

***Bheemamyces uvariae* sp. nov., a New Foliar Mycobiont from Andaman Archipelago, India**

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ABSTRACT

An infrequent foliicolous fungal species, *Bheemamyces uvariae* sp. nov., was found infecting the leaves of *Uvaria hamiltonii* Hook. f. and Thomson (Annonaceae), collected from Mount Harriet National Park, South Andaman is described and illustrated in detail. *Bheemamyces uvariae* is characterized in having both lateral appressoria on the main hyphae and lateral, sublateral to intercalary appressoria on the hyphae originated from the main hyphae, narrower, curved, slightly elevated from the host surface and pointed at the tip. This is the first record of the genus *Bheemamyces* on the members of the family Annonaceae.

Keywords: Annonaceae, *Bheemamyces*, Black mildew, New species, South Andaman

INTRODUCTION

Black mildews are strictly obligate biotrophs infecting wide range of flowering plants ranging from herbs to trees, weeds to economically important cultivated plants, etc. These fungi produce thin to black colonies on the surface of the leaves and must interact with living plant cells for growth and reproduction, they usually are host-specific or have a very narrow host range (Hansford, 1961; Hosagoudar, 1996). Their blackened mycelium covers the leaf surfaces and reduces the exposure area for sunlight (Hongsanan *et al.*, 2016). The assumption of host-specificity means this group is highly diverse, and it is imperative to identify the host before attempting to identify a fungal collection (Zeng *et al.*, 2017). It is also authoritative to identify the host, at least up to family level, before attempting to identify a new collection (Hansford, 1961; Hirata, 1972; Saenz and Taylor, 1999; Hongsanan *et al.*, 2015). The fungal species concept is based on the individual host plants and the fungal morphological characters.

These fungi in a forest canopy are regularly exposed to intense sunlight, driving winds, and pouring rain and commonly occur during the cool season in open lands of tropical and sub-tropical regions. They are absent in arid regions, which indicates a minimum water-requirement or humidity level, essential for their development. The growth of these fungi gets enhanced when moisture levels are high and temperatures are moderate (Hongsanan *et al.*, 2015; Sabeena *et al.*, 2020). The Indian climate, in general, is suitable for the growth of these fungi. These fungi occur a month or two after the monsoon as they appear scantily during summer and they are abundant during the winter season. However, the temperature and rainfall play a vital role in distributing black

mildew fungi. The number of species collected from the different climatic conditions revealed that the occurrence of black mildew fungi relatively correlated with rainfall and temperature. Studies on Black mildews to date elucidate that during torrential rain, the collection of the species was comparatively scanty than the remaining time. It was moderate during January to March while it was found marginally increased during September to October. The occurrence of these fungi was found flourishing during autumn in November and early part of winter season in December than the remaining months.

The Andaman-Nicobar Archipelago located between the latitudes 6° to 14° North and the longitudes 92° to 94° East in the Bay of Bengal, around 647 nautical miles away from the Coromandel Coast of the Peninsular India, is mostly uninhabited and with dense coverage of virgin low land tropical rainforests. This biogeographical zone, in terms of plant diversity, has a unique status in phytogeography as it represents the insular transitional zone vegetation between the South and Southeast Asia.

It is estimated that around 1.5-5.1 million fungi are known in the world (Hawksworth, 1991; Blackwell, 2011) and among them, 97,861 were identified (Kirk *et al.*, 2008). Where as in India, more than 29,000 fungal species have been described so far (Manoharachary *et al.*, 2005; Manoharachary and Nagaraju, 2016). As regards to insular floristic studies of Andaman-Nicobar Islands, the floristic enumerations are mostly concentrated with higher group of plants and interestingly, it is found that this insular region is highly rich in species diversity of higher plant groups; while, rather lesser known about the lower

