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A revision of *Boletellus* sect. *Ixocephali*

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Abstract Taxa included in *Boletellus* section *Ixocephali* sensu Singer are re-evaluated and species limits are clarified in a morphological context. In this revision, we recognize four distinct morphological species: *B. jalapensis*, *B. elatus*, *B. longicollis*, and *B. singerii*. Among these, we have ascertained that the concept of *B. jalapensis* was broadened to include another taxon (*B. singerii*) that was eventually recognized as distinct. Details of spore morphology that include size and shape also show that the precise longitudinal alignment and apical fusion or non-fusion of the costate ornamentation distinguishes two species pairs. These pairs occur on either side of the Pacific basin and include one velate and one non-velate species each: *B. longicollis*, *B. elatus* (E Asia) and *B. jalapensis*, *B. singerii* (America). Now that discrete morphological entities are clarified and recognizable, phylogenetic hypotheses can be attempted to test these concepts and perhaps infer the monophyly of section *Ixocephali* when appropriate sequence data are available from newly collected, properly vouchered and viable specimens.

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Introduction

Boletellus, as originally conceived by Murrill (1909), circumscribed just one species from the SE USA, *B. ananas* (Curt.) Murrill. With the compilation by Singer (1986), the genus morphologically delimited 33 species in seven sections, with either smooth or variously ornamented basidiospores. Other features, including moisture content and/or scaliness of the pileus or degree of stipe ornamentation, were used to define sections. Whether or not these features are functional for inferring phylogeny will remain unknown until the morphological concepts of the described species are clarified and revised for distinguishing taxa.

Boletellus sect. *Ixocephali* was introduced by Singer (1945) to include taxa of boletoid mushrooms distinguishable by more or less viscid, sterile surfaces (i.e., pileus, stipe, and/or veil), longitudinally ribbed spores and a stipe lacking waxy lacunae. Singer originally placed two species in this section: *B. singaporensis* (Pat. & C.F. Baker) E.-J. Gilbert and *B. jalapensis* (Murrill) E.-J. Gilbert. The former taxon was designated as the type for the section but that name has since been considered a later synonym for *B. longicollis* (Ces.) Pegler & T.W.K. Young (Corner 1972). After the descriptions of *B. elatus* Nagasawa (1984) and *B. singerii* Gonz.-Velázq. & R. Valenz., these two species were added to the section (Singer et al. 1992, González-Velázquez and Valenzuela 1995). The distributions of the two original species were originally considered to be tropical (Singer 1986), although *B. longicollis* is now known from Japan (Nagasawa 1997). Current distribution records suggest that *B. longicollis* and *B. elatus* are restricted to Nepal and E and SE Asia whereas *B. jalapensis* and *B. singerii* are only known from northern Central

America and Mexico. However, Singer (1973) found material reported as *B. jalapensis* from Hunan, China, based on a Handel-Mazzetti specimen deposited in the University of Vienna (WU). This material was recognized originally by Lohwag (1926), later placed in another genus (Lohwag 1937), and examined by Singer (1973), who thought the Chinese and Mexican material were in close agreement. However, this specimen is likely an earlier collection of *B. elatus*, but was not recognized as such at that time.

Perreau (1964) provided the first detailed examination of spores from the type specimen of *B. jalapensis* (NY) using light microscopy. Of critical importance here is her observation of how the ornamentation is manifested at the apex of the spore: "Ces ornaments se réunissent au sommet autour d'une depression circulaire, indice de pore apical." (Perreau 1964, p. 759). Singer's (1973, p. 317) description of the spore morphology in the Chinese specimen indicates a similar distinctive morphology: "Spores . . . suddenly rounded off at distant pole." Later, Singer et al. (1983) published a description of *B. jalapensis* which combined data from his analysis of the type and the Chinese specimen in Vienna. García et al. (1987) provided a detailed description thought to be a second report of *B. jalapensis* from Mexico derived from three collections from Veracruz State. One of the specimens cited was seen in fresh condition. The line drawings of the three basidiomata accompanying the description illustrate a bolete with a subalveolate pileus, a very long stipe (in proportion to pileus diameter), a complete membranous veil on one basidioma, a second basidioma lacking a veil or annulus, and an annulate third basidioma. The spores are portrayed with conspicuous ribs that are free from one another at the apex and do not coalesce around a circular depression as described by Perreau. Thus, the veil and spore morphology of *B. jalapensis* as noted by García et al. (1987) are in conflict with the features exhibited by Murrill's type specimen and has resulted in "concept drift."

