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Russulae in the Montane and Subalpine Belts of the Tatra Mountains (Western Carpathians)

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We present 36 species of *Russula* collected over the last ten years in the Tatra Mountains. Fourteen species are reported from the area for the first time, six are new to Poland and two are new to Slovakia. Two rare species, *R. roseipes* and *R. sapinea*, are described in detail and illustrated. Micromorphological variability of several other species is briefly discussed. Ecological preferences of the fungi are analysed and compared with the data available in the literature, and a group of mountain species is distinguished. The composition of *Russulae* known from the Tatra Mountains is compared with that of other mountain regions of Europe.

Keywords: Agaricomycetes, Russulales, ectomycorrhizal fungi, taxonomy, biogeography, ecology, Poland, Slovakia

Situated along the border between Poland and Slovakia, the Tatra Mountains constitute the highest part of the Carpathians. They stretch over a surface of 220 km^2 (Radwańska-Paryska & Paryski 1995) and comprise all mountain vegetation belts, including subalpine and alpine zones. The Tatra Mountains are among the most interesting natural areas in Poland and Slovakia, protected as national parks on both sides of the border. The region's great diversity of habitats results in an interesting flora and fauna (Mirek 1996) where a rich and remarkable funga could be expected. However, the number of species reported from the area in the available literature seems moderate in comparison with that in other regions of Slovakia and Poland, which suggests that the local funga is poorly investigated (e.g. Adamčík *et al.* 2003, Wojewoda 1996). Thorough mycological studies are needed to fully assess fungal species diversity, ecological preferences, and potential threats caused by forest-management strategies.

The genus *Russula* comprises hundreds of species (Kirk *et al.* 2001) and represents one of the richest genera of agarics. *Russulae* are also among the most important ectomycorrhizal partners in for-

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est habitats and deserve special attention in mycological studies. The first data on the occurrence of fungi in the Tatra Mountains go back to the late 19th century. Krupa (1886) and Hazslinszky (1886) reported a few species from the Polish and Slovak parts, respectively. The first records of *Russula* species were made 40 years later by Pilát (1926). To date, a total of 54 representatives of the genus are known from the montane to alpine belts of the Tatra Mountains (Tatra National Park); most of them, however, from single or few localities.

The aim of this paper is to give an overview of the *Russula* species recorded in the Tatra Mountains over the last ten years. Special attention is paid to some rare species, such as *Russula roseipes* and *R. sapinea*. Ecological preferences of the collected *Russulae* are analysed and compared with the data available in the literature. A group of mountain species is distinguished.

Materials and Methods

Study area

The Tatra Mountains belong to the Carpathian chain (Fig. 1). They are divided into three physiographical units based on relief diversification and basement complexity: Western Tatra Mountains, High Tatra Mountains and Belanské Tatry Mountains (Radwańska-Paryska & Paryski 1995). The Western Tatra Mountains and the High Tatra Mountains are located in the Polish as well as Slovak parts, whereas the Belanské Tatry Mountains lie only within Slovakia (Fig. 2). The Tatra Mountains are built up of crystalline, metamorphic and sedimentary rocks. The main ridge of the massif and its southern slopes are mainly granitic, while some parts of the Western Tatra Mountains and the Belanské Tatry Mountains are predominately built up of calcareous rocks, dolomite or sandstone (Radwańska-Paryska & Paryski 1995). Diverse geological bedrocks of the Tatra massif as well as different climatic conditions along the altitudinal gradient influence vegetation types. Spruce forests predominate in the forest belt, but beech forests are present in some places at lower altitudes (lower montane zone), usually on calcareous bedrock. Beech forests cover large areas in the northern part of the Western Tatra massif (Poland) forming the *Dentario glandulosae-Fagetum* association (beech forest with an admixture of *Abies alba* and *Picea abies*), while it is very infrequent on the Slovak side, occurring there only on the northern slopes of the Belanské Tatry Mountains (Myczkowski & Lesiński 1974, Myczkowski 1975, Michalko *et al.* 1984, Piękoś-Mirkowa & Mirek 1996). Beech forests do not occur on the nutrient-poor siliceous bedrock and granitic moraines, and spruce forests are developed in both the lower and

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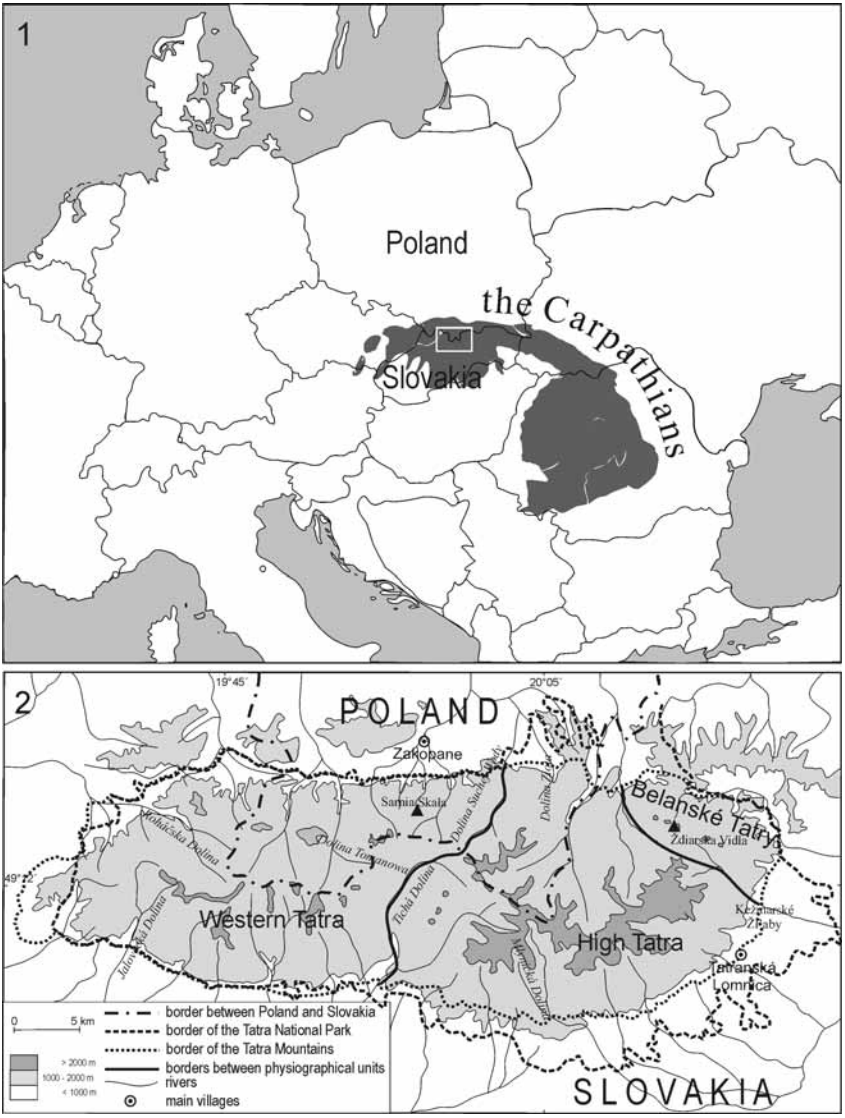
upper montane belts (Piękoś-Mirkowa & Mirek 1996). The subalpine zone extends up to 1800 m above the timberline, located at 1550 m on average (with the exception of the Sarnia Skała massif, where the timberline is naturally lowered to *ca.* 1300 m; Piękoś 1968). It is dominated by the dwarf mountain-pine (*Pinus mugo*) shrubland.