groups such as Algae, Fungi etc., owing to dearth of information. Nevertheless, detailed documentation on insular microfungial flora associated with higher plants has been initiated during the earlier part of the millennium and is still continuing (Mishra, 1986; Hosagoudar and Mathew, 2000; Hosagoudar *et al.*, 2014; Sabeena *et al.*, 2017; Mathew *et al.*, 2017; Sabeena *et al.*, 2018; Sabeena and Biju, 2022). Niranjana and Sarma (2018) enumerated the occurrence of 446 species of fungi distributed over 216 genera, 96 families, 44 orders, ten classes and seven phyla from Andaman and Nicobar Islands. Meanwhile, Rajamani *et al.* (2018) reported the presence of culturable fungal endophytes from 20 obligate mangrove hosts from South Andaman Islands. Apparently, the tropical humid climatological features of the insular region always provide ideal ecological niches for the luxuriant survival of foliicolous fungi among the islands. However, studies on insular fungal flora still remain at its preliminary phase. During the exploration of foliicolous fungi of Andaman Islands, the authors came across *Uvaria hamiltonii* Hook. f. and Thomson (Annonaceae) infected with black mildews. Microscopic examination of the fungus and critical review of the literature revealed that it is a hitherto undescribed species of the lesser-known genus, *Bheemamyces*. The systematic explorations and investigation by the authors have added a new foliicolous mycobiont to the lesser known Cryptogamic flora of the Andaman-Nicobar Islands.

Bheemamyces is a transitional genus between the genera *Asterina* and *Asterolibertia* and is characterized by intercalary, sublateral and lateral appressoria, hyphal tip forming whip-like structures, which often form a mycelial ring. Thyriothecia orbicular, stellately dehisce at the centre; asci globose, octosporous; ascospores conglobate, brown, uniseptate (Hosagoudar *et al.*, 2010; Hosagoudar, 2012; Hosagoudar and Fathima, 2013). The genus accommodates 5 species, all from the tropics, reported on the host families viz. Convolvulaceae, Capparaceae and Oleaceae (Hosagoudar, 2010; Hosagoudar, 2012; Hosagoudar and Fathima, 2013; Hosagoudar and Thomas, 2013). *Bheemamyces argyreicola*, the type species was collected from Malabar Botanic Garden, Kozhikode, Kerala, India (Hosagoudar *et al.*, 2010). This paper describes a new species, *Bheemamyces uvariae* found in association with a new host *Uvaria hamiltonii* Hook. f. and Thomson (Annonaceae). There are no previous reports of this genus infected on the host family Annonaceae.

MATERIALS AND METHODS

Leaves covered with black colonies were collected in polythene bags along with flowering/fruiting

twigs of the host plant species for confirming the identity. Primary field information on infection pattern, collection locality, altitude, date of collection, place of collection, other special information regarding Infected host plant, etc. were also being recorded in the field book during plant exploration. Plant parts were pressed neatly and dried between blotting papers. After ensuring their dryness, they were used for microscopic study. Nail polish technique (Hosagoudar and Kapoor, 1985) was used for the preparation of permanent slides to study the structural and morphological characters of the fungi in situ. These permanent slides were then used for further studies. Microscopic studies were carried out with a Leica DM 2000 compound microscope and illustrations were made using a Camera Lucida. Photographs were obtained on a Magnus MLX Plus microscope equipped with a digital camera. The identity of the fungus was confirmed by using standard literature (Hosagoudar *et al.*, 2010, Hosagoudar, 2012; Hosagoudar and Fathima, 2013; Hosagoudar and Thomas, 2013). After the detailed study the material was assigned to its taxonomic rank and retained in the Jawaharlal Nehru Tropical Botanic Garden Travancore Herbarium (TBGT).

TAXONOMY

Bheemamyces uvariae A. Sabeena and H. Biju sp. nov. MycoBank No.: MB 844394.

Type: India, South Andaman Islands, Mount Harriet National Park, on leaves of *Uvaria hamiltonii* Hook. f. and Thomson (Annonaceae), 21 February 2014, H. Biju *et al.*, 7124 (holotype TBGT!).