The other original species placed in sect. *Ixocephali*, and the type of the section, *B. singaporensis* (now=*B. longicollis*) was not well-characterized in a modern sense until Corner's (1972) treatment of Malaysian boletes. Although the type specimen has not been located, Corner contended that there is no other fungus with which it could be confused. Apparently, a type specimen among the SE Asian Beccari materials in Florence (FI) does not exist (C. Nepi, personal communication). However, after examination of the protologue and accompanying color plate (Cesati 1878), we would agree with Corner. The viscid surfaces and stature of the basidiomata along with the presence of an obvious veil and clearly ribbed, ovoid to short-ellipsoid spores are distinctive. Corner also illustrated the spores, the details of which were later only slightly enhanced by Pegler and Young (1981) using scanning electron microscopy. The illustrations do not explicitly indicate that the ribs are free from one another at the apex, but rather that they extend beyond the apex "simulating a small germ-pore." (Pegler and Young 1981, p. 115). Corner (1972) differentiated *B. longicollis* from *B. jalapensis* based on spore size (shorter in *B. longicollis*) and the presence of a veil in *B. longicollis* (absent in *B. jalapensis*).

Boletellus elatus, when described by Nagasawa (1984), was compared to *B. jalapensis* because of the similar spore morphology as noted first by Perreau (1964). The united ribs and circular depression at the spore apex are unequivocal in a SEM image (Nagasawa 1984, p. 362). However, Nagasawa placed the species in sect. *Chrysenteroidei* because of the dry nature of the basidiomatal surfaces. Based on a single specimen (Jalisco, Mexico, in IBUG) thought to be *B. elatus*, Singer et al. (1992) placed it in sect. *Ixocephali*.

Most recently, *Boletellus singerii* Gonz.-Velázq. & R. Valenz. was distinguished from the other three species based on some color differences, viscidity, veil characters, and spore size and shape (González-Velázquez and Valenzuela 1995).

Based on our examination of type specimens and other supporting materials, we provide a revision to the four species included in *Boletellus* sect. *Ixocephali*. Descriptions of the species are supported with diagnostic illustrations of spore morphology. A dichotomous key is provided to distinguish the taxa.

Materials and methods

Use of the word "spore" or "spores" refers to basidiospores. Spore size is determined from *n* number of spores, followed by the mean of spore lengths and widths, and the *Qm* value (median length/width ratio). Color names are from Smithe (1975), Ridgway (1912) or Rayner (1970); grid designations (e.g., 4A3) are from Kornerup and Wanscher (1983). Microscopic observations were made from dried material examined in 3% KOH and Melzer's reagent and examined with an Olympus BHS compound microscope equipped with Nomarski differential interference contrast (DIC) optics. Hymenophoral fragments were removed from dried basidiomata, mounted directly on aluminum stubs (EMS#75610) using carbon adhesive tabs (EMS#77825-12), and coated with 10 nm of gold using a Hummer 6.2 sputter coater. Scanning electron micrographs of the spores were captured digitally from a JEOL JSM-5410LV Scanning Microscope operating at 10 kV. Herbarium acronyms are those designated in the online version of Index Herbariorum (Holmgren and Holmgren 1998).

Results

Key to species of *Boletellus* sect. *Ixocephali*

1 Basidiomata viscid-glutinous overall and with a veil; costate ornamentation of the spores typically continuous from pole to pole, not united at apex; spore apex traversed by a continuous fissure or fissures

2 Spores broadly ellipsoid to ovoid, (9.5)11–14.5 µm long; Japan to SE Asia *B. longicollis*

2* Spores fusoid cylindric, (8.8)11.2–18.4(19.2) µm long; Mexico to Central America *B. singerii*

1* Basidiomata lacking a veil, with viscid glutinous pileus or not; costate ornamentation of the spores frequently foreshortened and attenuated, occasionally continuous from pole to pole, united at the apex around a shallow, circular depression

3 Basidiomata dry overall, rarely subviscid on the pileus when mature, subtomentose; Japan and Nepal *B. elatus*

3* Basidiomata with slimy pileus; Mexico *B. jalapensis*

Boletellus longicollis (Ces.) Pegler & T.W.K. Young, *Trans. Brit. Mycol. Soc.* 76: 115. 1981. Figures 1a, b; 2a

Boletus longicollis Ces., Atti R. Accad. Fis. Mat. Nap. 8: 4, Fig. 3. 1878.