Figs. 1–2. Study area. **1.** Location of the Carpathians in Europe; white square – the Tatra Mountains. **2.** The area of the Tatra Mountains; names of peaks and valleys given in the text are marked on the map.

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Alpine meadows are developed at higher altitudes, above 1800 m (Piękoś-Mirkowa & Mirek 1996).

The borders of the Tatra Mountains are not identical with the borders of the Tatra National Park (see Fig. 2). In the present paper we take into account the area from both overlapping areas.

Sampling and analysis of collections

The material was collected in the three parts of the Tatra Mountains (Tatra National Park) in summer and autumn over a period of ten years (1997–2007) in three vegetation zones: lower and upper montane belts and subalpine dwarf mountain-pine shrubs. Some sampling areas (Sarnia Skała massif, Polish Western Tatra) were visited regularly for a few years (see Ronikier 2005), while others were visited less often.

Species were identified based mainly on monographs by Romagnesi (1967) and Sarnari (1998, 2005). Micromorphological characters were observed with oil-immersion objectives at a magnification of 1000 × or 1500 × using Olympus CX-1 or Nikon Eclipse E600 microscopes. Pileipellis elements were observed in a solution of Congo red in ammonia and in 50 % solution of sulphovanillin in water; spores were observed in Melzer's reagent and primordial hyphae in basic fuchsin (Romagnesi 1967). Spores were photographed with an Olympus Artcam camera and measured using Quick Micro Photo (version 2.1) software with an accuracy of 0.1 µm and excluding ornamentation. The length/width ratio of spores (Q) was calculated. Statistics for measurements of microscopical characters are given as the mean value with its standard deviation and are based on 30 measurements. The minimum or maximum values recorded by us are given in parentheses. Drawings of pileipellis elements, hymenial cystidia, and basidia were made using a camera lucida (Nikon Y-IDT). Spores were drawn from enlarged photos. Descriptions are based on collections from the Tatra Mountains. Collections are deposited in KRAM and SAV. The list of species is presented in alphabetical order. Ecological preferences of the species (Tab. 1) were analysed using studies by Favre (1960), Horak (1963), Romagnesi (1967), Svrček *et al.* (1984), Einhellinger (1985), Schmid-Heckel (1985, 1988), Sarnari (1998, 2005), Gyosheva & Denchev (2000), Kränzlin (2005), Knudsen *et al.* (2008). The Sørensen index (SI) was used to calculate the similarity between the species composition found in the Tatra Mountains and other mountain regions of Europe: $q = 2c/(a + b)$, where 'c' is the number of *Russula* species shared by the Tatra Mountains and compared areas, 'a' the total number of *Russulae* in the Tatra Mountains, and 'b' – the total number of *Russula* species reported from the compared area.

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Tab. 1. – Habitat types of *Russulae* collected by us ('+') as compared with literature reports; see Material and Methods for references. 'Pale grey' indicates the habitat type (accompanying tree, bedrock type, and altitudinal range) known from the literature; 'dark grey' indicates the habitat type specified in the literature as preferable for a species; '+' indicates the environmental condition recorded at the locality of a species in the study area. Species from the Tatra Mountains (Tatra National Park) reported here for the first time, are boldfaced.

Ecology / Nº Species	Accompanying trees								Bedrock		Altitudinal range			
	Fagus	*Picea*	*Abies*	*Pinus*	*Larix*	*Betula*	*Quercus*	*Carpinus*	calcareous	acidic	lowland to colline	lower montane	upper montane	subalpine
1. ***R. acrifolia***		+							+			+		
2. ***R. albonigra***	+	+	+						+			+		
3. ***R. anthracina***	+	+	+						+			+		
4. *R. atrorubens*		+		+	+					+		+		
5. *R. aurea*	+	+	+						+	+		+		
6. ***R. aurora***	+	+	+						+			+		
7. *R. badia*		+		+	+					+		+		
8. ***R. cavipes***	+	+	+						+			+		
9. *R. cessans*		+		+					+	+		+		+
10. *R. chloroides*	+	+	+	+					+			+		+
11. *R. cyanoxantha*	+	+	+						+			+		
12. *R. decolorans*		+		+	+					+		+	+	+
13. *R. emetica*		+		+	+				+	+		+		
14. *R. favrei*		+							+				+	
15. ***R. fellea***	+	+	+						+			+		
16. *R. firmula*		+							+				+	
17. ***R. griseascens***		+								+			+	
18. *R. integra*		+	+		+				+	+		+	+	
19. ***R. laurocerasi***	+	+	+						+			+		
20. ***R. mairei***	+	+	+						+			+		
21. *R. mustelina*		+								+		+	+	
22. *R. nauseosa*		+		+	+				+	+		+	+	
23. *R. nigricans*	+	+	+						+			+		
24. *R. ochroleuca*	+	+	+						+	+		+	+	
25. *R. paludosa*		+		+	+					+		+		
26. ***R. postiana***	+	+	+						+			+		
27. *R. queletii*	+	+		+					+			+	+	+
28. *R. risigallina*	+	+	+						+			+		
29. ***R. romellii***	+	+	+						+			+		
30. ***R. roseipes***		+			+				+			+		
31. ***R. sapinea***		+		+	+				+			+	+	
32. *R. silvestris*		+		+	+				+	+		+		+
33. *R. turci*		+		+	+					+		+		
34. *R. vesca*		+								+		+		
35. ***R. veternosa***	+	+	+						+			+		
36. *R. vinosa*		+	+						+			+	+	

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Results

We examined 86 collections of *Russulae* and identified 36 species, six of which are reported for the first time for Poland (*R. anthracina*, *R. cessans*, *R. favrei, R. griseascens*, *R. romellii*, and *R. sapinea*); two species (*R. roseipes* and *R. sapinea*) are new to Slovakia. The latter two rare species are described and illustrated below. Micromorphological variability of basidiomata is also briefly discussed. Fourteen species are reported for the first time from the Tatra massif (Tab. 1).

Russula acrifolia Romagn.

Material examined. – SLOVAKIA, Western Tatra Mountains, lower part of the Jalovecká dolina valley, vicinity of Bobrovecká vápenica, alt. ca. 950 m, spruce forest, N 49° 10' 10" E 19° 38' 04", 26 Jun 1998, *leg.* S. Adamčík (SAV F-1277).

Russula albonigra (Krombh.) Fr.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, lower part of the Dolina Spadowiec valley, orographically right side of the valley, alt. 1000 m, *Dentario glandulosae-Fagetum,* N 49° 16' 36" E 19° 57' 18", 20 Aug 2001, *leg.* A. Ronikier (KRAM F-54733); alt. 980 m, *Dentario glandulosae-Fagetum,* N 49° 16' 41" E 19° 57' 17", 10 Sep 2003, *leg.* A. Ronikier (KRAM F-54734).

Russula anthracina Romagn.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, lower part of the Dolina Spadowiec valley, orographically right side of the valley, alt. 1000 m, *Dentario glandulosae-Fagetum,* N 49° 16' 37" E 19° 57' 17", 20 Aug 2001, *leg.* A. Ronikier (KRAM F-54431).

Note. – The most characteristic feature of this species is the lack of pileocystidia, a unique character among European members of the genus, only shared with *R. atramentosa*, described from the Mediterranean region (Sarnari 1998).

Russula atrorubens Quél.

