

An updated worldwide key to the genus *Hortiboletus*

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Abstract: Since the creation of the genus *Hortiboletus*, followed by the inclusion of several additional species from the genera *Boletus* and *Xerocomellus*, as well as the description of new species within this genus in recent years, a definitive overview of its actual distribution is far from complete. Therefore, an overview of the species known so far and an updated key are provided here.

Zusammenfassung: Seit der Schaffung der Gattung *Hortiboletus*, gefolgt von der Eingliederung einiger weiterer Arten aus den Gattungen *Boletus* und *Xerocomellus* sowie der Neubeschreibung von Arten innerhalb dieser Gattung in den letzten Jahren, ist eine endgültige Übersicht über die tatsächliche Verbreitung bei weitem noch nicht abgeschlossen. Daher wird hier eine Übersicht über die bisher bekannten Arten und ein aktualisierter Schlüssel gegeben.

Hortiboletus was erected as a new genus by SIMONINI, VIZZINI & GELARDI in 2015 (VIZZINI 2015), with only one species, *Boletus rubellus* KROMBH. as the type species. The genus is supported by phylogenetic analyses (NUHN & al. 2013; WU & al. 2014, 2016). In a recent study by BIKETOVA & al. (2025), morphological and molecular re-assessment, including phylogenetic delimitation, is addressed in more than sufficient detail in an almost monographic treatment. Therefore, further discussion is not the aim of this article but to give a short overview and an updated key to the species.

The first question to be addressed was to what extent the genus concept actually justified the separation from *Xerocomellus* ŠUTARA. A taxonomically critical genus in comparison was also *Rheubarbariboletus* VIZZINI, SIMONINI & GELARDI in Europe. The non-European genera *Parvixerocomus* G. WU & ZHU L. YANG and *Nigroboletus* GELARDI, VIZZINI, E. HORAK, T. H. LI & MING ZHANG are also phylogenetically related to the genus *Hortiboletus*.

XIE & al. (2020) published a worldwide key covering ten species. BIKETOVA & al. (2025), described 18 species of *Hortiboletus* worldwide, with up to seven additional undescribed ones mentioned in the genus and integrated into their phylogenetic tree. Several multigene analyses (ITS, LSU, *tef1-α*, and *rpb2*) support the integrity of the genus. Additionally, the genus diagnosis by SIMONINI & al. (VIZZINI 2015) was emended with a new, detailed description and discussion.

Alphabetical overview of *Hortiboletus* taxa with selected illustration references

- Hortiboletus amygdalinus* XUE T. ZHU, ZHU L. YANG 2016
Iconography (=IC): WU & al. (2016: fig. 45 m–o)
- Hortiboletus arduinus* N. K. ZENG, H. J. XIE, W. F. LIN 2020
IC.: XIE & al. (2020: fig. 2 a, b), ? WANG & al. (2024: fig. 14 j–k)
- Hortiboletus bubalinus* (OOLBEKK, DUIN) L. ALBERT, DIMA (2015)
IC.: BIKETOVA & al. (2025: fig.9), En 51, 52, GELARDI (2009: 12, 13), ÖZP 13: 257, Abb. XXII, *
- Hortiboletus campestris* (A. H. SM. & THIERS) BIKETOVA & WASSER 2015
IC.: BRB1 p. 288 l. a., BRB2 p. 222, *
- Hortiboletus coccyginus* (THIERS) C. F. SCHWARZ, N. SIEGEL, J. L. FRANK 2020
IC.: FRANK & al. (2020: figs. 7A–D), *
- Hortiboletus engelii* (HLAVÁČEK) BIKETOVA, WASSER 2015
IC.: BIKETOVA & al. (2025: fig. 11), BC 399, En 64, 65, *
- Hortiboletus flavorubellus* (THIERS & A. H. SM.) BIKETOVA & TREMBLE 2025
IC.: ? BRB1 p. 313 b. l., ? BRB2 p. 158, 159, *
- Hortiboletus hershenzoniae* BIKETOVA & WASSER 2025
IC.: BIKETOVA & al. (2025: figs. 13, 14), *
- Hortiboletus indorubellus* K. DAS, D. CHAKR., BAGHELA, S. K. SINGH, DENTINGER 2016
IC.: DAS & al. (2016: fig. 6)
- Hortiboletus kohistanensis* NASEER, S. SARWAR & KHALID 2019
IC.: NASEER & al. (2019: fig.1)
- Hortiboletus napaeus* N. K. ZENG, H. J. XIE, S. JIANG, ZHI Q. LIANG 2020
IC.: XIE & al. (2020: fig. 2 c–f)
- Hortiboletus rubellus* (KROMBH.) SIMONINI, VIZZINI & GELARDI 2015
IC.: BIKETOVA & al. (2025: fig. 6), BC150, En 54, 55, pl. 45/50, *
- Hortiboletus rubroreticulatus* T. H. G. PHAM, O. V. MOROZOVA, E. S. POPOV 2024
IC.: PHAM & al. (2024: fig. 4)
- Hortiboletus rufosquamosus* L. FAN, N. MAO & T. Y. ZHAO 2023
IC.: MAO & al. (2023: fig. 9 d–e)
- Hortiboletus rupicapreus* SVETASH., A. V. ALEXANDROVA, O. V. MOROZOVA, T. H. G. PHAM 2021
IC.: SVETASHEVA & al. (2021: fig. 15)
- Hortiboletus sinorubellus* YANG WANG, X. CHEN, B. ZHANG, YU LI 2024
IC.: WANG & al. (2024: fig. 14a–c)
- Hortiboletus subpaludosus* (W. F. CHIU) XUE T. ZHU, ZHU L. YANG 2016
IC.: WU & al. (2016: fig. 53/8a–d)
- Hortiboletus swaticus* Z. ULLAH, JABEEN, KHALID 2025
IC.: ULLAH & al. (2025: fig. 3)
- Hortiboletus tomentosus* L. FAN, N. MAO, T. Y. ZHAO 2023
IC.: MAO & al. (2023: fig. 9c)
- Boletus harrisonii* A. H. SM. & THIERS (= *H. campestris*)
- Boletus rubellus* var. *flammeus* A. H. SM. & THIERS (= *H. flavorubellus*)
- Boletus subfraternus* COKER & BEERS ex MEYERS & VAN T. COTTER (?= *H. flavorubellus*)
- Boletus erubescens* CADIÑANOS & MUÑOZ (?= *H. rubellus*)

