



## Additions to helicoid fungi from India

Singh PN<sup>1</sup> and Singh SK<sup>1</sup>

<sup>1</sup> National Fungal Culture Collection of India, Biodiversity and Palaeobiology Group, MACS' Agharkar Research Institute, GG Agarkar Road, Pune 411004, India

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### Abstract

The present paper describes four new species of helicosporous fungi, namely *Moorella heterosporous*, *Helicoma eucalypti*, *Helicosporium myrtacearum* (collected on *Eucalyptus* sp.) and *H. xylophilous* (collected on unidentified dead wood). All the treated taxa were gathered from Western Ghats region, India.

**Key words** – helicosporous fungi – hyphomycetes – taxonomy – Western Ghats

### Introduction

Review of literature reveals that certain fungi produce coiled two- or three-dimensional hollow conidia, consists of morphologically distinct and ecologically interesting group of micro fungi. Among helicosporous genera, *Helicoma* Corda, *Helicomycetes* Link and *Helicosporium* Nees are considered to be the earliest erected anamorphic genera (Ghao et al. 2007), and most of them survive as saprobes on plant litter, rotten wood, decaying twigs, occurring in moist places or around water body. Generic circumscription of *Helicoma*, *Helicosporium*, and *Helicomycetes* are complex and ambiguous due to architectural similarity especially in coiling of their conidia. Different treatments were proposed from time to time (Morgan 1892, Linder 1929, Moore 1955, Matsush.1975). Except for the conidial characteristic, emphasis was given to conidial attachment position, conidiogenous cells and presence of 'sclerotes pediceles' (Pirozynski 1972). Critical reviews of taxonomic criteria by Goos (1985, 1986, 1987, 1989) distinguished three genera. *Helicoma* produces non-hygroscopic conidia with relatively thick conidial filaments, while *Helicomycetes* and *Helicosporium* produce hygroscopic conidia having comparatively thin filaments in proportion to their length. However, *Helicomycetes* is distinguished from *Helicosporium* in having much reduced conidiophores which are lacking sometimes. The conidiophores are found well-developed in *Helicosporium*.

As a part of fungal biodiversity exploration and their documentation several micro and macro fungi have been reported recently from Western Ghats regions in Maharashtra (Karandikar et al. 2015, Singh et al. 2015, Rajeshkumar et al. 2016). Taxa described in this paper were also collected from same geographic locations (latitude of 18°31'N, longitude of 73°55' E), and upon critical study they turned out to be interesting helicosporous taxa not reported till date. They belong to the anamorphic genera *Helicoma*, *Helicosporium* and *Moorella*, growing saprophytically over the dead bark/dead woods. *Moorella*, however found growing on both the inner and outer surfaces forming uniform black and velvety colonies. Based on critical and comparative morphotaxonomic features like dimensions of conidiophores, number of coiling in conidia, septation and width of conidial filaments, these taxa are described in detail as new to science.

## Materials & Methods

### Isolates and morphology

After collection from type locality, specimens were brought to the laboratory in separate paper bags. A trinocular Nikon stereo microscope (Model SMZ-1500 aided with Digi-CAM) was used to study features of the fungus on substrates and photomicrographs were taken. A small portion/scrape taken from growing colonies were mounted in lactic acid and cotton blue, separately as well as in combination on glass slides, and examined under Carl Zeiss AXIO-10 microscope. Microphotographs of various morphological structures were taken. The holotype specimen is deposited in Ajrekar Mycological Herbarium (AMH) at MACS' Agharkar Research Institute, Pune, India. The present taxa were compared to the closely related species of *Moorella*, *Helicoma*, and *Helicosporium* in order to establish the novelty.

Attempts to in vitro culture of the new taxa on artificial media, such as potato dextrose agar and potato carrot agar (Tuite 1969) were unsuccessful.

## Results

### Taxonomy

#### *Moorella heterosporous* PN Singh, SK Singh, **sp. nov.**

Fig. 1

MycoBank MB 817600

*Facesoffungi* number: FoF 02633

Holotype – AMH 9746

Etymology – specific epithet heterosporous refers to the presence heteromorphic conidia.

