Competing sexual-asexual generic names of *Pezizomycetes* and recommendations for use

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**Abstract:** Following the change that eliminated dual naming of sexual and asexual morphs of fungi, generic names of *Pezizomycetes* have been evaluated to determine which of the competing names should be recommended for use. Evaluation is based on congruence of type species to determine if the names are congeneric and which name is most commonly cited as well as priority. In the *Pezizomycetes* six pairs of generic names were determined to compete. In all cases the older name, representing the sexual morph, is recommended for use, specifically *Caloscypha* rather than *Geniculodendron*, *Desmazeriella* rather than *Verticicladium*, *Miladinia* rather than *Actinosporella*, *Morchella* rather than *Costantinella*, *Sarcoscypha* rather than *Moliardiomycetes*, and *Trichophaea* rather than *Dichobotrys*.

**Key words:** Ascomycota dual nomenclature *Pezizomycetes* pleomorphic fungi protected lists taxonomy

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**INTRODUCTION**

With the changes in the *International Code of Nomenclature for algae, fungi, and plants* (ICN; McNeill et al. 2012), one species of fungus may no longer be referred to by more than one scientific name. The practice of giving separate scientific names to sexual and asexual morphs (dual nomenclature) of the same species is no longer acceptable (Art. 59). As for all organisms governed by the ICN, the correct scientific name for fungal species is determined primarily by the principle of priority of publication (Art. 11). However, in some cases it is expedient to use a later generic or specific name as of priority of publication (Art. 11). However, in some cases it is expedient to use a later generic or specific name as determined by an international cadre of mycologists familiar with the fungal group. Reviews of competing generic names along with recommendations for names to use have been published by Working Groups of the International Commission for the Taxonomy of Fungi (ICTF; e.g. Rossman et al. 2015, Rěbová et al. 2016). This paper reviews the competing sexual and asexual generic names in the *Pezizomycetes* and makes recommendations for the application of names.

The class *Pezizomycetes*, sometimes referred to by the ordinal name *Pezizales* or simply as ‘operculate discomycetes’, includes about 200 genera with 2000 species placed in 16 families (Kirk et al. 2008, Lumbsch & Huhndorf 2010). Molecular phylogenetic studies have added new families (Landvik et al. 1997, Harmaja 2002, Pfister et al. 2008), and demonstrate that additional research is needed to circumscribe the families and genera in this class (Hansen & Pfister 2006, Perry et al. 2007, Pfister et al. 2013, Hansen et al. 2013). Most species are known primarily as sexual morphs although asexual morphs are increasingly discovered. Studies of asexual morphs have been useful in defining species (Paden 1972, 1986, Paden et al. 1978, Carris et al. 2015).

Here we consider six competing generic names with pleomorphic type species in the *Pezizomycetes*. In all cases the generic name recommended here represents the older sexual morph as summarized in Table 1, thus no action is needed such as protection of a name or approval of the Nomenclature Committee for Fungi (NCF). No new combinations of species names are needed. Below is the detailed rationale for these recommendations.

In the following notes, (A) = a name typified by an asexual morph, and (S) = a name typified by a sexual morph.

**GENERIC NAMES RECOMMENDED FOR USE IN PEZIZOMYCETES**

**Use Caloscypha Boud. 1885 (S) rather than Geniculodendron G.A. Salt 1974 (A)**

The type species of *Caloscypha*, *C. fulgens*, is associated with conifers in the Northern Hemisphere (Pfister et al. 2013) and develops in early spring after the snow melts. One additional name, *C. musiva* (Fr.) Boud 1907, is currently accepted in *Caloscypha* but its identity is unclear (Pfister et al. 2013). The monotypic genus *Geniculodendron* based on *G. pyriforme*
was described as a psychrophilic fungus pathogenic on seeds of various conifers (Salt 1974). Paden et al. (1978) proved that G. pyriforme is the asexual morph of C. fulgens through comparing cultural characteristics, conidiophore and conidial morphology, and growth-temperature and pathogenicity studies. Geniculodendron has been cited in pathogenicity studies alongside Caloscyphe (e.g. Phillips & Burdekin 1992, Schröder et al. 2002), thus both names are used. Since Caloscyphe is the earliest name, is more widely used, and has priority, it is recommended for use over Geniculodendron.

Use Desmazerella Lib. 1829 (S) rather than Verticicladium Preuss 1851 (A)

Verticicladium trifidum, type of Verticicladium, was linked to Desmazerella acicola, type of Desmazerella, by Hughes (1951) using physical association and morphological methods, thus these generic names are synonyms. Verticicladium trifidum, the asexual morph, has long been associated with decaying pine needles (Mitchell et al. 1978). The asexual morph was most recently determined to consist of eight geographical lineages using ITS rDNA sequences, but morphology could not effectively distinguish most lineages (Martinović et al. 2016). These authors suggested that the sexual morph should be studied to determine whether there are multiple lineages (cryptic species) within the current concept of Verticicladium. It was suggested that the strains studied by Hughes (1951) belong to a European clade (Martinović et al. 2016). While RPB2 and 28S sequences of a sexual morph identified as D. acicola matched sequences of the asexual form in the Martinović et al. (2016) study, no ITS sequence of the sexual morph is available, and the types have not been sequenced. Historical confusion over the delimitation of Verticicladium is evidenced by the placement of many former species into other genera by Subramanian (1956), Hughes (1958), and Gams & Holubova-Jechova (1976). It is apparent that this genus requires a deeper study using molecular phylogenetics and comparative morphology of sexual morphs. We recommend the use of Desmazerella over Verticicladium because Desmazerella has priority. This was the recommendation of Martinović et al. (2016).

