

An updated worldwide key to the currently (April 2026) known species in the genus *Caloboletus*

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Abstract: Since the erection of the genus *Caloboletus* 2014 further species were described or recombined into this genus. A definitive overview of the actual distribution is still far from complete. An updated key, based on the current state of knowledge, is provided.

Zusammenfassung: Seit der Schaffung der Gattung *Caloboletus* 2014 wurden weitere Arten beschrieben oder in diese Gattung kombiniert. Eine endgültige Übersicht über die tatsächliche Verbreitung ist bei weitem noch nicht abgeschlossen. Ein aktualisierter Schlüssel, basierend auf dem aktuellen Kenntnisstand, wird bereitgestellt.

Caloboletus was erected as a new genus by VIZZINI (2014) with *Boletus calopus* PERS. 1801 as the type species, and 11 species were recombined into *Caloboletus*. The presence of first yellow then olive yellow tubes, yellow but in some taxa also orange to red pores changing to blue when injured, and the distinctly bitter taste of the context are the main characteristics of the genus. The genus is supported by phylogenetic analyses (GELARDI & al. 2013, NUHN & al. 2013; WU & al. 2014, 2016), the former *Boletus* section *Calopodes* is representing this new genus.

Many species have long been known, not only in Europe but also in North America (FROST in PECK 1878; COKER & BEERS 1943; SNELL 1936; SNELL & DICK 1941, 1970; DICK & SNELL 1969; THIERS 1965, 1975; GRAND & SMITH 1971), and in Asia (CHIU 1948, HONGO 1967). They were progressively recombined into the genus *Caloboletus* based on the latest insights (ESTADES & LANNOY 2001, 2004; FRANK 2014).

In the following, several taxa will be commented on, some misidentifications and the status of names will be addressed. It is regrettable that when describing new species, once their status has been confirmed by molecular genetics, other important characters are often neglected. In *Caloboletus*, this particularly includes taste, amyloidity, and microscopic characters such as cystidia or pileipellis hyphae. This bias arises because many species in this genus frequently show atypical traits, for example, absence of stipe reticulation or unusual colour variation.

ZHAO & al. (2014) and ZHANG & al. (2017) published worldwide keys. In the first one, including 6 species, there is a confusion in the initial stages making it unusable. The second one by ZHANG & al. (2017) included 13 species. Currently, one can assume at least 17 taxa that have also been confirmed by molecular genetics.

Phylogenetic trees in the above cited publications, generated from combined analysis of DNA sequences from four molecular markers (ITS, nrLSU, tef1- α and rpb1), included sequences from samples representing six and eight *Caloboletus* taxa, respectively.

Overview of *Caloboletus* taxa with selected illustration references, ordered alphabetically

***Caloboletus calopus* f. *calopus* (PERS.) VIZZINI 2014**

Iconography (=IC.): Mu 57a, 57c-g, SMJ137, MGS 215–217, *

***Caloboletus calopus* var. *ruforubriporus* (BERTÉA & ESTADÈS) BLANCO-DIOS 2015**

IC.: -

***Caloboletus conifericola* VIZZINI 2014**

IC.: BRB1: 289, PHILIPS (2010: 226 b. l.), WANG & al. (2025: fig. 66 a, b) *

***Caloboletus firmus* (FROST) VIZZINI 2014**

IC.: BRB1: 292, BRB2: 187, 188, PHILIPS (2010: 235 b. r.) *

***Caloboletus frustosus* (SNELL & E. A. DICK) D. ARORA & J. L. FRANK 2014**

IC.: BRB1: 287, KUO (2020a), SNELL & DICK (1970: pl. 37 ?! as *calopus*), *

***Caloboletus griseoflavus* L. FAN, N. MAO, T.Y. ZHAO 2023**

IC.: MAO & al. (2023: fig. 2: i, j)

***Caloboletus guanyui* N.K. ZENG, HUI CHAI & S. JIANG 2019**

IC.: CHAI & al. (2019: fig. 4 c–f), YANG (2023: pl. IV, fig. 2), * also as *Boletus quercinus*

