

## Ecology and distribution of white milkcaps in Slovakia

MIROSLAV CABOŇ, SLAVOMÍR ADAMČÍK

Institute of Botany, Department of Non-Vascular Plants, Slovak Academy of Sciences, Dúbravská cesta 9,  
SK-845 23 Bratislava, Slovakia; miroslav.cabon@savba.sk; slavomir.adamcik@savba.sk

Caboň M., Adamčík S. (2014): Ecology and distribution of white milkcaps in Slovakia. – Czech Mycol. 66(2): 171–192.

The study deals with the occurrence and ecology of five white milkcap species in Slovakia, *Lactarius controversus*, *Lactifluus bertillonii*, *Lactifluus glaucescens*, *Lactifluus piperatus* and *Lactifluus vellereus*. Recent molecular studies have shown that the reliability of field characters traditionally used for identification of white milkcaps is very low. Comparison of our field observations with microscopical analyses confirmed that the colour change of the latex is not a reliable feature to distinguish *Lactifluus glaucescens* and *Lactifluus piperatus*. An interesting result is the discovery that *Lactifluus bertillonii* was not recognised in the past (until 2013) and has been consistently misidentified as *Lactifluus vellereus* (8 herbarium specimens). Surprisingly, older specimens of *Lactifluus glaucescens* and *Lactifluus piperatus*, although well represented in the herbaria, were not frequently confused. Possible reasons are discussed.

**Key words:** *Lactarius controversus*, *Lactifluus bertillonii*, *Lactifluus glaucescens*, *Lactifluus piperatus*, *Lactifluus vellereus*, Slovakia, ecology, fungi, *Russulaceae*.

Caboň M., Adamčík S. (2014): Ekológia a rozšírenie bielych rýdzikov na Slovensku. – Czech Mycol. 66(2): 171–192.

Článok sa venuje výskytu a ekológii piatich bielych rýdzikov na Slovensku: *Lactarius controversus*, *Lactifluus bertillonii*, *Lactifluus glaucescens*, *Lactifluus piperatus* a *Lactifluus vellereus*. Nedávne molekulárne štúdie ukázali nízku spoľahlivosť terénnych znakov používaných tradične na rozlíšenie bielych rýdzikov. Porovnanie našich terénnych pozorovaní s určeniami za pomoci mikroskopu potvrdilo, že tradičný koncept založený na zmene farby mlieka nie je vhodný na rozlíšenie *Lactifluus glaucescens* a *Lactifluus piperatus*. Dôležitým zistením je, že *Lactifluus bertillonii* nebol v minulosti (do roku 2013) rozlišovaný a bol pravidelne zamieňaný za *Lactifluus vellereus* (8 herbárových položiek). Prekvapujúco sme nepotvrdili časté zámery *Lactifluus glaucescens* a *Lactifluus piperatus* medzi staršími herbárovými položkami, hoci oba druhy boli početné v študovanom materiáli; možné dôvody sú diskutované.

### INTRODUCTION

Milkcaps are traditionally defined as agarics with a trama composed of sphaerocytes and lactifers, easily recognised in the field by the non-fibrillose texture of the flesh which releases latex when bruised or cut (Buyck et al. on-line). In the past, they were classified within a single genus, *Lactarius* Pers. Recent phylogenetic studies (Buyck et al. 2008, Van de Putte et al. 2012, Verbeke et al. 2014, De Crop et al. 2014) have demonstrated a polyphyly of milkcaps and part of the

species is currently classified in the genus *Lactifluus* (Pers.) Roussel (Verbeken et al. 2011, 2012). A distinct morphological group are milkcaps with completely (at least when young) white basidiomata and white, acrid latex. They were often placed together in identification keys (e.g. Heilmann-Clausen et al. 1998) and sometimes also classified as one group, *Lactarius* sect. *Albati* Singer (Bon 1980). More recent publications classified white milkcaps in very different groups based on their pileipellis structure (Basso 1999, Heilmann-Clausen et al. 1998). Recent classifications based on phylogenetic studies (De Crop et al. 2014, Verbeken et al. 2014) do not put them into a single genus. Four European species with white basidiomata have been classified in the genus *Lactifluus* (further referred to as *Lf.*): *Lf. bertillonii* (Neuhoff ex Z. Schaef.) Verbeken, *Lf. glaucescens* (Crossl.) Verbeken, *Lf. piperatus* (L.) Roussel and *Lf. vellereus* (Fr.) Kuntze, whereas two white species are currently classified in the genus *Lactarius* (further referred to as *Lr.*): *Lr. controversus* Pers. and *Lr. resimus* (Fr.) Fr.

More recent molecular studies based on more extensive sampling of white milkcaps has also changed the morphological delimitation of the species. For example, De Crop et al. (2014) did not confirm the reliability of colour change and macrochemical reaction of the latex in distinguishing *Lf. piperatus* and *Lf. glaucescens*. The question therefore is: if the most frequently used identification keys to *Lactarius* sensu lato (Basso 1999, Heilmann-Clausen et al. 1998, Verbeken & Vesterholt 2008) were based on macromorphological characters which are now considered to have little phylogenetical significance, how many historical data are misidentified?

The objective of this study is a revision of the occurrence of five white milkcaps in Slovakia (the species listed above excluding *Lr. resimus*, which has not been reported from the country) based on the current species concept defined by micro-morphological characters. We have been motivated not only by the concept change of some species, but also by discrepancies in species reports from Slovakia in older and recent literature. Despite the numerous reports on white milkcaps from Slovakia (Lizoň & Bacigálová 1998), *Lf. glaucescens* was reported for the first time in 1999 (Kuthan et al. 1999) and *Lf. bertillonii* in 2013 (Adamčík et al. 2013). On the other hand, Adamčík et al. (2013) reported all four species of the genus *Lactifluus* as approximately equally frequent in thermophilous oak forest of SW Slovakia.

#### MATERIAL AND METHODS

This study is based on our own material (held in SAV) as well as on herbarium specimens deposited in the Slovak herbaria BRA, SAV and SLO (herbarium abbreviations according to Thiers on-line). The key by Heilmann-Clausen et al. (1998)

was used for preliminary identification of our own collections, which was mainly based on field characters. For identification of all herbarium material we used characters from species descriptions by Heilmann-Clausen et al. (1998) and for distinguishing *Lf. glaucescens* and *Lf. piperatus* also characters defined by De Crop et al. (2014). Both field and micro-morphological characters used in this study are presented in the Tab. 1. Heilmann-Clausen et al. (1998) distinguished the *Lactifluus* species also by a different colour change of the latex with KOH. A KOH solution was not used in this study since the diagnostic value of this macro-chemical reaction was disapproved (De Crop et al. 2013).

**Tab. 1.** Field characters (after Heilmann-Clausen et al. 1998) used for preliminary identification of the studied species and micro-morphological characters (according to De Crop et al. 2014) used for their final identification. Q is the length/width ratio of the spores.

	field characters	micro-morphological characters
<i>Lactifluus bertillonii</i>	cap velutinous, taste of latex acrid when isolated from flesh	pileipellis a lamprotrichoderm with thin-walled hyphal tips, average Q more than 1.3
<i>Lactifluus vellereus</i>	cap velutinous, taste of latex mild when isolated from flesh	pileipellis a lamprotrichoderm with thick-walled hyphal tips, average Q up to 1.3
<i>Lactifluus glaucescens</i>	cap smooth and dry, sometimes slightly wrinkled, milk turning greenish when drying	pileipellis a hyphoepithelium, suprapellis (consisting of narrow hyphae) thick, hiding the underlying cellular layer
<i>Lactifluus piperatus</i>	cap smooth and dry, milk turning whitish when drying	pileipellis a hyphoepithelium, suprapellis (consisting of narrow hyphae) thin, clearly showing the underlying cellular layer
<i>Lactarius controversus</i>	cap viscid, white with pinkish zones near cap margin, gills pinkish	pileipellis an ixocutis

Micro-morphological characters were observed under a Kapa Mic D117 light microscope at a magnification of 400× or with an oil-immersion lens at a magnification of 1000×. Spores were observed in Melzer's reagent. All other microscopic observations were made in ammoniacal Congo red, after a short treatment in aqueous 5% KOH. The identifications of *Lf. bertillonii* and *Lf. vellereus* are based on the average value of ten measurements. If the average spore length and width ratio (Q) was close to 1.3, we verified it by adding ten more measurements.

Information from herbarium labels listed in Material examined has been edited: data are arranged in a unified order and translated into English. Most herbarium specimens of the *Lactifluus* species were originally treated in the genus *Lactarius* (on herbarium sheets) because the first genus was only erected very recently (De Crop et al. 2014, Verbeken et al. 2014). The original identification is mentioned in Material examined only in case that the species was misidentified. The data are listed according to phytogeographical units (in alphabetical order) following the classification by Futák (1980). The location of the studied collec-

tions is presented in grid maps using the Central European grid mapping system (MTB) according to Niklfeld (1971), whereby the alphanumeric code starting with “Q” represents the grid square as defined in this mapping system.