Boletus altissimus Massee, Bull. Misc. Inf. Kew. 1909: 205. 1909.

Boletopsis singaporensis Pat. & C.F. Baker, J. Straits Branch Roy. Asiat. Soc. 78: 69. 1918.

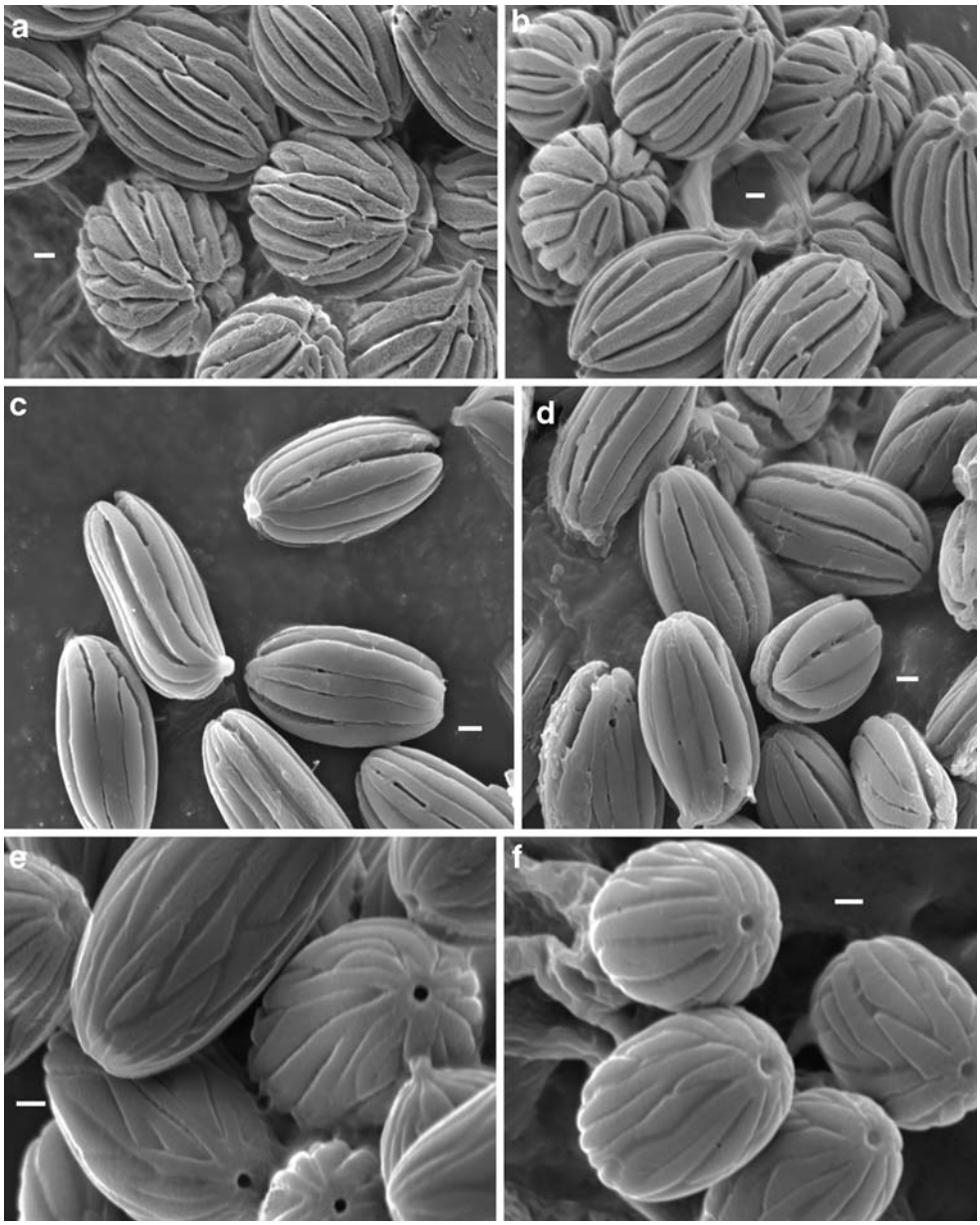

Fig. 1 **a**,**b** *Boletellus longicollis*. (TMI 13099). **c**,**d** *Boletellus singerii* (Chacón 1219). **e** *Boletellus elatus* (Isotype). **f** *Boletellus jalapensis* (Holotype). *Scale bar*=1 µm