Etymology: The new taxon is named after its host genus, *Uvaria hamiltonii* Hook. f. and Thomson, of the family Annonaceae.

Colonies mostly epiphyllous rarely amphigenous, subdense to dense, crustose, up to 3mm in diameter, often confluent. Hyphae of two types: straight to substraight, branching alternate to unilateral at acute to wide angles, loosely reticulate, cells 25-37×5-7 µm. Appressoria scattered, alternate to unilateral, unicellular, oblong, globose, entire, 5-12×5-10 µm. The second type of hyphae originated from the main hyphae, narrower, curved, slightly elevated from the host surface and pointed at the tip. These hyphae possess intercalary, sub intercalary and lateral appressoria. The intercalary and sub intercalary appressoria oval to globose, 5-12×5-7 µm. Thyriothecia scattered, orbicular, stellately dehiscent at the centre, up to 270 µm in diameter, margin crenate to fimbriate, fringed hyphae straight, flexuous; asci globose, octosporous, 35-50 µm in diameter; ascospores brown, conglobate, uniseptate, slightly constricted at the septum, 22-32×12-15 µm, wall smooth (**Figures 1-11**).

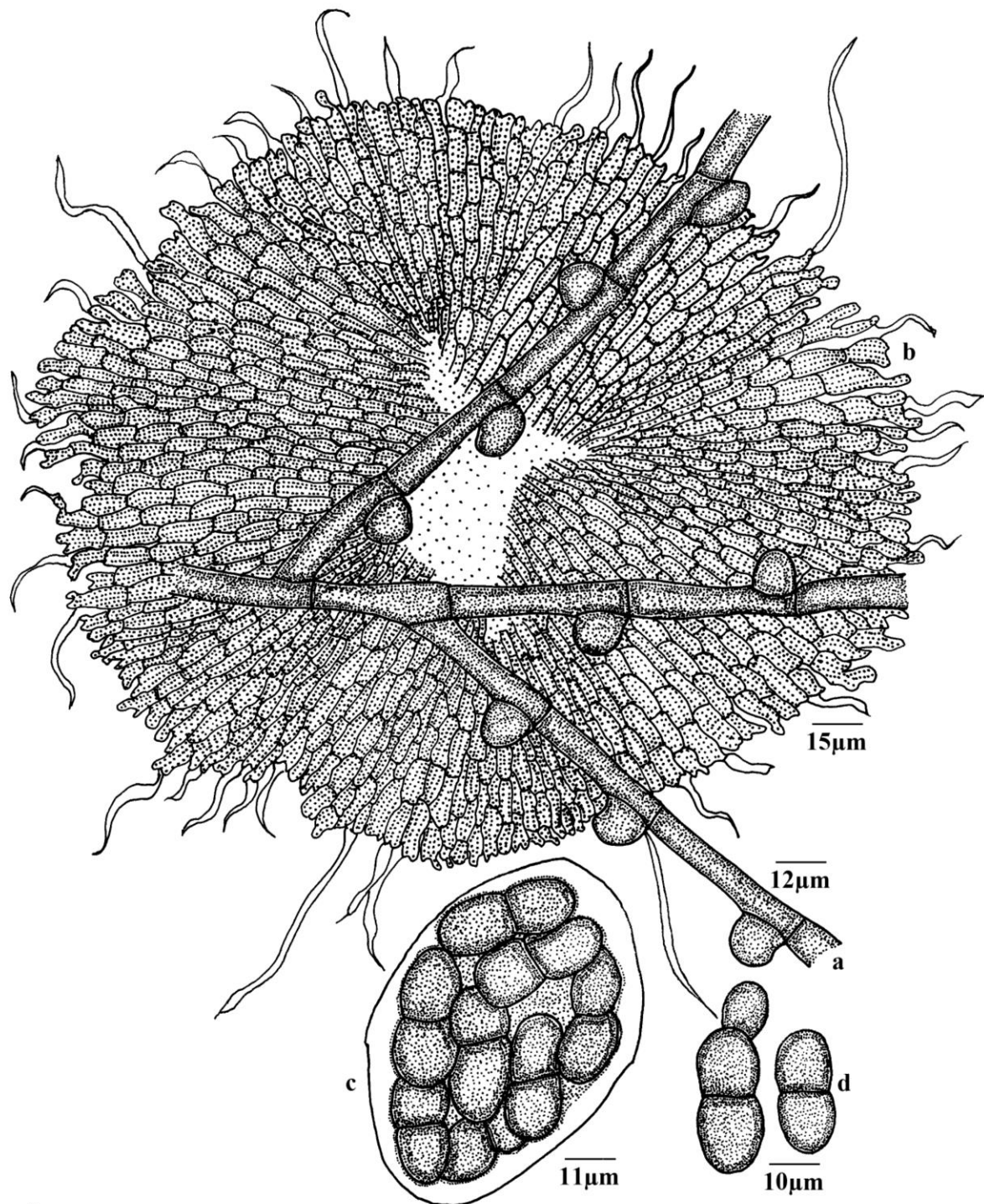


Figure 1: a, Appressoriolate mycelium; b, Thyriotheium; c, Ascus; d, Ascospores.

