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## *Heterobasidion australe*, a new polypore derived from the *Heterobasidion insulare* complex

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**Abstract** *Heterobasidion australe* sp. nov. is derived from the *Heterobasidion insulare* complex, and its illustrated description is given. It is similar to *H. ecrustosum* by morphology but closely related to *H. orientale* genetically. *Heterobasidion australe* is characterized by the effused-reflexed to sessile basidiocarps with a reddish-brown crust in the pileus, shining pore surface, regular and small pores, and by slightly smaller basidiospores than those in other taxa of the complex. *Heterobasidion australe* has so far been recorded only from southern China, where it seems to be relatively common in coniferous forests, growing mostly on dead wood of several genera of gymnosperm trees. Occasionally it has been recorded also on living trees, but its pathogenicity is uncertain.

**Key words** Basidiomycota · Bondarzewiaceae · New species · Wood-rotting fungi

### Introduction

*Heterobasidion* Bref. is one of the most important basidiomycetous genera because some members of this genus cause extensive root rot on coniferous trees in managed forests. Two taxa, the widely distributed *H. annosum* (Fr.) Bref. and East Asian *H. insulare* (Murrill) Ryvardeen, have generally been accepted in the genus (Gilbertson and Ryvardeen 1986; Ryvardeen and Gilbertson 1993; Núñez and Ryvardeen 2001). Mating studies carried out later showed that both *H. annosum* and *H. insulare* are species complexes (Korhonen 1978; Dai et al. 2002). Three Northern Hemisphere species were recognized in the former complex: *H. annosum sensu stricto*, *H. parviporum* Niemelä & Korho-

nen, and *H. abietinum* Niemelä & Korhonen (Niemelä and Korhonen 1998). The *Heterobasidion* taxon occurring in Australia and adjacent regions was named *H. araucariae* P.K. Buchanan (Buchanan 1988). Three intersterile groups (N, T, Y) were found in the East Asian *H. insulare* complex (Dai et al. 2002).

Recently, several species were described within the *H. insulare* complex. *Heterobasidion linzhiense* Y.C. Dai & Korhonen was described from Tibet of China, based on the results of mating tests and on the large basidiospores of this taxon (Dai et al. 2007). Furthermore, based on morphology, culture study, and phylogeny, the intersterility group N was described as *H. orientale* Tokuda, T. Hatt. & Y.C. Dai, and the intersterility group T as *H. ecrustosum* Tokuda, T. Hatt. & Y.C. Dai (Ota et al. 2006; Tokuda et al. 2009). The intersterility group Y, found in southern China, is microscopically similar to *H. ecrustosum* but intersterile with it. It is partially interfertile with *H. orientale* but has evident differences in morphology. Thus, it is treated here as an independent species.

### Materials and methods

The studied specimens are deposited at the herbarium of Institute of Beijing Forestry University (BJFC), the herbarium of Applied Ecology, Chinese Academy of Sciences (IFP), and the herbarium of the Botanical Museum of the University of Helsinki (H). Anatomy was studied, and measurements and drawings were made from slide preparations stained with cotton blue. Drawings were made with the aid of a drawing tube. The microscopic routine used in the study followed Yuan et al. (2006). In presenting variation in the size of the spores, 5% of the measurements at each end of the range are shown in parentheses. The following abbreviations are used: IKI = Melzer's reagent, IKI- = negative in Melzer's reagent, KOH = 5% potassium hydroxide, CB = cotton blue, CB+ = cyanophilous, CB- = acyanophilous, L = mean spore length (arithmetic average of all spores), W = mean spore width (arithmetic average of

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all spores),  $Q$  = variation in the L/W ratios between the specimens studied, and  $n$  = number of spores measured from given number of specimens. Special color terms are from Petersen (1996).

## Description

*Heterobasidium australe* Y.C. Dai & Korhonen, sp. nov.

Figs. 1–4

Mycobank no.: MB 514018.

Carpophorum perenne, effuso-reflexum vel pileatum; facies pororum nivea vel cremeo-bubalina, pori rotundi vel angulati, 4–5/mm. Systema hypharum dimiticum, hyphae generatoriae septatae sine fibulis, hyphae skeletales contexti 3.5–5  $\mu$ m in diametro. Sporae perlate ellipsoideae vel subglobosae, hyalinae, asperae, 4.3–5.5  $\times$  3.5–4.5  $\mu$ m.

Type: China. Jiangxi Province, Qianshan County, Wuyishan Forest Park, Huanggang Mts., stump of *Tsuga*

*chinensis* (Franch) Pritz., 21.X.2005, Dai 7296 (holotype in IFP, isotype in BJFC and H).

Etymology: Australe (Latin), south, referring to southern China.

Basidiocarps perennial, effused-reflexed to pileate, usually imbricate, leathery when fresh, corky when dry, without odor or taste. Pileus semicircular to fan shaped, projecting up to 3 cm, 7 cm wide, and 7 mm thick at base. Pileal surface white to cream when young, becoming reddish brown to dark brown with age, at least reddish brown at base, crustose, indistinctly zonate; margin white to cream, sharp to blunt. Pore surface white when fresh, cream to pale buff when dry, glancing; pores mostly round, occasionally angular, 4–5/mm; dissepiments thin, entire. Context cream, hard corky, azonate, up to 2 mm thick, with a thin crust except for the margin. Tubes cream to buff, hard corky, up to 5 mm long.



