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Distribution and ecology of *Lactarius rostratus* and *Lactarius rubrocinctus* (Basidiomycota, *Russulales*) in the Czech Republic

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Lactarius rostratus and *Lactarius rubrocinctus* are two insufficiently known species of the Czech mycobiota. The historical data on occurrence of both species in the Czech Republic are summarised and recent localities are published. Original descriptions and colour illustrations of the species are provided. Differences with similar taxa are highlighted. The ecological preferences of both taxa supported by measurements of soil parameters from selected recent localities are outlined and discussed. *L. rostratus* should be characterised as an indicator species of valuable and unusual ectomycorrhizal communities associated with nutrient-poor beech forests on steep slopes on shallow and sandy to loamy-sandy soils. *L. rubrocinctus* favours near-natural mesophilous beech forests on base-rich substrates, although in the Carpathian part of Moravia it was recorded on comparatively acid soils as well.

Key words: *Lactarius* subgenus *Russularia*, soil pH, bioindicator, distribution maps.

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Ryzec maličký (*Lactarius rostratus*) a ryzec rudohrdlý (*Lactarius rubrocinctus*) patří k málo známým a zřídka nalézaným druhům české mykoflóry. V článku jsou shrnuty historické údaje o jejich výskytu v České republice a uveřejněny nové, dosud nepublikované nálezy obou druhů z posledních let. Popisy plodnic na základě vlastních nálezů jsou doplněny barevnými fotografiemi. Nastíněny a diskutovány jsou ekologické nároky obou taxonů doplněné výsledky měření pH a zrnitosti půdních vzorků z vybraných recentních lokalit. *L. rostratus* může být považován za indikační druh cenných a druhovým složením ojedinělých společenstev mykorhizních hub v živinami chudých bučinách na mělkých a písčitých či hlinitopísčitých půdách. *L. rubrocinctus* upřednostňuje přírodě blízké květnaté bučiny na bazickém podloží, v moravských Karpatech byl však zaznamenán i na kyselých substrátech.

INTRODUCTION

Lactarius rostratus Heilmann-Clausen (= *L. cremor* Fr.) is a member of *L.* subgenus *Russularia* (Fr.) Kaufmann, section *Olentes* Bataille (Heilmann-Clausen et al. 1998), associated mainly with *Fagus sylvatica* (Courtecuisse & Duhem 1995,

Heilmann-Clausen et al. 1998). According to Verbeken & Vesterholt (2008) the species prefers clay soils, Nespiak (1968) finds it characteristic of nutrient-poor beech forests of the *Luzulo-Fagion* alliance in Poland. In south(-western) Europe *L. rostratus* possibly prefers habitats on bare soil (Pinho-Almeida & Baptista-Ferreira 1997) and also forms mycorrhiza with other members of *Fagaceae* – *Castanea sativa* (Basso 1999) and several species of oak – for example *Quercus rotundifolia* (Pinho-Almeida et al. 1999) and *Quercus pyrenaica* (Comesaña & Castro 2000). Data on the rarity of this species in Europe are non-uniform. In northern and central Europe, *L. rostratus* is regarded as rare or uncommon by most authors (Verbeken & Vesterholt 2008, Heilmann-Clausen et al. 1998, Senn-Irlet et al. 2007). On the other hand, in some regions of southern Europe it can be frequent and is probably not threatened (Pinho-Almeida et al. 1999).

Lactarius rubrocinctus Fr. is currently considered to be a member of *L.* subgenus *Russularia* (Fr.) Kaufmann, section *Tabidi* Fr. (Heilmann-Clausen et al. 1998). The species is mostly regarded as an uncommon exclusive mycorrhizal partner of *Fagus sylvatica* preferring calcareous or rich soils in Northern and Central Europe (Basso 1999, de Roman et al. 2005, Heilmann-Clausen et al. 1998, Schwöbel 1979, Verbeken & Vesterholt 2008). A few authors report unusual association of *L. rubrocinctus* with other trees – for example Benedek & Pál-Fám (2006), who discuss three Hungarian records, none of them from pure beech stands. In one case it was found in a thermophilous oak forest, a second collection comes from mixed oak-pine forest and only the third locality is situated in a oak-hornbeam-beech forest. The occurrence of *L. rubrocinctus* in Great Britain in association with *Helianthemum* sp. on calcareous substrate is also very interesting and unusual (Andrews 2011). In south Europe (Corse island) it was collected several times in old stands with *Quercus ilex*, *Arbutus unedo* and *Cistus* species (Richard et al. 2004). According to the authors it is considered to form mycorrhiza with a broad range of angiosperms.

In the Czech Republic, both *L. rostratus* and *L. rubrocinctus* represent rare and insufficiently known milkcap species in terms of distribution and ecology. In the current Red list of fungi of the Czech Republic, *L. rostratus* figures in the Data Deficient category, whereas *L. rubrocinctus* is regarded to be critically endangered (Beran 2006a, b).

Only a few sporadic findings of both species are known from the country to date – probably partly due to neglect and confusion with similar taxa. In the last few years, several new localities have been discovered during field studies by the author and his colleagues.

The aim of this paper is (1) to publish original descriptions of macro- and microscopic characters of both species and discuss possible confusion with similar taxa, (2) to summarise both historical and recent field data on the occurrence of both species in the Czech Republic, and (3) to outline their ecological demands in

the Czech Republic and compare these findings with available literature from other parts of Europe.

