Cryptogam Biodiversity and Assessment
Vol 5, No. 1 (2021), e-ISSN : 2456-0251

Contributions to the lichen genus *Crypthonia* (Arthoniales) in India

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Publication Info

Article history:
Received : 22 June 2021
Accepted : 10 July 2021
DOI: 10.21756/cab.v5i1.3

Keywords:
Arthoniaceae,
Distribution mapping,
Diversity,
Lichenized Ascomycota,
Taxonomy

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ABSTRACT

The lichen genus *Crypthonia* in India is represented by two species namely, *Crypthonia albida* (Fée) Frisch & G. Thor and *Crypthonia palaeotropica* Frisch & G. Thor. The taxonomic descriptions and diagnostic characteristics that distinguish these from allied species are discussed. Brief notes on geographic distribution, ecology, along with a world distribution map and key of all known species of *Crypthonia* are provided.

INTRODUCTION

The genus *Crypthonia* Frisch & G. Thor (Arthoniaceae) was established by Frisch and Thor (2010) to accommodate species having *Herpothallon*-like thalli with maculate ascomata, asci, and ascospores similar to those found in *Arthonia s. l.* (Frisch et al. 2014). So far, the genus comprises 16 species globally (Frisch & Thor 2010; Menezes et al. 2013; Aptroot et al. 2014; Cáceres & Aptroot 2016; Sipman 2018). The genus is generally characterized by its loosely attached byssoid thallus with colored prothallus, ascomata lacking a distinct exciple, asci of the *Arthonia*-type, lacking a hemiamyloid ring in the tholus, transversely septate to submuriform, hyaline ascospores, lacking lichen substances or with mainly divaricatic, gyrophoric, norstictic, psoromic, usnic acids, and lichexanthone.

During the ongoing revisionary studies on the Arthoniales of India, some of the interesting specimens having byssoid thallus and colored hypothallus were studied in detail, which resulted in two species of *Crypthonia.* These specimens belonged to the Western Ghats, and hence the species recorded their extended distribution from the earlier known localities of Assam, Andaman Islands, and Darjeeling hills. A detailed taxonomic account of both the species and world key is provided.

MATERIALS AND METHODS

The specimens examined in the present study were housed at herbarium LWG (CSIR-National Botanical Research Institute, Lucknow). The morphological details were examined using a Leica S8APO stereomicroscope, and anatomical details were studied using a Leica DM2500 light microscope equipped with camera and image analysis software. The hand-cut sections of thalli and ascomata mounted in distilled water, KOH solution (K), and lactophenol cotton blue (LPCB) were studied. The amyloid reactions were tested in Lugol's iodine solution without (I) or with pre-treatment with KOH (KI). All the measurements were made on material mounted in distilled water. The chemistry was studied by spot tests and thin layer chromatography (in solvent system C) following Orange et al. (2001). The world distribution map of *Crypthonia* is prepared by using the software QGIS 3.6 (Fig. 2). The GPS coordinates were procured from the published references (Table 1). The species for which geographical coordinates were not available, were georeferenced by use of specimens examined information and Google Earth Pro 7.3.

THE SPECIES

1. *Crypthonia albida* (Fée) Frisch & G. Thor, Mycol. Progr. 9(2): 290. 2010. *Hypochnus albidus* Fée, Essai crypt. écorces exot. offic., suppl. et révis.: 13. 1837. *Chiodecton sterile* Müll. Arg., Mém. Soc. Phys. Hist. Nat. Genève 29(8): 65. 1887, non *Chiodecton albidum* (Taylor) Leight. *Herpothallon albidum* (Fée) Aptroot, Lücking & G. Thor, Biblioth. Lichenol. 99: 29. 2009. **(Fig. 1A).**

Thallus corticolous, up to 8 cm diam., greyish to pale yellowish green, byssoid, more or less loosely appressed to the substrate, 120–250 µm thick, with scattered calcium oxalate crystals, 2–10 µm in diam. Hypothallus dark olivaceous-green, byssoid, hyphae 1–3 µm wide. Prothallus white, up to 3 mm wide, fibrous-like. Pseudoisidioid outgrowths few to numerous, polymorphic, irregularly cushion-shaped, fluffy-felty with many projecting hyphae at the centre of the thallus, small globular to short branched at periphery regions, whitish, up to 2 × 1 mm. Photobiont cells 5–14 × 4–9 µm. Ascomata and pycnidia not seen.