Material examined. – SLOVAKIA, Popradská Kotlina, Kežmarské Žl'aby N-E of the Kežmarská Biela voda stream, alt. ca. 980 m, windfall with *Picea abies, Larix decidua, Pinus sylvestris*, 11 Sep 2007, *leg.* S. Adamčík (SAV F-1282, SAV F-1283).

Note. – Specimens of one collection had typical purple-red pilei with darker centers, while specimens in another collection had

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greenish-brownish caps with a discolored center. Remaux *et al.* (1996) and Francini & Moreau (2002) distinguish another species, *R. subaffinis* Bidaud & Moreau, characterized by similar colors and a slightly darker spore print than those of *R. atrorubens*. We do not have spore prints of our specimens, and as other characters distinguishing these two species are minor, we follow Sarnari (1998) accepting the wide concept of the species. Knudsen *et al.* (2008) also consider the two species to be conspecific.

Russula aurea Pers.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, lower part of the Dolina Białego valley, the Droga pod Reglami hiking trail, alt. 940 m, *Dentario glandulosae-Fagetum,* N 49° 16' 44" E 19° 57' 23", 21 Aug 2002, *leg.* A. Ronikier (KRAM F-54390); High Tatra Mountains, Dolina Złota valley, Wiktorówki, N of the Rusinowa Polana meadow, alt. ca. 1100–1200 m, spruce forest, 28 Aug 2005, *leg.* D. Zdebska (KRAM F-45069).

Russula aurora (Krombh.) Bres.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, lower part of the Dolina Białego valley, the Droga pod Reglami hiking trail, alt. 940 m, *Dentario glandulosae-Fagetum*, N 49° 16' 42" E 19° 57' 27", 9 Sep 2001, *leg.* A. Ronikier (KRAM F-45059).

Russula badia Quél.

Material examined. – SLOVAKIA, Popradská Kotlina, Kežmarské Žľaby, N-E of the Kežmarská Biela voda stream, alt. ca. 980 m, windfall with *Picea abies, Larix decidua, Pinus sylvestris*, 11 Sep 2007, *leg.* S. Adamčík (SAV F-1313).

Russula cavipes Britzelm.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, Grześkówki ridge, mouth of the Dolina ku Dziurze valley, alt. 900 m, *Dentario glandulosae-Fagetum,* N 49° 16' 36" E 19° 56' 35", 4 Jul 2000, *leg.* A. Ronikier (KRAM F-50016).

Russula cessans A. Pearson

Material examined. – POLAND, Western Tatra Mountains, Dolina Suchej Wody valley, a road along the valley, E of the Niżni Staw Toporowy lake, alt. 1100 m, *Piceetum tatricum*, on soil N 49° 16' 50" E 20° 2' 10", 2001, *leg.* A. Ronikier, M. Ronikier (KRAM F-45065); upper part of the Dolina Tomanowa valley, on the hiking trail to the Chuda Przełączka pass, Czerwone Żlebki, alt. 1580 m, *Pinetum mugo carpaticum*, N 49° 13' 30" E 19° 53' 55", 26 Jul 2002, *leg.* A. Ronikier, M. Ronikier (KRAM F-45067); SLOVAKIA, Western Tatra Mountains, lower part of the Jalovecká dolina valley, vicinity of Bobrovecká vápenica, alt. ca. 950 m,

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spruce forest, N 49° 10' 10" E 19° 38' 04", 2 Aug 1997, *leg.* S. Adamčík (SAV F-1284).

Russula chloroides (Krombh.) Bres.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, by the Droga pod Reglami hiking trail, N slopes of the Spaleniec ridge, alt. 900 m, *Abieti-Piceetum,* N 49° 16' 43" E 19° 56' 57", 21 Jul 2000, *leg.* A. Ronikier (KRAM F-50145); Sarnia Skała massif, Grześkówki ridge, *Dentario glandulosae-Fagetum, leg.* A. Ronikier (KRAM F-54394); Sarnia Skała massif, by the Droga pod Reglami hiking trail, mouth of the Dolina Białego valley, alt. 930 m, *Dentario glandulosae-Fagetum,* N 49° 16' 43" E 19° 57' 27", 20 Aug 2001, *leg.* A. Ronikier (KRAM F-54392); Sarnia Skała massif, southern slope, near the summit, alt. 1350 m, *Pinetum mugo carpaticum,* N 49° 15' 54" E 19° 56' 30", 12 Oct 2001, *leg.* A. Ronikier (KRAM F-54393); SLOVAKIA, mouth of the Jalovecká dolina valley, vicinity of Bobrovecká vápenica, alt. ca. 850 m, spruce forest, N 49° 10' 10" E 19° 38' 04", 26 Jun 1998, *leg.* S. Adamčík (SAV F-1276).

Note. – European members of *Russula* sect. *Plorantinae* Bataille (Romagnesi 1967) with pale spores [white to pale cream, Ib–IIa according to Romagnesi (1967)] are usually identified either as *R. delica* Fr. or as *R. chloroides*. Typical features of *R. chloroides* are: (i) a distinct central depression of the pileus, (ii) a more or less regular pileus margin (not lobate or undulate), (iii) a relatively long stipe, and (iv) narrow and crowded lamellae. Most of our collections have the typical habit of *R. chloroides*, but one collection (KRAM F-54393) with a deep central pileus depression has some features typical of *R. delica*: distinctly broad and distant gills and a short stipe. In addition, spores of this collection have more numerous line connections and more prominent spines than those of other collections. Romagnesi (1967) described a few varieties of *R. delica* and *R. chloroides* that differ from the typical varieties mainly by macromorphological characters. The description of *Russula delica* var. *trachyspora* Romagn. (Romagnesi 1967), a variety recently combined by Sarnari (1998) in *R. chloroides* [*R. chloroides* var. *trachyspora* (Romagn.) Sarnari], is quite consistent with our collection KRAM F-54393. According to Romagnesi (1967), *R. delica* var. *trachyspora* is less calciphilous than the typical variety, while all of our collections were found in calcareous parts of the Tatra Mountains.

Russula cyanoxantha (Schaeff.) Fr.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, lower part of the Dolina Białego valley, at the Droga pod Reglami hiking trail, alt. 940 m, *Dentario glandulosae-Fagetum,* N 49° 16 '44" E 19° 57' 23", 4 Jul 2000, *leg.* A. Ronikier (KRAM F-50009); Sarnia Skała massif, lower part of the Dolina ku Dziurze valley, orographically left side of the valley, alt. 920 m, *Dentario glandulosae-Fagetum,* N 49° 16' 36" E 19° 56' 37", 4 Jul 2000, *leg.* A. Ronikier (KRAM F-54437); Sarnia Skała massif, lower part of the Grześkówki ridge, alt.

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990 m, *Dentario glandulosae-Fagetum,* N 49° 16' 33" E 19° 56' 23", *leg.* A. Ronikier (KRAM F-54438).

Russula decolorans (Fr.) Fr.