MATERIAL AND METHODS

The macroscopic descriptions are based on a study of fresh fruitbodies and true colour pictures of the author's recent collections. Microscopic structures were observed on dried material under a light microscope in Melzer's reagent (spores size and ornamentation) and in 5% Congo-red in ammonia (basidia, cystidia, pileipellis) at magnifications of 400× and 1000×. Five to ten of each microscopic element were measured in each collection, resulting in values reflecting all measurements.

Three soil samples were taken at a depth of 10 cm at each of the selected localities in autumn 2011 to measure pH and (at localities of *L. rostratus*) grain size distribution. The soil samples were analysed in the pedological laboratory of the Department of Geography, Faculty of Science, Masaryk University, Brno. Soil pH values were determined in a water suspension.

Herbarium abbreviations used: PRM – National Museum, Prague; BRNM – Moravian Museum, Brno; CB – Museum of South Bohemia, České Budějovice; JB – private collection of Jan Běťák, Brno; DDv – private collection of Daniel Dvořák, Brno; HD – private collection of Helena Deckerová, Ostrava; VB – private collection of Vít Balner, Opava.

RESULTS AND DISCUSSION

Lactarius rostratus Heilmann-Clausen, in Heilmann-Clausen, Verbeken & Vesterholt, Fungi of Northern Europe (Greve) 2: 216 (1998). Figs. 1–5

= *Lactarius cremor* Fr., Epicr. syst. mycol. (Upsaliae): 343 (1838) [1836-1838].

Description. Fruitbodies rather small, solitary or rarely clustered, usually growing in large groups in moss cushions or on bare soil. Cap 15–40(50) mm, convex, applanate or undeeply depressed, sometimes with inconspicuous umbo or papilla; margin slightly inrolled or decurved when young and often remaining so until maturity, usually crenulate or shortly striate; surface dry, mat, usually distinctly rugulose and wrinkled, sometimes weakly radially venose in the central part, vividly orange or orange-brown when young, later brick orange to ochraceous orange, rarely somewhat paler in the outer part. Gills narrow and rather crowded, broadly adnate to distinctly decurrent, pale apricot when young, later more ochraceous and with rusty spots when bruised. Stem 12–30 × 3–10 mm,

cylindrical or flattened, at first pale ochraceous, later pale brick-brown to reddish brown. Flesh (pale) ochraceous, usually stuffed in the stem, mild to weakly disagreeable. Milk abundant, watery white to almost watery transparent, mild and sweetish. Smell distinct, sweetish resinous, rather unpleasant and strong when old.

Spores 6.7–8.0 × 5.7–7.0 µm, average 7.2 × 6.4 µm, Q = 1.06–1.32, average 1.14, subglobose or broadly ellipsoid; ornamentation up to 1.5 µm high, composed of warts and ridges connected into a zebra-like or irregular pattern with occasional closed meshes. Basidia clavate, 2- to 4-spored (also 3-spored basidia rarely observed), 30–48 × 8–11 µm. Cheilomacrocystidia small but very numerous, 20–35 × 4.0–6.5 µm, fusiform with thin acute to rostrate, rarely slightly moniliform apex. Pleuromacrocystidia similarly shaped as cheilocystidia but longer and not so numerous, 36–56 × 5–7.5 µm. Pileipellis a hyphoepithelium with subisodiametrical to isodiametrical cells in subpellis, with terminal elements up to 6 µm broad.

Notes on identification. In the field, *Lactarius rostratus* might be mistaken for especially other members of section *Olentes* Bataille. *Lactarius camphoratus* (Bull.) Fr. usually lacks vivid orange colours and the cap surface is usually smooth (not rugulose). Nevertheless, young or small specimens of *L. camphoratus* may sometimes remind old, dark or dry fruitbodies of *L. rostratus* in habit and colour. Although *L. camphoratus* has a broader ecological amplitude, both species are found at the same localities quite often. The smell is considered to be a good distinguishing feature in the literature. It is strong curry-like in *L. camphoratus* and also strong, but more sweetish resinous in *L. rostratus* (like bugs or *Hedera* leaves, according to Heilmann-Clausen et al. 1998 or Basso 1999). However, in a few cases I had problems in deciding whether the strong smell in old and dry fruitbodies of *L. rostratus* is sweetish or spicy. If in doubt, microscopic features allow to distinguish between these species: the warts of the spore ornamentation of *L. camphoratus* are almost isolated or only shortly connected and the cystidia are not so distinctly acute and rostrate at apex as in *L. camphoratus*.

Also *Lactarius serifluus* (DC.) Fr. may be found in the same habitats as *L. rostratus* and has a similar (but weaker) smell, but is characterised by usually larger fruitbodies with duller colours without orange tinges. In sect. *Olentes*, *Lactarius atlanticus* Bon is, concerning the colour, probably the most similar species to *L. rostratus*, but this is a south European species associated with Mediterranean oaks (mainly *Quercus ilex*) (Basso 1999) and has not yet been reported from the Czech Republic. Microscopically, *L. serifluus* and its relatives are easily distinguished from *L. rostratus* by the lack of true cystidia.

Fig. 1. *Lactarius rostratus*, Czech Republic, Chřiby hills, Smutný žleb Nature Reserve, 3 Aug. 2010 (JB10/771). Photo J. Běťák.

Fig. 2. *Lactarius rostratus*, Czech Republic, Kokořínsko, Osinalické bučiny Nature Monument, 19 Aug. 2010 (JB10/938). (JB 10/938). Photo J. Běťák.