Colonies on dead bark uniformly spreading, moldy, effuse, blackish brown to black, velvety, growing on both outer and inner surfaces. Conidiophores macronematous, mononematous, erect, straight to slightly flexuous, septate, dark brown to black, smooth-walled, short and numerous branches form verticills (4–5) along the stipe, up to 400 µm long, 5–10 µm thick at the base, 5–8 µm thick at the apex. Conidiogenous cells integrated, terminal, polyblastic, branches are rarely discrete, sub-spherical to ellipsoidal, denticulate. Conidia solitary, dry, smooth-walled, non-hygroscopic, hyaline or sub-hyaline, developing at a time or successively from a pale brown, thin walled protrusion at the apex of each conidiogenous cell, simple, helicoids, 1–1½ times coiled, 1–9 (mostly 3–6) septate, 9–13 µm diam. with filament 3–5 µm thick, heteromorphic (V and Y shaped), some conidia are olivaceous brown at basal half portion, smooth-walled.

Material examined – INDIA, Maharashtra, Pune, Agharkar Research Institute campus (18° 31' N, 73° 55' E), on dead bark of *Eucalyptus* (Myrtaceae), 28 April 2015, coll. P.N. Singh, AMH 9746 (holotype), PNS-ARI 12 (isotype).

Notes – As per index fungorum, only two species of *Moorella* are reported from all over the world including type, viz., *M. speciosa* (Rao and Rao 1964) and *M. monocephala* (Matsush 1993). Critical examinations of the collected specimens reveal that though the present species share a few morphological features with earlier reported two species, such as colony color, number of coils in conidia, and conidial septation, it significantly differs in overall dimension of conidiophores and conidia which are slender. In addition, presence of three types of conidia (heteromorphic), viz., helicoid, V and Y shaped in present taxon clearly separates it from other reported species of *Moorella*. Therefore, based on these distinct morphological features, present taxon is described and illustrated as new species, *Moorella heterosporus*.