## RESULTS AND DISCUSSION

In total, 139 collections of white milkcaps were studied: 82 from BRA, 47 from SAV (our own material) and 10 from the SLO herbarium. As a result of our revision 17 collections of *Lf. bertillonii*, 15 of *Lr. controversus*, 16 of *Lf. glaucescens*, 54 of *Lf. piperatus* and 32 of *Lf. vellereus* were identified (Tab. 2). One specimen (BRA CR17675, as *Lr. piperatus*) was not in a condition suitable for revision of microscopic characters. According to our revision of microscopic characters, 15 specimens (9%) had been misidentified. Four of them (three specimens originally identified as *Lr. piperatus* and one as *Lr. controversus*) are not related to any of the five white milkcaps. Eight specimens originally identified as *Lr. vellereus* turned out to be *Lf. bertillonii*, so these two species were the most frequently confused. Three collections originally named *Lf. piperatus* were according to our revision misidentified: one of them corresponds to *Lf. glaucescens* and two to *Lf. vellereus*.

**Tab. 2.** Number of confirmed identifications and originally misidentified specimens according to our revision of white milkcap species deposited in Slovak herbaria based on observations of micro-morphological characters. The table does not include herbarium specimens not belonging to any of the five species (according to our revision).

		Original identification				
		<i>Lactifluus bertillonii</i>	<i>Lactarius controversus</i>	<i>Lactifluus glaucescens</i>	<i>Lactifluus piperatus</i>	<i>Lactifluus vellereus</i>
Our revision	<i>Lf. bertillonii</i>	9				8
	<i>Lr. controversus</i>		15			
	<i>Lf. glaucescens</i>			15	1	
	<i>Lf. piperatus</i>				54	
	<i>Lf. vellereus</i>				2	30

The results of our field identifications were also compared with results based on observations of micromorphological characters (Tab. 1) for 43 of our collections deposited in SAV. This batch of specimens does not include our collections of *Lf. vellereus* collected before 2008, because in that period we did not distinguish it from *Lf. bertillonii* in the field. In most cases, the results of our field identifications correspond to the microscopy-based identifications. Three of our collections of the *Lf. glaucescens* – *Lf. piperatus* complex (out of 28 collections of

both species) were either incorrectly identified in the field or the identification was uncertain (intermediate change of latex colour after exposition to air).

Comparison of ITS sequences of 7 specimens (3 specimens identified as *Lf. glaucescens*, 3 as *Lf. piperatus* and one with greenish milk but spores and cap structure corresponding to *Lf. piperatus*) confirmed all identifications based on the microscopic characters observed by us (De Crop, unpublished data). The collection with greenish milk but the microscopic structure of *Lf. piperatus* also had an ITS sequence corresponding to the latter species, confirming that colour change of the latex is not a suitable character to distinguish these two species (De Crop et al. 2014).

***Lactifluus bertillonii* (Neuhoff ex Z. Schaef.) Verbeken**

Figs. 1, 6

**Ecology.** *Lactifluus bertillonii* grows in deciduous, preferably temperate broadleaved forests. It is mostly associated with *Quercus*, *Fagus*, *Betula* and *Castanea* (Heilmann-Clausen et al. 1998, Basso 1999). Basso (1999) also listed a collection associated with *Picea abies* from an altitude of 900 m a.s.l. among the studied material. In Fennoscandia and Denmark it is restricted to deciduous or mixed forests in the hemiboreal zone and the southern boreal zone (Kytövuori & Korhonen 1990). In Europe, it is widely distributed but only locally common (Heilmann-Clausen et al. 1998).

Most collections from Slovak herbaria were found in thermophilous oak forests (10 out of 17 specimens). Another type of habitat represented in herbarium data are mostly mixed montane forests (4 specimens), but collection BRA CR17718 is reported from montane spruce forest. The studied and published data suggest that this species is rather exclusively associated with deciduous trees, which were possibly overlooked in the collections from boreal/montane spruce forests. It seems that none of the Slovak collections originated from an altitude higher than 1000 m a.s.l.

**Occurrence in Slovakia.** The grid map in Fig. 1 indicating localities of 16 studied specimens shows two clusters. The larger cluster including the Trábeč Mts., Pohronský Inovec Mts. and Štiavnické vrchy Mts. is represented by collections from oak forests. The other smaller cluster in the north of Slovakia contains collections from montane forests. It seems that in some parts of the country the species is rather rare. For example, according to our revision of material used for the monograph of the fungi of the Vihorlat Mts. (Ripková et al. 2007), this species was not collected in the area during long-term research. Only one older specimen collected in 1888 (BRA CR17730, as *Lactarius vellereus*) was collected in that area.

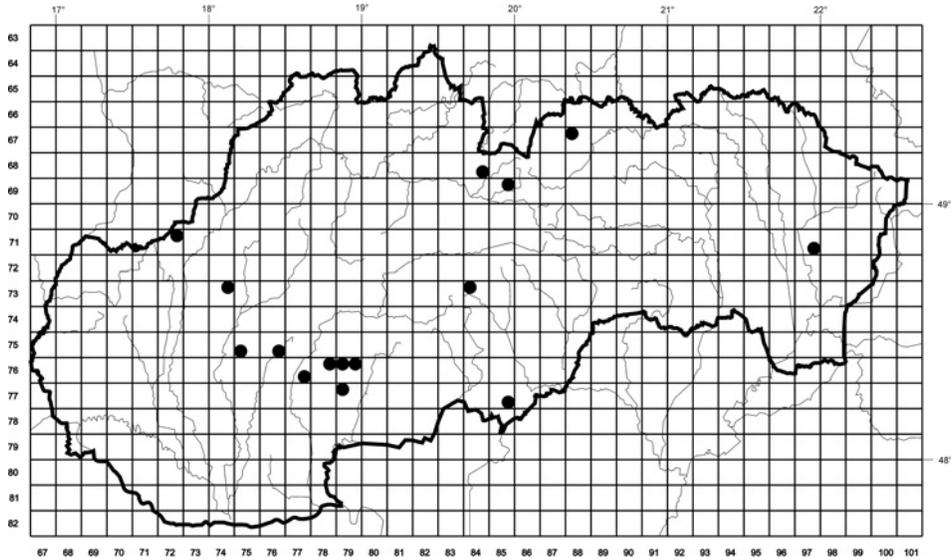


Fig. 1. Occurrence of *Lactifluus bertillonii* in Slovakia based on studied herbarium material.

*Lactifluus bertillonii* was first reported from Slovakia only very recently by Adamčík et al. (2013), but we demonstrated that the species is just as frequent as *Lf. vellereus* in the area of thermophilous forests in SW Slovakia. It was Norwegian mycologist Per Marstad, who alerted us to the presence of this species in Slovakia during joint field work in 2008. Since then, we not only have repeatedly collected and identified it, but we have demonstrated that the species had been completely ignored in the past, all available collections being deposited under the name *Lf. vellereus*. The first specimens of *Lf. bertillonii* identified as *Lr. vellereus* were collected in 1888. It is possible that among 10 older publications reporting *Lf. vellereus* some actually represent *Lf. bertillonii*, but we were able to locate only three herbarium specimens corresponding to these reports (see comments on *Lf. vellereus*).

**Notes.** In several cases it was necessary to combine both micro-morphological characters (Tab. 1) to distinguish *Lf. bertillonii* and *Lf. vellereus*, because either the spores were of intermediate shape or the wall thickness of hyphal terminations in the pileipellis was variable within a single collection. Considering morphology and ecological preferences, both species are apparently closely related, but no molecular studies have been published confirming the distinction of these two species. Our preliminary phylogenetic analyses of an alignment containing two UNITE sequences of *Lf. bertillonii* (<http://unite.ut.ee/>) and six UNITE sequences of *Lf. vellereus* provide strong support for distinction of the species pair (unpublished data).