***Caloboletus inedulius* (MURRILL) VIZZINI 2014**

IC.: BRB1: 297, BRB2: 190, KUO (2020b), PHILIPS (2010: 226 b. r.), *

***Caloboletus kluzakii* (ŠUTARA & ŠPINAR) VIZZINI 2014**

IC.: SMJ141, MGS 232–235, *

***Caloboletus marshii* D. ARORA, C. F. SCHWARZ & J. L. FRANK 2014**

IC.: *

***Caloboletus panniformis* (TANEYAMA & HAR. TAKAH.) VIZZINI 2014**

IC.: TAKAHASHI & al. (2013: figs. 1–2), RAJPUT & al. (2025: fig. 2), YANG (2023: pl. IV, fig. 3), *

***Caloboletus peckii* (FROST) VIZZINI 2014**

IC.: SNELL & DICK (1970: pl. 36 r.), Mushroom Observer (cited coll.), *p.p.

***Caloboletus polygonius* var. *polygonius* (A. E. HILLS & VASSILIADES) VIZZINI 2014**

IC.: MGS 221, 223a, HILLS & VASSILIADES (1999: 160), ROUX & CHAPON (2020: 44) *

***Caloboletus polygonius* var. *ereticulatus* (ESTADÈS & LANNOY) CHAPON & P. ROUX 2020**

IC.: MGS 220, 223 b., 225, ESTADÈS & LANNOY (2004: 50a), ROUX & CHAPON (2020: 45) *

Caloboletus radicans (PERS.) VIZZINI 2014

IC.: Mu 58a, b, 58d, SMJ 139, MGS 226–231, *

Caloboletus roseipes (BESSETTE, BOTH & A. R. BESSETTE) VIZZINI 2014

IC.: BRB2: 192, *

Caloboletus roseo-olivaceus (J. BLUM) N. SCHWAB 2019

IC.: -

Caloboletus rubripes (THIERS) VIZZINI 2014

IC.: SMITH (1975: pl. 46), PHILIPS (2010: 226 a. r.), BRB1: 309, THIERS (1975: microfiche 17) *

Caloboletus taienus (W. F. CHIU) MING ZHANG & T. H. LI 2017

IC.: ZHANG M. & al. (2017: fig. 2 d = CHIU 1948, e, f), YANG (2023: pl. IV, fig. 4)

Caloboletus xiangtoushanensis MING ZHANG, T. H. LI & X. J. ZHONG 2017

IC.: ZHANG & al. (2017: fig. 2 a–c), CHAI & al. (2019: fig. 4 g–j), YANG (2023: pl. IV, fig. 5), *

Caloboletus yunnanensis KUAN ZHAO & ZHU L. YANG 2014

IC.: ZHAO & al. (2014: fig. 3), YANG (2023: pl. IV, fig. 6), *

Boletus sanguineipes PANZERA 1997

IC.: PANZERA (1996: 152), PANZERA (1997: 305), SILVIANI (2008: 58, 60), *

Boletus coniferarum E. A. DICK & SNELL 1969, nom. illeg. (= *C. conifericola*)

Boletus piedmontensis GRAND & A. H. SM. 1971 (= *C. firmus*)

Boletus quercinus HONGO 1967, nom. illeg. (= *C. guanyui*)

Boletus satanas var. *americanus* COKER & BEERS 1943 (= *C. firmus*)

Boletus subclavatosporus SNELL 1936 (= ? *C. inedulis*)

IC.: SNELL & DICK (1970: pl. 37 b.)

A worldwide key to *Caloboletus* species

- 1 Pores with yellow, olive, or brownish colours (but compare those that often have an orange tint with age, for example 3) 2
- 1* pores with red or orange colours 17
- 2 basidiomata usually without any red or reddish colours 3
- 2* basidiomata usually anywhere with red or reddish colours, but compare 4, 5, 5* .. 6
- 3 basidiomata where red colours have not been observed: pileus grey-white to greyish, then greyish brown, –7.5 cm wide, pores bright yellow, then orange-yellow with age, turning blue when bruised. Stipe bright yellow, then yellowish brown with yellowish brown reticulations. Context white to pale yellow, turning blue. Spores 12–15(–16) × 4.5–5.5(–6) µm, Qm = 2.6, in broadleaf forests (*Quercus*), China *C. griseoflavus*
- 3* basidiomata where, in rare exceptional cases, red colours may occur 4