World-wide key to *Hortiboletus* species

- | | | |
|----|--|----|
| 1 | Pileus surface usually, at least young, with dominant red colours (note that some other species can exhibit such red colours in an exceptionally rare appearance, such as <i>H. engelii</i> , compare 13) | 2 |
| 1* | Pileus surface without pure red colours in any stage (but see 9*, 12, 12*) | 13 |
| 2 | Pileus colour nearly not changing from red to brownish tones or not strongly bleaching | 3 |
| 2* | Red pileus colour later changing to brownish tones or strongly bleaching | 7 |
| 3 | Context and /or hymenophore not turning bluish when bruised. pileus rosy red to pink, that typically does not crack when mature. Spores $11\text{--}17.5 \times 5\text{--}7 \mu\text{m}$, coniferous forest, North America <i>H. coccyginus</i> | |
| 3* | Context and /or hymenophore turning bluish when bruised | 4 |
| 4 | Spores relatively short ($8.5\text{--}11 \mu\text{m}$) and not wider than $5 \mu\text{m}$ | 5 |
| 4* | Spores longer ($11\text{--}17 \mu\text{m}$) and wider than $5 \mu\text{m}$ | 6 |
| 5 | Pileus red, fiery-red spores $8.5\text{--}11 \times 4\text{--}5 \mu\text{m}$, $Q_m=2.04$, lawns, mixed forest?, China <i>H. arduinus</i> | |
| 5* | Pileus currant red to vivid red, cracked at mature, spores $10.7\text{--}11 \times 4.4\text{--}4.5 \mu\text{m}$, $Q_m=2.45$, coniferous forest, China <i>H. sinorubellus</i> | |
| 6 | Pileus red, later distinctly areolate, densely covered with red, dark red to reddish-brown squamules $11\text{--}14.5\text{--}17 \times 5\text{--}6.5\text{--}7 \mu\text{m}$, $Q_m=2.16$, in broadleaf forest dominated by <i>Quercus</i> , China <i>H. rufosquamosus</i> | |
| 6* | Pileus rose-red becoming paler pinkish-red, areolate in age, spores $11\text{--}14(15) \times 5\text{--}6\text{--}7 \mu\text{m}$, in open hardwoods, parks and shaded lawns, North America <i>H. campestris</i> | |
| 7 | Species with generally red pilei when young | 8 |
| 7* | Species often not with red pilei when young, but reddish tints possible at any stage (see also 13) | 12 |
| 8 | With orange-red dots in the stipe base context. Pileus surface old cracking | 9 |
| 8* | Without orange-red dots in the stipe base context | 10 |
| 9 | Pileus initially blood red, wine red, cherry red, rose red, often ochraceous-brownish bleaching, stipe red, context light blue on exposure, spores $10.3\text{--}11.6\text{--}12.8 \times (4.7\text{--})5.0\text{--}5.5\text{--}6 \mu\text{m}$, $Q_m=2.31$, in gardens, urban parks, lawns, fields, meadows, disturbed roadsides, forests, mostly under broadleaved trees, preferably <i>Quercus</i> , occurrence outside Europe and western Asia, as often cited in the literature, is not confirmed by molecular genetics <i>H. rubellus</i> | |