#### *Helicoma eucalypti* PN Singh, SK Singh, **sp. nov.**

Fig. 2

MycoBank MB 817603

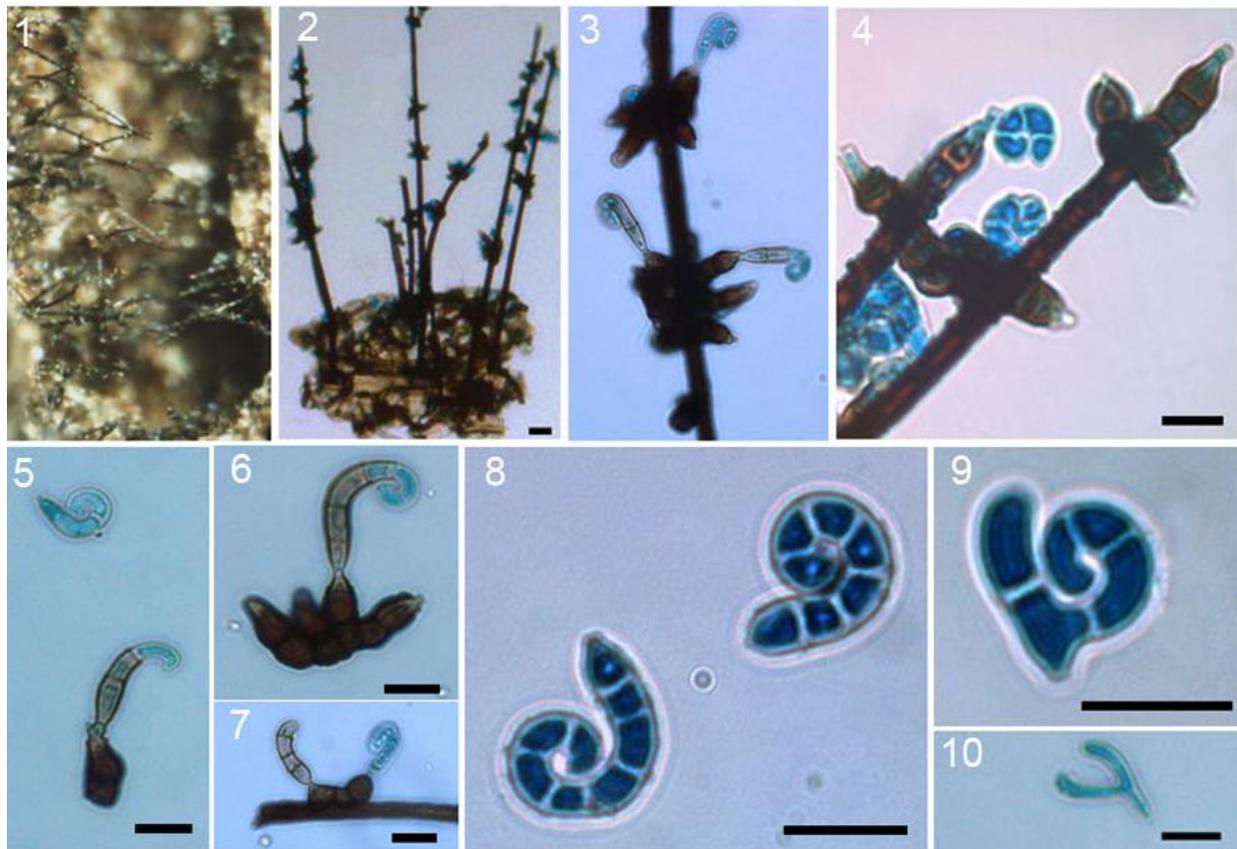
*Facesoffungi* number: FoF 02634

Holotype – AMH 9745

Etymology – specific epithet refers to the host genus, *Eucalyptus*.

**Table 1** Comparison of morphotaxonomic features of *Moorella heterosporous*, *M. monocephala* and *M. speciosa* (type species).

Species	Conidiophore size ( $\mu\text{m}$ )	Conidial shape & diam ( $\mu\text{m}$ )	Number of coils	Conidia Septation	Width of conidial filament ( $\mu\text{m}$ )	Colony color
<i>M. speciosa</i>	360 $\times$ 8–11	Helicoid, 10–16	1–1½	4–7	4–6	Blackish brown to Black
<i>M. monocephala</i>	-	Helicoid, 9–12	1½	6–7	4–6	-
<i>M. heterosporous</i> sp. nov	400 $\times$ 5–10	Helicoid, V & Y, 9–13	1–1½	1–9	3–5	Black



**Fig. 1** – *Moorella heterosporous* (AMH 9746, **holotype**). **1**. Stereoscopic view of colonies on dead bark. **2** Conidiophores emerging from substrate bearing multiple fertile verticils. **3** Conidiophore and verticils of conidiogenous cells with attached conidia. **4** Magnified view of conidiophores and conidiogenous cells. **5, 6, 7** Conidiogenous cells with attached conidia in different magnifications. **8** Magnified view of helicoid conidia with truncate base. **9** Magnified view of 'V'-shaped conidium. **10** Magnified view of 'Y' shaped conidium. Bars: 2 = 20  $\mu\text{m}$ , 3–10 = 20  $\mu\text{m}$ .

Colonies on dead bark, effuse cottony, tan brown to brown, superficial, Stroma none. Conidiophores macronematous, mononematous, simple to dichotomously branched near the base, straight to flexuous, septate, dark brown towards base, paler towards apex, multiseptate, thick-walled, apex swollen, verruculose, up to 256.5  $\times$  8–10  $\mu\text{m}$ . Conidiogenous cells mono- to polyblastic, integrated and terminal, bears dark brown to black, denticulate terminal and lateral scars. Conidia solitary, dry, non-hygroscopic, acropleurogenous, 6– 8 septate, helicoids, 1–1¼ times tightly coiled, 16.5–20.3  $\mu\text{m}$  diam. Basal cell of conidial filament 4  $\mu\text{m}$  wide, 9.8  $\mu\text{m}$  wide in middle (broadest part), smooth-walled, hyaline, guttulate, dry, rounded at the apex, tapering towards base with a truncated scar.