- 4 stipe not reticulated, pileus white to greyish white, later buff or tan, –15(20) cm wide, context pallid, blueing on exposure. Pores yellow, staining blue when fresh, stipe yellow, - temporarily with small reddish dots, changing to blue when exposed, swollen or bulbous in lower part, not reticulated, spores $11-14 \times 4.5-6 \mu\text{m}$, $Q_m = 2.5$, with *Quercus*, North America ***C. marshii****
- 4* stipe reticulated..... 5
- 5 pileus occasionally –30 cm wide, whitish, beige-white, grey-brown, pores (lemon)yellow, bruising deep blue, stipe swollen, later clavate, base usually rooting, yellow to ochraceous, - temporarily with (brownish)red areas, very fine reticulated, context (yellowish)white, - temporarily with pinkish tints at the base of stipe, turning light blue throughout on exposure, spores $12-13(-14.5) \times 4-5.5(-6) \mu\text{m}$, $Q_m=2.5$, hyphae inamyloid, in broadleaf forest, parks, gardens (*Quercus*, *Betula*), Europe, North Africa, Asia..... ***C. radicans****
- 5* pileus –15 cm wide, dark brown to olivaceous-brown, pores yellow to dingy buff, context instantly blue where bruised, stipe yellow, - temporarily with areas with pinkish-brown tints, predominantly at and inside base, finely reticulate, changing to blue where handled. Spores $12-16.5 \times 4-5.5(-6) \mu\text{m}$, $Q_m=2.7$, hyphae amyloid, associated with conifers (*Tsuga*, *Abies*), North America, China ***C. conifericola****
- 6 stipe surface not reticulated or longitudinal striate 7
- 6* stipe surface reticulated or with longitudinal streaks (compare 9+) 10
- 7 species with relatively short and broad spores: $8.5-9(-10.5) \times 6.5-7(-8) \mu\text{m}$, $Q_m=1.81$, pileus –10 cm in diam., with fibrillose to tomentose squamules, ochraceous to pallid yellow, context pink to reddish in stipe, light blue when injured, pores yellow, injured blueing, stipe smooth, yellowish grey to grey but becoming purplish upwards, with *Pinus*, China ***C. yunnanensis****
- 7* species with longer spores, hyphae inamyloid 8
- 8 with relatively narrow spores, $12.5-17.6 \times 4-5 \mu\text{m}$, pileus –16 cm in diam., deep olive buff, fading in age, stipe yellow above, pink to red below, context buff to yellow, in stipe occasionally dark red, blueing when cut, pores yellow, bruising blue, in coniferous and mixed forests. North America ***C. rubriceps****
- 8* spores wider and not as long either 9
- 9 spores $13.5-16 \times 4.5-5.5 \mu\text{m}$, $Q_m=3$, especially in the Mediterranean area with *Quercus ilex*, Europe, pileus –17 cm in diam., white then pallid hazel, pores yellow, injured blueing, stipe yellow above when young, turning whitish, yellow above, blood-red below, touched blueing, context whitish, blueing when cut, particularly in pileus, nearly not in stipe, blood red in the lower part of the stipe.
..... ***Boletus sanguineipes*#**
- 9* spores $12-15 \times 4.5-6 \mu\text{m}$, $Q_m=2.9$, primary with *Abies*, pileus whitish ivory, old darker, –25 cm in diam., soon tessellate, disrupting into polygonal squamules, pores light yellow, darkening to olivaceous brown, stipe yellow, red granulated, often longitudinally striped, context white to pale yellow, dark blue on exposure, cheilocystidia rather lageniform, Europe ***C. polygonius****
- 9+ spores sometimes somewhat wider, $Q_m=2.7$, also with *Fagus*, pileus pale grey, tan, –15 cm with a tendency to break up less strongly scaly, stipe tan to red carmine dotted, cheilocystidia more fusiform, Europe ***C. polygonius* var. *ereticulatus****

