker & W.T. Dale) Maas Geest., Proc. Kon. Ned. Akad. Wetensch. Ser. C 77: 221. 1974. Figures 1 and 2.

Pileus up to 17 mm in diam., broadly convex; surface smooth, black colored (between OAC 901-908 or



**Figure 1.** *Sarcodon atroviridis* (DLK36). **A:** basidiomata. **B:** spines at stereomicroscopic (25 ×). **C:** spore print. **D:** hymenial superficie at SEM, spines are broken. **E:** basidiospores at SEM. Scale bars: A = 10 mm; D = 30 μm; E = 5 μm.



**Figure 2.** *Sarcodon atroviridis* (DLK36) microscopic features. **A:** basidiospores. **B:** basidium with basidiopores. **C:** basidium. **D:** context with clamp connections. **E:** Stipitipellis with clamp connections. **F:** pileipellis with green pigments. Scale bars = 10 μm.

N8oC3oA6o) and olive green (OAC866 or N99CooAoo) when dried, margin plane; context soft. Hymenium spinose, with spines up to 2 mm long and less than 0.5 mm wide, obtuse, very crowded about 9 spines per 1 mm<sup>2</sup>, adnexed, black in fresh material, white granules around the spines at stereomicroscope (25 ×; Figure 1B), and becoming brownish in dried state. Stipe 25 mm long and up to 4 mm wide, central, cylindrical black (between OAC 901-908 or N8oC3oA6o) then olive green (OAC866 or N99CooAoo) when dried, concolorous with the pileus, smooth and glabrous, context the same color of pileus. Spore print brown (OAC841).

Basidiospores 6.3–8.2 (–8.4) × 5.6–7.9 μm, L = 7.1±0.6 μm, W = 6.7±0.6 μm, Q = 1.00–1.14 (–1.19), Qm = 0.106±0.05, globose to subglobose, brownish, irregular in out-line due to the presence of numerous tubercles, inamyloid. Basidia 31–44 × 6.5–11.5 μm, club-shaped to slender clavate, 4-sterigmate, sterigmata up to 6 μm long, clamped; basidioles club-shaped, very numerous, clamped. Cystidia absent. Hyphae of the spines parallel, 3–4 μm wide. Hymenophoral trama regular, composed of cylindrical hyphae, around 5 μm wide, septate, thin-walled, hyaline, clamped, sometimes anastomosing. Pileipellis composed of cylindrical hyphae, up to 8 μm wide, septate, thin-walled, clamped, greenish pigments, which are dissolved in 3%KOH. Clamp connections abundant in all tissues examined.

Habitat: solitary, on sandy soil in campinarana forest, surrounded by Clusiaceae, Melastomataceae, Malpighiaceae and Myrtaceae trees.

Known distribution: USA, Trinidad and Tobago, Bolivia and Brazil (Amazonas, São Paulo, Rio de Janeiro, Paraná, Santa Catarina, Rio Grande do Sul and now Roraima).

Material examined: Brazil, Roraima, Caracará, Parque Nacional Viruá, 01°28'05" N, 061°00' 32" W, 17 October 2011, D.L. Komura & P.A. Pereira DLK 036 (INPA 258619).

Morgan (1895) protologued *Hydnum atroviride* as follows: “fleshy-coriaceous, thin, convex then expanded, orbicular or somewhat irregular, glabrous. Stipe more or less deformed, short or elongated, central or eccentric. Teeth slender, acute. Spores dark green, rough and irregular, 6–9 μm in diam. Growing on old wood. Auburn, Ala., Prof. George F. Atkinson. Pileus 1–2 cm in diameter, the stipe 1–2 cm in length. It is easily recognized by the dark green color in every part, even of the spores”.

However, recent description by Baird et al. (2013) revealed much larger basidiomes ranging to 120 mm and somewhat larger basidiospores 8–9 × 7–8 μm (X = 9±0.6 × 8±0.4 μm) and reported growing in “mixed hardwood stands”.

Differently to protologue by Morgan (1895), who found *Hydnum atroviride* growing on wood, and the materials cited by Baird et al. (2013), other entities of

*Sarcodon atroviridis* sensu lato (including our material) were referred as growing on soil.

Later, Baker and Dale (1951) described '*Hydnum*' *bambusinum* as follow: 'Pileus to conic, umbonate, 20–40 mm, grayish brown, noted, sericeous, small black zone, margin remote. Context pale brown, centre thick then thinning toward margin. Stipe central, white-gray 20–35 × 3–6 mm, fistulose, narrower toward base. Tooth whitish then pale brown. Basidia clavate, 25–30 × 7–10 μm, 4 sterigmate, each 6–7 μm long; Spores subglobose, fuscous-olivaceous, stringly tuberculate 6.5–7 (–9) × 5–7 μm. Solitary on soil in bamboo plantation in Trinidad' (translated from Latin). This material was requested from K, but according to Begoña Aguirre-Hudson (pers. corresp.) the material is poorly preserved and unable to observe the macroscopic features for comparison to Roraima's material.

Leelavathy et al. (1986–1987) reported *S. atroviridis* from India with pileus ranging to 75 mm, smoke brown to sepia brown in when mature also on soil. This report might correspond to an introduced exotic fungus, since it was collected in a botanical garden (Sulzbacher et al. 2013).