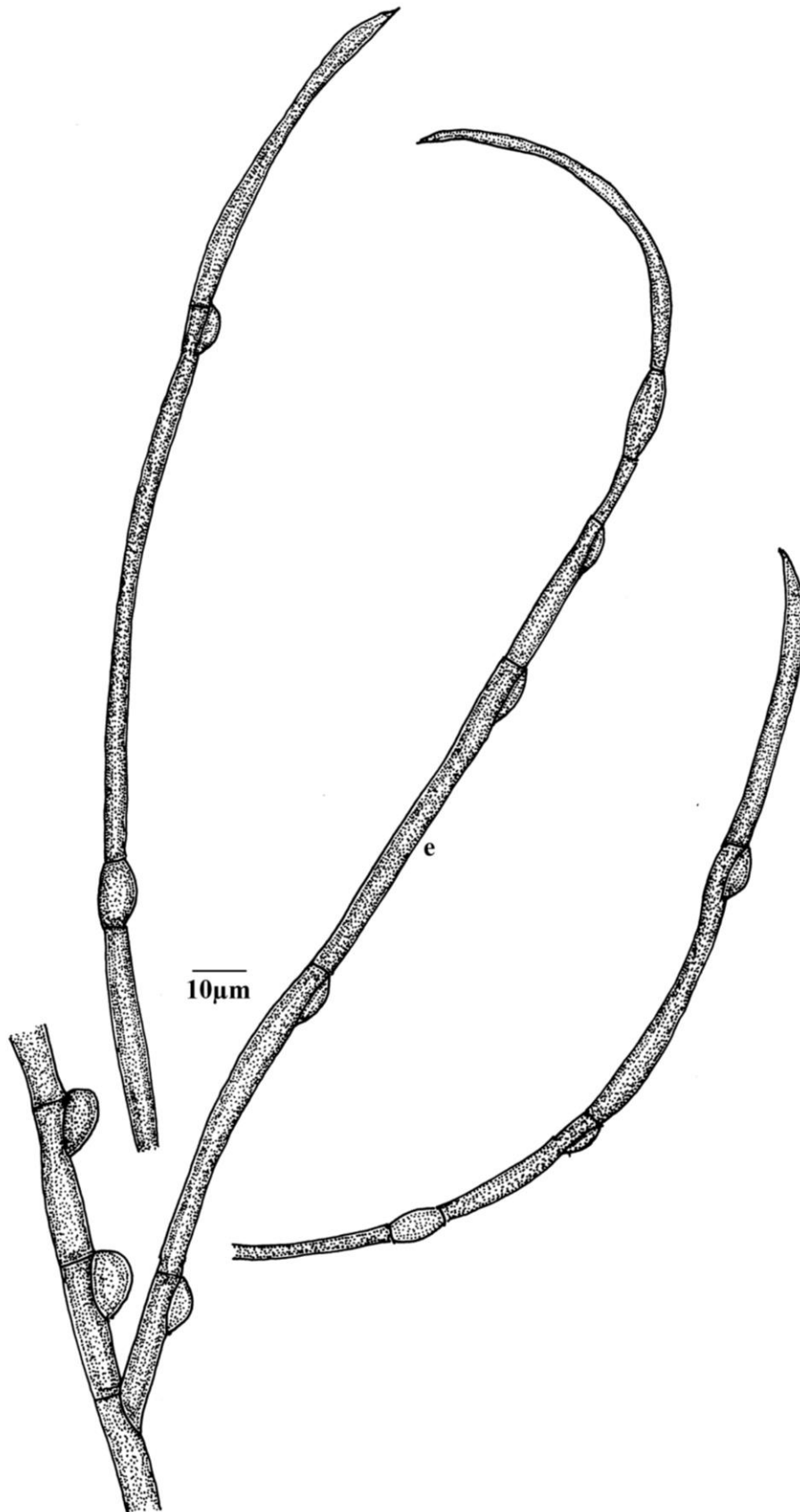