Fig. 3. *Lactarius rostratus*, unusually large fruitbodies, Slovakia, Poloniny National Park, Udava National Nature Reserve, 16 Aug. 2011 (JB11/388). Photo J. Běťák.

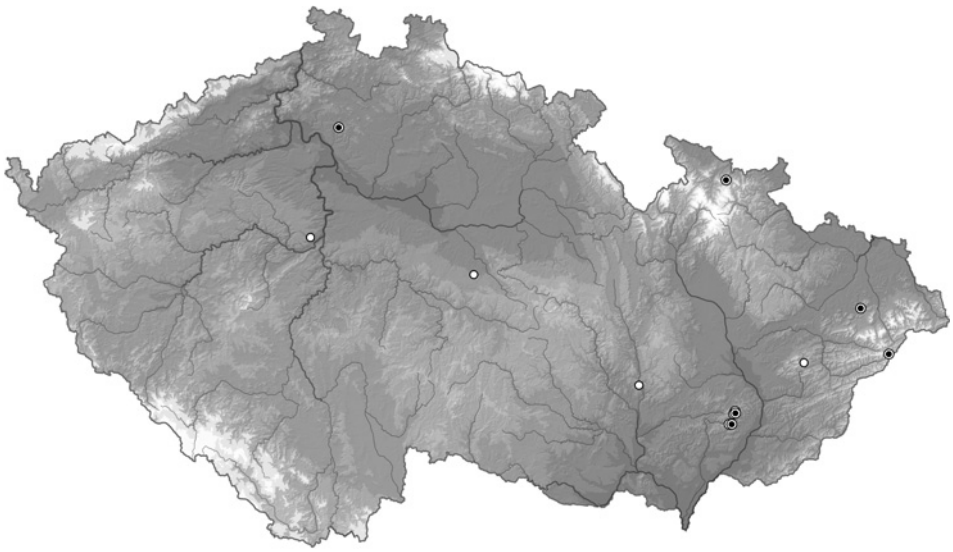

Fig. 4. *Lactarius rostratus* – distribution in the Czech Republic (black symbols highlight the localities discovered after 2000).

Fig. 5. Acidophilous beech forest (*Luzulo-Fagion*) – typical habitat of *Lactarius rostratus*, Czech Republic, Chřiby hills, Smutný žleb Nature Reserve. Photo J. Běťák.

Comments on distribution and ecology. According to my field observations in the Czech Republic, *L. rostratus* has very specific ecological requirements, which agree well with Nespiak (1968), who considers *L. rostratus* a characteristic species of acidophilous beech forests (*Luzulo-Fagion* association). Almost all recent Czech collections come from well-preserved, near-natural or extensively managed acidophilous beech forest reserves on steep slopes at middle altitudes on substrates with a high tendency of desiccation. It has rarely been collected at higher altitudes in beech-fir forests. Two historical collections from the Czech Republic come from an oak forest and a mixed forest without the presence of beech.

L. rostratus is in the Czech Republic mostly found on bare soil or in moss cushions (usually *Leucobryum glaucum*, *Polytrichum* sp. or *Dicranum* sp.). Most authors (Heilmann-Clausen et al. 1998, Basso 1999, Beran 2006a) report that the species favours heavy clay soils, but this does not agree with the results of the soil analysis from Moravian localities. The analysed soil samples were poor in fine grains (only 10 to 22 % of grains smaller than 63 µm, see Tab. 1) and according to Schoeneberger et al. (1998) the soils should be classified as loamy-sand soils.

Tab. 1. Brief characteristics of recent localities of *Lactarius rostratus* in the Czech Republic
[1)] average values of three soil samples from each locality

Area	**Locality**	**Date of collection**	**Substrate** (according to Geological Map 1:50000, taken from www.geology.cz)	**pH**[1)]	**Soil grain distribution**[1)] (weight % grains < 0.063 µm)	**Habitat**	**Altitude** (m a.s.l.)	**Collection number**
Moravskoslezské Beskydy Mts.	Salajka National Nature Reserve	VIII/2010	flysch (sandstone)	not measured	not measured	natural beech-fir forest	ca 750	HD
Podbeskydská pahorkatina hills	Hradní vrch Hukvaldy Nature Monument	VI/2010	flysch (sandstone/claystone)	not measured	not measured	nutrient-poor beech forest	400	VB
Chřiby hills	Maršava Nature Monument	VII–IX/2010	flysch (sandstone)	3.95	9.95; sand to loamy sand	near-natural acidophilous forest	360	JB 10/795, JB 10/805, JB 10/1303
Chřiby hills	Holý kopec Nature Reserve	IX/2010	flysch (sandstone/claystone)	not measured	not measured	near-natural nutrient poor beech forest	470	JB 10/1260
Chřiby hills	Máchova dolina Nature Monument	IX/2010	flysch (sandstone)	3.68	15.22; loamy sand	near-natural acidophilous forest	430	JB 10/1327
Chřiby hills	Smutný žleb Nature Reserve	VI–IX/2010	flysch (sandstone)	3.85	21.84; sandy loam	near-natural acidophilous forest	450	JB 10/498, JB 10/771, JB 10/1366
Chřiby hills	Salaš	VII/2011	flysch (sandstone)	3.96	16.11; loamy sand	nutrient-poor beech forest	320	JB 11/188
Kokořínsko	Osinalické bučiny Nature Monument	VIII/2010	quarcit sandstone with loess overlays	not measured	not measured	near-natural nutrient-poor forest	320	JB 10/938
Hrubý Jeseník Mts.	Prameny Javorné	VIII/2011	marble/phyllite	3.85	12.30; loamy sand	nutrient-poor beech forest	680	JB 11/448

The soil pH at the sampled localities varies between 3.7 and 4.0 (see Tab. 1), but their low trophic level might not be caused primarly by strong bedrock acidity. The species occurs at sites where the soil properties are apparently influenced by other ecological factors. An important role might be played by the relief – location on steep and convex parts of slopes (where the leaf litter has little chance to accumulate and water easily flows off) might be essential. A herb layer in such places is often completely missing or is represented by just a few acidophilous species (*Luzula luzuloides*, *Calluna vulgaris*, *Vaccinium myrtillus*, *Veronica officinalis*, etc.). On the contrary, the moss layer is usually well developed.