Fig. 1. Basidiocarps of *Heterobasidium australe* (Dai 7298)

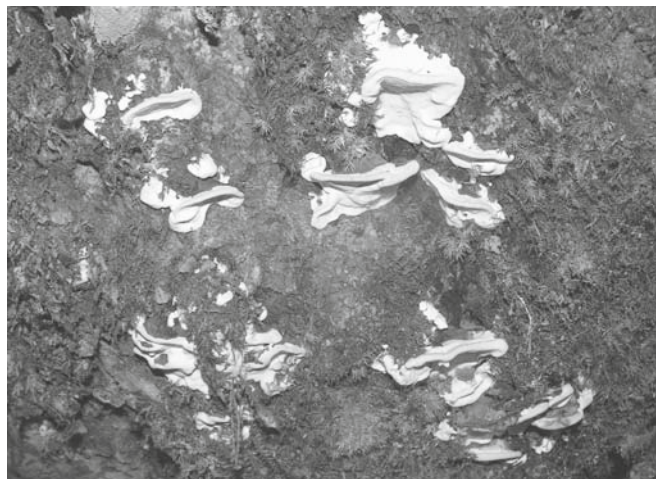


Fig. 2. Basidiocarps of *Heterobasidium australe* (Dai 7324)

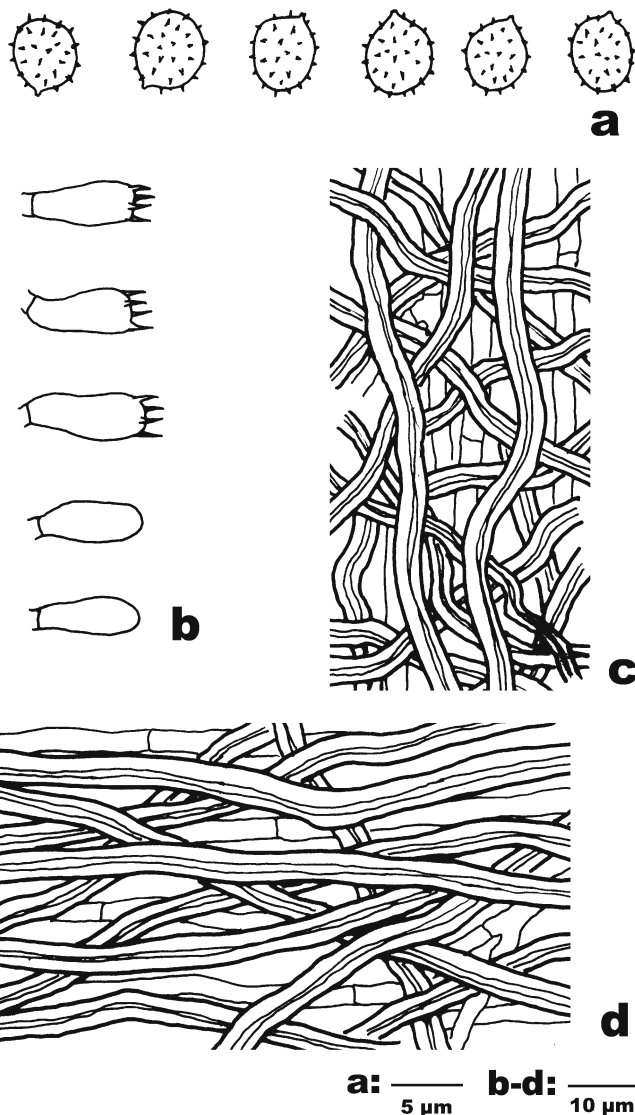


Fig. 3. Microscopic structures of *Heterobasidium australe* (drawn from Dai 7296). **a** Basidiospores. **b** Basidia and basidioles. **c** Hyphae from tube. **d** Hyphae from context

**Fig. 4.** Distribution of *Heterobasidion australe* in China, indicated by diamond symbols



Hyphal system dimittic; generative hyphae without clamp connections; skeletal hyphae IKI-, CB+, hyphae unchanged in KOH (not dissolved). Contextual generative hyphae hyaline, thin walled, frequently simple septate and branched, 2–4  $\mu\text{m}$  in diameter; contextual skeletal hyphae dominant, hyaline, thick walled with a narrow lumen, rarely branched, flexuous, interwoven, 3.5–5  $\mu\text{m}$  in diameter. Tramal generative hyphae hyaline, thin walled, frequently simple septate, occasionally branched, 2–3.5  $\mu\text{m}$  in diameter; tramal skeletal hyphae dominant, hyaline, thick walled with a medium to narrow lumen, rarely branched, flexuous, interwoven, 2.5–4.5  $\mu\text{m}$  in diameter. Cystidia and cystidioles absent; basidia short clavate to barrel shaped, with a simple basal septum and four sterigmata, 10–16  $\times$  5–6  $\mu\text{m}$ ; basidioles in shape similar to basidia, but smaller. Basidiospores broadly ellipsoid to subglobose, hyaline, fairly thick walled, asperulate, usually guttulate, IKI-, CB+, (4.1–)4.3–5.5(–6.2)  $\times$  (3.3–)3.5–4.5(–5.5)  $\mu\text{m}$ , L = 4.95  $\mu\text{m}$ , W = 4.01  $\mu\text{m}$ , and Q = 1.17–1.28 ( $n = 150/5$ ).