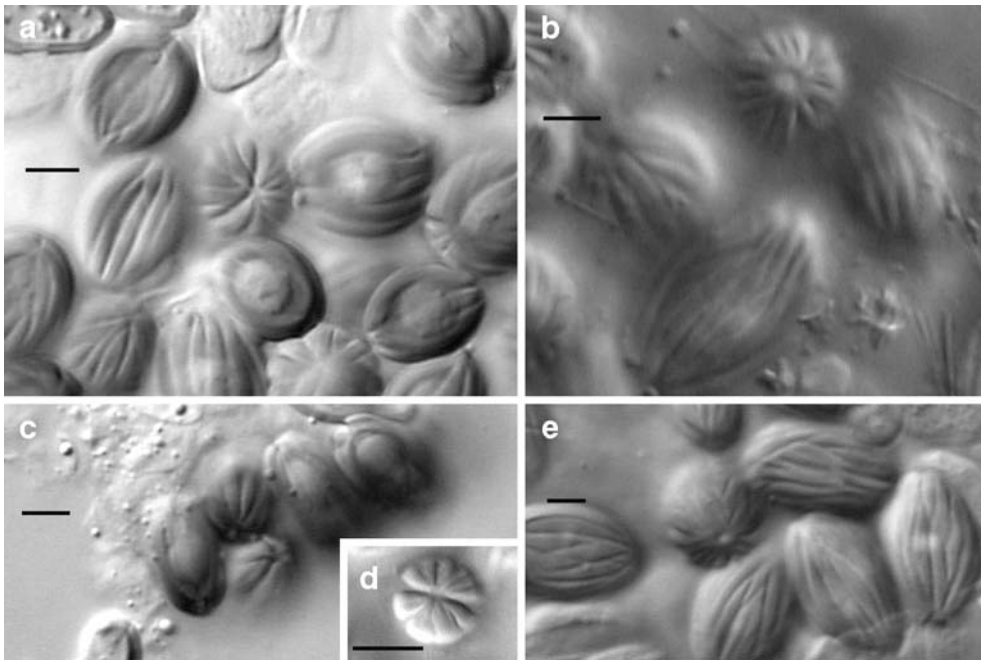

Fig. 2 **a** *Boletellus longicollis* (TMI 13099). **b** *Boletellus elatus* (Isotype). **c** *Boletellus singerii* (BOS 468). **d** *Boletellus singerii* (Ventura 12955). **e** *Boletellus jalapensis* (Holotype). *Scale bar*=5 μm

Boletellus singaporensis (Pat. & C.F. Baker) E.-J. Gilbert, Les bolets, p. 107. 1931.

The following description of features is modified from Corner (1972), p. 92); microscopic features are updated with corroboration from TMI 13099.

Pileus 3–8 cm, conical, strongly umbonate then plano-convex, glutinous viscid, at first rugose, dark rufous brown or liver brown, paler rufous brownish on expansion, Tawny-Olive to Clay Color when dried (Ridgway, 1912), innately streaked; margin at first shrouded with the long white gelatinous appendiculate veil. *Flesh* 4–8 mm thick in the center of the pileus, 1.5–3 mm halfway to the margin, rather soft in the pileus, pale yellowish, pale pinkish fawn below the surface of the pileus and stem, unchanging. *Tubes* 10–15 mm, angular, pale yellow to dark olive. *Stipe* 13–28 cm×5–7 mm at the apex, 12–20 mm at the base, tall, slender, solid, straight or flexuous, viscid, slippery, smooth, pale rufous fawn; base villous with the white mycelium; ring 8–10 mm wide, placed 12–25 mm below the stem-apex, rarely about half-way down the stem, white, floccose, firm, spreading, viscid on the underside.

Spores dark fuscous olive in the mass, (9.5)11–14.5(16.1)×(8)9–11.5 μm (n=40, 13.8×11.4 μm, Q_m=1.2), broadly ellipsoid or ovoid, with longitudinal or rarely oblique ridges, continuous or rarely interrupted, 10–15 (13–18 fide Corner) per spore, 6–7 in side-view, cleft at the apex. *Basidia* 28–48×13–16.5 μm, clavate, 4-sterigmate. *Pleurocystidia* up to 45×6–9 μm, subventricose to fusiform, with obtuse apex 4–5 μm wide, thin-walled, soon collapsing. *Cheilocystidia* forming a sterile edge of short, clavate cells. *Tramal hyphae* up to 20 μm wide in the pileus and stipe, hyaline, inamyloid. *Tube trama* boletoid with hyphae 7–12 μm wide. *Pileipellis* an ixotrichodermium up to 500 μm thick on the center, thinner towards the margin, with hyphae 3–7 μm wide, arising from a firm compact layer of repent, radiating and interwoven hyphae 7–12 μm wide with brownish pigment incrustations; oleiferous hyphae occasional. *Stipitipellis* an ixotrichodermium similar to the pileipellis, perpendicular from the surface, with some end cells subclavate 6–7 μm wide, arising from a repent layer of slightly thick walled hyphae. *Velar material* with the same structure as the pileipellis and lacking an organized hymenium on the inner surface. *Clamp connections* absent.