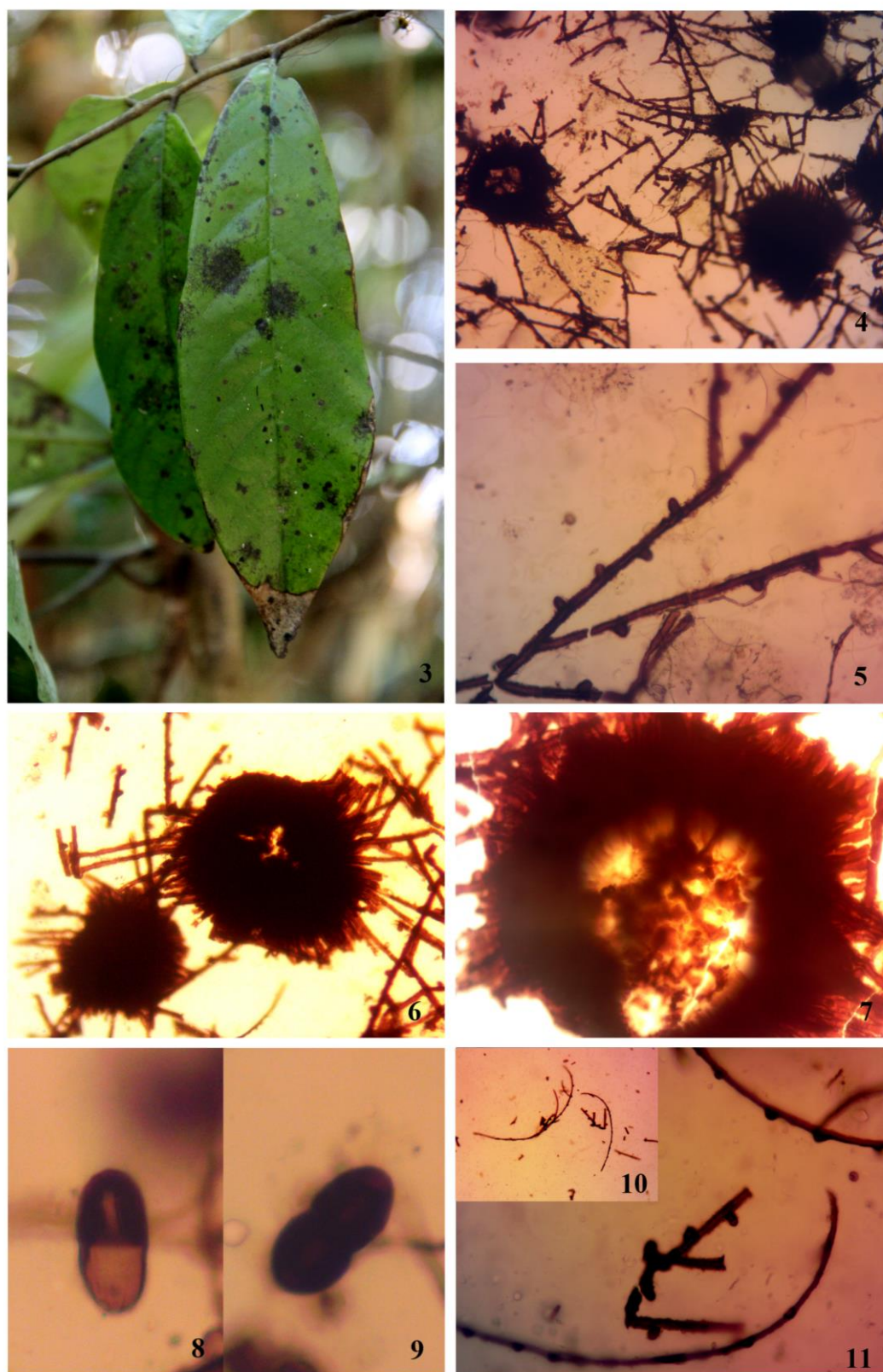