Chemistry: Thallus K−, C−, P+ yellow, UV−; psoromic acid detected in TLC.

Remarks: *C. albida* is a sterile species having *close morphological* similarity to *C. palaeotropica* Frisch & G. Thor, which has an olive-brown to blackish rather than dark green hypothallus and more compact pseudoisidia (Frisch and Thor 2010). The species is somewhat similar in thallus structure to *Dichosporidium nigrocinctum* (Ehrenb.) G. Thor. The fluffy outgrowths (pseudoisidia) of *C. albida*

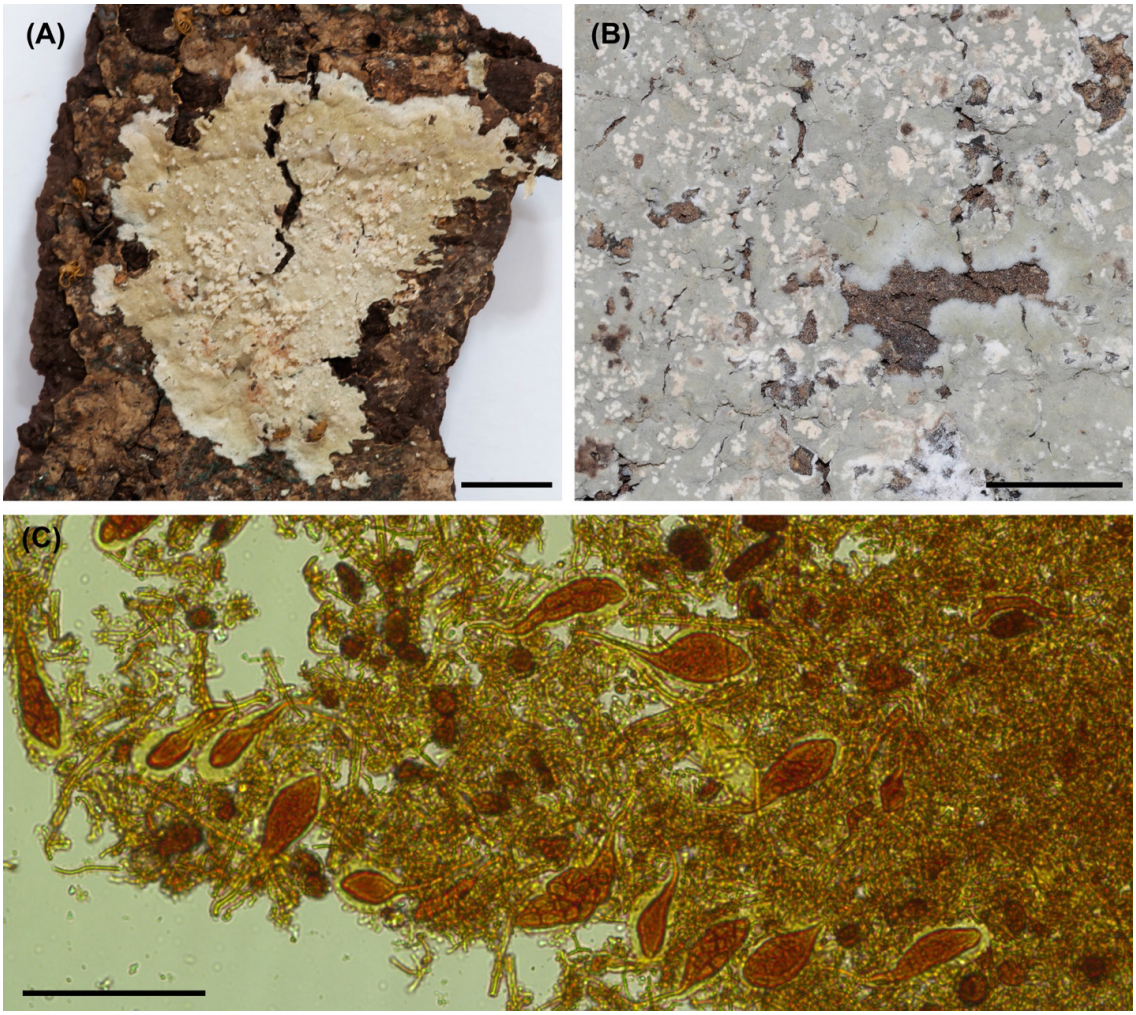

Fig. 1: (A) habit of *Crypthonia albida*, (B–C) *C. palaeotropica*, (B) habit, (C) section of ascomata showing asci, ascospores and paraphysoids mounted in Lugol's iodine solution. Scale bar: (A–B) 1 cm, (C) 50 µm.