Use Miladina Svrček 1972 (S) rather than Actinospora Descals et al. 1999 (A)

The monotypic genus Miladina is based on Peziza lecithina. The orange ascomata of Miladina occur mostly on partly submerged woody substrates in freshwater streams. An aquatic hyphomycete Actinosporella megalospora was described in the illegitimate monotypic fungus genus Actinospora (Ingold 1952; non Actinospora Turtzaninov 1835, Ranunculaceae) and later renamed Actinospora megalospora, type of the monotypic Actinospora (Descals et al. 1999). The connection between Miladina lecithina and Actinospora megalospora was originally ascertained by monoascosporic isolates from M. lecithina yielding A. megalospora conidia after submerging pieces of the cultures in water (Descals & Webster 1978). Thus these two generic names are synonyms. Apothecia of M. lecithina from nature were sequenced; this species was placed in the well-supported Scutellinia/Miladina lineage of Pyrenomataceae (Hansen et al. 2013). Isolates from the asexual morph were not sequenced. The generic names of both morphs are used more or less equally. Miladina has priority and is recommended for use rather than Actinospora.

Use Morchella Dill. ex Pers. 1794 (S) rather than Costantinella Matr. 1892 (A)

The type species of Morchella, M. esculenta, has long been known to be associated with an asexual morph described as Costantinella cristata (Mollard 1904), a name regarded as C. terrestris by Hughes (1958). The linkage between Morchella and Costantinella was confirmed by later authors through cultural and molecular studies (Paden 1972, Volk & Leonard 1990, Carris et al. 2015). Since the type species of Costantinella,
C. cristata, refers to the asexual morph of the type species of Morchella. M. esculenta, these generic names are synonyms. The genus Morchella includes at least 65 phylogenetically distinct species, many of which are highly prized edibles, and commercially valued in the morel-rich countries of China, Europe, Turkey, and the USA (Du et al. 2015, Richard et al. 2015), with significant advances toward their cultivation (e.g. Ower et al. 1986, 1988, Masaphy 2010). A costantinella-like asexual morph was determined with molecular methods to also occur in the related genera Disciotis Boud. 1885, Gyromitra Fr. 1849, and Hydnorvra Berk. & Broome 1846 (Carris et al. 2015). Costantinella is less frequently used than Morchella and includes only seven species. There is no question that the generic name Morchella has priority and is widely used, thus we recommended it for adoption.

Use Sarcoscypha (Fr.) Boud. 1885 (S) rather than Molliariomyces Paden 1984 (A)
The asexual morph of Sarcoscypha coccinea, type of Sarcoscypha, was originally described as Molliariomyces coccineus, type of Molliariomyces, suggesting that these generic names are synonyms. Later, as part of a monographic account of Sarcoscypha in North America, Harrington (1990) concluded that the sexual morph of M. coccineus is S. austriaca while the asexual morph of S. coccinea is M. eucoccineus F.A. Harrington 1990. Nevertheless, the type species of Sarcoscypha and Molliariomyces are congeneric and the generic names are synonyms. Ten names have been placed in Molliariomyces, however, these have been linked to species throughout the family Sarcoscyphaceae. Molliariomyces domingensis Paden 1984 is considered the asexual morph of Phillipsia domingensis Berk. 1881 while M. cupressinus Paden 1984 was described as the asexual morph of Pithya cupressina (Batsch) Fuckel 1870 (Paden 1984). Most of the names in Molliariomyces were established by Paden (1984) using cultural methods, and thus are later names than those of their sexual morphs. Sarcoscypha is widely used, includes over thirty species, and has priority, thus the use of Sarcoscypha is recommended.

Use Trichophaea Boud. 1885 (S) rather than Dichobotrys Hennebert 1973 (A)
The genus Dichobotrys was established for D. abundans, and considered to be the asexual morph of Trichophaea abundans. In the same study, three additional species of Dichobotrys were connected to described species of Trichophaea: D. brunnea Hennebert 1973 was linked to Trichophaea brunnea (Alb. & Schwein.) L.R. Batra 1963, D. parvispora Hennebert 1973 was linked to T. saccata (H.C. Evans) Korf 1973, and D. sessilispora Hennebert 1973 was linked to T. minuta (Cain) Korf (Hennebert 1973). The linkage between sexual and asexual morphs was determined by the production of both morphs in the same culture (Hennebert 1973). Hansen et al. (2013) showed through a multi-genie phylogenetic analysis that the type species of Trichophaea, T. woolhopeia, was congeneric with T. abundans. Trichophaea has been demonstrated to be paraphyletic, but the majority of sequenced species, including T. brunnea, T. minuta, and T. saccata, belong to the clade with T. woolhopeia (Perry et al. 2007, Hansen et al. 2013). Neither Trichophaea hybrida nor T. hemisphaerioides, which are only distantly related to the core clade of Trichophaea, are known to produce an anamorph. While Trichophaea includes 46 species, Dichobotrys with four species has not been widely used. Given its widespread use and priority, the use of Trichophaea is recommended.

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