**Material examined**

Slovakia. Biele Karpaty Mts. (southern part), Q 7172b: Nová Bošáca, ca. 1.5 km NNE of the church in the village, Grúň Nature Monument, coord. 48°53'39.2" N, 17°47'48.9" E, alt. 463 m, forest with *Quercus* sp., 9 Jul 2002, leg. S. Ripková as *Lr. vellereus* (SLO 517). – Ipeľsko-Rimavská brázda furrow, Q 7785d: Hajnáčka, 3.5 km NNE, NW slope of Steblová skala hill, coord. 48°14'47.46" N, 19°58'41.42" E, alt. 250–450 m, terrestrial, *Quercus* sp., *Fagus sylvatica*, 25 Oct 2002, leg. S. Adamčík (SAV F-945). – Liptovská kotlina basin, Q 6884d: Pribylina, 4 km ENE, site named Hrdovo, spruce forest, 17 Aug 1995, leg. P. Škubla as *Lr. vellereus* (BRA CR17718). – Q 6985b: Východná, 3 km NNE, site named Krátke, under *Corylus*, 19 Sep 1985, leg. J. Kuthan as *Lr. vellereus* (BRA CR17722). – Podunajská nížina lowlands, Q 7374b: Nemečky, ca 1 km W, near lake Duchonka, oak forest, 12 Jun 1983, leg. L. Hagara as *Lr. vellereus* (BRA CR17720). – Pohronský Inovec Mts., Q 7576d: Obyce, 1 km ENE, coord. 48°26'06" N, 18°28'38" E, alt. 350–500 m, terrestrial, *Quercus*, 6 Sep 2007, leg. S. Adamčík (SAV F-1376). – Poľana Mts., Q 7384a: Drábsko, 3.5 km NE, Dobročský prales National Nature Reserve, coord. 48°41'01" N, 19°40'45" E, alt. 800–1000 m, terrestrial, *Abies*, *Fagus*, 29 Sep 2009, leg. S. Ripková as *Lr. vellereus* (SLO 516). – Spišské kotliny basin, Q 6788a: Vojňany, 2 km WNW, Dlhá Hora ridge, southern slope, 49°15'37" N, 20°24'42.92" E, alt. 780–850 m, *Corylus*, *Picea*, *Abies*, 26 Aug 2014, leg. M. Caboň (SAV F-4339). – Štiavnické vrchy Mts., Q 7677d: Nová Dedina, 3.5 km N, Sovia dolina valley, coord. 48°19'09" N, 18°38'37" E, alt. 390–410 m, terrestrial, *Quercus*, *Carpinus*, 21 Jul 2008, leg. S. Adamčík (SAV F-2490). – Q 7678b: Jabloňovce, 4 km N, Bohunický Roháč hill, coord. 48°21'43" N, 18°46'41" E, alt. 380–500 m, terrestrial, *Quercus* sp., 27 Jun 2006, leg. S. Adamčík (SAV F-1470). – Q 7679a: Prenčov, 3 km NNW, slope of Sitno hill, coord. 48°23'04" N, 18°53'32" E, alt. 520–540 m, terrestrial, *Quercus*, *Carpinus*, 22 Jul 2008, leg. S. Adamčík (SAV F-2491). – Q 7679a: Prenčov, 2.5 km NW, Horné Majere settlement, coord. 48°22'54" N, 18°54'01" E, alt. 420–460 m, terrestrial, *Quercus*, *Carpinus*, 22 Jul 2008, leg. S. Adamčík (SAV F-2492). – Q 7679b: Prenčov, 1888, leg. A. Kmeť as *Lr. vellereus* (BRA CR17734). – Q 7679b: Prenčov, site named Čierne blatá, 10 Jul 1988, leg. A. Kmeť as *Lr. vellereus* (BRA CR17737). – Q 7779a: Sebechleby, 3.5 km WNW, Stará Hora settlement, coord. 48°16'54" N, 18°54'13" E, alt. 290–300 m, terrestrial, *Quercus*, *Carpinus*, 13 Jul 2010, leg. S. Adamčík (SAV F-4159). – Tríbeč Mts., Q 7575c: Jelenec, 2 km NW, around campsite, coord. 48°24'04" N, 18°12'26" E, alt. 230–250 m, terrestrial, *Quercus*, *Carpinus*, 12 Jul 2010, leg. S. Adamčík (SAV F-4160). – Vihorlatské vrchy Mts., Q 7197d: Kaluža, 1 km NE, forest with *Quercus* and *Carpinus*, 17 Jul 1988, leg. J. Humeňanský as *Lr. vellereus* (BRA CR17730).

***Lactarius controversus* Pers.: Fr.**

Figs. 2, 7

**Ecology.** This species is known to be associated with preferably *Populus* or *Salix*. It is reported as particularly frequent from coastal dunes with *Salix repens* (Rayner 2005), roadside plantations of *Populus* × *canadensis* (Heilmann-Clausen et al. 1998), wooded meadows and pioneer forests with *Populus tremula* (<http://unite.ut.ee/>), and margins of forests with *Populus* or *Salix* (Basso 1999). Basso (1999) also lists tree genera *Castanea*, *Quercus* as possible mycorrhizal partners.

Most of the 15 studied Slovakian specimens are reported to be associated with *Populus*. One collection is associated with *Salix caprea* and *Picea*, another one is reported from *Alnus* forest and a third one reported to grow under *Carpinus*. All types of habitat known from the literature (see previous paragraph) are also mentioned in the Slovak herbaria. The most frequent habitat is *Populus* plantations in

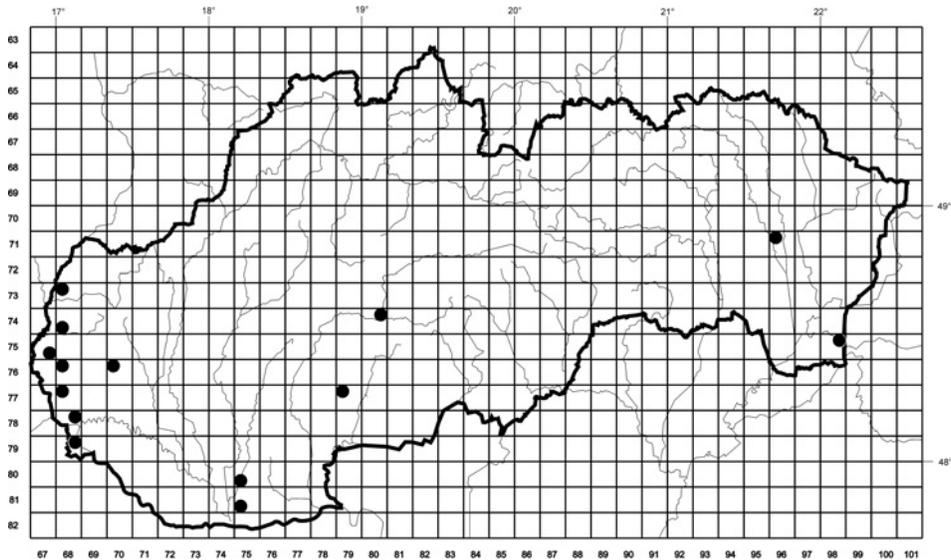


Fig. 2. Occurrence of *Lactarius controversus* in Slovakia based on studied herbarium material.

urban areas. In addition, we have two records from a pond shore and one from a floodplain forest, which seems to be another habitat preferred by the species.

**Occurrence in Slovakia.** According to herbarium data, the species is well distributed from the west to the east of the country (Fig. 2). Most herbarium collections (9 of 15 studied) originate from lowlands in the southern part of the country. Those from the Záhorská nížina lowlands, an area known for sandy soil, are especially frequent. All other collections are from foothills and low altitudes.

*Lactarius controversus* was reported from Slovakia in seven publications (Dermek & Pilát 1974, Dermek & Michalko 1975, Fábry et al. 1975, Dermek 1978, Hagara 1992, 1993 and Adamčík & Hagara 2003) which mention habitats similar to the herbarium data. All data originate from lowlands or low altitudes and four publications report collections exclusively from the Záhorská nížina lowlands. We did not locate any specimen mentioned in this literature in Slovak herbaria.

**Notes.** The large white basidiomata combined with pinkish gills and a sticky to slimy cap, which is often zonate and has pink to purple tinges as well, seem to be sufficient characters to recognise *Lr. controversus*. Accordingly, this is the only species not confused with other species of large white milkcaps. The most similar in the field is *Lr. evosmus*, which may also have a similar ecology (e.g. floodplain forests with *Quercus* and *Populus*), but differs in a darker brownish yellow and usually more distinctly zonated cap.

**Material examined**

Slovakia. Malé Karpaty Mts., Q 7768a: Marianka, 0.5 km NE, Starý Háj forest, on top of Svätý vrch hill, under young trees of *Populus tremula*, 6 Oct 1990, leg. J. Sand (BRA CR20903). – Q 7868b: Bratislava-Krasňany, near factory of Meopta, under *Populus* sp., 3 Oct 1980, leg. Z. Novák (BRA CR20906); *ibid.*, 28 Sep 1981, leg. Z. Novák (BRA CR20905). – Podunajská nížina lowlands, Q 7670a: Budmerice, in park near the castle, under *Populus tremula*, 23 Sep 1989, leg. L. Hagara (BRA CR20904). – Q 7968b: Bratislava-Rusovce, on ground in park near the castle, 10 Aug 1980, leg. I. Záborský (BRA CR20899). – Q 8075c: Hurbanovo, ca 1.2 km NW, Pavlov Dvor hamlet, north bank of the pond, on sandy soil under *Populus*, 10 Sep 2006, leg. L. Hagara (BRA CR17950). – Q 8175c: Chotín, Chotínske piesky National Nature Reserve, on the ground under *Populus*, 2 Oct 1983, leg. J. Kuthan (BRA CR20902). – Poľana Mts., Q 7480b: Zvolen, 2 km N, Arborétum Borová Hora, coord. 48°35'51" N, 19°08'17" E, alt. 300–370 m, *Salix caprea*, *Picea*, 28 Jun 2009, leg. S. Ripková (SLO 518). – Štiavnické vrchy Mts., Q 7779a: Ladzany, 3 km NW, Háj forest, under *Carpinus betulus*, 20 Sep 1984, leg. Procházka (BRA CR20900). – Východoslovenská nížina lowlands, Q 7196a: Vranov nad Topľou, 500 m NW, *Atrius* forest, 5 Sep 1993, leg. S. Adamčík (BRA CR20901). – Q 7598b: Botany, Latorický luh National Nature Reserve, poplar forest (*Populus nigra*), alt. 101 m, 15 Sep 1996, leg. L. Hagara (BRA CR18097). – Záhoriská nížina lowlands, Q 7368a: Brodské, 14 Sep 1969, leg. A. Dermek (BRA CR18959). – Q 7468c: Závod, 1 km ESE, Abrod National Nature Reserve, coord. 48°32'00" N, 17°00'25" E, alt. 150 m, on pond bank, in bushes under *Populus alba*, 26 Sep 2013, leg. M. Caboň (SAV F-4217). – Q 7567d: Láb – Jakubov (nearby villages; herbarium label without clearer information), 9 Sep 1972, leg. I. Fábry (BRA CR18958). – Q 7668a: Plavecký Štvrtok, 12 Sep 1963, leg. I. Fábry (BRA CR18957).