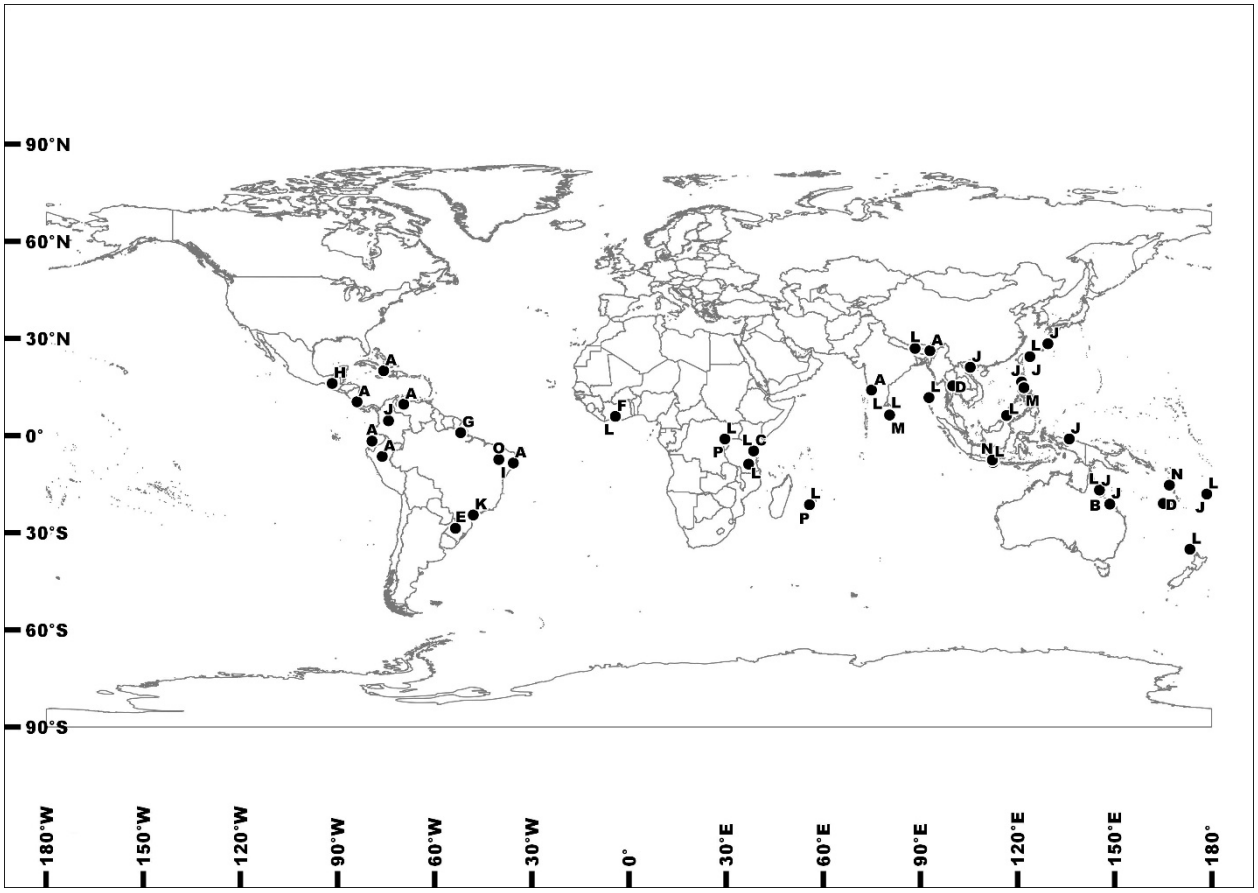

Fig. 2: Map of world distribution of *Crypthonia* species. (A) *C. albida*, (B) *C. athertoniensis*, (C) *C. bella*, (D) *C. biseptata*, (E) *C. brevispora*, (F) *C. citrina*, (G) *C. corticorygmoides*, (H) *C. divaricatica*, (I) *C. lichexanthonica*, (J) *C. mycelioides*, (K) *C. olivacea*, (L) *C. palaeotropica*, (M) *C. polillensis*, (N) *C. streimannii*, (O) *C. submuriformis*, (P) *C. vandenboomii*.

appear as reminiscent of the cylindrical pseudoisidia of *D. nigrocinctum* but remain short and irregular in structure (Aptroot et al. 2009). The species was first reported from India as *Herpothallon albidum* from West Bengal by Jagadeesh Ram & Sinha (2009). Later, they reidentified it as *Crypthonia palaeotropica* (Jagadeesh Ram & Sinha 2017). Behera et al. (2021) mentioned the occurrence of this species (as *H. albidum*) in Assam.

Specimens examined: India, Karnataka, Uttara Kannada district, Karwar-Hubli road, 24 February 2018, on bark, S. Nayaka & party 18-029164 (LWG); *ibid*., Shimoga dist., Hosanagra, Ripponpete, elev. 693 m a.s.l., N13°55'44.9'', E75°15'40.7'', 21 February 2018, on bark, S. Nayaka & party 18-034281 (LWG); *ibid.