Material examined – INDIA, Maharashtra, Pune, Agharkar Research Institute campus (18° 31'N, 73°55' E), on dead bark of *Eucalyptus* sp. (Myrtaceae), 28 April 2015, coll. P.N. Singh, AMH 9745 (holotype), PNS-ARI 13 (isotype).

Notes – Present fungus is a saprobe with conidiophores loosely aggregated to form fascicles and non-hygroscopic, coiled, multi septate conidia produced acropleurogenously from small denticles. Based on salient features, the present fungus is placed under the genus *Helicoma* Corda (1837). Index fungorum records reveal that only two species, *H. narsapurensis* (Rao and Rao 1964) and *H. indicum* (Gawas and Bhat 2007) are reported from India. Present taxon differs from *H. narsapurensis* in having significantly smaller and wider conidiophores and smaller conidia which are generally 6–8 septate. Similarly it is different from *H. indicum* in having longer and significantly wider conidiophores and multiseptate conidia. In addition, the present fungus is different from other species of sect. *Helicoma* in having widest conidiophores and combination of other morphological characteristics (Table 2).

***Helicosporium myrtacearum* PN Singh, SK Singh, sp. nov.**

Fig. 3

MycoBank MB 817604

*Facesoffungi* number: FoF 02635

Holotype – on AMH 9748

Etymology – specific epithet 'myrtacearum' refers to the host family.

Colonies on dead bark white, effuse, appears in patches, mycelium superficial. Conidiophores macronematous, mononematous, simple to dichotomously branched, anastomosis, straight or flexuous, septate, olivaceous brown, multiseptate, thick-walled and darkened, 80–175 µm long, 3.8–8 µm thick. Conidiogenous cells monoblastic, lateral, cylindrical, denticulate, sometimes ampulliform, olivaceous, 1.3–9.8 × 1.2–4.2 µm. Conidia solitary, dry, acrogenous to acropleurogenous, helicoids, 2–2½ times coiled, 13–18.5 µm diam. Conidial filaments hygroscopic, smooth-walled, hyaline, guttulate, dry, rounded at the apex, tapering towards base with a truncated scar, 8–12 septate, 1.8–2 µm wide.

Material examined – INDIA, Maharashtra, Pune, Agharkar Research Institute campus (18°31'N, 73°55'E), on dead bark of *Eucalyptus*, 28 April 2015, coll. P.N. Singh, AMH 9748 (holotype), PNS-ARI 14 (isotype).

Notes – Present taxon is compared with *H. raghuveerii* (Rao and Varghese 1988) earlier described from India. It differs in having smaller conidiophores, slender and less septate conidia from *H. raghuveerii*. However, it is also different with type species; *H. vegetatum* in having smaller conidiophores with smaller diameter of conidia consists of less coiling and less septation (Table 2). These significant features separate present taxon from other species in the genus.

***Helicosporium xylophilous* PN Singh, S.K Singh, sp. nov.**

Fig. 4

MycoBank MB 817605

*Facesoffungi* number: FoF 02636

Holotype – AMH 9744

Etymology – specific epithet refers to the substrate from which it was collected.

**Colonies** on dead wood, effuse superficial white. Conidiophores arising from superficial hyphae macronematous to mononematous, simple or dichotomously branched, straight or flexuous, septate, suhyaline to light olivaceous, 3–7 septate, tip obtuse, smooth, wall thickened and darkened 16–65 µm long, 4–6.3 µm thick. Conidiogenous cells monoblastic, cylindrical to denticulate, arising from upper half of the conidiophores, cylindrical, denticulate to ampulliform, light olivaceous to suhyaline, 3–2.2 µm. Conidia solitary, dry, acropleurogenous, helicoids, 1½–2½ times coiled, 13.8–40 µm diam. Conidial filaments hygroscopic, smooth-walled, hyaline, guttulate, dry, rounded at the apex, tapering towards base with a truncated scar, 17–24 septate, 3.5–4.3 µm wide.