Material examined. – SLOVAKIA, High Tatra Mountains, lower part of the Mlynická Dolina valley, at a hiking trail (yellow) to the Bystré sedlo pass, alt. 1400 m, spruce forest with *Pinus cembra*, among mosses (*Sphagnum*), N 49° 08' 7" E 20° 03' 22", 19 Sep 2000, *leg.* A. Ronikier, M. Ronikier (KRAM F-50576); Popradská Kotlina, Kežmarské Žľaby, N-E of the Kežmarská Biela voda stream, alt. ca. 980 m, windfall with *Picea abies, Larix decidua, Pinus sylvestris*, 11 Sep 2007, *leg.* S. Adamčík (SAV F-1310); Belanské Tatry Mountains, S-E slopes of the Ždiarska vidla (Plačlivá skala) massif, about 160 m N-W of the Široké sedlo pass, alt. 1850 m, *Pinetum mugo carpaticum*, N 49° 14' 19" E 20° 12' 41", 23 Jul 2007, *leg.* A. Ronikier, S. Adamčík (KRAM F-45054).

Russula emetica (Schaeff.) Pers.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, *leg.* A. Ronikier, (KRAM F-54430); Sarnia Skała massif, upper part of the Dolina ku Dziurze valley, near caves, alt. 1060 m, *Polysticho-Piceetum,* N 49° 16' 15" E 19° 56' 37", 21 Aug 2002, *leg.* A. Ronikier (KRAM F-54429); SLOVAKIA, Western Tatra Mountains, lower part of the Roháčska dolina valley, N-E of Brestová village, at the road from Brestová to Zverovka, Mačie diery nature reserve, alt. ca. 1000 m, spruce forest, N 49° 15' 31" E 19° 40' 38", 10 Sep 2006, *leg.* V. Kučera (SAV F-1281); Popradská Kotlina, Kežmarské Žľaby, N-E of the Kežmarská Biela voda stream, alt. ca. 980 m, windfall with *Picea abies, Larix decidua, Pinus sylvestris*, 11 Sep 2007, *leg.* S. Adamčík (SAV F-1311).

Russula favrei M.M. Moser

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, S-SW slope of the Sarnia Skała massif, alt. 1170 m, *Polysticho-Piceetum,* N 49° 16' 3" E 19° 56' 18", 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54436); 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54435); Sarnia Skała massif, upper montane belt, *Polysticho-Piceetum*, 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54434); upper part of the Dolina Tomanowa valley, E edge of the Wyżnia Tomanowa Polana meadow, alt. 1450 m, spruce forest, N 49° 13' 20" E 19° 53' 50", 26 Jul 2002, *leg.* A. Ronikier, M. Ronikier (KRAM F-45071).

Russula fellea (Fr.) Fr.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, lower part of the Dolina Białego valley, on the Droga pod Reglami hiking trail, alt. 940 m, *Dentario glandulosae-Fagetum,* N 49° 16 '44" E 19° 57' 23", 3 Oct 2002, *leg.* A. Ronikier (KRAM F-54225); Sarnia Skała massif, upper part of the Dolina ku Dziurze valley, alt. 1050 m, windfall with *Sorbus aucuparia* and *Picea abies,* N 49° 16' 14" E 19° 56' 37", 24 Sep 1999, *leg.* A. Ronikier (KRAM F-50047).

Russula firmula Jul. Schäff.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, upper part of the Dolina Spadowiec valley, alt. 1145 m, *Polysticho-Picee-*

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tum, N 49° 16' 15" E 19° 56' 54", 9 Sep 2001, *leg.* A. Ronikier (KRAM F-54735); 20 Aug 2001, *leg.* A. Ronikier (KRAM F-54737); 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54757); Sarnia Skała massif, S-SW slope of the Sarnia Skała massif, alt. 1170 m, *Polysticho-Piceetum,* N 49° 16' 3" E 19° 56' 18", 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54756); 22 Aug 2001, *leg.* A. Ronikier (KRAM F-54736); Sarnia Skała massif, S-W slope of the Sarnia Skała massif, on a path, alt. 1160 m, *Polysticho-Piceetum,* N 49° 16' 4" E 19° 56' 16", 22 Aug 2001, *leg.* A. Ronikier (KRAM F-54738).

Note. – We accept Sarnari's (1998) concept of the species following Schäffer (1933, 1952), who recognized *R. firmula* basidiomata as moderately large, with firm flesh, violaceous-purple color of the pileus, acrid taste, yellow spore print, spores with isolated spines, and occurring in coniferous mountain forests. Recent authors (e.g. Einhellinger 1985) follow this interpretation of the species, while *R. firmula* in the sense of Romagnesi (1967) is characterized by different spores, ornamented with low warts.

Russula griseascens (Bon & Gaugé) Marti

Material examined. – POLAND, Western Tatra Mountains, Dolina Suchej Wody valley, vicinity of the Wyżni Toporowy Staw lake, alt. 1130 m, *Piceetum tatricum*, N 49° 16' 48" E 20° 01' 58", 27 Jul 2002, *leg.* A. Ronikier, M. Ronikier (KRAM F-45064).

Russula integra (L.) Fr.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, upper part of the Dolina Białego valley, N slopes of Dziadowiec, alt. 1180 m, *Polysticho-Piceetum,* N 49° 15' 54" E 19° 57' 7", 9 Sep 2003, *leg.* A. Ronikier (KRAM F-54748); Sarnia Skała massif, 14 Oct 2003, *leg. A. Ronikier* (KRAM F-45244); Sarnia Skała massif, mouth of the Dolina Spadowiec valley, alt. 930 m, *Abieti-Piceetum,* N 49° 16' 44" E 19° 57' 7", 12 Jul 2002, *leg.* A. Ronikier (KRAM F-54747); SLOVAKIA, Western Tatra Mountains, mouth of the Jalovecká dolina valley, vicinity of Bobrovecká vápenica, alt. ca. 850 m, spruce forest with *Larix decidua*, N 49° 10' 10" E 19° 38' 04", 3 Aug 1997, *leg.* S. Adamčík (SAV F-1287); 2 Aug 1997, *leg.* S. Adamčík (SAV F-1288; SAV F-1289); Western Tatra Mountains, upper part of the Tichá dolina valley, S-E slopes of Suchý vrch Kondracký, by the Tichý potok stream, alt. ca. 1350 m, spruce forest, N 49° 13' 06" E 19° 56' 20", 29 Oct 2003, *leg.* S. Adamčík (SAV F-1290).

Note. – *Russula integra* is a conifer-associated species characterized by a mild taste, a yellow spore print, incrusted pileocystidia with the sulphovanillin positive reaction, and spores with isolated spines (Romagnesi 1967). The great variation of micromorphological characters, such as the intensity of incrustation and spore ornamentation, observed among various collections of the *R. integra* complex is reflected in the identification of infraspecific taxa (e.g. *R. integra* var. *oreas* Romagn., Romagnesi 1967) or the

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description of new, similar species (e.g. *R. integriformis* Sarnari; Sarnari 1994). We also found a significant variability of micromorphological characters in our collections. Most of them have distinctly incrusted pileocystidia, while the incrustation of two others (KRAM F-45244, SAV F-1290) is indistinct and present only in their basal part. The terminal cells of generative hyphae in the center of the pileus in most specimens studied by us are frequently constricted at the apex up to 2 µm, apart from two collections (SAV F-1290, KRAM F-54747) in which we found wider (obtuse) apices. Specimens of these two collections also differ in the shape and size of pileocystidia. Their terminal cells are more slender and shorter (average values per collection are 34.5 × 5.1 and 25.2 × 5.8 µm, respectively) than in other collections (average values per collections 37.1 × 6.9 µm, 48.6 × 6.1 µm, 57.2 × 9 µm, and 38.7 × 8.1 µm).