*, Sagara taulk, Honnemaradu, elev. 643 m a.s.l., 19 March 2001, on the bark of *Olea dioica* Roxb., S. Nayaka 01-107278 (LWG); *ibid.,* Mattikoppa, elev. 603 m a.s.l., 17 March 2001, on bark, S. Nayaka 01-67381, 01-67386, 01-67392 (LWG); *ibid*., Negiloni, elev. 710 m a.s.l., 18 March 2001, on the bark of *Aglaia elaegnoidea* (Juss.) Benth., S. Nayaka 01-107239 (LWG); *ibid*., Holebagilu, elev. 623 m a.s.l., 16 March 2001, on the bark of *Diospyros crumenata* Thw., S. Nayaka 01-222800 (LWG); *ibid.,* Karumane, elev. 599 m a.s.l., 21 March 2001, on the bark of *Pterospermum reticulatum* Wight & Arn., S. Nayaka 01-66197 (LWG); *ibid*., Hubse, elev. 594 m a.s.l., 16 March 2001, on the bark of *Ventilago maderaspatana* Gaertn., S. Nayaka 01-222736 (LWG); *ibid.*, on the bark of *Artocarpus integer* (Thunb.) Merr., S. Nayaka 01-222706 (LWG); *ibid*., on the bark of *Ficus* sp., S. Nayaka 01-222728 (LWG).

2. *Crypthonia palaeotropica* Frisch & G. Thor, Mycol. Progr. 9(2): 300. 2010. **(Fig. 1B&C).**

Thallus corticolous, up to 10 cm diam., surface pale greenish, byssoid, more or less loosely attached to the substrate, 100–300 µm thick, calcium oxalate crystals numerous, 5–12 µm in diam. Hypothallus dark olivaceous brown, byssoid, hyphae 1–3 µm wide. Prothallus white, up to 2 mm wide, fibrous-like. Broder line dark brownish, ca. 0.2 mm wide. Pseudoisidioid outgrowths present, usually restricted to the

Table 1: The known distribution of the species of *Crypthonia* in the world.