In South America, a description of *Sarcodon atroviridis* sensu lato was given by de Meijer and Baird (1992) from Paraná state, South Brazil. They also reported it growing on soil, but with dark violet and purplish tints, a longer stipe up to 100 mm, mostly cylindrical to subcylindrical in form, and no evidence of olivaceous color after dried. Recently Magnago et al. (2015) also reported somewhat similar specimens of Santa Catarina and Rio Grande do Sul, South Brazil. Baird et al. (2013) considered now *S. fumosus* a synonym of *S. scabripes* despite the presence of clamps and subtle olive green color change in the context of *S. fumosus*. This decision is supported by spore measurements, context color and other morphological characters described in the note provided by K.A. Harrison after reviewing collection MICH 10272 (Baird et al. 2013).

At the moment, we consider our collection to be '*Sarcodon atroviridis* sensu lato', mostly due to the habit on soil and distribution in tropical South America (Figure 3), rather than on wood as occurring with the North American taxon. Phylogenetic studies with these taxa will be necessary for future clarification of the species concept within this group.

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**Figure 3.** Geographical distribution of *Sarcodon atroviridis*. **A:** The shade areas represent previous reports from literature. **B:** Distribution in Brazil (yellow) and the new site of collection (green).

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## LITERATURE CITED

- Baird, R. and S.R. Khan. 1986. The stipitate hydnums (Thelephoraceae) of Florida. *Brittonia* 38: 171–184. doi: [10.2307/2807273](https://doi.org/10.2307/2807273)
- Baird, R., L.E. Wallace, G. Baker and M. Scruggs. 2013. Stipitate hydroid fungi of the temperate southeastern United States. *Fungal Diversity* 62: 41–114. doi: [10.1007/s13225-013-0261-6](https://doi.org/10.1007/s13225-013-0261-6)
- Baker, R.E.D. and W.T. Dale. 1951. Fungi of Trinidad and Tobago. *Mycological papers* 33: 1–123.
- Banker, H.J. 1906. A contribution to a revision of the North America Hydnceae. *Memoir of the Torrey Botanical Club* 12: 99–194.
- Banker, H.J. 1913. Type studies in the Hydnceae III. The genus *Sarcodon*. *Mycologia* 5: 12–17. doi: [10.2307/3753221](https://doi.org/10.2307/3753221)
- Bononi, V.L.R. 1981. Alguns basidiomicetos hidnóides da região Amazônica. *Rickia* 9: 17–30.
- de Meijer, A.A.R. and R.E. Baird. 1992. Macromycetes from the state of Paraná, Brazil. 3. Stipitate hydnums. *Arquivos de Biologia e Tecnologia* 35: 635–640.
- Gribel, R., C.A.C. Ferreira, L.S. Coelho, J.L. dos Santos, J.F. Ramos and K.A.F. da Silva. 2009. Vegetação do Parque Nacional do Viruá – RR. Relatório para ICMBio.
- Karsten, P.A. 1881. Enumeratum Hydnearum Fr. Fennicarum, systemate novo dispositarum. *Revue Mycologique* 3: 19–21.
- Kuppers, H. 1979. Atlas de los colores. Barcelona: Blume. 161 pp.
- Leelavathy, K.M., P. Manimohan and P.N. Ganewsh. 1986/1987. *Sarcodon atroviridis* — a stipitate *Hydnum* new to India. *Sydowia* 39: 124–125 [http://www.landmuseum.at/pdf\\_frei\\_remote/Sydowia\\_39\\_0124-0125.pdf](http://www.landmuseum.at/pdf_frei_remote/Sydowia_39_0124-0125.pdf)
- Magnago, A.C., Mueller, A.C.N., Silveira, R.M.B. 2015. *Sarcodon atroviridis* (Bankeraceae, Thelephorales): new records for the southern Atlantic Forest, Brazil. *Brazilian Journal of Botany*. doi: [10.1007/s40415-014-0131-9](https://doi.org/10.1007/s40415-014-0131-9)
- Morgan, H.J. 1895. New North American fungi. *Journal of the Cincinnati Society of Natural History* 18: 36–45. <http://www.biodiversitylibrary.org/item/151029>
- Online Auction Color. 2004. Online auction color chart. Accessed at <http://www.onlineauctioncolorchart.com>, 22 May 2014.
- Peck, C.H. 1906. New species of fungi. *Bulletin of the Torrey Botanical Society* 33: 213–221.
- Programa de Pesquisa em Biodiversidade-PPBio. 2014. Parque Nacional

- do Viruá. Accessed at <http://ppbio.inpa.gov.br/sitios/virua>, 22 April 2014.
- Singer, R., I.J.S. Araujo and M.R. Ivory. 1983. The ectotrophically mycorrhizal fungi of the neotropical lowlands, especially central Amazonia. *Beihefte zur Nova Hedwigia* 77: 1–339.
- Sulzbacher, M.A., T. Grebenc, R.J.S. Jacques and Z.I. Antonioli. 2013. Ectomycorrhizal fungi from southern Brazil — a literature-based review, their origin and potential hosts. *Mycosphere* 4(1): 61–95. doi: [10.5943/mycosphere/4/1/5](https://doi.org/10.5943/mycosphere/4/1/5)
- Vizzini, A., M. Carbone, F. Boccardo and E. Ercole. 2013. Molecular validation of *Sarcodon quercinofibulatus*, a species of the *S. imbricatus* complex associated with Fagaceae, and notes on *Sarcodon*. *Mycological Progress* 12(3): 465–474. doi: [10.1007/s11557-012-0851-9](https://doi.org/10.1007/s11557-012-0851-9)
- Wartchow, F. 2012. *Clavulina incrustata*, a new species from Pernambuco, Brazil. *Cryptogamie, Mycologie* 33: 105–113. doi: [10.7872/crym.v33.iss1.2012.105](https://doi.org/10.7872/crym.v33.iss1.2012.105)
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