

**TAXONOMY OF *MERULIUS EUROCEPHALUS* (BERK. & BR.) PETCH V/S *BONDARZEWIA BERKELEYI* (FR.) BOND. & SING. (BASIDIOMYCOTA: AGARICOMYCETES): SYNONYM STATUS REVIEWED**

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During a study of polypores in northern India we came across the descriptions of two morphologically dissimilar species: *Merulius eurocephalus* (Berk. and Br.) Petch and *Bondarzewia bekeleyi* (Fr.) Bond. & Sing. which are being treated as synonyms (Mycobank, CBS-KNAW Fungal Biodiversity Centre). A third species *Merulius similis* was also taken into consideration which has been treated as a synonym of *Merulius eurocephalus* (Petch 1910; Bakshi 1971; Corner 1971). A comparative analysis of the descriptions of the three fungi and an examination of the available specimens was made to draw a conclusion in the present study.

**Materials and Methods:** Literature regarding two species under reference was thoroughly reviewed for comparison of morphological, microscopic and cultural characters (Petch 1910; Saccardo 1944; Nobles 1948; Boedijn 1951; Bakshi 1971; Corner 1971; Ginns 1971; Sen 1973; Rattan 1977; Stalpers 1978; Ryvarden & Johansen 1980; Ryvarden 1984, 1991). Specimens examined for comparison were *M. eurocephalus* (FPD/FRI-8628) deposited at Forest Pathology Herbarium

Forest Research Institute, a new specimen collected (FPD/FRI-8670) and a specimen (NEHU-M303) received from Shillong, Meghalaya.

The macroscopic and microscopic examination in the study follows the descriptions and terminology as used by Ryvarden & Johansen (1980).

**Material examined:** FPD/FRI-8628, sporophore sessile, brittle, dry, shrunken, 12x15x0.5 cm; upper surface dark brown due to heavy deposition of spores, white in some areas, glabrous, uneven; margin folded, unequal, thick; context cream colour, soft thin, zonation not seen, very thin as it is dried (0.4cm); hymenial surface rusty brown, pores meruloid, 1–2 per mm; basidia not seen, basidiospores yellow ovoid, slightly thick walled, apiculate, 4–5.5x3.2–3.8 µm; hyphal system dimitic, difficult to observe due to heavy spore deposition, generative hyphae hyaline, thin walled, branched, with clamp, 1.5–6 µm in diameter, skeletal hyphae thick-walled, solid, 1.5–3.5 µm in diameter. Determined as *Serpula similis* (Berk. & Br.) Ginns (= *Merulius eurocephalus* Berk. & Br.)

Submitted as *Merulius eurocephalus* Berk. & Br.; Host: *Thyrsoctachys oliveri* Gamble (Bamboo), Sept. 1986; by Sujan Singh. Locality: Central Terai Forest Division Haldwani, Uttarakhand (erstwhile Uttar Pradesh) India.

FPD/FRI-8670, sporophore annual, effused-reflexed, sessile imbricate, fleshy watery when fresh due to absorption of rain water, becomes rigid when somewhat dry, shrinking, 15x9x2 cm; upper surface white to light



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yellow, the surface becomes light yellowish-brown due to heavy deposition of spores from the fruit bodies situated above it when growing in imbricate clusters, glabrous uneven; margin rounded, unequal thick; context white or cream colour, azonate, 2–3 cm thick, cheesy, elastic threads form on tearing, Hymenial surface mustered yellow in the beginning turns ochre to umber at a later stage, shallow, angular unequal, meruloid, 1–2 per mm, up to 2mm long; Basidia persistent, narrow club shaped, 7–8  $\mu\text{m}$  broad; Basidiospores bright yellow to ochre, ovoid slightly thick walled, apiculate, 4.5–5.5x3.5–3.8  $\mu\text{m}$ ; Hyphal system dimitic; generative hyphae hyaline, thin walled branched, with clamps, 1.8–7  $\mu\text{m}$  diameter and skeletal hyphae nearly hyaline, thick walled, some with obliterated lumen, ends tapering, 4–5  $\mu\text{m}$  diameter.