Species	*Known Distribution*	*References*
C. albida (Fée) Frisch & G. Thor	Brazil, Costa Rica, Cuba, Ecuador, India, Peru, Venezuela	Aptroot et al. (2009), Frisch & Thor (2010), Behera et al. (2021), In this paper
C. athertoniensis Frisch & G. Thor	Australia	Frisch & Thor (2010)
C. bella Frisch & G. Thor	Tanzania	Frisch & Thor (2010)
C. biseptata (Aptroot & Wolseley) Frisch & G. Thor	New Caledonia, Thailand	Frisch & Thor (2010), Aptroot & John (2015)
C. brevispora Frisch & G. Thor	Brazil	Frisch & Thor (2010)
C. citrina Frisch & G. Thor	Ivory Coast	Frisch & Thor (2010)
C. corticorygmoides Aptroot & M.Cáceres	Brazil	Cáceres & Aptroot (2016)
C. divaricatica Aptroot & Sipman	Mexico	Aptroot et al. (2014)
C. lichexanthonica A.A. Menezes, M. Cáceres & Aptroot	Brazil	Menezes et al. (2013)
C. mycelioides (Vain.) Frisch & G. Thor	Australia, Colombia, Fiji Islands, Indonesia, Japan, Philippines, Vietnam	Aptroot & Sipman (2006), Aptroot et al. (2009), Frisch & Thor (2010), Lucking et al. 2021
C. olivacea Frisch & G. Thor	Brazil	Frisch & Thor (2010)
C. palaeotropica Frisch & G. Thor	Australia, Fiji Islands, India, Indonesia, Ivory Coast, Japan, La Réunion, Malaysia, New Zealand, Sri Lanka, Tanzania, Uganda	Frisch & Thor (2010), Frisch et al. (2015), Paukov et al. (2017), Jagadeesh Ram & Sinha (2017), In this paper
C. polillensis (Vain.) Frisch & G. Thor	Philippines, Sri Lanka	Frisch & Thor (2010), Weerakoon et al. (2016)
C. streimannii Sipman	Indonesia, Vanuatu	Sipman (2018)
C. submuriformis A.A. Menezes, M. Cáceres & Aptroot	Brazil	Menezes et al. (2013)
C. vandenboomii Frisch & G. Thor	La Réunion, Uganda	Frisch & Thor (2010), Frisch et al. (2015)

peripheral parts of the thallus, short, globular to coralloid type with projecting hyphae. Photobiont cells 5–12 × 3–8 µm. Ascomata white, sometimes with light rose tinge, raised, irregularly shaped, and simple to branched, up to 1.5 mm wide. Excipulum indistinct. Epithecium 5–10 µm thick. Hymenium 30–70 µm high, with brownish granules and small calcium oxalate crystals, I−. Paraphysoids highly branched and anastomosing, 1–2 µm wide. Hypothecium 40–70 µm high. Asci *Arthonia*-type, 8-spored, 35–50 × 12–17 µm. Ascospores hyaline, 1-septate, 8–14 × 3–4.5 µm. Pycnidia not seen.

Chemistry: Thallus K−, C−, P+ yellow, UV−; psoromic acid detected in TLC.

Remarks: *Crypthonia palaeotropica* is a fertile species having pseudosidia. The pseudoisidia are mainly restricted to the peripheral regions of the thallus where ascomata are absent. So far, only four species of *Crypthonia* are reported with psesudoisidioid outgrowths, viz., *C. albida*, *C. mycelioides* (Vain.) Frisch & G. Thor, *C. palaeotropica*, and *C. streimannii* Sipman. Among these the presence of ascomata were reported only in *C. palaeotropica* and *C. streimannii*, and the latter species differs from the former species by its chemistry (containing terpenoids instead of psoromic acid) (*fide* Sipman 2018). In India, *C. palaeotropica* is known from the Andaman Islands and West Bengal (Jagadeesh Ram & Sinha 2017). The current report indicates its extended distribution to the Western Ghats biodiversity hotspot.

Specimen examined: India, Karnataka, Shimoga dist., Sagara taulk, Holebagilu, elev. 623 m a.s.l., on bark, 16 March 2001, S. Nayaka 01-222770 (LWG).

