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Crocinoboletus, a new genus of Boletaceae (Boletales) with unusual boletocrocin polyene pigments

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Abstract

Crocinoboletus is described as a new genus of Boletaceae to accommodate *Boletus rufoaureus* and *B. laetissimus*, characterized by its brilliant orange color of basidiomata caused by the presence of unusual boletocrocin polyene pigments, bluish olivaceous staining of all parts when bruised, smooth basidiospores, and the pileipellis which has an interwoven trichoderm at the middle part of the pileus and a cutis at the margin of the pileus. Prior molecular phylogenetic analyses also confirmed the two taxa are not members of the genus *Boletus* s.s., but form a well-supported generic lineage within Boletaceae. Consequently a description, color photos of fresh basidiomata, line-drawings of microstructures and a comparison of *Crocinoboletus* with allied taxa are presented.

Key words: boletes, molecular phylogenetics, mycorrhizal fungi, taxonomy

Introduction

During a study of Chinese boletes (Li *et al*. 2011, 2014; Zeng *et al*. 2012, 2013), several collections of *Boletus rufoaureus* Massee (Boletaceae, Boletales), a species originally described from Singapore (Massee 1909; Corner 1972), were found in subtropical and tropical regions of China. The species is characterized by the brilliant orange color of the pileus, hymenophore and stipe, which readily distinguishes this species from many other species of Boletaceae. Interestingly, Kahner *et al*. (1998) detected unusual boletocrocin polyene pigments from the fruit bodies of the fungi, which account for the intense color. Like the genus *Retiboletus* Manfr. Binder & Bresinsky with retipolides (Binder & Bresinsky 2002), *B. rufoaureus* probably is representative of a new genus of Boletaceae due to the characteristic secondary metabolites.

Our recent molecular phylogenetic analyses based on the nuclear ribosomal large subunit (nrLSU), the gene encoding the largest subunit of RNA polymerase II (*rpb1*), the second largest subunit of RNA polymerase II (*rpb2*), and the translation elongation factor 1α (*tef1-*α) indicated that *B. laetissimus* Hongo (as "*Boletus* sp. HKAS 59701" in Wu *et al*. 2014) and *B. rufoaureus* cluster together and represent a well-supported distinct lineage (named "clade 41" in Wu *et al*. 2014) within Boletaceae. And, thus, a new genus, *Crocinoboletus*, is proposed herein to accommodate *B. rufoaureus* and *B. laetissimus*.

Materials and Methods

Specimens were photographed and described in the field, and deposited in the Herbarium of Cryptogams, Kunming Institute of Botany, Chinese Academy of Sciences (HKAS). Sections of the pileipellis on the pileus from the middle

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Discussion

Rapid progress in molecular phylogenetic methods has revealed a lot of new generic lineages within Boletaceae, providing a better understanding of the relationships within the family (Binder & Hibbett 2007; Nuhn *et al*. 2013; Wu *et al*. 2014). However, many of them were difficult to delimit just based on morphological characters alone, and, thus, the chemical analysis of pigments was also used to recognize lineages of boletes (Binder & Bresinsky 2002). The boletocrocin polyrene pigments, responsible for the brilliant orange color (Kahner *et al*. 1998) in *Crocinoboletus* can also help to delimit.

Crocinoboletus rufoaureus and *C. laetissimus* were originally placed in the genus *Boletus* (Massee 1909; Hongo 1968, 1984; Corner 1972; Horak 2011). Corner (1972) suspected *C. rufoaureus* was a member of *Leccinum* Gray on account of the coarse scurfy particles on the surface of the stipe. However, *Crocinoboletus* is clearly different from the modern concept of *Boletus* and *Leccinum* (den Bakker 2004; Dentinger *et al*. 2010; Feng *et al*. 2012; Wu *et al*. 2014) on account of the brilliant orange color, the bluish olivaceous staining of all parts when bruised, and the presence of boletocrocins.

Phylogenetically, *Crocinoboletus* nested in the major clade "*Pulveroboletus* group" (Wu *et al*. 2014). *Crocinoboletus* formed a monophyletic lineage with a high statistical support in the group (Wu *et al*. 2014), but its relationship to other genera was not resolved. The genera *Boletus* s.s. and *Leccinum* s.s, belonging to the subfamily Boletoideae and Leccinoideae, respectively, are distinct from *Crocinoboletus* (Wu *et al*. 2014).

So far, *Crocinoboletus* contains at least two species, viz. *C. rufoaureus* and *C. laetissimus*, both containing boletocrocins (Kahner *et al*. 1998). Morphologically, the two taxa are so highly similar to each other that Horak (2011) suspected that they were conspecific. The phylogenetic distance is 0.161 between the two taxa (Wu *et al*. 2014), which is significantly greater than the value for the inter-specific variation of other boletes (Li et al. 2013). Morphologically, *C. laetissimus* has relatively smaller basidiospores, as previously noted by Hongo (1968; 1984). Consequently, we treated them as two different species. *Boletus flammeus* R. Heim, first described from Papua New Guinea (Heim 1966; Corner 1972; Horak 2011), is also very similar to *C. rufoaureus*, and was regarded as a possible synonym of *C. rufoaureus* based on morphological studies (Corner 1972; Horak 2011).

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