Habit, habitat, and distribution: solitary in forests (probably Fagaceae) of Borneo, Malaya, Sarawak, and Singapore (Corner 1972); in woods of *Castanopsis cuspidata* (Thunb.) Schottky or mixed woods with *Castanopsis*; Honshu, Kyushu and Okinawa in Japan (Nagasawa 1997).

Material examined: JAPAN. Hiroshima Pref., Hiroshima, Higashi-ku, Fukuta, 20 Jul 1989, *E. Nagasawa 89-48* (TMI 13099: NY!). SINGAPORE: *Ridley 9* (holotype *B. altissimus*: K!).

Commentary: *Boletellus longicollis* is distinctive because of the glutinous-viscid pileus and stipe; these are features shared with *B. singerii*. These two species can be easily distinguished by differently shaped and sized spores and geographical distribution. Color illustrations in Corner (1972) indicate that the veil may form an annulus or could remain attached to the margin of the pileus.

Boletellus singerii Gonz.-Velázq. & R. Valenz., *Mycotaxon* 55: 400. 1995. Figures 1c, d; 2c, d

The following description is taken from Ortiz-Santana et al. (2007).

Pileus 26–71 mm diam., convex, with a thick glutinous pellicle, appressed fibrillose under gluten, rugose-areolate;

ground color white or Pale Pinkish Buff (5B3) with Brussels Brown (6E5) to Cinnamon Drab (7D4) to grayish reddish-brown (8D4) fibrils, negative in KOH and NH_4OH; margin appendiculate, white. *Context* soft, gelatinous, white, yellow above tubes, brown near stipe, not bruising, yellowish brown in KOH, negative in NH_4OH, 12 mm thick at center, 1–2 mm at margin. *Odor* not distinctive. *Taste* sweet. *Tubes* adnexed to free, depressed near stipe, 9–16 mm long, pale yellow or Olive Yellow (2C5) becoming greenish blue; yellowish brown in KOH, negative in NH_4OH; *pores* angular, 1–2/mm, concolorous with tubes, bruising Citrine (2E7-3D5). *Stipe* 130–147 mm long, 6–9 mm wide at apex, 10 mm wide at middle, 10–12 mm at base, equal to tapered at apex; glutinous, fibrillose under gluten, ground color white to pale Beige (7C3), yellow at base, with Cinnamon Drab fibrils; negative in KOH and NH_4OH. *Context* hard, fibrous, white, not bruising; yellowish brown in KOH, negative in NH_4OH. *Basal mycelium* white, viscid. *Partial veil* cottony, white, glutinous, extending from the pileus to the stipe, not forming an annulus (at least not present when collected), but leaving remnants at the pileus margin.

Spores olive brown in deposit, 11.2–18.4×7.2–9.6 µm (n=20; 15.54±1.57×8.4±0.61; Q_m=1.74±0.20), ellipsoid, longitudinally winged, projecting up to 1.8 µm, cleft at the apex, pale yellowish brown in KOH, some dextrinoid in Melzer's. *Basidia* 24–32×11.2–13.6 µm, clavate to obpyriform, (2) 4-sterigmate. *Basidioles* 17.6–23.2×9.6–12 µm, obpyriform to clavate. *Pleurocystidia* 32.8–47.2×8.8–15.2 µm, subclavate, fusoid, ventricose. *Cheilocystidia* 20–36×9.6–12 µm, clavate, fusoid to obpyriform. *Pileipellis* an ixotrichodermium of elongated, interwoven and gelatinized hyphae 4–12 µm diam, hyaline in KOH, yellow in Melzer's; end cells cylindrical or irregularly shaped. *Stipitipellis* hyphae 5.2–13 µm diam, interwoven, subgelatinous, hyaline in KOH. *Caulocystidia* 16.8–41.6×4–8 µm, cylindrical to cylindric-clavate or irregularly shaped, usually in clusters; hyaline in KOH. *Veil hyphae* parallel or interwoven, septate, hyaline in KOH; end cells 3.9–11.74 µm diam, irregularly shaped.