Additional specimens examined: China. Anhui Province, Huangshan County, Huangshan, Ciguangge, root of living tree of *Tsuga chinensis*, 13.X.2004, Dai 6138, 6164. Henan Province, Xinyang County, Jigongshan Forest Park, stump of *Pinus*, 25.VIII.2005, Li 191. Jiangxi Province, Qianshan County, Wuyishan Forest Park, Huanggang Mts., living tree of *Tsuga chinensis*, 21.X.2005, Dai 7298, 7324, 7347, 7352. Yunnan Province, Chuxiong County, Zixishan, root of *Pinus*, 31.VII.2005, Yuan 1191. Kunming, Golden Palace, stump of *Keteleeria*, 13.VI.1999, Dai 3050; fallen trunk of

*Keteleeria*, 19.VIII.2005, Yuan 1786. Lijiang County, Heishui River, fallen trunk of *Picea*, 15.VI.1999, Korhonen 99027. Sichuan Province, Jiuzhaigou County, Jiuzhaigou Nat. Res., fallen trunk of *Tsuga*, 14.X.2002, Dai 4211. Zhejiang Province, Jinan County, Tianmushan Nat. Res., stump of *Pseudolarix*, 16.X.2004, Dai 6411, 6426; stump of *Pinus*, 15.X.2004, Dai 6330, 6332, 6334, 6335.

## Discussion

Among the members of the *Heterobasidion insulare* complex, *H. australe* and *H. ecrustosum* have similar microcharacters in their hyphal structure and basidiospores. However, *H. ecrustosum* has an annual habit, and its pores are larger (2–4/mm). Its upper surface is pale yellow or yellowish brown, and its pore surface is not glancing (Tokuda et al. 2009). In contrast, *H. australe* has a perennial habit, and its pores are small (4–6/mm); its upper surface is reddish brown to dark brown, and its pore surface is glancing. In addition, *H. australe* and *H. ecrustosum* are almost intersterile when paired by homokaryotic mycelia (Dai et al. 2002).

*Heterobasidion orientale* and *H. australe* are partly compatible (Dai et al. 2002), but they have evidently different morphology. *Heterobasidion orientale* is a definitely annual species; its pores are round to labyrinthiform and large (1–3/mm), and its dissepiments are strongly lacerate to irpicoid

(Tokuda et al. 2009). Microscopically, its skeletal hyphae are subparallel along the tubes whereas they are interwoven in *H. australe*. Furthermore, the species have different distributions: *H. orientale* was found from northeast China, Japan, and the Russian Far East, while *H. australe* has its distribution in southern China (Fig. 4). The distribution areas of the two species do not overlap in China, and a gap of more than 1500 km exists between them. In any case, *H. orientale* and *H. australe* are very close relatives, as indicated also by DNA investigation by Dai et al. (2002), and their present geographic isolation and partial intersterility may be the result of the gap where is lack of natural coniferous forests in northern China.

*Heterobasidion linzhiense* differs from *H. australe* by its annual habit, larger pores (2–4/mm), larger basidiospores (5.7–7.8 × 4.1–6.1 μm), and the presence of subulate cystidioles (Dai et al. 2007).

The type of *Heterobasidion insulare* was collected on *Pinus* from Philippines (Murrill 1908), but we were unable to obtain any living stocks of *H. insulare* sensu typi, and compatible matings between *H. australe* and *H. insulare* sensu typi are unknown. However, *H. insulare* sensu typi seems to be an annual species with large pores (2–4/mm), its dissepiments are entire, and the pore surface is not shining. Microscopically, it has slightly larger basidiospores, (4.8–)4.9–6.5(–8.1) × (3.7–)3.9–5.2(–5.9) μm, L = 5.63 μm, W = 4.47 μm, and Q = 1.24. Additionally, some conductive hyphae are present in its trama, and these hyphae are 4–8 μm in diameter, distinctly thicker than normal skeletal hyphae.

Besides the *Heterobasidion insulare* complex, *H. arbutarium* (Corner) T. Hatt. and *H. araucariae* were described from southeast Asia and the southern Pacific area; *H. arbutarium* differs from *H. australe* by lacking crust at context, having distinctly thick context (thicker than tubes), slightly larger pores (3–4/mm), and evidently subglobose basidiospores (4.5–5.5 × 4–5 μm; Hattori 2001). *Heterobasidion araucariae* differs from *H. australe* by its large pores (1–2/mm), thicker basidiocarps (up to 30 mm thick), and the presence of cystidioles (Buchanan 1988).

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