Material examined – INDIA, Maharashtra, Pune, Agharkar Research Institute campus (18°31' N, 73° 55'E), on unidentified dead wood, 28 April 2015, coll. P.N. Singh, AMH 9744 (holotype), PNS-ARI 15 (isotype).

**Table 2** Comparison of morphotaxonomic features of *Helicoma eucalypti* sp. nov. with other species of sect. *Helicoma* (Goos 1986; Ghao et al. 2007).

Fungi	Conidiophore size ( $\mu\text{m}$ )	Diameter of conidia ( $\mu\text{m}$ )	Width of conidial filament ( $\mu\text{m}$ )	Number of coils in conidia	No. of Septa in filament
<i>H. ambiens</i>	200 $\times$ 3.5–6	18–20	6–7	1½–1¾	6–8
<i>H. asperothecum</i>	55–250 $\times$ 5.5–7.5	15–25	4.5–6.5	1½–1¾	8–10
<i>H. casuarinae</i>	20–60 $\times$ 4–5	10–13	3–3.5	1.5–2¼	0–3
<i>H. chlamydosporum</i>	4.5–13 $\times$ 2.4–4.8	14.4–17.8	4–6	1¼–1¾	2–6
<i>H. conicodentatum</i>	20–125 $\times$ 4–5	14–20	5–5.5	1¼–1.75	5–7
<i>H. dennisii</i>	470 $\times$ 5–8	19–22	7–10	1¼–1½	7–8
<i>H. divaricata</i>	100–350 $\times$ 4–5	11.5–16	4.5–6.5	1¼–1½	4–9
<i>H. hainanense</i>	150–400 $\times$ 2.5–4.5	12–16	2.5–4	1¼–1¾	Inconspicuous
<i>H. inflatum</i>	18–120 $\times$ 5–7	13–18	5–6	1¼–1¾	5–6
<i>H. indicum</i>	200 $\times$ 2–3	5.5–7.5	3–3.5	0.5–0.8	1
<i>H. muelleri</i>	200 $\times$ 5–7.5	14–21	3.5–7	1½–1¾	5–8
<i>H. narsapurensis</i>	145–335 $\times$ 6–9	20–27	6–10	1¼–1.5	3–8
<i>H. palmarum</i>	--	4.5–6.5	2–3	1–1¼	2
<i>H. recurvum</i>	200 $\times$ 5–9	15–20	7–8	1–1¾	6–8
<i>H. scarabaeiforme</i>	40 $\times$ 2.5–4	6–7.5	2–3	¾–1	2–3
<i>H. taenia</i>	600 $\times$ 4	15–20	5.5–9	1½–1¾	7–16
<i>H. taiwanensis</i>	100–400 $\times$ 3–4	7–15	4–6	1–1½	3–5
<i>H. vaccinii</i>	64–145 $\times$ 2.5–5	8.0–13.	2–4	1½–1¾	4–8
<i>H. eucalypti</i> sp. nov	256.5 $\times$ 8–10	16.5–20.3	4–9.8	1–1¼	6–8

Source of Table: All measurements and identification characteristics are as per Ghao et al. (2007) except Indian species which are added in the table for the purpose of comparative study.