- 10 pileus with reddish tints (compare also 15*)..... 11
- 10* pileus without reddish tints..... 13
- 11 hyphae inamyloid 12
- 11* hyphae amyloid, pileus brownish, yellowish-greenish-beige, sometimes more, sometimes less carmine red, occasionally even with a hint of dark red, velvety, stipe bright yellow, dirty yellow above, broad red part below, greyish reticulated, context cream-coloured, often slightly pinkish under pileus cuticle or with occasional reddish spots, ± at the top of the stipe, spores 11–13 × 5–8 μm, hyphae amyloid, Europe *C. roseolivaceus*#
- 12 pileus –6 cm in diam., subtomentose to glabrous, dull pinkish-red, middle fading to brownish, context whitish to pale yellow, blueing upon exposure, reddish to deep raspberry red in most parts of the stipe, yellowish in the base, pores buff-yellow to dull, medium yellow, greyish-dingy yellow, blueing when bruised, spores 9–12 × 3.5–4.0(–5) μm, Qm=2.8, stipe apex lemon yellow, dark rose-red to pinkish red below, brownish to base, above reticulated, below ridged, under deciduous trees, North America. °*C. peckii**
- 12* pileus –25 cm in diam., only when young whitish-pallid, already there, but later unambiguous with pinkish-red to purple-pinkish tones, also reddening on pressure, tubes and pores yellow, on pressure blueing, stipe yellow, in the same colour reticulated, not radicating, context yellow, bruised blueing, under pileipellis reddish, spores 11.5–14(–16) × 4.8–6 μm, hyphae inamyloid, with deciduous trees, Europe *C. kluzakii**
- 13 hyphae amyloid 14
- 13* hyphae inamyloid 15
- 14 pileus –17 cm in diameter, pale, grey, light tan, brown olivaceous, tubes, pores and context lemon yellow, slightly blue in case of injury, context in base of stipe red, stipe above yellow otherwise raised blood red reticulum, spores 11–15(–16) × 4.5–5.5(–6) μm, with *Fagus* and notably montane with *Picea*, especially on acid soils. Europe, western Asia..... °*C. calopus* *
- 14* pileus –18 cm in diam., subglabrous, becoming areolate or fissured, yellowish-brown or greyish-brown, dark brown, context whitish(yellow), unchanging, in stipe red, partly blueing, pores yellow to greenish-yellow, staining blue, stipe thick, tapered towards base, finely reticulated, spores 11–15 × 4.5–5.5 μm, with conifers, North America..... *C. frustosus**
- 15 usually with coniferous trees..... 16
- 15* usually with deciduous trees or in mixed forests, pileus –13 cm in diam., whitish to greyish white or with pinkish grey tinge, becoming cracked, context whitish (yellowish), staining sky blue when exposed, in stipe with red zones, pores dull yellow at first, becoming olive or pale olive brown, bruising blue, stipe whitish or yellowish to brownish, above pink to red reticulum or dots, spores 9–15 × 3–5 μm, North America and Central America *C. inedulii**
- 16 pileus –14 cm in diam., felty-tomentose, scabrous, brown to brownish-orange, pores pale yellow, greyish yellow, changing to blue when bruised, context pale yellow, greyish red to brownish red at the base of stipe, changing to blue when cut, stipe red