- 9* Young basidiomata usually with red pileus and yellow stipe, with age pileus can fade to various tints of brown or greyish-brown, areolate, stipe surface develops a dark-red tint, context only erratically blueing, Spores $11.4\text{--}13.9 \times 6.0\text{--}6.6 \mu\text{m}$, $Q_m=2.02$, thermophilous forests, with *Quercus*, Israel, Lebanon ***H. hershenzoniae***
- 10 Pileus deep red, paler in age, finally bleaching to yellow, context bruising greenish-blue, tubes and pores staining greenish, stipe reddish-pruinose, spores $10\text{--}13 \times 4\text{--}5 \mu\text{m}$, sphaerocyst-like cells in the trichodermium of pileipellis, North America ***H. flavorubellus***
- 10* Pileus not deep red, context not or only occasionally turning bluish when bruised 11
- 11 Pileus with small red scales unevenly arranged into a reticulate pattern on a white background, small-sized, $\sim 2.5 \text{ cm}$, first pinkish-red, greyish-red or brownish-red, context yellowish, unchanging, in stipe greyish-red, brownish-vinaceous, spores $11.5\text{--}12.5(-13) \times 4\text{--}4.6 \mu\text{m}$, $Q_m=2.8$, in tropical mountain evergreen forests, Vietnam ***H. rubroreticulatus***
- 11* Pileus reddish with fine brown to reddish-brown squamules, context and hymenophore unchanging, only occasionally turning bluish when bruised, spores $9\text{--}11(-13) \times 4\text{--}5 \mu\text{m}$, $Q_m=2.3$, in forests dominated by fagaceous trees, China ***H. napaeus***
- 12 Pileus brownish when young, reddish-brown and rimose-areolate at maturity, context staining brown upon exposure, not bluing, pores staining brown upon bruising, spores $(7.7\text{--})9\text{--}11 \times (3.8\text{--})4\text{--}5.3 \mu\text{m}$, $Q_m=2.2$, with *Quercus*, Pakistan ***H. kohistanensis***
- 12* Pileus wine red, red-brown to dull brown, here context staining blue quickly, pores staining blue immediately when bruised, spores $11\text{--}13(-14) \times (4\text{--})4.5\text{--}5(-5.5)$, $Q_m=2.46$. In forests dominated by *Pinus*, *Quercus*, and *Lithocarpus*, China ***H. subpaludosus***
- 13 Frequently with orange-red dots in the stipe base context, pileus usually dark brown then bleaching to ochraceous, buff, $\pm$ finely tomentose to sometimes rugulose, later areolate or with cracks over the whole surface, red stipe zones are rather rare, $Q_m=2.35$, Europe, under broadleaved trees, preferably with *Quercus*, North America, western Asia ***H. engelii***
- 13* Without or very seldom with orange-red dots in the stipe base context 14
- 14 Pileus context with pinkish zone under surface, pileus at first dark garnet red, margin pale orange. Later gradually fading to drab tinges and becoming orange ochraceous, sometimes with scattered pinkish hues, pores strongly bluing on bruising, context light green-blue to blue on exposure, Q = very variable $2.3\text{--}2.7$, $Q_m=2.46$, preferably with *Populus* (*Tilia*), Europe, North America, New Zealand ***H. bubalinus***