Figure 2: Whip-like apical portion of the mycelium with lateral, sublateral, and intercalary appressoria.



Figures 3-11: 3, Infected leaves of *Uvaria hamiltonii* Hook. f. Thomson; 4, Colony with thyriothecia; 5, Appressariate mycelium; 6, Mature thyriothecia; 7, Dehiscent thyriothecium showing ascus; 8-9, Ascospores; 10-11, Whip-like apical portion of the mycelium.

List of *Bheemamyces* species reported world-wide and their Nomenclatural Status

Fungal species	Host plant	Host family	Appressoria	Secondary hyphae	Ascus	Ascospores (µm)	Nomenclatural Status (as per MycoBank – accessed on 20 May 2022)
<i>Bheemamyces uvariae</i> A. Sabeena and H. Biju sp. nov.	<i>Uvaria hamiltonii</i> Hook. f. and Thomson	Annonaceae	Appressoria scattered, alternate to unilateral, unicellular, oblong, globose, entire, 5-12 × 5-10 µm.	The second type of hyphae originated from the main hyphae, narrower, curved, slightly elevated from the host surface and pointed at the tip. These hyphae possess intercalary, sub intercalary and lateral appressoria. The intercalary and sub intercalary appressoria oval to globose, 5-12 × 5-7 µm.	asci globose, octosporous, 35-50 µm in diameter	ascospores brown, conglobate, uniseptate, slightly constricted at the septum, 22-32 × 12-15 µm, wall smooth.	
<i>Bheemamyces argyreicola</i> Hosag. et al.,	<i>Argyreia nervosa</i> (Burm. f.) Bojer.	Convolvulaceae	alternate to unilateral, unicellular, ovate, oblong, globose, entire, angular to sublobate, 5-17 × 5-10 µm.	The second type of hyphae originated from the main hyphae, narrower, curved, slightly elevated from the host surface and sharply pointed at the tip. These hyphae possess intercalary, sub intercalary and lateral appressoria. Hyphal rings are formed randomly but are devoid of appressoria. The intercalary and sub intercalary appressoria oval to globose, having a central slightly hyaline spot, 5-10 × 5-7 µm.	asci globose, octosporous, 32-35 µm in diameter	ascospores brown, conglobate, uniseptate, constricted at the septum, 15-25 × 7-12 µm, wall smooth, readily germinated.	Legitimate
<i>Bheemamyces argyreiae</i> (Hansf.) Hosag.	<i>Argyreia</i> sp.	Convolvulaceae	Appressoria alternate to unilateral, scattered, mostly perpendicular to the hyphae, globose, ovate, clavate, stipitate to broad based, lobate to deeply lobate, 5-7 × 5-8 µm.	The presence of intercalary and subintercalary appressoria	asci many, globose, 8-spored, 20-28 µm in diameter	ascospores conglobate, oblong to cylindrical, brown, uniseptate, constricted at the septum, 16-18 × 6-8 µm.	Legitimate
<i>Bheemamyces capparisidis</i> Hosag.	<i>Capparis</i> sp.	Capparaceae	Appressoria alternate 10% opposite; head cells unicellular, ovate,	The second type of hyphae originated from the main hyphae, narrower, curved, slightly elevated	asci globose, octosporous, 17-	ascospores, conglobate, uniseptate,	Legitimate