Determined as *Serpula similis* (Berk. & Br.) Ginns (= *Merulius eurocephalus* Berk. & Br.) (= *Merulius similis* Berk. & Br.) (Image 1)

12.viii.2013 by Manoj Kumar. Host *Cupressus cashmeriana* Royle ex. Carriere. Locality New Forest Campus, Forest Research Institute Dehradun, India (30°20'38.04"N & 77°59'44.94"E). This specimen has a specific soothing spicy smell which is not mentioned by earlier workers.

NEHU-M303, sporophore stipitate, developed from underground sclerotium, stipe branched, up to 6cm long and 3.5cm thick, pileus imbricate, fan shaped 14x22.5x3 cm, upper surface with tinge of tan, azonate, finely tomentose, margin concolorous, thick; context pale buff, azonate, corky, up to 2cm thick, tube layer concolorous and continuous with the context, decurrent on the stipe, up to 1cm thick; hymenial surface tan, dried specimen has blackish hymenium, the pores circular to angular, 1–2 per mm, with thick dissepiments that are lacerate; Hyphal system dimitic, generative hyphae hyaline, thin walled, simple-septate, branching not seen, 3.2–6  $\mu\text{m}$  in diameter, skeletal hyphae thick-walled, 2–12  $\mu\text{m}$  in diameter. basidia clavate, 4-sterigmate, 40–50x8–12  $\mu\text{m}$ , simple-septate at the base, basidiospores globose to subglobose, hyaline, echinulate, 5–6  $\mu\text{m}$ .

Determined as *Bondarzewia berkeleyi* (Fr.) Bond. & Sing. (Image 2)

09.x.2011 by Aroma Lyngdoh. Host buried wood (probably oak wood). Locality Mawphlong Sacred Grove, East Khasi Hills District, Shillong, Meghalaya, India (25°28'09.74"N & 91°46'31.04"E).

**Result:** From the above description it is clear that the two species, *M. eurocephalus* and *B. berkeleyi*, mentioned differ macroscopically as well as microscopically.

Cultural studies by Nobles (1948), Sen (1973) and Stalpers (1978) also throw some light on the

differences between the two species. Sen (1973) has described cultural characteristics of *M. eurocephalus* which is similar to *M. similis* described by Banerjee & Mukhopadhyay (1962). Stalpers (1978) has done a cultural study of *B. berkeleyi*. He has also mentioned that the culture of *M. similis* has been described under the name of *M. eurocephalus*. The main differences are summarised in Table 1.

**Discussion:** Petch (1910) described *Merulius eurocephalus* (Berk. & Br.) Petch found on bamboo. This species has been treated under the valid name of *Bondarzewia berkeleyi* (Fr.) Bond. & Sing. (Mycobank, CBS-KNAW Fungal Biodiversity Centre). The examined specimens were identified on the basis of descriptions given by Bakshi (1971) and found that the species were confirmed with the description of *M. eurocephalus* given by Petch (1910), Bakshi (1971) and Corner (1971) but was quite dissimilar with the description given by Ryvarden & Johansen (1980) for the species *B. berkeleyi*. The most striking difference between the two species was of spores. The former has subglobose to ovoid bright yellow smooth spores while the latter has hyaline asperulate spores. Culture studies by Nobles (1948), Banerjee & Mukhopadhyay (1962), Sen (1973) and Stalpers (1978) were also helpful in determining the differences between the two species. So the two species are not synonymous as given in Mycobank but are two different species.