While the species obviously prefers habitats which are depleted of nutrients (as mentioned above) on sedimentary rocks of the flysch Carpathians, the habitats of *L. rostratus* in areas where strongly acidic bedrock dominates (localities in Kokořínsko and Hrubý Jeseník Mts.) are apparently influenced by the presence of comparatively more alkaline rocks (loess overlays and marble outcrops). However, this assumption of *L. rostratus* being associated with a special type of substrate should be further verified in the future, when more localities of the species will be discovered.

Some other uncommon ectomycorrhizal fungi often occur at the same localities with *L. rostratus*. For example, in the Chřiby hills, where the most abundant populations of the species were recorded, it was accompanied by *Albatrellus pescaprae*, *Boletus pinophilus* and several *Ramaria* species (*R. fennica* var. *fumigata*, *R. rubripermanens*, *R. flavescens*, *R. flavosalmonicolor*, *R. sanguinea*). Some rare hydnaceous fungi (*Hydnellum caeruleum*, *Hydnellum concrescens*, *Hydnellum compactum*, *Phellodon confluens*, *Phellodon niger*) were collected at the same localities as well.

There are nine recent localities of *Lactarius rostratus* known from the Czech Republic, two more are known from the 1980s (BRNM 457573 and 457577, Beran 2006a) and two collections are 70 years old (PRM 195215 and 193651). It is surprising that *L. rostratus* is not included in Schaefer's unpublished monography of Czechoslovak *Lactarii* (Schaefer, undated), although he knew this species with certainty already in 1940, as suggested by his revision of the voucher specimen from Golčův Jeníkov (PRM 195215). Most of the new finds from Moravia are located in the Chřiby hills, but the species was also recorded at higher altitudes in the Moravskoslezské Beskydy and Hrubý Jeseník mountains in the last two years. Just a single recent record comes from Bohemia (PLA Kokořínsko). For an overview of the Czech localities of *L. rostratus*, see Tab. 1 and Fig. 4.

Its small, possibly overlooked fruitbodies, which might be relatively easily confused with similar taxa, the irregular fructification (due to the easily desiccating habitats) and possibly also the lack of suitable well-preserved habitats could be the main reasons why the species has escaped the attention of mycologists in the Czech Republic for such a long time. On the other hand, *L. rostratus* has a com-

paratively long fructification period (late June to October with its maximum in August) and according to my observations it can be found in large quantities at its localities during favourable weather conditions in certain years.

Material studied

C z e c h R e p u b l i c. B o h e m i a. Českomoravská vrchovina Mts., Golčův Jeníkov, in moss cushion under *Quercus*, *Picea* and *Carpinus*, 5 Aug. 1940 leg. J. Herink, det. Z. Schaefer (PRM 195215, as *L. cremor*). – Český kras, Kosoř, Kopanský les, 24 Aug. 1941 leg. et det. S. Havlena (PRM 193651, as *L. cremor*). – Kokořínsko Protected Landscape Area, Osinalice, Osinalické bučiny Nature Monument, nutrient-poor beech stand, in *Polytrichum* sp. cushion under *Fagus sylvatica*, 19 Aug. 2010 leg. et det. J. Běťák (JB 10/938). – M o r a v i a. Moravskoslezské Beskydy Mts., Bílá, Salajka National Nature Reserve, old-growth beech-fir forest, in litter under *Fagus sylvatica*, 27 Aug. 2010, leg. et det. H. Deckerová (herb. HD). – Podbeskydská pahorkatina hills, Hukvaldy, Hradní vrch Hukvaldy Nature Monument, in mosses on a stony slope under *Fagus sylvatica*, 23 Jun. 2010, leg. et det. V. Balner et M. Graca (herb. VB). – Chřiby hills, Buchlovice, Maršava Nature Monument, acidophilous beech forest, on bare soil and in *Polytrichum* sp. cushion under *Fagus sylvatica*, 5 Jul. 2010 leg. et det. J. Běťák (JB 10/542). – Ibid., 4 Aug. 2010 leg. et det. J. Běťák (JB 10/795, JB 10/805). – Ibid., 15 Sep. 2010 leg. et det. J. Běťák (JB 10/1303). – Chřiby hills, Buchlovice, Holý kopec Nature Reserve, SE part, in poor beech-oak stand on bare soil under *Fagus sylvatica*, 14 Sep. 2010 leg. et det. J. Běťák (JB 10/1260). – Hostýnské vrchy hills, Košovy near Bystřice pod Hostýnem, in litter under *Carpinus betulus*, *Fagus sylvatica* and *Picea abies*, 19 Aug. 1984 leg. A. Vágner et D. Vágnerová, det. A. Vágner (BRNM 457577, as *Lactarius cremor*). – Salaš, ca. 1.2 km WNW of „Salaš tragedy" memorial in the Salašský stream valley (49°9'12.918" N, 17°18'57.303" E), nutrient-poor beech stand on steep slope, under *Fagus sylvatica* in *Leucobryum glaucum* cushion, 25 Jul. 2011 leg. et det. J. Běťák (JB 11/188). – Chřiby hills, Salaš, Máchova dolina Nature Monument, acidophilous beech forest, on bare soil under *Fagus sylvatica*, 16 Sep. 2010 leg. et det. J. Běťák (JB 10/1327). – Chřiby hills, Salaš, Smutný žleb Nature Reserve, acidophilous beech forest, under *Fagus sylvatica* in cushions of *Polytrichum* sp. and *Leucobryum glaucum*, 27 Jun. 2010 leg. et det. J. Běťák (JB 10/498). – Ibid., 3 Aug. 2010 leg. et det. J. Běťák (JB 10/771). – Ibid., 17 Sep. 2010 leg. et det. J. Běťák (JB 10/1366). – Hrubý Jeseník Mts., Rejvíz, Prameny Javorné (proposed Nature Reserve), ca. 650 m NW of the church in the village (50°14'3.969" N, 17°18'3.162" E), nutrient-poor beech stand, in *Polytrichum* sp. and on bare soil under *Fagus sylvatica*, 26 Aug. 2011 leg. et det. J. Běťák (JB 11/448). – Drahanská vrchovina hills, Útěchov near Brno, Coufavá National Nature Reserve, ca. 1 km NE of Útěchov, under *Quercus* sp. in moss, 31 Aug. 1985 leg. et det. A. Vágner (BRNM 457573, as *Lactarius cremor*).