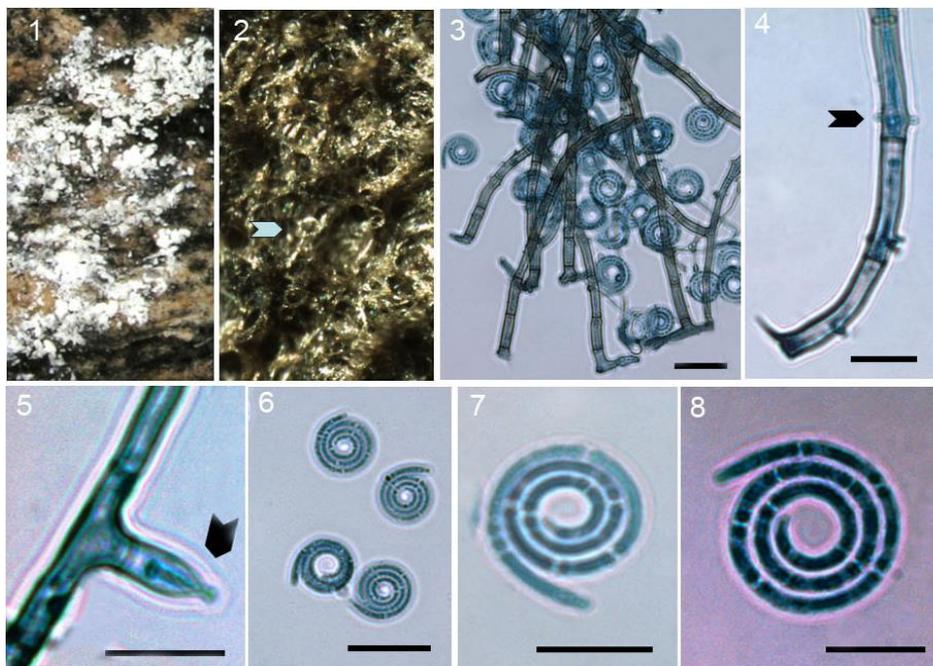
**Table 3** Comparison of diagnostic characteristics of *Helicosporium* spp. recorded from India, and with type species.

Species	Conidiophore size ( $\mu\text{m}$ )	Diameter of conidia ( $\mu\text{m}$ )	Width of conidial filament ( $\mu\text{m}$ )	Number of coils in conidia	No. of Septa in filament
<i>H. abuense</i>	95–100 $\times$ 5.5	12–24	2–3½	6–18	2–2.7
<i>H. decumbense</i>	75–200 $\times$ 4–5	6–9	1–2	-	0.75–1.5
<i>H. gracile</i>	150 $\times$ 2.5–5	10–15	3–3¼	-	1–1.5
<i>H. griseum</i>	- $\times$ 3.5–5	18–25	2–4	10–14	1–2.5
<i>H. guianense</i>	480 $\times$ 2.5–4.5	20–22	3–3½	-	1–5
<i>H. hiospiroides</i>	150–250 $\times$ 5.5–8.5	21–35	1–4	1–4	1.5–3
<i>H. indicum</i>	19–43 $\times$ 3–5	25.2–36	1½–3½	5–12	1.4–2.5
<i>H. lumbricopsis</i>	-	20–28	3–4	18–25	1.5–2.5
<i>H. nizamabadense</i>	57–198 $\times$ 3–5	18.2–28	2–3½	15	1.4–2.2
<i>H. panacheum</i>	40–70 $\times$ 4.5–6	(15) 20–30	2–4	multiseptate	2.5–4.5
<i>H. raghuveeri</i>	80–170 $\times$ 6–8.5	60–85	1½–2½	20	3.5–7
<i>H. vegetum</i> (type)	600 $\times$ 3–6	10–20	2–4	14–19	0.8–1.3
<i>H. myrtacearum</i> sp. nov.	80–175 $\times$ 3.8–8	13–18.5	2–2½	8–12	1.8–2
<i>H. xylophilous</i> sp. nov	16–65 $\times$ 4–6.3	13.8–40	1½–2½	17–24	3.5–4.3