Habit, habitat and distribution: Gregarious under *Quercus* in Belize. In Mexico, solitary to subgregarious in forests of *Quercus* and *Quercus* mixed with *Pinus* (Singer et al. 1992, González-Velázquez and Valenzuela 1995).

Material examined: BELIZE. Cayo District: Mountain Pine Ridge Forest Reserve, near Cooma Cairn Station, intersection with Bradley Road, 17°N, 88°W, 900 m, 27 Nov 2002, *BOS 468* (BRH, CFMR). MEXICO. State of Mexico. Mpio. de Tejupilco, km 8, unpaved road to Nanchichitla, 1,900 m, 6 Sep 1986, *González-Velázquez 516* (Isotype: F-1086514!); 23 Aug 1987, *González-Velázquez 715* (F-1086510!); km 11, unpaved road to Nanchichitla, 2,000 m, 22 Aug 1987, *González-Velázquez 693* (F-1086511!); 30 Jul 1988, *González-Velázquez 833* (F-1086512!). State of Guerrero. Mpio. de Taxco, km 0–2 detour to Cerro del Huisteco, 2,200–2,400 m, 10 Aug 1985, *Venegas & Santiago 57* (F-1086497!).

The following are cited by Singer et al. (1992) as *B. jalapensis*, wherein they repeat the spore measurements of the type specimen of *B. jalapensis*, but they describe the macromorphology of *B. singerii*.

MEXICO. State of Veracruz. Mpio. de Atzalan, La Calvera, 1,100 m, 10 Jul 1976, *F. Ventura 12955* (F-1097236!); Los Pinos, 10 km before Totutla, road to Xalapa, 27 Jul 1983, 1,400 m, *S. Chacón 1219* (F-1097229!); 4 km east of Lencero, road from Xalapa to Veracruz, 7 Jul 1985, *G. Carrión 708* (F-1097237!).

Commentary: All specimens in F are just wedge-shaped portions of pilei with context and hymenophore. The surfaces as dried exhibit some degree of shallow rugulosity. The Belize collection is characterized by the white to pinkish buff ground color with pale brown to pale reddish-brown fibrils, a rugose pileus with white margin, a glutinous basidioma and the presence of a veil, leaving remnants on the pileus margin but not forming an annulus. García et al. (1987, as *B. jalapensis*) noted similar colors, moisture content, and topography as well as a veil that collapses as an annulus or detaches from the stipe. The concept employed by Singer et al. (1992, as *B. jalapensis*) is essentially a repeat of García et al. (1987), although the spore size is from Singer's (1945) type study of *B. jalapensis*.

The drift in concept of *B. jalapensis* began as a misinterpretation (García et al. 1987) and eventually circumscribed two taxa: *B. jalapensis* (spore dimensions) and *B. singerii* (viscid basidiomata with a veil) (Singer et al. 1992). Thus, González-Velázquez and Valenzuela (1995) recognized *B. singerii* as a distinct, new taxon, because of shorter spores and the presence of a veil compared to true *B. jalapensis*. *Boletellus singerii* shares the velar features, viscidity, and some colors with the Asian *B. longicollis*, but the spores of this latter are even shorter and differently shaped. Finally, *B. elatus* (see below) is distinguished by its lack of glutinosity, lack of veils, and obvious brown pigmentation.

Boletellus elatus Nagasawa, *Trans. Mycol. Soc. Japan* 25: 361. 1984. Figures 1e; 2b

The following description is modified from Nagasawa (1984); the capitalized color names are from Rayner (1970).

Pileus 3–9 cm broad, hemispheric to convex, later becoming expanded, dark brown to brown (Dark Brick to Sepia, or near Chestnut), evenly colored overall or somewhat paler toward the margin, subtomentose, nearly glabrous when very old, subviscid when moist and mature. *Flesh* soft, relatively thin in the pileus, whitish then

yellowish, with a faint tint under the pileipellis, unchanging or sometimes slightly changing to vinaceous on cutting; *odor* and *taste* mild. *Tubes* adnexed to nearly free, often strongly convex at maturity, 1–3 cm long, yellow to olivaceous (Pure Yellow then Citrine to Greenish Olivaceous), unchanging when cut; *pores* at first small, up to 2 mm broad with age, angular, concolorous, unchanging when bruised. *Stipe* 9–23 cm long, 6–12 mm broad at the apex, tall and slender, broader (1.4–4 cm) at the curved base, dry, pruinose velutinous, longitudinally rugulose, not reticulate or at times obscurely rugulose-reticulate at the apex, concolorous with pileus or more or less darker (near Brown Vinaceous) when old, often pinkish tan (Vinaceous Buff) toward the apex when young; basal mycelium white, usually copious. *Veil* absent.