The species *Polyporus eurocephalus* Berk. & Br. was established by Berkeley & Broome (1874) but its full description could not be found, only fruiting body characters have been mentioned (Saccardo 1944). It was changed to (adopted as) *M. eurocephalus* (Berk. & Br.) Petch by Petch (1910) who had first given the full description of the fungus in Annals of Royal Botanic Gardens Peradeniya as parasitic to bamboo plants and gave *P. eurocephalus*, *Polyporus sulfureus* and *M. similis*

**Table 1. Cultural characteristic differences between *Merulius eurocephalus* Berk. & Br. & *Bondarzewia berkeleyi* (Fr.) Bond. & Sing.**

	<i>Merulius eurocephalus</i> Berk. & Br. (= <i>Merulius similis</i> Berk. & Br.)	<i>Bondarzewia berkeleyi</i> (Fr.) Bond. & Sing.
1	Spores are not produced in culture	Produces spores similar to basidiospores (conidiospores) on irregularly shaped, sterigmate sporogenous cells in culture
2	Conidiogenous vesicles absent	Conidiogenous vesicles present
3	Hyphal clamps absent	Hyphal clamps present
4	Submerged and aerial mycelium branched	Hyphae not branched
5	Hyphae not with incrustation	Hyphae with incrustation

Image 1. *Serpula similis*Image 2. *Bondarzewia berkeleyi*

as its synonyms. Berkley & Broome (1874) had also described another species *Merulius similis* Berk. & Br. which was considered as a synonym of *M. eurocephalus* by Petch (1910), Bakshi (1971) and Corner (1971). Cooke (1957) described another species with the name *Serpula eurocephala* (Berk. & Br.) Cooke under coloured spore category as are *M. eurocephalus* and *M. similis* and gave *Polyporus eurocephalus*, *Merulius similis*, *Polyporus sulfureus* Fr. sensu Berk. & Br., *M. eurocephalus*, *Merulius pseudolacrymans* Henn., *Merulius binominatus* Masee, *Merulius consimilis* Lloyd, *Merulius giganteus* Sauter, *Merulius insignis* Wakefield, *Merulius sessilis* Berk. & Br. f. *Pileata* Bres., *Merulius subambiguus* Henn., *Merulius tessellates* Bres. as its synonyms. However, according to Ginns (1971) it was misidentified by Cook. He said that the type (K) he studied had asperulate spores. Later on it was synonymised with *B. berkeleyi* (Ginns 1976). He also separated the species with hyaline spores in *Merulius* while the species with coloured spores was shifted to *Serpula* by Burt (1917) and Ginns (1968) and *Merulius similis* has been given the valid name of *Serpula similis* (Berk. & Br.) Ginns by Ginns (1971).

It appears that the confusion started with the observations made by Boedijn (1951) while describing *Bondarzewia berkeleyi*. He had mentioned that the type of *P. eurocephalus* at Kew was in bad shape and he saw the specimen at Herbarium of Bresadola at Stockholm with label written *P. eurocephalus* = *P. berkeleyi*. He has stated that as he could not see any difference with *Polyporus berkeleyi* and *P. eurocephalus*, he considered *P. eurocephalus* as a synonym of *P. berkeleyi*. Petch (1910) while describing *M. eurocephalus* mentioned that the type specimen of *P. eurocephalus* kept at Peradeniya was reported to be parasitized by *Hypomyces* and its

tubes were filled with globose spores of 5–7  $\mu$ , covered with a close set of spines. So, it is possible that the actual specimen might not have been studied. Ryvardeen & Johansen (1980) under the description of *B. berkeleyi* have treated *P. eurocephalus* as synonym. Ryvardeen (1984) while conducting a series of type studies in the Polyporaceae examined the polypores described by Berkeley, either alone or together with other mycologists treated *Polyporus eurocephalus* Berk. & Br. as a synonym of *B. berkeleyi*. Ryvardeen (1991) retained this synonym in his work 'Nomenclature and Taxonomy of Polypores'. Due to synonymy with *P. eurocephalus*; *M. eurocephalus* might be considered as the synonym of *B. berkeleyi*. Vaidya & Rabba (1993) while giving an account of valid names of Indian wood decaying fungi had shown *M. eurocephalus* as synonymous to *B. berkeleyi* quoting Ryvardeen (1991). It seems after this the synonymy of *M. eurocephalus* was retained with *B. berkeleyi* and continued in subsequent work in India.