Some characters observed by us are distinctive of other similar and recently described species: for instance, wide and obtuse terminal cells of generative hyphae are characteristic of *R. integriformis* (Sarnari 2005); we could not find, however, other typical features of this fungus (e.g. incrustation of pileocystidia and spore ornamentation). We identified all specimens of our collections as *R. integra*, being aware that the taxonomical value of the characters observed by us should be verified on a more extensive body of material.

Russula laurocerasi Melzer

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, middle part of the Grześkówki ridge, alt. 1000 m, *Dentario glandulosae-Fagetum,* N 49° 16' 30" E 19° 56' 21", 22 Aug 2001, *leg.* A. Ronikier (KRAM F-51604).

Russula mairei Singer

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, Grześkówki ridge, alt. 1060 m, *Dentario glandulosae-Fagetum,* N 49° 16' 19" E 19° 56' 13", 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54427); Sarnia Skała massif, upper part of the Dolina ku Dziurze valley, orographically the right side of the valley, just above the caves, alt. 1050 m, *Dentario glandulosae-Fagetum,* N 49° 16' 17" E 19° 57' 52", 1 Jun 2003, *leg.* A. Ronikier (KRAM F-54428).

Russula mustelina Fr.

Material examined. – POLAND, High Tatra Mountains, Dolina Złota valley, Wiktorówki, N of the Rusinowa Polana meadow, alt. ca. 1100–1200 m, spruce forest, 28 Aug 2005, *leg.* D. Zdebska (KRAM F-45070); SLOVAKIA, Western Tatra Mountains, upper part of the Tichá dolina valley, S-E slopes of Suchý vrch Kondracký, by The Tichý potok stream, alt. ca. 1350 m, spruce forest, N 49° 13' 06" E 19° 56' 20", 29 Oct 2003, *leg.* S. Adamčík (SAV F-1278).

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Russula nauseosa (Pers.) Fr.

Material examined. – POLAND, Western Tatra Mountains, upper part of the Dolina Tomanowa valley, E edge of the Wyżnia Tomanowa Polana meadow, alt. 1450 m, spruce forest, N 49° 13' 20" E 19° 53' 50", 26 Jul 2002, *leg.* A. Ronikier, M. Ronikier (KRAM F-45068); SLOVAKIA, Western Tatra Mountains, lower part of the Jalovecká dolina valley, vicinity of Bobrovecká vápenica, alt. ca. 950 m, spruce forest, N 49° 10' 10" E 19° 38' 04", 2 Aug 1997, *leg.* S. Adamčík (SAV F-1285); lower part of the Jalovecká dolina valley, S slopes of Babky peak, on the hiking trail to the Sivý vrch massif, alt. ca. 1150 m, spruce forest with *Pinus sylvestris* and *Larix decidua*, N 49° 10' 17" E 19° 37' 52", 3 Aug 1997, *leg.* S. Adamčík (SAV F-1286).

Russula nigricans (Bull.) Fr.

Material examined. – POLAND, Western Tatra Mountains, lower part of the Dolina Białego valley, on the Droga pod Reglami hiking trail, alt. 940 m, *Dentario glandulosae-Fagetum,* N 49° 16' 44" E 19° 57' 23", 22 Aug 2001, *leg.* A. Ronikier (KRAM F-51563).

Russula ochroleuca (Pers.) Fr.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, a ridge between the Dolina Białego valley and the Dolina Spadowiec valley, alt. 1020 m, *Dentario glandulosae-Fagetum,* N 49° 16' 28" E 19° 57' 20", 8 Nov 2000, *leg.* A. Ronikier (KRAM F-50392); SLOVAKIA, Western Tatra Mountains, upper part of the Tichá dolina valley, S-E slopes of Suchý vrch Kondracký, by the Tichý potok stream, alt. ca. 1350 m, spruce forest, N 49° 13' 06" E 19° 56' 20", 29 Oct 2003, *leg.* S. Adamčík (SAV F-1291).

Russula paludosa Britzelm.

Material examined. – POLAND, Western Tatra Mountains, Dolina Suchej Wody valley, N of the Niżni Toporowy Staw lake – "Brzeziny", alt. 1050 m, *Piceetum tatricum*, N 49° 17' 10" E 20° 01' 50", 27 Jul 2002, *leg.* A. Ronikier, M. Ronikier (KRAM F-45063); SLOVAKIA, Popradská Kotlina, Kežmarské Žľaby, N-E of the Kežmarská Biela voda stream, alt. ca. 980 m, windfall with *Picea abies*, *Larix decidua*, *Pinus sylvestris*, 11 Sep 2007, *leg.* S. Adamčík (SAV F-1312); Western Tatra Mountains, lower part of the Roháčska dolina valley, N-E of Brestová village, by the road from Brestová to Zverovka, Mačie diery nature reserve, alt. ca. 1000 m, spruce forest, N 49° 15' 31" E 19° 40' 38", 10 Sep 2006, *leg.* V. Kučera (SAV F-1705).

Russula postiana Romell

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, N slopes of the Grześkówki ridge, by the Droga pod Reglami hiking trail, alt. 910 m, *Dentario glandulosae-Fagetum,* N 49° 16' 43" E 19° 56' 27", *leg.* A. Ronikier (KRAM F-54439); SLOVAKIA, Western Tatra Mountains, lower part of the Jalovecká dolina valley, vicinity of Bobrovecká vápenica, alt. ca. 950 m, spruce forest, N 49° 10' 10" E 19° 38' 04", 2 Aug 1997, *leg.* S. Adamčík (SAV F-1279).

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Russula queletii Fr.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, upper part of the Dolina Spadowiec valley, alt. 1145 m, *Polysticho-Piceetum,* N 49° 16' 15" E 19° 56' 54", 20 Aug 2001, *leg.* A. Ronikier (KRAM F-54432); Sarnia Skała massif, W slope of the massif, alt. 1250 m, *Polysticho-Piceetum/ Pinetum mugo carpaticum,* N 49° 15' 58" E 19° 56' 17", 22 Aug 2001, *leg.* A. Ronikier (KRAM F-51591); Sarnia Skała massif, upper part of the Dolina Strążyska valley, by the Ścieżka nad Reglami hiking trail, alt. 1100 m, spruce forest with young beech trees, N 49° 15' 45" E 19° 55' 57", 5 Sep 2000, *leg.* A. Ronikier (KRAM F-50605); Sarnia Skała massif, mouth of the Dolina Białego valley, alt. 940 m, spruce forest with *Fagus sylvatica* and *Aces pseudoplatanus,* N 49° 16' 44" E 19° 57' 27", 8 Sep 2001, *leg.* A. Ronikier (KRAM F-51659).

Russula risigallina (Batch) Sacc.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, middle part of the Dolina Spadowiec valley, orographically right side of the valley, alt. 1040 m, *Dentario glandulosae-Fagetum,* N 49° 16' 30" E 19° 57' 7", 7 Jul 2001, *leg.* A. Ronikier (KRAM F-51515); Sarnia Skała massif, Dolina Spadowiec valley, western slope (right side of the valley), alt. 1020 m, *Dentario glandulosae-Fagetum,* N 49° 16' 26" E 19° 57' 1", 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54433); Sarnia Skała massif, lower part of the Dolina Białego valley, at the Droga pod Reglami hiking trail, alt. 940 m, *Dentario glandulosae-Fagetum,* N 49° 16' 44" E 19° 57' 23", 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54389); Sarnia Skała massif, upper part of the Grześkówki ridge, alt. 1100 m, *Dentario glandulosae-Fagetum,* N 49° 16' 17" E 19° 56' 17", 20 Aug 2002, *leg.* A. Ronikier (KRAM F-54388).