***Lactifluus glaucescens* (Crossl.) Verbeke**

Figs. 3, 8–9

**Ecology.** Information on the ecology of *Lactifluus glaucescens* in monographic publications is very general. It is known from deciduous forests and has a wide distribution range in Europe. Heilmann-Clausen et al. (1998) suggest its preference for calcareous soil. According to Basso (1999), it grows in summer soon after *Lf. piperatus* appears, which corresponds with our experience.

Most of the 16 Slovak collections examined in our study were collected recently (after 2000), originating from thermophilous forests at low altitudes and associated with *Quercus* and *Carpinus*. Most collections listed in the monograph by Basso (1999) are associated with *Castanea* or *Fagus* (the latter tree also listed with a few Slovak collections). Basso also listed one Swedish collection associated with *Betula*. We recently confirmed the wide host range of *Lf. glaucescens* by collecting it in mixed forest (*Corylus*, *Picea* and *Abies*) at an altitude of ca. 800 m a.s.l. According to the distribution of the basidiomata under the trees it seemed to form mycorrhiza with *Corylus*. We cannot confirm a preference of this species for calcareous soil, since most studied collections originate from areas with andesite bedrock and argillaceous brown forest soil with a pH typically decreasing with altitude (Čurlík & Števcík 1999).

**Occurrence in Slovakia.** Herbarium data and our personal experience suggest that *Lf. glaucescens* is not a common species in general but is locally common. In Slovakia it is especially common in the area of the Štiavnické vrchy Mts.

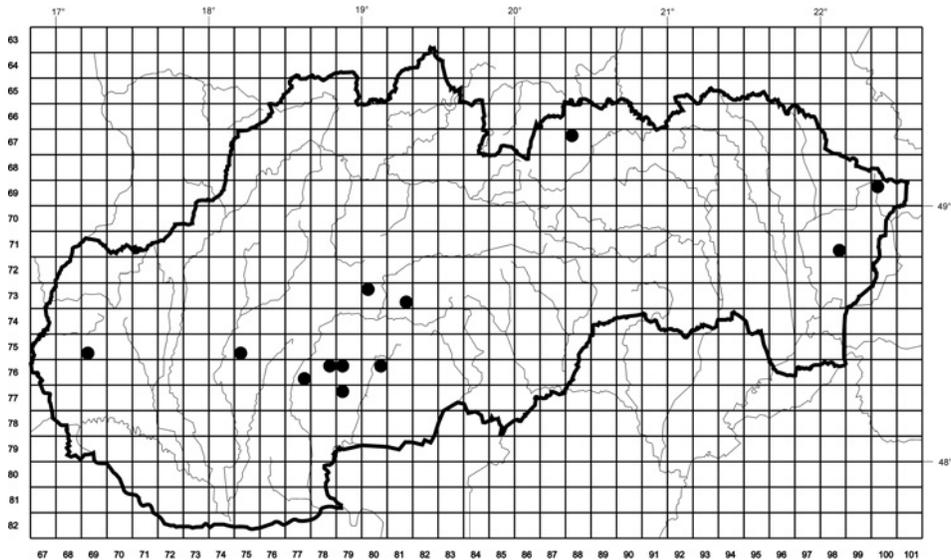


Fig. 3. Occurrence of *Lactifluus glaucescens* in Slovakia based on studied herbarium material.

(Fig. 3). Published lists of collections from long-term research in the Poloniny Mts. (Kuthan et al. 1999), Vihorlatské vrchy Mts. (Ripková et al. 2007) and Biele Karpaty Mts. (Adamčík et al. 2006a) show that *Lf. piperatus* is more common and *Lf. glaucescens* is rather rare. Our microscopy-based revision of herbarium specimens confirmed the rare occurrence of *Lf. glaucescens* not only in the above-mentioned areas, but revealed the same pattern for the Malé Karpaty Mts., where only three out of 16 specimens of the *Lf. piperatus*-complex belong to *Lf. glaucescens*.

To our surprise, there is only one specimen in the BRA and SLO herbaria identified as *Lactarius piperatus*, which is in fact *Lf. glaucescens* (BRA CR17678), another 39 specimens correspond to *Lf. piperatus*, and two were revised as *Lf. vellereus*. This *Lf. glaucescens* specimen is the oldest (collected in 1977) that we studied, but Kuthan et al. (1999) mentions two specimens collected in 1969 and deposited in the Czech PRM herbarium, which might be the oldest documented records published in the country. In our opinion, the dominance of *Lf. piperatus* among older collections in the BRA and SLO herbaria, contrasting with an almost equal number of both species among our recent collections (13 our collections of *Lf. glaucescens* vs. 14 of *Lf. piperatus*), does not reflect the increasing spread of *Lf. glaucescens*. Our data suggest that older collections originate from areas where *Lf. glaucescens* is rare. There are seven older collections of *Lf. piperatus* from the Štiavnické vrchy Mts., but six are from the Prenčov area, where *Lf. piperatus* recently dominated and the second species was very rare.

A more prosaic explanation of the unequal proportion of *Lf. glaucescens* among older material is that *Lf. piperatus* grows before and after dry periods, so it is often one of the few available species to pick for herbarium objectives, while *Lf. glaucescens* grows in a season with the highest diversity of fruiting agarics (Basso 1999).

Notes. All four publications reporting *Lf. glaucescens* from Slovakia (Adamčík et al. 2006b, Adamčík et al. 2013, Ripková et al. 2007, Kuthan et al. 1999) are relatively recent. We confirmed the identification of at least one specimen reported in each of them.

#### Material examined

Slovakia. Bukovské vrchy Mts., Q 69100a: Ruské, on dry site under *Betula* and *Fagus*, 6 Jul 1995, leg. S. Adamčík (BRA CR17673). – Kremnické vrchy Mts., Q 7380a: Badín, Badínsky prales National Nature Reserve, on the ground under *Fagus*, 13 Jun 1983, leg. J. Kuthan (BRA CR17672). – Malé Karpaty Mts., Q 7569c: Kuchyňa, site named Vývrať, on the ground in oak forest, 19 Jul 1977, leg. P. Lizoň as *Lr. piperatus* (BRA CR17678). – Q 7569c: Kuchyňa, 3.5 km NE, Vývrať, W slopes of Bučková hill, coord. 48°25'24.45" N, 17°11'37.23" E, alt. 350–430 m, terrestrial, *Quercus* (*Fagus*), 6 Jul 2011, leg. V. Kučera (SAV F-3362). – Poľana Mts., Q 7381d: Hrochoť, 1 km SE, site named Hrochofský mlyn, coord. 48°38'53" N, 19°19'44" E, alt. 540–620 m, terrestrial, *Quercus petraea*, 8 Jul 1997, leg. S. Adamčík (SAV F-1832). – Spišské kotliny basin, Q 6788a: Vojňany, 2 km NWW, Dlhá Hora ridge, southern slope, 49°15'37" N, 20°24'42.92" E, alt. 780–850 m, *Corylus*, *Picea*, *Abies*, 26 Aug. 2014, leg. S. Adamčík (SAV F-4340). – Štiavnické vrchy Mts., Q 7677d: Nová Dedina, 3.5 km N, Sovia dolina valley, coord. 48°19'09" N, 18°38'37" E, alt. 390–410 m, terrestrial, *Quercus*, *Carpinus*, 21 Jul 2008, leg. S. Adamčík (SAV F-2481). – Q 7677d: Nová Dedina, 4.5 km N, Sovia dolina valley, near bridge, coord. 48°19'33" N, 18°38'56" E, alt. 365–380 m, terrestrial, *Quercus*, *Carpinus*, 21 Jul 2008, leg. S. Adamčík (SAV F-2480). – Q 7678b: Jablonožce, 4 km N, Bohunický Roháč hill, coord. 48°21'43" N, 18°46'41" E, alt. 380–500 m, terrestrial, *Carpinus betulus*, *Quercus* sp., 27 Jul 2005, leg. S. Adamčík (SAV F-1139). – Q 7679a: Prenčov, 2.5 km NW, Horné Majere settlement, coord. 48°22'54" N, 18°54'01" E, alt. 420–460 m, terrestrial, *Quercus*, *Carpinus*, 22 Jul 2008, leg. S. Adamčík (SAV F-2482). – Q 7679a: Prenčov, 3 km NNW, slope of Sitno hill, coord. 48°23'04" N, 18°53'32" E, alt. 520–540 m, terrestrial, *Quercus*, *Carpinus*, 22 Jul 2008, leg. S. Adamčík (SAV F-2483); *ibid.*, 5 Jul 2011, S. Adamčík (SAV F-3351). – Q 7680b: Krupina, 4 km NNE, Mäsiarsky bok National Nature Reserve, coord. 48°23'16" N, 19°05'22" E, alt. 420–500 m, terrestrial, *Quercus*, *Carpinus*, 25 Jul 2008, leg. S. Adamčík (SAV F-2484). – Q 7779a: Sebechleby, 3.5 km WNW, Stará Hora settlement, coord. 48°16'54" N, 18°54'13" E, alt. 290–300 m, terrestrial, *Quercus*, *Carpinus*, 13 Jul 2010, leg. S. Adamčík (SAV F-3655). – Tríbeč Mts., Q 7575c: Jelenec, 2 km NW, around campsite, coord. 48°24'04" N, 18°12'26" E, alt. 230–250 m, terrestrial, *Quercus*, *Carpinus*, 23 Jul 2008, leg. S. Adamčík (SAV F-2485). – Vihorlatské vrchy Mts., Q 7198d: Jovsa, 1.5 km E, Jovsianska Hrabina National Nature Reserve, W part, coord. 48°49'24" N, 22°06'44" E, alt. 150–180 m, terrestrial, *Carpinus*, *Quercus*, 11 Jul 2001, leg. S. Adamčík (SAV F-79).