- downward, greyish yellow at the apex, densely reddish brown to greyish red pruinose, spores 13.6–15.2(–16.4) × 5.4–6.0(–6.5) μm, highland (subalpine) forests dominated by *Abies*. Asia..... *C. panniformis**
- 16* pileus –12 cm in diam., tomentose, olive-brown, greyish brown, greyish tan, context white(yellowish), staining blue when exposed, in stipe with reddish areas, pores pale yellow, olive yellow, brownish yellow, staining blue when bruised, stipe scurfy-punctate, apex yellow, rosy red areas below, spores 10–14 × 3–4.5 μm, with *Tsuga* and *Picea*, North America..... *C. roseipes**
- 17 species with relatively short spores 18
- 17* species with longer spores..... 19
- 18 spores 8–10.5(–11) × 4–4.5(–5) μm, Qm=2.28, pores deep red, brownish red to ruby, unchanging when mature, quickly staining dark blue to blackish when bruised. pileus –7 cm in diameter, olive yellow, greyish yellow to brownish yellow, context white to pale red, turning bluish in the pileus and upper part of the stipe and pale red to dull red in the lower part when cut, stipe greyish yellow to greyish orange covered with deep red, brownish red to ruby reticulation, in broadleaf forests, China *C. taienus**
- 18* spores 9–11(–12) × 3.5–4.5 μm, Qm=2.43, pores reddish to reddish brown, later yellow or yellowish brown, changing bluish black when injured, pileus –10 cm in diameter, tomentose, dirty white to pale brown, context white, changing bluish quickly when injured, in stipe sometimes tinged with pale red, unchanging, stipe covered with pale brown, brown to reddish brown minute squamules, in forests dominated by *Castanopsis* or *Lithocarpus*, Asia *C. guanyui**
- 19 pores at first deep orange to reddish orange, greenish yellow to olive yellow when mature, staining dark blue when injured, spores 9–13(–13.5) × 4–5 μm, Qm=2.54, pileus –9 cm in diam., with fibrils or tomentose squamules, often slightly areolate or cracking, dull red to brownish orange, fading to greyish yellow, context white to yellowish, faint pinkish tinted and purplish pink beneath the pileipellis, staining light blue when exposed, in stipe brown to reddish brown, slowly blueing when injured, stipe yellowish white with a (vivid) red reticulation or longitudinal striated, in broadleaf forests (Fagaceae), China..... *C. xiangtoushanensis*
- 19* pores red or fox red or red orange, unchanging when mature 20
- 20 spores 9–15 × 3.5–5 μm, Qm=2,38, pores red to red-orange, unchanging when mature, blueing when bruised, pileus –15 cm in diameter, whitish to greyish, tan to pinkish tan or pale greyish olive, context whitish, to pale yellow, blueing when cut, stipe like pileus coloured, sometimes with reddish tints, with a slight red rediculation, in broadleaf and mixed forests (*Quercus*, *Fagus*), North and Central America. *C. firmus**
- 20* identical features as *C. calopus*, but pileus saturated chamois-beige, brownish, pores fox-red to red, Europe *C. calopus* var. *ruforubraporus*

Comments to some taxa

The many names cited as synonyms (generally not cited here, compare e.g. MIKŠIK & al. 2025) of *Caloboletus calopus*, but especially those from more recent times, give rise to the suspicion that there might be another species hidden behind them. There are even

some further European samples, designated as *Boletus calopus*, *Boletus pachypus* or *Caloboletus* sp. in GenBank. They show clear deviations from typical *Caloboletus calopus* but also from *Caloboletus polygonius/ereticulatus* and could very well represent another (new) species. Therefore, for example, the synonyms listed in the latest publication on boletes by MIKŠIK & al. (2025) could only be confirmed if the possible existence of different new species were established through macro- and microscopic description of the materials supplied to GenBank.

The same situation applies to *Caloboletus radicans*, where significant genetic diversity was found in the molecularly analysed samples of *C. radicans* from various parts of Europe. Interestingly, the GenBank contains sequences that show hardly any similarities to those of other *Caloboletus* species, and even some that point to (unidentified) species of other genera. One could also suspect that *Boletus sanguineipes* is one of the divergent samples. The differences are discussed in detail by PANZERA (1996, 1997) and SIVIANI (2008). The possible distinctness of the species can probably only be determined on a molecular genetic basis.

The occurrence of *Caloboletus calopus* outside Europe and western Asia is doubtful; in North America (BESSETTE & al. 2016) and East Asia (IMAZEKI & al. 1988) confusion with several species native to those regions, including those of other genera, is to be expected. BESSETTE & al. (2016) synonymized one of the North American species, *C. frustosus*, with *C. calopus*. The brown-capped *C. frustosus* in North America is one of the species that may have been misidentified as *C. calopus*. MILLER & WATLING (1969) already concluded that typical *B. calopus* does not occur in North America; however, they reduced *B. frustosus* to varietal status. KUO (2020a) shares this opinion, and ultimately, the independence of *C. frustosus* was confirmed based on molecular genetic findings (RAJPUT & al. 2025).

The same applies to *Caloboletus conifericola*, which is frequently misidentified as the aforementioned species, due to their high similarity. This issue also affects GenBank entries for both taxa. Collections reported as *C. conifericola* from China match North American material macro- and microscopically but show clear molecular genetic divergence (WANG & al. 2025). Whether this represents a cryptic lineage or an ecotype remains open.