Spores Olive in deposit, (12)16–19(20)×(7.5)9–11(12.5) µm, (Q_m=1.6–1.8), ellipsoid to oblong-ellipsoid in face view, more or less inequilateral with a broad, often obscure suprahilar depression, longitudinally winged with 14–18 ridges united at the apex, narrowly truncated with a circular depression, with ridges sometimes forked and/or anastomosed, projecting 0.5–1 µm. *Basidia* 32.5–50×12.5–17.5 µm, broadly clavate, 2–4 sterigmate. *Pleurocystidia* scattered, 33–75(–80)×6–12.5 µm, narrowly ventricose-fusoid to subclavate, thin walled, hyaline to yellowish in KOH. *Cheilocystidia* frequent, 20–50×5–11 µm, narrowly ventricose-fusoid to subclavate, thin walled, hyaline in KOH. *Tube trama* boletoid with hyaline lateral strata, with elements 5–12.5 µm broad. *Pileipellis* a trichodermium of loosely tangled tubular hyphae up to 200 µm long, 5–12.5 µm broad, with walls more or less gelatinized, encrusted with brown to brownish yellow pigment granules, dissolving in KOH, hyaline or brownish orange in Melzer's. *Stipitipellis* a continuous hymeniform layer, 25–35 µm deep, with sterile clavate elements intermixed with caulobasidia and caulocystidia; these latter 30–140×10–20 µm, fusoid ventricose to subcylindric, sometimes septate, thin walled, hyaline to yellowish in KOH. *Clamp connections* absent.

Habit, habitat, distribution: In Japan on soil in *Abies firma–Castanopsis cuspidata* woods and in *Quercus acutissima–Q. serrata* stands, rarely intermixed with *Pinus densiflora* Siebold & Zucc. M. Christensen, Copenhagen (personal communication) has found material in a forest dominated by *Shorea robusta* Roth from the Kaski District of Nepal that he attributes to this taxon. The Chinese specimen cited by Singer (1973), and attributed to *B. jalapensis*, and is very likely *B. elatus*.

Material examined: JAPAN. Tottori Pref., Tottori City, Yutokoro, 22 Aug 1976, *E. Nagasawa* (Holotype: TMI-6563; Isotype F-1030213!); Oro-yama, 8 Sep 1979 *E. Nagasawa* (TMI-6567; F-1030211!); Ochidani, 9 Sep 1979 (TMI-7773; F-1030212!); 6 Sep 1996 (leg. Kimito Mimura, det. E. Nagasawa, TMI-22101 (NY!); Tottori City, Katsurami, 14 Sep 2006, *E. Nagasawa 06-204NR* (NY!). CHINA. Hunan Prov. monte Yün-schan, near Wukang, 1,280 m, 19 Aug 1918, *Handel-Mazzetti 12457* (WU!).

Commentary: As described by Nagasawa and confirmed by us, the spore morphology of *B. elatus* is identical to that of true *B. jalapensis*. Furthermore, these two species lack a veil. According to the protologues, *B. elatus* is only subviscid when moist and mature while *B. jalapensis* was described as slimy. The latter is also differently colored and smaller. However, the holotype of *B. jalapensis* consists of only one basidioma and we suspect that size, moisture content, and other macromorphological variation may not be truly representative of the species as portrayed in the type. One specimen from Jalisco, Mexico, cited by Singer et al. (1992) as *B. elatus* is most likely the second known collection of *B. jalapensis*. See further discussion under *B. jalapensis*. The specimen from China (WU) examined by us possesses spores identical to *B. elatus* and *B. jalapensis* and consists of one fragmented basidome in good condition. Until such time that additional specimens can be compared, we maintain *B. elatus* separate from *B. jalapensis*.

Boletellus jalapensis (Murrill) E.-J. Gilbert, Les bolets, p. 107. 1931. Figures 1f; 2e

Ceriomyces jalapensis Murrill, Mycologia 2: 248. 1910.

Boletogaster jalapensis (Murrill) Lohwag, Beih. Bot. Centralbl. 42: 274. 1926.