#### *Lactifluus piperatus* (L.: Fr.) Kuntze

Figs. 4, 9–10

Ecology. *Lactifluus piperatus* is locally one of the most common species of ectomycorrhizal fungi in Europe, growing in a variety of deciduous forests from early summer to September, especially in temperate broadleaved forests, often fruiting before and after a dry summer season (Heilmann-Clausen et al. 1998,

Basso 1999). Especially *Quercus*, *Castanea*, *Fagus*, but also other deciduous trees (rarely also conifers) are reported as host trees.

Our study material originated from probably all areas with deciduous forests visited by mycologists. According to published data as well as our experience, *Lf. piperatus* is the most frequent species of the group, sometimes present in huge quantities (Adamčík et al. 2006b). All herbarium data are from temperate broadleaved forests equally represented by *Fagus* and *Quercus* dominated forests, and three collections are also reported with just *Carpinus*. There are no collections from mixed forest, coniferous forests or pioneer vegetation (*Betula*, *Salix caprea*, *Populus tremula*), so it seems that the species prefers old-grown temperate broadleaved forests.

Škubla (1996) reported two collections of *Lf. piperatus* from spruce forest, but one of them appeared to be *Lf. vellereus* as the result of our revision.

**Occurrence in Slovakia.** Most herbarium data originate from forests at foothills of mountains surrounding the Podunajská nížina lowlands in the SW part of Slovakia (Fig. 4). The species has not been collected in the lowland area, because it is largely deforested and lacks continuous broadleaved forests. This scarce occurrence of *Lf. piperatus* corresponds with the situation in the Netherlands: similar lowlands, agriculturally highly utilised countryside where forests are limited to small groves and roadside plantations (Noordeloos, pers. comm.). The low number of records in the south-east probably reflects a low level of exploration (Lizoň & Bacigálová 1998). The species is very frequent at lower altitudes, but becomes rare or absent at higher elevations. Among the studied material, specimens from the Bukovské vrchy Mts. collected at an altitude of ca. 800 m a.s.l. (BRA CR17692, BRA CR17702) probably originate from the highest altitudes.

The density of dots in the map in the eastern part of the country (Fig. 4) would be higher if we included also non-documented collections reported by Adamčík et al. (2006b) and Ripková et al. (2007) from the Vihorlatské vrchy Mts. and by Kuthan et al. (1999) from the Bukovské vrchy Mts. In total, *Lf. piperatus* is reported from Slovakia in 14 publications. Our revision of corresponding herbarium material shows that not all records are correct. We confirmed identifications by Hagara (1992, 1993), and also part of the records by Kuthan et al. (1999), Adamčík et al. (2006a, 2006b, 2013), and Ripková et al. (2007), but collection BRA CR17712 published by Škubla (1996) was reidentified as *Lf. vellereus*. A number of the published records were not documented by a herbarium specimen, some of which reported from blank areas in our map (Fig. 4): Fábry et al. (1975) from the south side of the Podunajská nížina lowlands, Dermek (1976) and Lizoň (1977) from the Záhorská nížina lowlands, and Pilát (1926) from the Vysoké Tatry Mts. The latter is a critical collection requiring urgent revision because it is an area with high elevations and montane spruce-dominated forests.

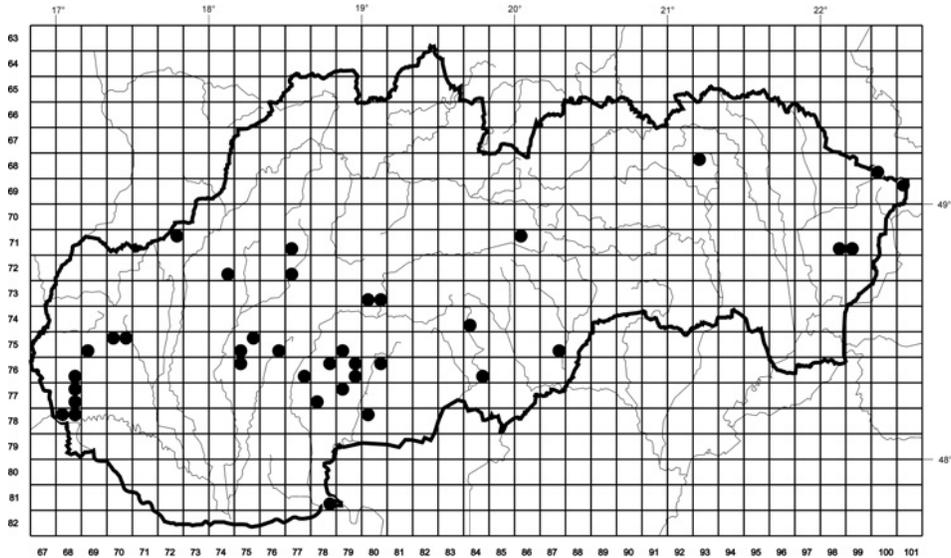


Fig. 4. Occurrence of *Lactifluus piperatus* in Slovakia based on studied herbarium material.

Notes. It is interesting that *Lf. piperatus* has been confused with *Lf. vellereus* (twice) rather than with *Lf. glaucescens* (once), despite the fact that the first species are not at all related. Possible reasons are discussed above in the text on *Lf. glaucescens*.

#### Material examined

Slovakia. Biele Karpaty Mts. (southern part), Q 7172b: Nová Bošáca, 1.5 km N, Grúň Nature Monument, coord. 48°53'39" N, 17°47'37" E, alt. 420–480 m, terrestrial, deciduous trees, 26 Jul 2001, leg. S. Ripková (SAV F-938). – Q 7172b: Nová Bošáca, ca. 1.5 km ENE of the church, Grúň Nature Monument, coord. 48°53'39.6" N, 17°47'57.2" E, alt. 427 m, forest with *Quercus* sp. and *Fagus sylvatica*, in fallen leaves under *Fagus sylvatica*, 26 Jul 2001, leg. S. Ripková (SLO 510); *ibid.*, 7 Jul 2002, leg. S. Ripková (SLO 509); *ibid.*, 7 Jul 2002, leg. I. Kautmanová (SLO 513). – Bukovské vrchy Mts., Q 68100c: Ruské, in Cirocha river valley, on the ground under *Carpinus*, 9 Aug 1990, leg. J. Kuthan (BRA CR17705). – Q 69101a: Nová Sedlica, Patrikúsky forest, slope of Packova Kyčera hill, on the ground under *Fagus* trees, 5 Jul 1988, leg. J. Terray (BRA CR17692); *ibid.*, leg. J. Kuthan (BRA CR17702). – Burda Mts., Q 8178d: Chľaba, ca. 2 km NW, Burdov National Nature Reserve, oak forest, 8 Jul 1984, leg. L. Hagara (BRA CR17684). – Čergov Mts., Q 6893a: Hradisko, 6 km NW, rather old beech forest, 4 Sep 1988, leg. J. Humeňanský (BRA CR17706). – Devínska Kobyla Mt., Q 7868a: Bratislava-Devín, Fialková dolina National Nature Reserve, coord. 48°10'08" N, 17°00'22.7" E, alt. 221 m, 15 Jun 2007, leg. S. Ripková (SLO 512). – Ipeľsko-Rimavská brázda furrow, Q 7587d: Figa, ca. 2.3 km NNE, Stránska forest, site named Farská studňa, under *Quercus cerris*, 30 Jun 1982, leg. L. Hagara (BRA CR17688). – Q 7684d: Šávol, ca. 3 km N, oak-hornbeam forest, 3 Aug 1984, leg. K. Tolnay (BRA CR17700). – Q 7778c: Čenkov, site named Horná hora, on the ground under *Quercus* trees, 23 Jun 1983, leg. J. Kuthan (BRA CR17693). – Q 7880a: Pláštove, 7 km NE, NE of Krašoria hill, coord. 48°11'55.46" N, 19°03'17.48" E, alt. 420–440 m, terrestrial, *Quercus*, *Carpinus*, 4 Jul 2011, leg. S. Adamčík (SAV F-3325).