Note. – Our specimens were characterized by yellow pilei. Based on macromorphological characters (e.g. color of spore print, smell, and pileus colors), Sarnari (2005) and Romagnesi (1967) distinguish several taxa related to *R. risigallina*. Because some of these macrocharacters are often unstable and micromorphological differences are very small, we accept the wide concept of *R. risigallina* in which morphotypes with yellow pilei are included.

Russula romellii Maire

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, lower part of the Dolina Białego valley, by the Droga pod Reglami hiking trail, alt. 940 m, *Dentario glanulosae-Fagetum*, N 49° 16' 42" E 19° 57' 27", 20 Aug 2002, *leg.* A. Ronikier (KRAM F-45066).

Russula roseipes Secr. ex Bres., Figs. 3–9.

Pileus 32–80 mm, soon expanding, plane and with low central depression, margin not striate or only indistinctly so when mature, surface first bright orange-red with brownish tints in the center, later discoloring to pink, orange, bright egg-yellow to almost white in the center, discolored areas sometimes forming white spots at the

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margin, pileipellis shining when wet. – Stipe 25–75 × 7–24 mm, cylindrical, stuffed, with distinct longitudinal striation, white and usually with pinkish shade, either as pink spots at the base or present on larger parts of the stipe surface. – Lamellae moderately distant, first pale yellow, then bright yellow. – Flesh compact in stipe and pileus, with faint sweetish smell when fresh, taste mild. – Spore print bright yellow, IVd according to Romagnesi's (1967) scale. – Basidia (37) 39–50 (56) × (10) 10.5–11.5 (12) µm, av. 44.7 × 11 µm, 4-spored, clavate (Fig. 7). – Cheilocystidia numerous. – Pleurocystidia scattered, (44) 51–70 (79) × (7.5) 8.5–11 (12) µm, av. 60.6 × 9.9 µm, distinct and protruding from hymenium, clavate with obtuse apices, in Congo red with heteromorphous content forming a distinct spot in the apical part, with sulphovanillin-positive content (granulose), slightly thick-walled (Fig. 8). – Spores (7.5) 7.9–8.7 (9.6) × (5.8) 6.2–6.8 (7.2) µm, av. 8.3 × 6.5 µm, Q = (1.19) 1.23–1.34 (1.39), av. Q = 1.29, amyloid ornamentation formed by 0.3–0.5 µm high warts, mostly isolated and occasionally fused in pairs or short crests, rarely connected by line connections, suprahilar plage distinctly amyloid (Fig. 9). – Pileipellis composed of incrusted primordial hyphae and generative hyphae. – Primordial hyphae covered with thick incrustation along their whole length; incrustation present also in lower parts of primordial hyphae, in subpellis (or trama) layers; incrustation disappearing in Congo red, content with heteromorphous inclusion mostly in the apical part of terminal cells or in their upper half, but sometimes also close to the first septum, otherwise the content is clear; terminal cells of primordial hyphae (18) 25–54 (76) × 5–7 (8) µm, av. 39.3 × 6.1 µm, mostly cylindrical or narrowly clavate, rarely (when longer) slightly narrower at apex, distinctly longer and wider than terminal cells of generative hyphae (Figs. 3–4). – Generative hyphae from margin of pileus with terminal cells (10) 14–22.5 (30) × (3) 4–5.5 (6) µm, av. 18.3 × 4.5 µm, mostly narrowly clavate, occasionally cylindrical, very rarely with terminal constriction or with lateral nodules; subapical cells mostly branched, irregularly interwoven and with frequent irregular nodules, branches or constrictions (Fig. 6). Terminal cells from the center of pileus similar to those from the margin, but more slender, (10) 13.5–21 (27.5) × (2.5) 3–3.5 (4) µm, av. 17.3 × 3.1 (Fig. 5).

Material examined. – SLOVAKIA, Western Tatra Mountains, mouth of the Jalovecká dolina valley, vicinity of Bobrovecká vápenica, alt. ca. 850 m, spruce forest with *Larix decidua*, N 49° 10' 10" E 19° 38' 04", 26 Jun 1998, *leg.* S. Adamčík (SAV F-1294).

Note. – *R. roseipes* is the only member of *Russula* subsect. *Amethystinae* (Romagn.) Bon (Sarnari 1998, 2005) with red-colored pileus, incrusted primordial hyphae and yellow spore print, and is

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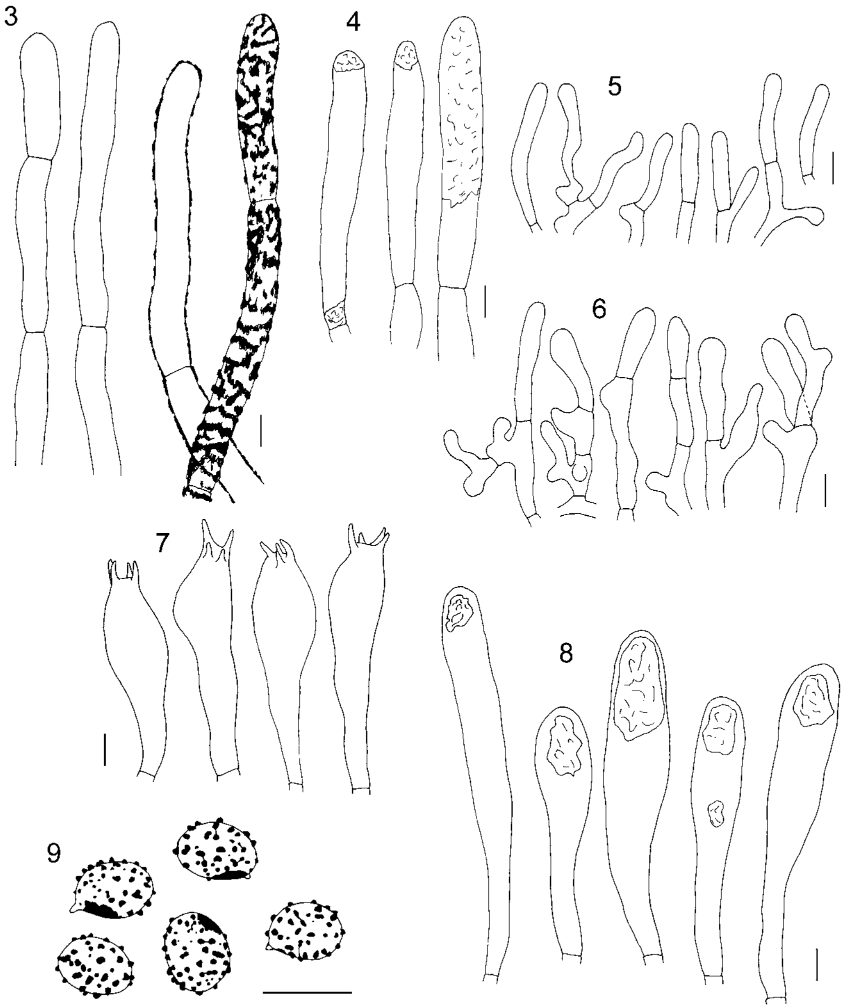

Figs. 3–9. *Russula roseipes* (coll. SAV F-1294): **3.** Primordial hyphae in basic fuchsin. **4.** Primordial hyphae in Congo red; note the heterogeneous content in some parts of the terminal cell. **5.** Terminal cells of generative hyphae from the center of the pileus. **6.** Terminal cells of generative hyphae from the margin of the pileus. **7.** Basidia. **8.** Pleurocystidia. **9.** Spores. Scale bar = 10 µm.

therefore easy to identify. There are, however, some dissimilarities in micromorphology between our observations and literature data: the spore size of our collection agrees with the values in the literature, but the ornamentation does not exceed 0.6 µm. Both Romagnesi (1967) and Sarnari (2005) specify an ornamentation height of at least 0.6 µm. Secondly, the type of ornamentation differs also: the specimens of our collection do not have distinctly crested or subreticulate

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spores as described and drawn by the two authors mentioned before. This is in agreement with Hesler (1961) and Einhellinger (1985) who also observed a lower ornamentation (up to 0.5 µm) with few connections on spores in Julius Schaeffer's material and in additional material from Germany.