G e r m a n y. Saarland, Brenschelbach, Grosser Wald, ca. 1 km NW of the village, in beech forest on clay soil in litter under *Fagus sylvatica*, 310 m a.s.l., 10 Oct. 2006 leg. et det. M. Beran (CB 15401). – Saarland, Buchholz, Mandelbachtal, ca. 4 km S of the village, beech stand with *Quercus robur* and *Larix decidua*, on clay soil, ca. 350 m a.s.l., 13 Oct. 2006 leg. et det. M. Beran (CB 15424).

S l o v a k i a. Poloniny National Park, Nová Sedlica, Rabia skala, under *Fagus*, 6 Aug. 1966 leg. et det. K. Kult (PRM 622217, as *L. cremor*). – Poloniny National Park, Osadné, Hlboké Nature Reserve, ca. 1.5 km NE from the church in the village, under *Fagus sylvatica* in acidophilous beech forest, 15 Aug. 2011 not. J. Běťák. – Poloniny National Park, Osadné, Udava National Nature Reserve, southern part by the tourist trail (49°10.782" N, 22°12.783" E), natural beech-fir forest, under *Abies alba* in fir-dominated stand, 16 Aug. 2011 leg. et det. J. Běťák (JB 11/388).

***Lactarius rubrocinctus* Fr.**, Monogr. Hymenomyc. Suec. (Upsaliae) 2(2): 176 (1863). Figs. 6–9

≡ *Lactifluus rubrocinctus* (Fr.) Kuntze, Revis. gen. pl. 2: 857 (1891).
= *Lactarius iners* Kühner, Bull. trimest. Soc. mycol. Fr. 69: 362 (1954) [1953].
= *Lactarius subsericeus* Hora, Trans. Br. mycol. Soc. 43(2): 445 (1960).

Description. Fruitbodies solitary or in small groups, typically stout and distinctly firm. Cap 40–130 mm, applanate or slightly convex when young, later becoming somewhat depressed in centre; surface dry or only slightly greasy, gradually becoming distinctly radially venose from centre, but sometimes (when young) only rugulose or nodulated, fulvous, pale orange-brown or pale ochraceous, sometimes more vivid ochraceous brown when young, often distinctly paler in outer part, fading during development, usually with rusty or orange-brown dots or spots when older. Gills narrow and rather crowded, broadly adnate to distinctly decurrent, sometimes forked and rarely anastomosing near the stem, pale apricot to pale pinkish-ochraceous, becoming weakly violaceous when gently rubbed in young specimens, later with numerous rusty or orange-brown spots. Stem ± cylindric, 40–80 × 10–23 mm, smooth, usually partly hollow, sometimes shallowly wrinkled in upper part, at first pale ochraceous, but soon brick or dark brick, with narrow dark vinaceous brown zone at top of stem, which is often (but not as a rule) most deeply coloured. Flesh firm, pale ochraceous to ochraceous-brown, mild, but slightly acrid or bitter after a while. Smell not very distinct, sweetish, similar to *Lactarius quietus*, but fainter. Milk white, unchanging, taste mild, sometimes slightly bitter or unpleasant after short time.

Spores ellipsoid to broadly ellipsoid, 7.9–9.7 × 6.0–7.5 µm, average 8.6 × 6.8 µm, Q = 1.09–1.59, average 1.26; ornamentation up to 1.0 µm high, formed by elongate warts and short ridges which are partly connected with thin lines to form an incomplete reticulum with rare closed meshes. Basidia cylindric to subclavate, 32–63 × 8–12 µm, average 41.6 × 10.1 µm, 4-spored, rarely 2-spored. Pleuromacrocystidia numerous and large, 65–115 × 8.5–14.5 µm, average 90.5 × 11.5 µm, conical with ± acute tips, sometimes slightly moniliform at apex. Cheilomacrocystidia shaped similarly but smaller, 32–80 × 5.0–13.0 µm, average 52.4 × 9.0 µm. Pileipellis a hyphoepithelium with isodiametrical to subisodiametrical elements (ca. 25 µm in diameter) in subpellis layer. Terminal cells usually shortly cylindric to clavate, up to 8 µm broad.