– Kremnické vrchy Mts., Q 7380c: Kováčová, 2.5 km NW, Bjenska dolina valley, oak forest, 13 Jul 1985, leg. L. Hagara (BRA CR17698). – Q 7380d: Sliach, deciduous forest, 22 Jul 1963, leg. E. Končeková (BRA CR17691). – Malé Karpaty Mts., Q 7569c: Kuchyňa, site named Vývrať, 29 Jun 1974, leg. A. Dermek (BRA CR647); *ibid.*, on the ground, 2 Aug 1973, leg. A. Dermek (BRA CR17676). – Q 7569c: Kuchyňa, 4.1 km ENE, on top of Bučková hill, under *Fagus*, 26 Jun 1988, leg. L. Hagara (BRA CR17686). – Q 7569c: Kuchyňa, 2 km E, Modranská skala rock, coord. 48°24'06" N, 17°11'28" E, alt. 320–400 m, terrestrial, *Fagus*, 17 Jul 2010, leg. S. Adamčík (SAV F-4163). – Q 7569c: Rohožník, 3.5 km ESE, near the quarry, SE slopes of Vajarská hill, 48°26'33.34" N, 17°12'45.23" E, alt. 350–400 m, terrestrial, *Fagus*, 7 Jul 2011, leg. S. Adamčík (SAV F-3407). – Q 7570a: 5 km SW of Lošonec, Rybářeň settlement, coord. 48°27'37.02" N, 17°21'43.15" E, alt. 290–330 m, terrestrial, *Fagus*, *Carpinus*, 16 Jul 2006, leg. S. Adamčík (SAV F-4162). – Q 7570b: Horné Orešany, on the ground, 30 Jul 1977, leg. B. Matoušek (BRA CR17713). – Q 7668d: Lozorno, 3.5 km ESE, Bukovina forest, coord. 48°19'34.77" N, 17°05'31.60" E, alt. 270–320 m, terrestrial, *Fagus*, 7 Jul 2011, leg. S. Adamčík (SAV F-3395). – Q 7768b: Marianka, 1.5 km NE, site named Na Fuskovom, on gravel and clay substrate [unreadable], under *Carpinus* and *Quercus*, 12 Jul 1987, leg. J. Sand (BRA CR17677). – Q 7768b: Marianka, 1.5 NE, site named Na Fuskovom, Svätý vrch hill, mixed forest (*Fagus*, *Quercus*, *Betula*), 14 Jul 1990, leg. J. Sand (BRA CR17704). – Q 7768d: Bratislava-Rača, NW slope of Veľká Baňa hill, on the ground, 19 Jul 1972, leg. P. Lizoň (BRA CR17714). – Q 7868b: Bratislava, site named Železná studienka, 8 Jul 1961, leg. I. Fábry (BRA CR17687). – Q 7868b: Bratislava, slope of Kamzík hill, on the ground, 30 Jul 1972, leg. L. Opold (BRA CR17690). – Nízke Tatry Mts., Q 7186a: Skalka, N of Kúria castle ruins, coord. 48°68'86" N, 20°12'29" E, alt. 370 m, terrestrial, *Carpinus*, 7 Jul 2009, leg. D. Blanár (SAV F-2956). – Podunajská nížina lowlands, Q 7868b: Bratislava, oak forest, 3 Jul 1966, leg. J. Kollár (BRA CR17707). – Pohronský Inovec Mts., Q 7576d: Obyce, 1 km ENE, coord. 48°26'06" N, 18°28'38" E, alt. 350–500 m, terrestrial, *Quercus*, *Carpinus*, 24 Jul 2008, leg. S. Adamčík (SAV F-2478); *ibid.*, 3 Jul 2009, leg. S. Ripková (SLO 514). – Považský Inovec Mts., Q 7274d: Zlatníky, deciduous forest, under *Quercus*, 11 Jul 1971, leg. J. Kuthan (BRA CR17680). – Slovenské Rudohorie Mts., Q 7484c: 4 km SW of Ďubákovo, site named Osičiny, beech forest, 13 Aug 1988, leg. J. Humeňanský (BRA CR17694). – Strážovské and Súľovské vrchy Mts., Q 7177c: Šútovce, oak forest, 7 Sep 1972, leg. J. Kuthan (BRA CR17683). – Q 7177c: Seč, 1.6 km ENE, W slope of Fintov laz hill, beech forest, 7 Sep 1982, leg. L. Hagara (BRA CR17689). – Q 7277c: Nováky, 1.2 km N, site named Srdec, under *Quercus* trees, 2 Aug 1986, leg. L. Hagara (BRA CR17697). – Štiavnické vrchy Mts., Q 7579c: Počúvadlo, near the lake, on the ground, 23 Jun 1972, leg. A. Horváthová (BRA CR17699). – Q 7677d: Nová Dedina, 4.5 km N, Sovia dolina valley, near the bridge, coord. 48°19'33" N, 18°38'56" E, alt. 365–380 m, terrestrial, *Quercus*, *Carpinus*, 21 Jul 2008, leg. S. Adamčík (SAV F-2479); *ibid.*, 3 Jul 2009, leg. S. Ripková (SLO 515). – Q 7678b: Jabloňovce, 4 km N, Bohunický Roháč hill, coord. 48°21'43" N, 18°46'41" E, alt. 380–500 m, terrestrial, *Quercus* sp., 27 Jun 2006, leg. S. Adamčík (SAV F-1469). – Q 7679b: Prenčov, site named Bardínová, 2 Aug 1885, leg. A. Kmeť (BRA CR17674, BRA CR17711). – Q 7679b: Prenčov, 12 Jul 1888, leg. A. Kmeť (BRA CR17710). – Q 7679d: Prenčov, site named V Stráňach, 14 Jul 1888, leg. A. Kmeť (BRA CR17708). – Q 7679d: Prenčov, site named Na Kopaničky, 14 Jul 1888, leg. A. Kmeť (BRA CR17709). – Q 7680b: Krupina, 4 km ENE, Mäsiarsky bok National Nature Reserve, coord. 48°23'16" N, 19°05'22" E, alt. 420–500 m, terrestrial, *Quercus*, *Carpinus*, 25 Jul 2008, leg. S. Adamčík (SAV F-2477). – Q 7779a: Ladzany, Veľký Gregor hill, 30 Jun 1995, leg. L. Varjú (BRA CR17685). – Trábeč Mts., Q 7575c: Jelenec, 2 km NW, around the campsite, coord. 48°24'04" N, 18°12'26" E, alt. 230–250 m, terrestrial, *Quercus*, *Carpinus*, 12 Jul 2010, leg. S. Adamčík (SAV F-3654). – Q 7575b: Zlatno, 2 km NNE, valley S of Čierny hrad ruins, coord. 48°28'17" N, 18°18'28" E, alt. 370–410 m, terrestrial, *Fagus*, *Quercus*, *Carpinus*, 12 Jul 2010, leg. S. Adamčík (SAV F-4161). – Q 7675a: Žirory, on the ground in forest on slope of Predhorie hill, 9 Jul 1972, leg. L. Opold (BRA CR17703). – Vihorlatské vrchy Mts., Q 7198d: Jovsa, 1.5 km E, W part of Jovsianska Hrabina National Nature Reserve, coord. 48°49'24" N, 22°06'44" E, alt. 150–180 m, terrestrial, *Carpinus*, *Quercus*, 11 Jul 2001, leg. S. Adamčík (SAV F-84). – Q 7199c: Hlivištia, 1 km NW, forest on N margin of the village, coord. 48°48'19" N, 22°13'53" E, alt. 280–300 m, terrestrial, *Carpinus*, 13 Jun 2002, leg. Z. Argalášová (SAV F-83).

***Lactifluus vellereus* (Fr.: Fr.) Kuntze**

Figs. 5, 11

**Ecology.** *Lactifluus vellereus* is a common species preferably growing in temperate broadleaved forests, but also known from mixed and coniferous forests (Heilmann-Clausen et al. 1998, Basso 1999). Kytövuori & Korhonen (1990) report the species from the Nordic countries as especially common in the northern temperate zone, in broadleaved forests in Denmark, southernmost Sweden and westernmost Norway. In the hemiboreal zone, it is rarer and concentrated near the coast.

Most data from herbarium labels refer to temperate broadleaved forests with *Fagus*, *Quercus* and *Carpinus* as possible host trees. Interesting are three collections from mixed pioneer forests with *Betula*, *Populus tremula*, *Corylus* and *Picea* (only once *Picea*) from Liptovská Kotlina valley at an altitude of min. 700 m a.s.l. The species has also been reported twice from pioneer forests in the Malá Fatra Mts. and Západné Beskydy Mts. A collection from the Poľana Mts. probably originated from a mixed forest of *Fagus* and *Abies* at the highest altitude (more than 800 m a.s.l.).

**Occurrence in Slovakia.** The spatial distribution of the studied collections covers almost the entire area of Slovakia and this confirms that the species has a broader ecological amplitude compared to the other species included in this study (Fig. 5). According to our experience, it is a common species but its basidiomata never occur in such numbers as in *Lf. piperatus*.

The species has been reported from Slovakia in 11 publications, but except of publications co-authored by S. Adamčík (Adamčík et al. 2006a, 2006b, 2013, Ripková et al. 2007), only specimens corresponding to reports by Hagara (1992, 1993) were found in the Slovak herbaria. Both reports on *Lf. piperatus* by Škubla (1996) from Liptovská kotlina valley are probably *Lf. vellereus* (see comments on the first species above). The species is also known from other areas in Slovakia which our study of herbarium material did not cover: Bukovské vrchy Mts. (Kuthan et al. 1999), Vysoké Tatry Mts. (Pilát 1926) and Západné Tatry Mts. (Dermek 1983).