*M. similis* was reported from India in the early 20<sup>th</sup> century as *M. pseudolacrymans* from Saharanpur on tree roots by Hennings (1901). Bose (1919) reported it from Hoogly causing decay in exposed roots of *Bambusa*. This fungus was also reported on *Bambusa arundinacea* and *B. flabelifer* near Calcutta by Banerjee (1947) and from Nainital by Mitter & Tandon (1932). Banerjee & Mukhopadhyay (1962) studied *M. similis* and associated bamboo-rot. Bakshi (1971) gave its description as growing on the roots of living and dead bamboo. *M. similis* is known from tropical regions in Africa and South-east Asia, where it is usually found on Bamboo

and hardwoods (Ginns 1971; Carlier et al. 2004). There were also some reports where fungi on bamboo have been reported either as *M. eurocephalus* or *M. similis* (Khan et al. 1995; Mohanan 1997; Panda 2011; Lee et al. 2012). It appears that the parasitic fungi of bamboo were treated as *M. eurocephalus* or *M. similis* or both as synonyms of each other.

Recently, a sample from northeastern India (Shilong, Meghalaya) was identified as *B. berkeleyi* on the basis of characters described by Ryvarden & Johansen (1980). We did not find earlier records (Bilgrami et al. 1979, 1981, 1991; Jamaluddin et al. 2004) of *B. berkeleyi* or its synonym from India. *M. eurocephalus* has long been treated as *B. berkeleyi* before we found it as a distinct species and previous reports were only synonyms given to *M. eurocephalus* which was not correct as discussed above. The fungus reported on *Cupressus cashmeriana* from Forest Research Institute, Dehradun is *Serpula similis* as a new host record as earlier it was reported on bamboo and hardwoods (Ginns 1971; Carlier et al. 2004).

**Conclusion:** The basidiospore morphology of *Bondarzewia berkeleyi*, i.e., globose and ornamented with spines closely resembles the basidiospores of *Russula* and *Lactarius* instead of the smooth, elliptical or cylindrical spores of most other polypores. Recent molecular studies have confirmed this suspected close association between these groups and have placed the genus *Bondarzewia* in the Russulales (Miller et al. 2006). Molecular studies have shown that *Serpula* have diverged from Tapinellia (Skrede et al. 2011). *Serpula similis* has not been extensively studied for molecular aspects as its other sister lineages like *Serpula lacrymans* (Wulfen) J. Schröt. The branch in the phylogenetic tree leading to *S. similis* is very long, indicating an increased rate of molecular evolution (Skrede et al. 2011). Three *Serpula* species *S. incrasata* (Berk. & M.A. Curtis) Donk, *S. similis* and *S. pulverulenta* are oldest species within Serpulaceae family (Skrede et al. 2011). The relationship between *Serpula* and ectomycorrhizal fungi *Austropaxillus* Bresinsky & Jarosch and *Gymnopaxillus* Horak is already established (Hallenberg & Eriksson 1985). Traditionally, *Serpula* has been recognised as member of Coniophoraceae (Donk 1948; Jarosch 2001) while molecular results showed it to be distantly related (Skrede et al. 2011).

On the basis of the study of the available specimens and review of literature discussed above; we suggest that *M. eurocephalus* should not be treated as a synonym of *B. berkeleyi* but should be treated as *M. similis* under the valid name of the species as *Serpula similis* (Berk.

& Broom) Ginns. Literature regarding change of *M. eurocephalus* to *B. berkeleyi* should be reviewed so that the confusion prevailing over the synonyms can be overcome.

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