The species *Boletus peckii* FROST caused the greatest confusion within the genus. The first material in GenBank, collected by R. PETERSEN in Tennessee in 1963, USA, with specimen number 3959 (GenBank accession no. JQ326999) deposited under this name was used for years in all publications on boletes (e.g. NUHN & al. 2013, WU & al. 2014) in phylogenetic trees, leading to great confusion. Molecular genetic results clearly showed that this specimen cannot be assigned to the genus *Caloboletus*. It could be a misidentified collection of a North American *Butyriboletus* species, when comparing with similar species in GenBank; e.g. compare *Butyriboletus pulchriceps* (BOTH, BESSETTE & R. CHAPM.) KUAN ZHAO & ZHU L. YANG (2015) and *Butyriboletus taughan-nockensis* I. SAFONOV (2017).

This led to a further misjudgment: ZHAO & al. (2015) transferred *Caloboletus peckii* into *Butyriboletus* based on this misidentified material.

A misinterpretation of *Boletus peckii* is, however, even more widespread among American mycologists in the literature, noticing in a discussion with E. BOTH (pers.

comm). BESSETTE & al. (2000, 2016) adopted BOTH's (1993) view of the species. Interestingly, in their 2016 description, changes to the text appear in some passages with "variously" and "or" (after the recombination to *Butyriboletus* in 2015?!).

Conclusions are drawn from the above facts and explanations by I. SAFONOV in Mushroom Observer forum, regarding a bolete that also agrees macro- and microscopically with the original description (compare also the type study by SMITH & THIERS 1971). SAFONOV described this species in Mushroom Observer obs. #MO246697, 286214, 283600, > GenBank acc. no. MH318614, MH347321, MH337297 (*Tef1*, which cluster all within *Caloboletus* and show that VIZZINI was right in making *peckii* a member of *Caloboletus* based on the morphology alone.

Unfortunately, the incorrect name "*Butyriboletus*" *peckii* is still largely retained in literature and in the worldwide web.

Boletus peckii, misidentified material from HONGO and other authors from Japan in GenBank: compare material that was named as *Boletus odaiensis*, *Boletellus indistinctus*, *Butyriboletus pseudocalopus*, possibly also undescribed species.

Based on the description provided by DAS (2013), the Indian "*B. rubripes*" should be *C. panniformis*.

Caloboletus guanyui, *C. griseoflavus*: Genus-relevant characteristics such as amyloid status and taste were not specified in the descriptions.

New combinations were created with *C. calopus* var. *ruforubriporus* [as '*ruforubraporus*'] (BLANCO-DIOS 2015) and *Caloboletus roseo-olivaceus* (SCHWAB 2019) and. No new findings were reported to confirm the recombination of the latter (BLUM 1970 himself is uncertain about the species and his information is very limited).

Comparisons of diverse sequences often show that misidentified material should be evaluated from a cross-continental perspective. This is precisely why worldwide comparisons make sense when dealing with atypical finds.

Given current knowledge, worldwide keys are needed, not only for *Caloboletus*. For example, *Chalciporus pseudopiperatus* KLOFAC & KRISAI is now considered to have a worldwide distribution (KLOFAC & KRISAI-GREILHUBER 2025).

The key included questionable taxa to highlight them, since atypical records are often not pursued and rare or locally restricted species may be misidentified.

Because some species are already recognized but still unnamed, the present key offers only a provisional overview.

Abbreviations of cited illustrations (IC.)

BRB1 BESSETTE A. E., ROODY, BESSETTE A. R. 2000: North American Bolete

BRB2 BESSETTE A. E., ROODY, BESSETTE A. R. 2016: Boletes of Eastern North America

MGS MIKŠIK, GELARDI, SIMONINI 2025: European Boletes 1

Mu MUNOZ, J. A. 2005: Fungi Europaei Boletus s. l.

SMJ ŠUTARA, J., MIKŠIK, M., JANDA, V. 2009: Hřibovité houby

* Authentic images available online in the worldwide web

not confirmed by molecular phylogenetic analysis

° material reviewed by the author

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