**Notes.** For delimitation of the species, see notes on *Lf. bertillonii* above.

**Material examined**

Slovakia. Biele Karpaty Mts. (southern part), Q 7172b: Nová Bošáca, ca. 3 km N of the church in the village, Grúň settlement, site named Ondrášky, on blue-marked tourist trail, direction to Veľký Lopeník hill, coord. 48°54'35.3" N, 17°47'32.6" E, alt. 712 m, forest with *Quercus* sp. and *Fagus sylvatica*, in fallen leaves under *Fagus sylvatica*, 27 Jul 2001, leg. S. Ripková as *Lr. piperatus* (SLO 511). – Q 7172b: Nová Bošáca, 1.5 km N, Grúň Nature Monument, coord. 48°53'39" N, 17°47'37" E, alt. 420–480 m, terrestrial, deciduous trees, 18 Oct 2001, leg. V. Kučera (SAV F-940). – Čergov Mts., Q 6893c: Terňa, 3 km N, old beech forest, 27 Aug 1988, leg. J. Humeňanský (BRA CR17733). – Ipeľsko-Rimavská brázda furrow, Q 7684d: Šávol, 1.5 km N, on the ground in oak-hornbeam forest, 13 Aug 1983, leg. K. Tolnay (BRA CR17729). – Liptovská kotlina basin, Q 6884d: Pribylina, ca 5 km

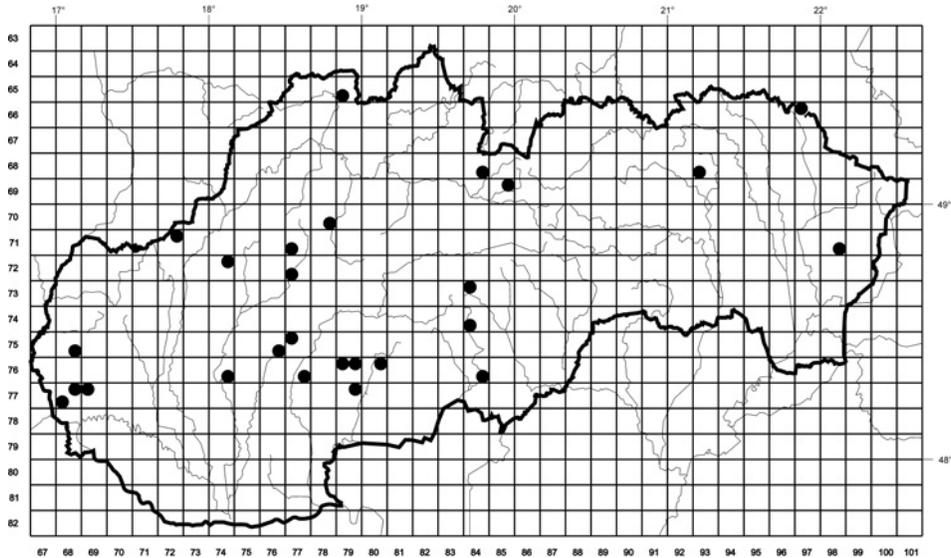


Fig. 5. Occurrence of *Lactifluus vellereus* in Slovakia based on studied herbarium material.

NE, site named Hrdovo, spruce forest, 17 Aug 1984, leg. P. Škubla as *Lr. piperatus* (BRA CR17712). – Q 6985b: between the villages of Východná and Važec, pasture under *Corylus* trees, 17 Aug 1977, leg. J. Kuthan (BRA CR17721). – Q 6985b: between the villages of Východná and Važec, pasture with solitary *Picea*, *Betula* and *Populus tremula* trees, 2 Sep 1978, leg. J. Kuthan (BRA CR17717). – Malá Fatra (Lúčanská Fatra) Mts., Q 7078d: Slovenské Pravno, 2 km SW, birch forest, 19 Jul 1984, leg. P. Tolnay (BRA CR17726). – Malé Karpaty Mts., Q 7568d: Kuchyňa, 7 Sep 1964, leg. Z. Novák (BRA CR17741). – Q 7768c: Marianka, Nová hora hill, beech forest, 3 Sep 2002, leg. J. Červenka (BRA CR85). – Q 7768b: Marianka, 1.5 km NE, site named Na Fuskovom, beech forest, 12 Jul 1987, leg. J. Sand (BRA CR17716). – Nízke Beskydy Mts., Q 6697a: Habura, nearby forest, terrestrial, *Fagus sylvatica*, 20 Sep 2006, leg. S. Ripková (SAV F-3542). – Podunajská nížina lowlands, Q 7769a: Myslenice, 14 Sep 1968, leg. I. Fábry (BRA CR17742). – Pohronský Inovec Mts., Q 7576d: Obyce, forest 1 km NEE, coord. 48°26'06" N, 18°28'38" E, alt. 350–500 m, terrestrial, *Quercus*, *Carpinus*, 24 Jul 2008, leg. S. Adamčík (SAV F-2488). – Q 7577a: Malá Lehota, 3 km E, Dudkov vrch hill, coord. 48°29'39" N, 18°31'41" E, alt. 250–570 m, terrestrial, *Quercus*, *Fagus*, 6 Sep 2006, leg. S. Adamčík (SAV F-1420). – Poľana Mts., Q 7384a: Drábsko, 3.5 km NE, Dobročský prales National Nature Reserve, coord. 48°41'01" N; 19°40'45" E, alt. 800–1000 m, terrestrial, *Abies*, *Fagus*, 29 Sep 2011, leg. S. Adamčík (SAV F-3474). – Považský Inovec Mts., Q 7274b: Dubodiel, on the ground, 23 Sep 1972, leg. A. Dermek (BRA CR17731, BRA CR17743). – Slovenské Rudohorie Mts., Q 7484c: Ďubákovo, 3 km SW, site named Osičiny, old beech forest, 6 Aug 1988, leg. J. Humeňanský (BRA CR17732). – Strážovské and Súľovské vrchy Mts., Q 7177c: Dĺžin, 1.8 km ENE to NE of the village, western slope of Boškovie laz hill, old beech forest, 26 Jul 1981, leg. L. Hagara (BRA CR17715). – Q 7177c: Seč, 1.3 km ENE, Flintov laz hill, beech forest, 25 Sep 1984, leg. L. Hagara (BRA CR17727). – Q 7277c: Nováky, 1.7 km WNW, site named Sučianske, in oak forest, 6 Sep 1982, leg. L. Hagara (BRA CR17719). – Štiavnické vrchy Mts., Q 7677d: Nová Dedina, 4.5 km N, Sovia dolina valley, near the bridge, coord. 48°19'33" N, 18°38'56" E, alt. 365–380 m, terrestrial, *Quercus*, *Carpinus*, 21 Jul 2008, leg. P. Marstad (SAV F-2487). – Q 7679a: Preňčov, 3 km NNW, slope of Sitno hill, coord. 48°23'04" N,



**Fig. 6.** Basidiomata of *Lactifluus bertillonii* (slope of Sitno hill near Prenčov; SAV F-2491). Photo Per Marstad.



**Fig. 7.** Basidiomata of *Lactarius controversus* (Arborétum Borová Hora near Zvolen; SLO 518). Photo Per Marstad.



**Fig. 8.** Basidiomata of *Lactifluus glaucescens* (Stará hora near Sebechleby; SAV F-3655). Photo Per Marstad.



**Fig. 9.** Basidiomata of *Lactifluus piperatus* (Bohunický Roháč near Jabloňovce; SAV F-1469 – left) and *Lactifluus glaucescens* (Mäsiarský bok National Nature Reserve; SAV F-2484 – right). For reliability of the well-visible difference in latex colour change, see last paragraph under Conclusions. Photo Per Marstad.



**Fig. 10.** Basidiomata of *Lactifluus piperatus* (Bohunický Roháč near Jabloňovce; SAV F-1469). Photo Per Marstad.



**Fig. 11.** Basidiomata of *Lactifluus vellereus* (Sovia dolina near Nová Dedina; SAV F-2487). Photo Per Marstad.

18°53'32" E, alt. 520–540 m, terrestrial, *Quercus*, *Carpinus*, 22 Jul 2008, leg. S. Adamčík (SAV F-2486). – Q 7679b: Prenčov, 26 Jul 1888, leg. A. Kmeť (BRA CR17735). – Q 7680b: Krupina, 4 km NNE, Mäsiarsky bok National Nature Reserve, coord. 48°23'16" N, 19°05'22" E, alt. 420–500 m, terrestrial, *Quercus*, *Carpinus*, 25 Jul 2008, leg. S. Adamčík (SAV F-2489). – Q 7779b: Ladzany, ca. 3 km NW, Háj hill, under *Quercus* trees, 20 Sep 1984, leg. K. Tolnay (BRA CR17728). – Trábeč Mts., Q 7674d: Nitra, Zobor hill, on the ground under [unreadable], 2 Nov 1970, leg. L. Opold (BRA CR17724). – Vihorlatské vrchy Mts., Q 7198d: Jovsa, 1.5 km E, Jovsianska Hrabina National Nature Reserve, W part, coord. 48°49'24" N, 22°06'44" E, alt. 150–180 m, terrestrial, *Carpinus*, *Quercus*, 18 Sep 2001, leg. E. Ripková (SAV F-97). – Západné Beskydy Mts., Q 6579c: near Ošadnica, on the ground in forest, *Picea*, *Betula*, *Corylus*, 18 Sep 1988, leg. O. Kovář (BRA CR17725). – without information about locality: 21 Sep 1965, leg. I. Fábry (BRA CR17740). – leg. A. Kmeť (BRA CR17736).

## CONCLUSIONS

Revision of herbarium material deposited in three Slovak herbaria together with our recent data proved that all five studied white milkcap species are common or locally common in deciduous forests of Slovakia and according to our experience often very abundant. Most Slovak collections of *Lactarius controversus* were collected with *Populus* and often in urban habitats, few were associated with *Salix* and *Alnus*. All other studied species grow preferably in association with broadleaved trees (*Fagus*, *Quercus*, *Carpinus*, etc.). The species with the broadest ecological amplitude seems to be *Lactifluus bertillonii*, growing also in mixed montane forests. Some studied collections of *Lf. bertillonii* and *Lf. vellereus* were reported from spruce forest, but this is in contrast with our experience. We therefore suggest verifying their association with conifers by means of additional research.