NOTES ON THE ECOLOGY AND DISTRIBUTION OF *CRYPTHONIA*

The maximum number of species of genus *Crypthonia* are known from Brazil with 6 spp. (Table 1). The most common and widely distributed species is *C. palaeotropica* and so far, known from Australia, Fiji Islands, India, Indonesia, Ivory Coast, Japan, La Réunion, Malaysia, New Zealand, Sri Lanka, Tanzania, and Uganda. During the studies of epiphytic lichen communities of Bwindi Impenetrable National Park in African Montane Rain Forests of southwest Uganda, Frisch et al. (2015) recorded the 59 individual occurrences of *C. paleotropica*. Frisch & Thor (2010) noted that the occurrences of *C. albida* in Vanuatu and Vietnam (Aptroot et al. 2009) should be checked against *C. palaeotropica*. The occurrence of *C. mycelioides* in Vietnam (Aptroot & Sipman 2006; as *Chiodecton mycelioides*) is neither commented nor included in Frisch & Thor (2010). However, Joshi et al. (2018) included the species in the key to the Arthoniaceae species from Vietnam.

According to the current distributional records, the genus *Crypthonia* is strictly restricted to the tropics (Fig. 2). Further, most of its species are rare and known only from the type locality. The species of *Crypthonia* require high moisture as they are typically found in shady microhabitats and on substrates with increased water holding capacity (Frisch & Thor 2010). In India, the species are known from the tropical rain forests of Andaman Islands, Darjeeling hills, and Western Ghats. They were found growing on the decaying bark at the base of old trees along with the mosses. Frisch & Thor (2010) also noted that the *Crypthonia* species occurs in habitats shaded from direct rainfall, growing on soft and slightly decaying bark or over a thin layer of corticolous bryophytes or detritus that had been accumulated on the stem. However, *C. mycelioides* from the Philippines have been collected from rock, but no further information about the habitat is available. The two specimens of *C. albida* from Costa Rica were found to be growing on the living leaves (Frisch & Thor 2010).

WORLD KEY TO THE SPECIES OF *CRYPTHONIA*

(Modified from Frisch & Thor 2010)

1a Thallus with psesudoisidioid outgrowths ……..2
1b Thallus without psesudoisidioid outgrowths ……..5

2a Thallus with norstictic acid ……..... *C. mycelioides*
2b Thallus with other chemical combinations …… 3

3a Hypothallus olivaceous-green, ascomata and ascospores absent ……*C. albida*
3b Hypothallus olive brown, dark brown to blackish, ascomata and ascospores present ….....…… 4

4a Thallus with psoromic acid……. *C. palaeotropica*
4b Thallus with terpenoids ……..……. *C. streimannii*

5a Ascospores muriform …..... *C. submuriformis*
5b Ascospores transversely septate ……..... 6

6a Thallus UV+ yellow, lichexanthone present..... *C. lichexanthonica*
6b Thallus UV−/white, lichexanthone absent …….. 7

7a Ascospores up to 3-septate ……8
7b Ascospores more than 3-septate ……. 15

8a Ascospores 1-septate …… 9
8b Ascospores (1–)2–3-septate ……..... 12

9a Thallus with rugulosin, hypothallus lemon yellow.. *C. citrina*
9b Thallus without rugulosin, hypothallus olive-brown or green ….....… 10

10a Thallus with unknown terpenoids, hypothallus olive-brown ……..…… *C. polillensis*
10b Thallus with psoromic acid, hypothallus variable … 11

11a Hypothallus dark green, ascospores 7.5–10 µm long ……..…… *C. brevispora*
11b Hypothallus olive-brown, ascospores 11–14 µm long ……..…. *C. vandenboomii*

12a Thallus with rugulosin ……..…… *C. bella*
12b Thallus without rugulosin ……..…....13
13a Thallus with gyrophoric acid ……..…… *C. olivacea*
13b Thallus with psoromic acid ……..……...… 14

14a Ascospores 10–16 µm long, widest in the upper half ……..…. *C. athertoniensis*
14b Ascospores 16–19 µm long, widest in the middle .....…. *C. biseptata*

15a Thallus without lichen substances, ascospores 3–5-septate …..…… *C. corticorygmoides*
15b Thallus with divaricatic and usnic acids, ascospores 5–9-septate ……..... *C. divaricatica*

ACKNOWLEDGEMENTS

The authors are grateful to the Director, CSIR-National Botanical Research Institute (CSIR-NBRI), Lucknow for providing facilities. The author (SJ) is also thankful to the Department of Science & Technology (DST), New Delhi for the financial assistance under INSPIRE Faculty scheme (IFA18-LSPA 124).

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