Fungal species	Host plant	Host family	Appressoria	Secondary hyphae	Ascus	Ascospores (µm)	Nomenclatural Status (as per MycoBank – accessed on 20 May 2022)
and A. Sabeena			entire to sublobate, 5-7 × 5-10 µm.	from the host surface and sharply pointed at the tip. These hyphae possess intercalary, sub intercalary and lateral appressoria. The intercalary and sub intercalary appressoria ovate, 5-12 × 5-7 µm.	25 µm in diameter	constricted at the septum, 17-22 × 7-10 µm, wall slightly echinulate.	
<i>Bheemamyces oleae</i> Hosag. and B. Fathima	<i>Olea polygama</i> Wight	Oleaceae	appressoria alternate to unilateral, oblong, entire, angular to sublobate, 8-11 x 8-10 µm	Sublateral and intercalary appressoria originate from the whip like hyphal apical portion, which are narrower, curved, slightly elevated from the host surface and sharply pointed at the tip; intercalary and sublateral appressoria oval to globose, sublateral appressoria 10-12 x 7-9 µm, intercalary appressoria 8-10 x 5-7 µm.		ascospores oblong to cylindrical, uniseptate, slightly constricted at the septum, 14-15 x 5-7 µm.	Invalid
<i>Bheemamyces jasmini</i> Hosag. and Sony Thomas	<i>Jasminum</i> sp.	Oleaceae	Appressoria alternate to unilateral, distantly placed, ; head cells ovate, oblong to globose, sublobate to stellately lobate, 5-11 x 5-7 µm.	Apical portion of the hyphae whip like, narrower, curved to uncinat at the tip, slightly elevated from the host surface and sharply pointed at the tip, apical portion coiled and devoid of appressoria, but the penultimate portion appressoriate, appressoria lateral, sublateral to intercalary. The intercalary and sub intercalary or sublateral appressoria restricted to the penultimate tip of the appressoria, oval to globose, having slightly hyaline spot at the centre, 5-10 x 5-7 µm	asci globose, octosporous, 25-27 x 22-25 µm in diameter	ascospores brown, conglobate, uniseptate, constricted at the septum, 20-25 x 17-12, wall echinulate	Invalid

DISCUSSION

The genus *Bheemamyces* possesses both lateral appressoria on the main hyphae, and lateral, sublateral to intercalary appressoria on the apical whip like secondary hyphae, which bears acute tips. So far, *Bheemamyces argyreicola* Hosag. *et al.*, *B. argyreiae* (Hansf.) Hosag., *B. capparidis* Hosag. and Sabeena, *B. oleae* Hosag. and Fathima and *B. jasmini* Hosag. and Sony Thomas are the known *Bheemamyces* species on members of the family Convolvulaceae, Capparaceae and Oleaceae respectively (Hosagoudar *et al.*, 2010; Hosagoudar, 2012, Hosagoudar and Fathima, 2013; Hosagoudar and Thomas, 2013). This is the first species of the genus *Bheemamyces* reported on the members of the family Annonaceae. *Bheemamyces uvariae* is close to *B. argyreicola* Hosag. *et al.* *B. argyreiae* (Hansf.) Hosag. and *B. oleae* Hosag. and Fathima in having unicellular appressoria but distinctly differs from it in possessing oblong, globose appressoria with entire margin. Moreover, it differs from other known *Bheemamyces* species in having larger asci and ascospores.

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