Notes on identification. Although *Lactarius rubrocinctus* is well characterised by the combination of macroscopic features, its identification may not be always easy in the field. Some of the most important characters are strongly influenced by the age of fruitbodies, e.g. the violaceous reaction of the gills or the dark brick coloured narrow zone on the upper part of the stem may be inconspicuous or completely missing in older specimens and the radially venose

surface of the cap may not be seen in young fruitbodies. On the other hand, the brick coloured stem, fading cap colours and rusty spots on the uneven cap surface and on gills in older specimens, as well as the stoutness of the fruitbodies seem relatively reliable features.

It is quite easy to verify field identification of *L. rubrocinctus* microscopically. The similar, but usually more vividly coloured species *Lactarius fulvissimus* Romagn. has spores with a lower Q-value and distinctly shorter and narrower cheilo- and pleuromacrocystidia. Furthermore, *L. fulvissimus* has a different type of pileipellis (ixotrichoderm), pleurocystidia are usually sparse and basidia are a bit longer (more than 50 µm on average). I do not find the character of spore ornamentation a reliable character distinguishing *L. rubrocinctus* and *L. fulvissimus*, as stated by Heilmann-Clausen et al. (1998). According to my observations, the spores of *L. fulvissimus* are characterised by a partly reticulate ornamentation with quite some ridges, which agrees well with Basso (1999).

Another similar but disputable species, *Lactarius britannicus* Reid, has presumably not been reported from the Czech Republic to date, but its occurrence in beech forests cannot be excluded. According to Basso (1999), this species differs mainly by darker pileus colours, slowly yellowing milk on a white handkerchief and isolated spore ornamentation. Heilmann-Clausen et al. (1998) found *Lactarius britannicus*, after revision of the holotypus, conspecific with *Lactarius fulvissimus*. Also the name *L. tithymalinus* (Scop.) Fr. refers to a doubtful taxon, which was used by Neuhoff (1956) for *L. rubrocinctus*. However, according to Heilmann-Clausen et al. (1998), the original description of *L. tithymalinus* probably represents another species. For further discussion on the identity of *L. tithymalinus*, see e.g. Schwöbel (1979) and Engel & Engel (1972).

When not paying sufficient attention, *L. rubrocinctus* may be mistaken also for the common *L. subdulcis*. The latter has distinctly smaller and more brittle fruitbodies with duller colours, lacks a violet reaction on the gills and a radially venose cap surface. Microscopically, both species look very similar, but the latter has somewhat smaller cystidia and a different type of pilleipellis (for more distinguishing features, see e.g. Heilmann-Clausen et al. 1998 and Basso 1999).

Comments on distribution and ecology. The first mention of *L. rubrocinctus* Fr. in the Czech Republic comes from 1954 (Schaefer 1955), but according to the description of the collection (yellowing drops of dried milk on the gills, more intensely orange colours, no violaceous reaction of the gills, occurrence under oaks), this clearly represents another taxon. The same author, in his unpublished monography of the Czechoslovak Lactarii (Schaefer, undated) assumed that Fries's *L. rubrocinctus* described from central Sweden differs from modern *L. rubrocinctus* sensu Lange (Lange 1928, 1940), and proposed the nomen novum *Lactarius langei* for Lange's taxon. Schaefer's description of this taxon is based on a study of fresh material from NE Poland and except for its

Fig. 6. *Lactarius rubrocinctus*, young fruitbody without typically radially venose cap surface, Czech Republic, Chřiby hills, Holý kopec Nature Reserve, 27 Jul. 2011 (JB11/250). Photo J. Běťák.

Fig. 7. *Lactarius rubrocinctus*, weak violaceous reaction of gently rubbed gills and well-developed dark zone at the stem top of young fruitbody, Czech Republic, Chřiby hills, Holý kopec Nature Reserve, 27 Jul. 2011 (JB11/250). Photo J. Běťák.

Fig. 8. *Lactarius rubrocinctus*, typical collection, Czech Republic, Kokořínsko, Břehyně-Pecopala National Nature Reserve, 18 Aug. 2010 (JB10/926). Photo J. Běťák.

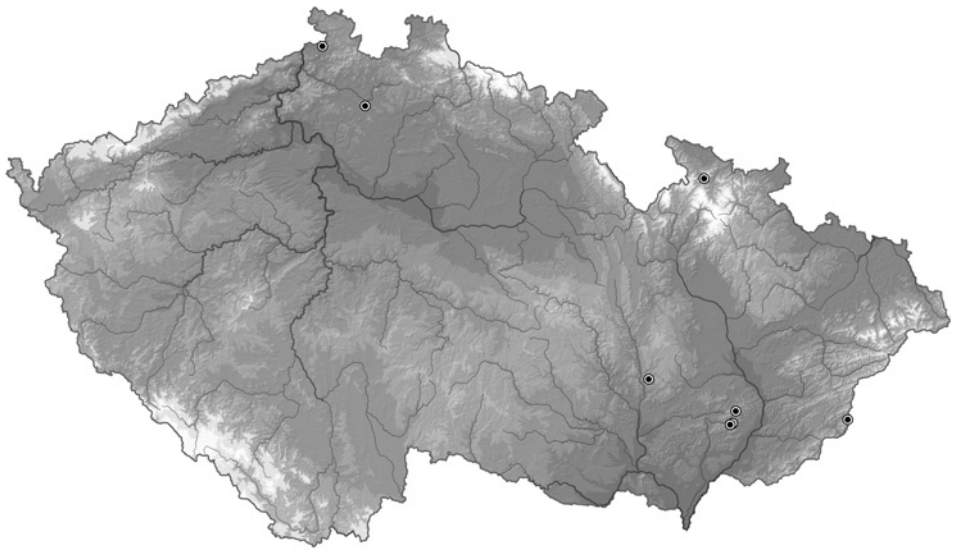

Fig. 9. *Lactarius rubrocinctus* – distribution in the Czech Republic (only reliably documented localities are shown).