Some representatives of *Russula* subsect. *Chamaeleontinae* form spores covered with isolated warts, like in our specimens of *R. roseipes,* with the pileus of similar colors, but they differ in their slender habit, fragile flesh, and their slender, incrusted primordial hyphae, which are hardly thicker than 5 µm (Sarnari 2005).

Russula sapinea Sarnari**,** Figs. 10–16.

Pileus 30–60 mm, soon expanding, plane and with low central depression, margin distinctly striate when mature; surface shining when wet, greyish-pink, center darker brown-purple, discoloring towards margin into greyish-ochraceous spots and becoming variegated. – Stipe 35–50 × 8–17 mm, typically slightly clavate, almost smooth, first white, later becoming distinctly pale rusty brown in central part, white and usually with pinkish shade, fragile, stuffed. – Lamellae rather distant when adult, first cream, then ochraceous and often with rusty brown edges. – Flesh fragile, without smell, taste mild. – Spore print ochraceous, IIIc according to Romagnesi's (1967) scale. – Basidia (32) 39.5–48.5 (50) × (10) 11–12.5 (13) µm, av. 43.9 × 11.7 µm, 4-spored, clavate (Fig. 15). – Pleurocystidia scattered. – Cheilocystidia numerous, (39) 40.5–62 (76) × (8) 8.5–10.5 (11) µm, av. 51.3 × 9.4 µm, clavate or fusiform, mostly with obtuse tips, occasionally with terminal constriction or appendage, cell walls slightly thickened except from terminal part where they are very thin and easily collapsing, with heteromorphous content in Congo red, sulphovanillin reaction positive (Fig. 16). – Spores (8.2) 8.8–10 (10.8) × (6.9) 7.5–8.5 (9) µm, av. 9.4 × 8 µm, Q = (1.1) 1.14–1.22 (1.28), av. Q = 1.18, amyloid ornamentation formed by 0.3–0.5 µm high warts, which are isolated and often fused into groups or crests, occasionally connected with line connections, suprahilar plage distinctly amyloid (Fig. 14). – Pileipellis composed of pileocystidia and generative hyphae. – Pileocystidia with sulphovanillin-positive content, with distinctly heteromorphous content in Congo red, composed of distinctly wider cells than generative hyphae, terminal cells 15–40 (44) × 3.5–4.5 (7) µm, av. 27.2 × 5.9 µm, more than the half of pileocystidia are one-celled, but pileocystidia with 2–7 cells are also frequent. (One-celled pileocystidia are usually longer than the terminal cells of multi-celled pileocystidia.) (Figs. 10, 12). – Generative hyphae at the pileus margin mostly branched at second or third cells from the top, cells in lower layers irregularly interwoven,

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terminal cells (19) 26–54 (75) × 3–4 µm, av. 40.3 × 3.4 µm, very irregularly nodulose, molliniform, slender and long, constricted only at tips, sometimes also attenuated, tips 1.5–3.5 µm wide (av. 2.2) (Fig. 11). The terminal cells in the center of pileus, (14) 18–33.5 (38) × 2–3.5 (4) µm, av. 26 × 3 µm, similar to those from the margin, but shorter, very dense, irregular in shape, more frequently nodulose and frequently also fusiform or attenuated; the terminal part more distinctly constricted and mostly 1–1.5 (2) µm wide (Fig. 13).

Material examined. – POLAND, Western Tatra Mountains, upper part of the Dolina Tomanowa valley, E edge of the Wyżnia Tomanowa Polana meadow, alt. 1450 m, spruce forest, N 49° 13' 20" E 19° 53' 50", 26 Jul 2001, *leg.* A. Ronikier, M. Ronikier (KRAM F-45061); SLOVAKIA, Western Tatra Mountains, lower part of the Jalovecká dolina valley, S slopes of Babky peak, by the hiking trail to the Sivý vrch massif, alt. ca. 1150 m, spruce forest with *Pinus sylvestris* and *Larix decidua*, N 49° 10' 17" E 19° 37' 52", 3 Aug 1997, *leg.* S. Adamčík (SAV F-1292).

Note. *Russula sapinea* may be confused with *R. puellaris*, which also occurs in coniferous forests, is similar in habit and pileus colors, and with yellowing flesh. *Russula puellaris* differs in having a slightly paler spore print, more distinctly and more strongly yellowing flesh, smaller spores, and a lower number of septa in pileocystidia (Sarnari 2005). Sarnari (2005) also mentions differences in the size of basidia, but we could not confirm this character with our material.

Russula aff. ***silvestris*** (Singer) Reumaux

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, southern slope, near the summit, alt. 1350 m, *Pinetum mugo carpaticum,* among mosses, N 49° 15' 54" E 19° 56' 30", 8 Sep 2001, *leg.* A. Ronikier (KRAM F-54426); SLOVAKIA, Popradská Kotlina, Kežmarské Žl'aby, N-E of the Kežmarská Biela voda stream, alt. ca. 980 m, windfall with *Picea abies, Larix decidua, Pinus sylvestris*, 11 Sep 2007, *leg.* S. Adamčík (SAV F-1281).

Note. – The specimens of our two collections had spores 8.5–11 (12) × 7–9 µm, with prominent spines connected to an almost complete reticulum, slender and fragile basidiomata with distinctly discolored pileus centers. Two taxa are characterized by small basidiomata and discoloring pileus: *R. sylvestris*, occurring in hardwood forests on acidic soil, and *R. betularum* Hora, found primarily under *Betula*. Our collections are more consistent with *R. silvestris*, but have slightly bigger spores. According to Sarnari (1998) and Kränzlin (2005), *R. silvestris* spores are smaller [7.2–9.8 × 6.2–7.8 (8.2) µm], while those of *R. betularum* are 8–11.8 × 7.3–9.6 µm. Some authors, however, report a similar spore size for both species: 8–10 (11) × (6.5) 7–8.5 (e.g. Däncke & Däncke 1980, Knudsen & Stordal 1992).