Macroscopic description from the protologue (Murrill 1910); microscopic description from Singer (1970):

> "Pileus small, convex, circular in outline, 2.2 cm. in diameter, 1 cm thick; surface isabelline to fulvous, slimy, smooth: context white to faintly roseus, mild to the taste, 2 mm. thick behind; hymenium convex, depressed in the form of a crater about the stipe, tubes pale-greenish, 7 mm. long, mouths large, rounded, 1–2 to a mm., edges thin; spores ellipsoid, deep-ferruginous, distinctly longitudinally striate, copious, 13–15×7–9 µ: stipe central, slender, tapering upward, concolorous, smooth, glabrous, not conspicuously slimy like the cap, swollen and white at the base, 6 cm. long, 4 mm. thick at the middle."

> " . . . spores 16–18(–25) × 10–11(–13) µ, deep melleous, with 10–14 longitudinal lamellate ribs which project 1–1.5 µ, with scarce anastomoses but usually once or twice forked ribs observed; hymenium: basidia 38–42 × 14–15.5 µ, 4-spored; cystidia not found but probably present; hyphae without clamp connections; covering layers of the pileus with clampless elongated elements, some clavate, some very thin, of variable diameter, yellowish-subhyaline, obviously embedded in a gelatinous mass."

Material examined: MEXICO. Xalapa: 12–20 Dec 1909, *W.A. & E.L. Murrill 354* (Holotype: NY!; Isotype: FH!). Jalisco: Mpio. de Zapopan, Bosque La Primavera, in the neighborhood of the Balneario Cañon de Las Flores, 4 Oct 1980, *S. Fabian Montes s.n.* (F1097234: F!; IBUG!).

Commentary: With the publication of García et al. (1987), *B. jalapensis* assumed a new macromorphology, and then retained the spore size of Murrill's type (as reported by Singer 1945; 1970; Singer et al. 1992). This is the concept employed most recently by Singer et al. (1992) in distinguishing *B. jalapensis* from other species placed in sect. *Ixocephali*. These latter authors also included another velate species, *B. singerii*, distinguished, attributed to, and validly described 3 years later by González-Velázquez and Valenzuela (1995). *Boletellus singerii* was recognized because of shorter spores compared to Singer's measurement of the type (inflated to 25 µm as part of the normal, rather than exceptional, range in length). The specimen from Jalisco, was first determined as *B. elatus*, but is most probably *B. jalapensis* if we allow that Murrill's type is not truly representative of morphological variation in the species. Unfortunately, the Jalisco specimen lacks fresh field notes, but in the dried state, it is very similar in macromorphology to the isotype of *B. elatus*. Our alternative hypothesis for these discrepancies is as follows.

In Murrill's holotype, the circular depression at the apex of the spore surrounded by the coalescence of the ribs is readily obvious if a spore is viewed in the proper polar orientation (Fig. 2e), and this morphology is unequivocal with the SEM (Fig. 1f). In addition, some ribs are not continuous from pole to pole but are foreshortened and attenuated. This has been described as anastomosed or forked. The fissures between ribs are shallow. This morphology is also present in *B. elatus* spores (Figs. 1e; 2b). The spore length reported by Perreau (14–16 µm) and Murrill (13–15 µm) is shorter than that reported by Singer [16–18(25) µm] for the same type specimen. Our measurements of the spores from Murrill's type are 14–17(19) µm, overlapping the ranges reported. The spores as reported by Singer et al. (1992) for the Jalisco material is (12.8)16–19 (23)×(6.4)8.8–9.7(12.8) µm. These spore ranges are essentially the same for *B. jalapensis* and *B. elatus*. Because we know of only two *Boletellus* specimens from Mexico that possess spores with a circular depression at the apex, compared to more abundant materials in Japan, we are not ready to acknowledge synonymy. Whether or not these two taxa are actually the same species with an amphi-Pacific distribution will require further analysis from comparison of fresh material.

In conclusion, it is always exciting to discover that one has collected a species of *Boletellus* when the majority of taxa in the Boletineae are smooth-spored. However, particular observation of the ribs and fissures, along with the manifestation of the apical region, is paramount for accurate characterization and identification. Now that these four species are distinguished on a morphological and, to a lesser extent, biogeographic basis, fresh material needs to be collected with the goal of acquiring appropriate gene sequences. These latter data can then be used to support or modify species recognition and possibly infer the monophyly of section *Ixocephali*.

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