ecology (old-growth hemiboreal forest) fits very well to Lange's conception. Nowadays, Fries's original *L. rubrocinctus* is considered to be possibly identical with *L. fulvissimus* (for more discussion, see Heilmann-Clausen et al. 1998). However, because the modern interpretation of the name *L. rubrocinctus* is well established, it is problematic to reject it. Instead, Heilmann-Clausen et al. (1998) proposed conservation of the name in the present sense, along with a neotypification. Schaefer reports *Lactarius langei* from four sites in the Czech Republic in his study, but only one of them is located in a beech forest (Javorina Nature Reserve in the White Carpathian Mountains). Unfortunately, probably none of the Czech collections of *Lactarius langei* was studied by Schaefer in fresh condition and, since neither his herbarium collections have been preserved (except some type specimens, not including *L. langei*), it is problematic to rely on his identification.

Only a few other voucher specimens are located in Czech herbariums under the name *L. rubrocinctus*. Kubička collected the species in 1977 in a spruce forest on limestone bedrock near Strakonice, but this represents very probably *Lactarius fulvissimus* (CB1381, Beran 2006b). Also historical collections under this name from PRM (PRM 608985) and BRNM (BRNM 305880) represent other taxa. Therefore, the first reliably documented locality of *L. rubrocinctus* in the Czech Republic dates from 2007, when it was collected in Bohemian Switzerland (PRM 909171). Since then, seven new localities of *L. rubrocinctus* were discovered in the Czech Republic, most of which are situated in protected areas in well-preserved old-growth submontane beech forests. Four localities are scattered throughout the calcareous and basalt areas of the country, four other records come from beech forests on flysch bedrock in the Carpathian part of Moravia. The Czech localities are situated at altitudes between 350 and 650 m, but on calcareous soil the species could also be found in montane beech-fir forests, as collections from the Veľká Fatra mountains in Slovakia indicate.

The preferences of *L. rubrocinctus* for base-rich substrates may not be as strict as reported (Basso 1999, Heilmann-Clausen et al. 1998, Verbeken & Vesterholt 2008). Soil reaction was measured at three localities on flysch substrates (pH = 3.92–4.44) and one on limestone (pH = 6.1). It appears that although the species generally prefers basic substrates, it may rarely also occur on acid soils with a pH of around 4 (see Tab. 2).

According to my field observations, *L. rubrocinctus* seems to prefer microhabitats with sufficient leaf litter and avoids steep slopes. In contrast to *L. rostratus* I have never collected this species growing on bare soil or in moss cushions. In three cases it was found at sites where nutrient-poor beech forest on a steep, convex slope, passes gradually into a mesophilous, herb-rich stand with sufficient leaf litter (at lower or concave parts of slopes). These sites are also the microhabitats with the lowest measured values of soil pH of all known Czech

localities (unsampled localities are situated on strongly base-rich substrates, whose pH should be distinctly higher – see Tab. 2).

At its localities, *L. rubrocinctus* often occurs together with other uncommon or rare mycorrhizal fungi with similar preferences. For example, in the Chřiby mountains, where the species was found at three localities, it shares its habitats with *Lactarius acris*, *L. pterosporus*, *L. romagnesii*, *L. ruginosus*, *Russula farinipes*, *R. puellula*, *R. solaris*, *Cortinarius cinnabarinus*, *C. croceocaeruleus*, *C. melanotus*, *C. subpurpurascens*, *C. turgidus*, *Inocybe corydalina* and *Hygrophorus poetarum*. Also the localities in the Moravian Karst and in the Rychlebské hory Mts. are situated in limestone beech forests, where many other rare mycorrhizal fungi occur.

The most important ecological characteristics of all recent localities of the species are given in Tab. 2.