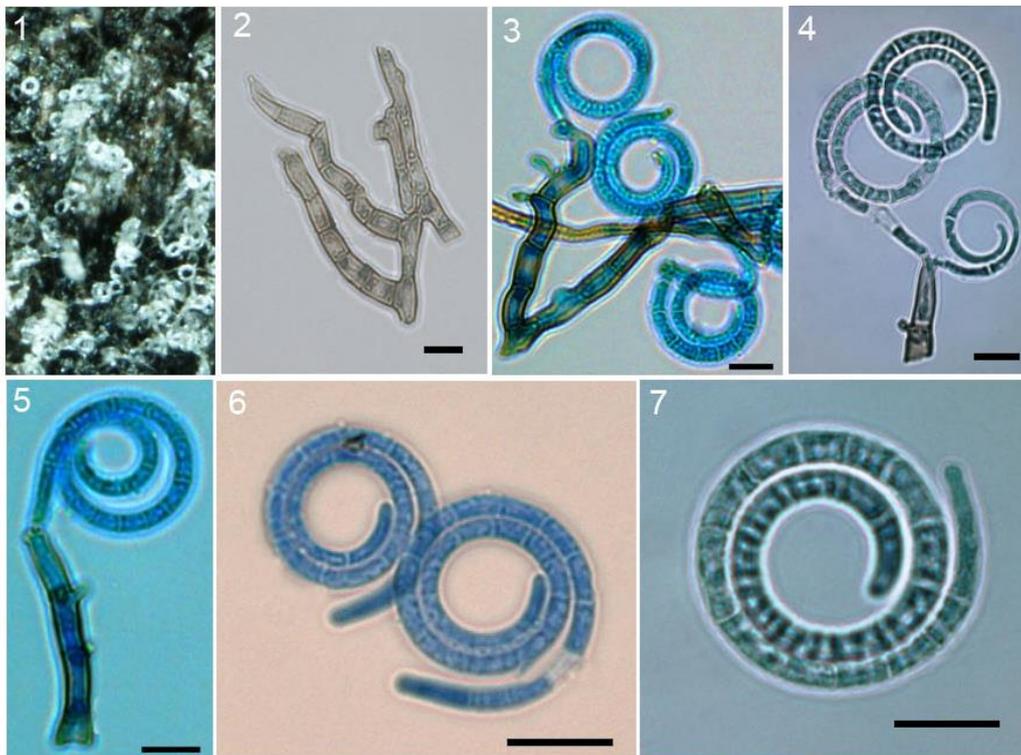
Source of Table: all characters and measurements were taken from description included in Manoharachary and Kunwar (2010).



**Fig. 2** *Helicoma eucalypti* (AMH 9745, **holotype**). **1** Stereoscopic view of natural colonies on dead bark. **2** Conidiophores in dense fascicles. **3** Intact fasciculate conidiophores emerging from substratum. **4** Magnified view basal portion of conidiophores. **5** Magnified view showing branching in conidiophore. **6** Swollen and verruculose terminal portion of a conidiophore bearing acrogenous denticulate conidiogenous cell. **7–8** Tightly coiled conidia with tapered darkened base. Bars: 2–3 = 20  $\mu\text{m}$ , 4–8 = 10  $\mu\text{m}$ .



**Fig. 3** *Helicosporium myrtacearum* (AMH 9748, **holotype**). **1** Natural colonies on dead bark. **2** Stereoscopic view of colonies on substrate. **3** Conidiophores and conidia. **4** Magnified view of a part of conidiophore (arrow showing denticulate conidiogenous cell). **5** A Part of conidiophore bearing ampulliform conidiogenous cell (arrow showing ampulliform conidiogenous cell). **6** Coiled conidia in lower magnification. **7–8** Magnified view of conidia. Bars: 3 = 20  $\mu\text{m}$ , 4–8 = 10  $\mu\text{m}$ .



**Fig. 4** *Helicosporium xylophilous* (AMH 9744, **holotype**). **1** Stereoscopic view of natural colonies on dead wood, **2** Conidiophores with denticulate conidiogenous cell. **3** Branched conidiophore with ampulliform conidiogenous cells and conidia. **4** A part of conidiophore with attached conidia. **5** A conidiophore with terminally attached conidium. **6, 7** Magnified view of conidia. Bars 2-7 = 10  $\mu$ m.

Notes – Critical assessment of overall morphological features suggests that the present taxon is comparable with 3 species, *H. indicum*, *H. lumbricopsis*, and *H. panacheum* out of 12 species recorded from India (Manoharachary and Kunwar 2010). Present taxon differs from *H. indicum* in having longer and wider conidiophores and number of conidial septation (17–24) and wider filaments (3.5–4.3), from *H. lumbricopsis* in having helicoid conidia which are greater in diameter and wider filament, from *H. panacheum* in having helicoid conidia which are greater in diameter, and coiling. In addition, the present taxon is also different from other species recorded from India including *M. myrtacearum* sp. nov. in having significantly smaller conidiophores, and in other combination of morphological characters (Table 3).

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