- 14* Pileus context without pinkish zone under surface 15
- 15 Stipe developing reddish brown to violet brown anastomosing veins, context bruising brownish to brownish-orange, unchanging or faintly bluing, with non areolate brown to dark brown pileus surface, pores 1 mm in diam., spores $10.6\text{--}15.3 \times 4.3\text{--}5.5 \mu\text{m}$, $Q_m=2.48$, subtropical broadleaf forest, India *H. indorubellus*
- 15* stipe yellow to yellowish brown 16
- 16 Spores $11\text{--}13 \times 4.5\text{--}5(-5.5) \mu\text{m}$, $Q_m=2.45$, basidiomata unchanging in colour when exposed, pileus liver brown, tomentose, pores 1–2 mm in diam., broadleaf forest, *Quercus*, China *H. tomentosus*
- 16* With areolate, rimose-diffract, cracking or squamulose pileus surface 17
- 17 Hymenophore turning blue 18
- 17* Hymenophore not turning blue, pores only 0.2–0.25 mm in diam., pileus brown, scaly, areolate, spores $(7\text{--})8.4\text{--}10.5(-11.7) \times (3.1\text{--})3.3\text{--}4.5(-4.8) \mu\text{m}$, $Q_m=2.4$, in *Quercus*-dominated forests, Pakistan *H. swaticus*
- 18 Pores 0.5–1 mm in diam., pileus surface strongly rugose when young, becoming glabrous and rimose-diffract with age, yellow-brown, red-brown, grey-brown, smell amygdaline or unpleasant, spores $10\text{--}12(-13.5) \times 5\text{--}6.5(-7) \mu\text{m}$, $Q_m=2.0$, forests of *Pinus*, *Fagaceae* (*Lithocarpus*), China *H. amygdalinus*
- 18* Pores larger, 1–1.5(–2) mm, with age becoming radially elongated up to 2–2.5 mm in diam., pileus buff, beige, pale ochraceous brown to (yellow)brown, cracking into tiny squamules, spores $9.4\text{--}11.2 \times 4.1\text{--}4.7 \mu\text{m}$, $Q_m=2.3$, tropical mountain evergreen forests, Vietnam *H. rupicapreus*

Extra-European collections that were identified as European species are based on misidentifications. Worldwide there are collections erroneously named *Boletus rubellus*. Until now the distribution of this species outside Europe has not been confirmed by molecular phylogenetic analysis. For example, *Boletus rubellus* identifications in USA are either *Hortiboletus flavorubellus* or new, unnamed species. The status of the many subspecies of *Boletus rubellus* as well as several other species described mostly from North America, such as *Boletus rubeus* FROST and *B. fraternus* PECK, still requires further research.

A possible identity between *H. amygdalinus* and *H. tomentosus* does not appear to be fully clarified, but a close relationship can be assumed, as evidenced by phylogenetic trees (MAO & al. 2023, BIKETOVA & al. 2025). However, the descriptions of the latter species in MAO & al. (2023) and WANG & al. (2024) differ considerably.

In the study of BIKETOVA & al. (2025), material from Austria (partly collections of *H. engelii*, respectively *Xerocomus quercinus* examined by H. ENGEL) was neither examined, nor included in the tree. The numerous finds of *Hortiboletus* species from Austria listed in the database (AUSTRIAN MYCOLOGICAL SOCIETY 2021– or deposited in the

herbarium WU-Myc were barely mentioned or listed in the distribution maps. Therefore, here is a supplementary overview.

The Austrian herbarium WU-Myc contains 26, the herbarium GJO seven specimens of *H. engelii*, WU-Myc nine specimens, GJO one specimen of *H. bubalinus*, WU-Myc 31, and GJO 23 specimens of *H. rubellus*. The Mycological Database of the AUSTRIAN MYCOLOGICAL SOCIETY (2021–) reports 246 finds of *H. engelii*, 11 of *H. bubalinus* and 265 of *H. rubellus*.

In addition, what is likely the first known collection of *H. bubalinus* outside the Netherlands, in Austria, was described and documented in detail, including photographs, by HAUSKNECHT & KLOFAC (2004).

Especially due to today's knowledge, worldwide keys are necessary, not only in the specific case of *Hortiboletus*, where, e.g., the occurrence of *H. bubalinus* also in North America and New Zealand must be taken into account. Thus, the occurrence of *Chalciporus pseudopiperatus* KLOFAC & KRISAI has, based on the latest results, already been extended to a worldwide distribution (KLOFAC & KRISAI-GREILHUBER 2025).

Due to the numerous species already recognized but unnamed, the present key only provides a current overview.

Abbreviations of cited illustrations (IC.)

- BC Bolets de Catalunya
 BRB1 BESSETTE A.E., ROODY, BESSETTE A. R., 2000: North American Boletes
 BRB2 BESSETTE A.E., ROODY, BESSETTE A. R., 2016: Boletes of Eastern North America
 En ENGEL, DERMEK, KLOFAC, LUDWIG, 1996: Schmier- und Filzröhrlinge s. l. in Europa
 ÖZP Österreichische Zeitschrift für Pilzkunde / Austrian Journal of Mycology
 * Authentic images available online in the world wide web

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