Material studied

Czech Republic. Bohemia. Polomené hory hills, Hradčany, Břehyně-Pecopala National Nature Reserve, part called Pecopala, under *Fagus sylvatica* in old, near-natural beech forest, 18 Aug. 2010 leg. et det. J. Běťák (JB 10/926). – České Švýcarsko National Park, Vysoká Lípa, 2.7 km SSE of Hotel Lípa in the village, SE slope of the northern top of Mlýny hill, under *Fagus sylvatica* in near-natural forest on basalt rock, 18 Sep. 2007 leg. et det. J. Holec (PRM 909171). – Moravia. Chřiby hills, Buchlovice, Holý kopec Nature Reserve, northern slopes (48°06'21.8" N, 17°17'22.1" E), under *Fagus sylvatica* in near-natural beech forest, 2 Aug. 2010 leg. et det. J. Běťák (JB 10/735). – Ibid., 13 Sep. 2010 leg. et det. J. Běťák (JB 10/1181). – Ibid., 27 Jul. 2011 leg. et det. J. Běťák (JB 11/250). – Chřiby hills, Buchlovice, Maršava Nature Monument, southernmost segment, on slope over right bank of Dlouhá řeka stream, in litter under *Fagus sylvatica* in pure beech stand, 15 Sep. 2010 leg. et det. J. Běťák (JB 10/1279). – Moravský kras, Habrůvka, Habrůvecká bučina National Nature Reserve, E part, in pure beech stand on limestone, 5 Aug. 2010 leg. et det. D. Dvořák (DDv 186/10). – Rychlebské hory Mts., Lipová-lázně, Na Pomezí National Nature Monument, ca. 2 km N of railway station, S part, mixed forest with beech dominancy on limestone, 16 Aug. 2011 leg. et det. D. Dvořák (DDv 180/11). – White Carpathians Mts., Nedašov, Hrušová valley N–NW of the village, beech stand in southern part of valley (close to Jalovcová stráň Nature Reserve), under *Fagus sylvatica* and *Picea abies*, 5 Sep. 2010 leg. V. Antonín et S. Komínková, det. V. Antonín (as *Lactarius fulvissimus* Romagn.), rev. J. Běťák (BRNM 733479). – Chřiby hills, Salaš, Máchova dolina Nature Monument, in litter under *Fagus sylvatica* in nutrient-poor old beech stand, 16 Sep. 2010 leg. et det. J. Běťák (JB 10/1338).

Austria. Oberösterreich, Höllbachtal, limestone beech forest, 21 Sep. 1994 leg. et det. M. Beran (CB10641). – Oberösterreich, Kreh, on the ground in mixed forest (*Fagus*, *Picea*), 18 Sep. 1994 leg. et det. W. Klofac (CB 10731).

Slovakia. Veľká Fatra Mts., Ľubochňa, Ľubochnianska dolina valley, Čierny Kameň National Nature Reserve, mixed montane forest (*Fagus*, *Picea*, *Acer pseudoplatanus*, *Abies*), in litter under *Fagus sylvatica* and *Picea abies*, 29 Aug. 2002 leg. et det. A. Vágner (BRNM 670891). – Ibid., 29 Aug. 2002 leg. A. Vágner, det. M. Beran (CB). – Velká Fatra Mts., Ľubochňa, Ľubochnianska dolina valley, Kundračka National Nature Reserve, mixed montane forest (*Fagus*, *Picea*, *Acer pseudoplatanus*, *Abies*), in litter under *Fagus sylvatica* and *Picea abies*, 31 Aug. 2002 leg. et det. A. Vágner (BRNM 670876). – Ibid., 31 Aug. 2002 leg. et det. M. Beran (CB).

Switzerland. Brienz, mixed forest, 3 Oct. 1969 leg. et det. Z. Schaefer (BRNM 325842).

Tab. 2. Brief characteristics of recent localities of *Lactarius rubrocinctus* in the Czech Republic.
[1)] average values of three soil samples from each locality

Area	**Locality**	**Date of collection**	**Substrate** (according to Geological Map 1:50000, taken from www.geology.cz)	**pH**[1)]	**Habitat**	**Altitude** (m a.s.l.)	**Collection number**
Bohemian Switzerland	Vysoká Lípa	IX/2007	basalt	not measured	near-natural beech forest	420	PRM 909171
Chřiby hills	Holý kopec Nature Reserve	VIII, IX/2010 VII/2011	flysch (sandstone/claystone)	4.44	near-natural mesophilous beech forest	470	JB 10/735, JB 10/1181, JB 11/250
Chřiby hills	Maršava Nature Monument	IX/2010	flysch (sandstone)	4.04	near-natural nutrient-poor beech forest	360	JB 10/1279
Chřiby hills	Máchova dolina Nature Monument	IX/2010	flysch (sandstone)	3.92	near-natural nutrient-poor beech forest	430	JB 10/1338
Polomené hory hills	Břehyně-Pecopala National Nature Reserve	VIII/2010	sandstone (overlayed by loess?)	not measured	near-natural nutrient-poor beech forest	360	JB 10/926
Moravian Karst	Habrůvecká bučina National Nature Reserve	VIII/2010	limestone	not measured	near-natural mesophilous beech forest	400–450	DDv 186/10
White Carpathian Mts.	Nedašov	IX/2010	flysch (sandstone/claystone)	not measured	beech forest with spruce	650	BRNM 733479
Rychlebské hory Mts.	Na Pomezí National Nature Monument	VIII/2011	limestone	6.07	mixed forest with beech dominancy	ca. 600	DDv 180/11

CONCLUSIONS

Lactarius rostratus and *L. rubrocinctus* are in the Czech Republic known from nine and eight recent localities, respectively. Since most of them were discovered in a short period of 2 years, it is presumable that both species had partly been overlooked or misidentified for a long time. Nevertheless, since both species are found almost exclusively in well-preserved beech forest reserves, they should be considered threatened and should be included in the next version of the Red list of fungi of the Czech Republic. Insensitive forest management and fragmentation of suitable forest habitats are probably the main factors of threat for both species. The number of existing records is insufficient to reliably assess the ecological preferences of studied species, thus there is a need for further investigation. However, it seems that (at least in the Carpathians) *L. rostratus* should be considered a good indicator species of valuable and unusual ectomycorrhizal communities associated with nutrient-poor beech forests on steep slopes with shallow and sandy soils. *L. rubrocinctus* undoubtedly prefers habitats on neutral to base-rich soils with sufficient leaf litter in unmanaged or extensively managed old-growth beech forests, but may occasionally also be found on rather acid soils.

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