Three of the studied species, *Lactarius controversus*, *Lactifluus piperatus* and *Lf. vellereus*, are well known with the public since long thanks to popular mushroom handbooks (e.g. Dermek 1976, 1983, Dermek & Pilát 1974). Only six publications published before 1999 are documented by herbarium specimens, two of which were misidentified. In addition, reports of *Lf. vellereus* from coniferous or mixed montane forests are possibly misidentified, because it is a habitat more typical for *Lf. bertillonii* according to our experience and published data. For these reasons, we recommend treating older, unverified published data as dubious.

*Lactifluus bertillonii*, not reported from the country until 2013, proved to be consistently confused with *Lf. vellereus*: out of 17 studied collections of the species 8 had been misidentified. Other species reported for the first time recently (Kuthan et al. 1999) is *Lf. glaucescens*, but this study suggests that this species has been overlooked and not confused with the similar *Lf. piperatus*.

This study tested the reliability of field characters used in older keys for species identification. In our experience, the colour change of latex after air exposi-

tion in *Lf. glaucescens* and *Lf. piperatus* is not a reliable character for distinguishing these species, but its probability rate is relatively high, approximately 90%. We confirmed that the remaining three species can be safely identified using field characters.

#### ACKNOWLEDGEMENTS

We are very grateful to Zuzana Fačkovcová for preparing the grid maps and to Per Marstad for the photos of basidiomata used in this study as well as for assistance in field. The curators of the BRA and SLO herbaria are acknowledged for loans of herbarium specimens. We thank Peter Potocký for help with the literature. Review of the manuscript by anonymous reviewers is acknowledged. This study was funded from Slovak national grant VEGA 02/0075/14.

#### REFERENCES

- ADAMČÍK S., HAGARA L. (2003): Macrofungi of the Abrod reserve. – *Cathatelasma* 4: 9–17.
- ADAMČÍK S., JANČOVIČOVÁ S., VALACHOVIČ M. (2013): *Russulaceae* (*Russulales*, Agaricomycotina, fungi) in the thermophilous oak forests of W Slovakia. – *Scripta Botanica Belgica* 51: 60–72.
- ADAMČÍK S., RIPKOVÁ S., KUČERA M. (2006a): Contribution to the knowledge of macrofungi in the Biele Karpaty Mts. – *Cathatelasma* 8: 17–28.
- ADAMČÍK S., RIPKOVÁ S., ZALIBEROVÁ M. (2006b): Diversity of *Russulaceae* in the Vihorlatské vrchy Mts. (Slovakia). – *Czech Mycology* 58(1–2): 43–66.
- BASSO M.T. (1999): *Lactarius* Fr. – *Fungi Europaei* 7, Mykoflora, Alassio.
- BON M. (1980): Clé monographique du genre *Lactarius* (Pers. ex Fr.) S.F. Gray. – *Documents Mycologiques* 10(40): 1–85.
- BUYCK B., HOFSTETTER V., EBERHARDT U., VERBEKEN A., KAUFF F. (2008): Walking the thin line between *Russula* and *Lactarius*: the dilemma of *Russula* subsect. *Ochriconcompactae*. – *Fungal Diversity* 28: 15–40.
- BUYCK B., FLORIANI M., NUYTINCK J., PIEROTTI A., VERBEKEN A., ADAMČÍK S., eds. (on-line): *Russulales* news. – <http://www2.muse.it/russulales-news/>. [accessed October 2014]
- ČURLÍK J., ŠEFCÍK P. (1999): Geochemický atlas Slovenskej republiky, Časť V. – Pôdy [Geochemical atlas of the Slovak Republic, Part V. – Soils]. – MŽP SR, Bratislava. [in Slovak]
- DE CROP E., NUYTINCK J., VAN DE PUTTE K., LECOMTE M., EBERHARDT U., VERBEKEN A. (2014): *Lactifluus piperatus* (*Russulales*, Basidiomycota) and allied species in Western Europe and a preliminary overview of the group worldwide. – *Mycological Progress* 13: 493–511.
- DERMEK A. (1976): Huby lesov, polí a lúk [Fungi of forests, fields and meadows]. – Osveta, Bratislava. [in Slovak]
- DERMEK A. (1978): Príspevok k mykoflóre lesov na okolí Brodského, Čárov, Gbelov, Kopčian, Kútov a Smolinského (západné Slovensko) [A contribution to the mycoflora of forests in the environs of the villages Brodské, Čáry, Gbely, Kopčany, Kúty and Smolinské (West Slovakia)]. – *Česká Mykologie* 32(4): 215–225. [in Slovak]
- DERMEK A. (1983): Atlas našich húb [Handbook of our fungi]. – Obzor, Bratislava. [in Slovak]

- DERMEK A., MICHALCO J. (1975): Mykoflóra lesov v okolí Brodského a Kopčian [Mycoflora of forests in the environs of the villages Brodské and Kopčany]. – Správy hubárskej poradne 3: 7–9. [in Slovak]
- DERMEK A., PILÁT A. (1974): Poznávajme huby [Let's recognize mushrooms]. – Veda, Bratislava. [in Slovak]
- FÁBRY I., FUTÓ E., MICHALCO J. (1975): Mykoflóra širšieho okolia Hurbanova [Mycoflora of the environs of Hurbanovo]. – Správy hubárskej poradne 3: 12–14. [in Slovak]
- FUTÁK J. (1980): Fytogeografické členenie [Phytogeographic regions]. – In: Mazúr E., ed., Atlas Slovenskej socialistickej republiky [Atlas of the Slovak Socialist Republic], Bratislava, p. 88, table VII/14. [in Slovak]
- HAGARA L. (1992): Huby – dvojníky [Fungi – twins]. – Obzor, Bratislava. [in Slovak]
- HAGARA L. (1993): Atlas húb [Handbook of the fungi]. – Neografia, Martin. [in Slovak]
- HEILMANN-CLAUSEN J., VERBEKEN A., VESTERHOLT J. (1998): Fungi of northern Europe – Vol. 2. The genus *Lactarius*. – Skive Offset, Oddense.
- KYTÖVUORI I., KORHONEN M. (1990): *Lactarius vellereus* and *Lactarius bertillonii* in Fennoscandia and Denmark. – *Karstenia* 30(2): 33–42.
- KUTHAN J., ADAMČÍK S., TERRAY J., ANTONÍN V. (1999): Huby národného parku Poloniny. Fungi of the National Park Poloniny. – Správa národných parkov SR Liptovský Mikuláš, Správa národných parkov SR Poloniny, Košice. [in Slovak with English summary]
- LIZOŇ P. (1977): Exkurzie 1. mykologických dní na Slovensku [Excursions of the 1<sup>st</sup> mycological foray in Slovakia]. – Správy hubárskej poradne 4: 2–8. [in Slovak]
- LIZOŇ P., BACIGÁLOVÁ K., eds. (1998): Huby. Fungi. – In: Marhold K., Hindák F., eds., Zoznam nižších a vyšších rastlín Slovenska. Checklist of non-vascular and vascular plants of Slovakia, CD-ROM, Veda, Bratislava.
- NIKLFIELD H. (1971): Bericht über die Kartierung der Flora Mitteleuropas. – *Taxon* 20: 545–571.
- PILÁT A. (1926): Les *Agaricales* et *Aphylliphorales* des Carpathes Centrales. – *Bulletin de la Société Mycologique de France* 42: 81–120.
- RAYNER R.W. (2005): British Fungus Flora, Agarics and Boleti. – Royal Botanical Garden, Edinburgh.
- RIPKOVÁ S., ADAMČÍK S., KUČERA V., PALKO L. (2007): Fungi of the Protected Landscape Area of Vihorlat. – BÚ SAV, Bratislava.
- ŠKUBLA P. (1996): Mykoflóra Hrdova [Mycoflora of Hrdovo]. – Spravodajca Slovenských Mykológov 12: 23–25. [in Slovak]
- THIERS B. (on-line) [continuously updated]: Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. – <http://sweetgum.nybg.org/ih/>. [accessed 24 July 2014]
- VAN DE PUTTE K., NUYTINCK J., DAS K., VERBEKEN A. (2012): Exposing hidden diversity by concordant genealogies and morphology – a study of the *Lactifluus volemus* (*Russulales*) species complex in Sikkim Himalaya (India). – *Fungal Diversity* 55: 171–194.
- VERBEKEN A., NUYTINCK J., BUYCK B. (2011): New combinations in *Lactifluus*. 1. *L.* subgenera *Edules*, *Lactariopsis*, and *Russulopsis*. – *Mycotaxon* 118: 447–453.
- VERBEKEN A., STUBBE D., VAN DE PUTTE K., EBERHARDT U., NUYTINCK J. (2014): Tales of the unexpected: angiocarpous representatives of the *Russulaceae* in tropical South East Asia. – *Persoonia* 32: 13–24.
- VERBEKEN A., VAN DE PUTTE K., DE CROP E. (2012): New combinations in *Lactifluus*. 3. *L.* subgenera *Lactifluus* and *Piperati*. – *Mycotaxon* 120: 443–450.
- VERBEKEN A., VESTERHOLT J. (2008): *Lactarius*. – In: Knudsen H., Vesterholt J., eds., *Funga Nordica*, p. 82–107, Nordsvamp, Copenhagen.