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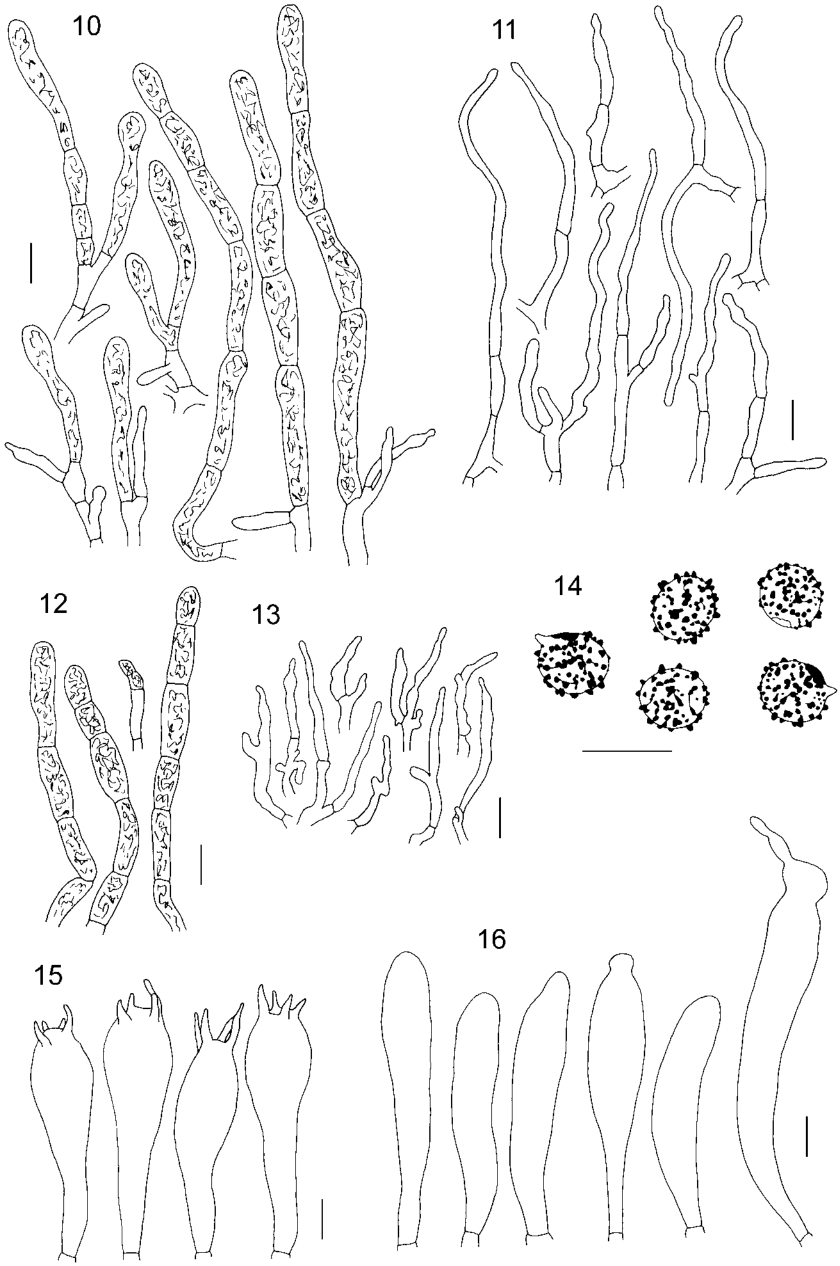

Figs. 10–16. *Russula sapinea* (coll. SAV F-1292): **10.** Pileocystidia from the margin of the pileus. **11.** Terminal cells of hyphae from the margin of the pileus. **12.** Pileocystidia from the center of the pileus. **13.** Terminal cells of hyphae from the center of the pileus. **14.** Spores. **15.** Basidia. **16.** Cheilocystidia. Scale bar = 10 µm.

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Russula turci Bres.

Material examined. – SLOVAKIA, Popradská Kotlina, Kežmarské Žľaby, N-E of the Kežmarská Biela voda stream, alt. ca. 980 m, windfall with *Picea abies, Larix decidua, Pinus sylvestris*, 11 Sep 2007, *leg.* S. Adamčík (SAV F-1314).

Russula vesca Fr.

Material examined. – POLAND, Western Tatra Mountains, Dolina Suchej Wody valley, vicinity of the Niżni Toporowy Staw lake, alt. 1100 m, *Piceetum tatricum*, N 49° 17' E 20° 2', 27 Jul 2001, *leg.* A. Ronikier, M. Ronikier (KRAM F-45062).

Russula veternosa Fr.

Material examined. – POLAND, Western Tatra Mountains, Sarnia Skała massif, Grześkówki ridge, alt. 1060 m, *Dentario glandulosae-Fagetum*, N 49° 16' 17" E 19° 56' 15", 5 Sep 2001, *leg.* A. Ronikier (KRAM F-45060).

Russula vinosa Lindblad

Material examined. – POLAND, Western Tatra Mountains, mouth of the Dolina Strążyska valley, by the Droga pod Reglami hiking trail, alt. 930 m, *Abieti-Piceetum,* N 49° 16' 44" E 19° 56' 27", *leg.* A. Ronikier (KRAM F-54440); S-SW slope of the Sarnia Skała massif, alt. 1170 m, *Polysticho-Piceetum,* N 49°16'3" E 19°56'18", 21 Aug 2002, *leg.* A. Ronikier (KRAM F-54391); S-W slope of the Sarnia Skała massif, by a path, alt. 1160 m, *Polysticho-Piceetum,* N 49° 16' 4" E 19° 56' 16", 22 Aug 2001, *leg.* A. Ronikier (KRAM F-51572). SLOVAKIA, Western Tatra Mountains, lower part of the Jalovecká dolina valley, Mních nature reserve, close to mount Sokol, alt. ca. 1300 m, *Piceetum tatricum*, N 49° 10' 20" E 19° 38' 10", 26 Jun 1998, *leg.* S. Adamčík (SAV F-1309).

Discussion

Forty-nine species of *Russula* were previously reported from the montane and subalpine belts of the Tatra Mountains (Tatra National Park). We found 22 of them at new localities and recorded 14 other species not known from the area (Table 1). *Russula roseipes* and *R. sapinea* are the two most interesting species. They are reported in this paper for the first time from Slovakia while the latter is also new to Poland. *Russula roseipes* was described in the past (Bresadola 1881); although widespread (known from Europe, North America, and Asia), it is a rare fungus preferring mountainous locations (e.g. Einhellinger 1985, Kränzlin 2005, Knudsen *et al.* 2008). *Russula sapinea* has been described by Sarnari (1994) only recently and its distribution and frequency are not yet fully known. It has been reported from Italy, Finland, Sweden and Norway (Sarnari 2005, Knudsen *et al.* 2008), and from Poland and Slovakia in this paper. It

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is possible that the fungus is not very rare, but has not been recognized.

As expected, many *Russulae* found by us in the Tatra Mountains are more widely considered to be mountain fungi (Tab. 1): *R. atrorubens*, *R. decolorans*, *R. emetica*, *R. firmula*, *R. integra*, *R. mustelina*, *R. paludosa*, *R. postiana*, *R. queletii*, *R. roseipes*, *R. sapinea* and *R. vinosa*. *Russula favrei* is probably common in montane forests, but was not distinguished from *R. xerampelina* for a long time (Moser 1979, Adamčík 2002); very little information on its altitudinal preferences is available in the literature. While it could be expected that mountain fungi should prefer higher elevations, most of them were found in the lower montane belt or in the lower and upper montane belts in the study area (Tab. 1). We noted only two mountain species, *R. decolorans* and *R. queletii*, in the subalpine shrubland. On the other hand, we recorded three non-mountain species, *R. chloroides*, *R. cessans*, and *R. silvestris*, in the subalpine *Pinetum mugo carpaticum*. Ronikier (2009) concluded that no fungi, either mycorrhizal or saprotrophic, may be considered to be associated exclusively with this plant association, and most ectomycorrhizal fungi recorded here are typical symbionts of pines in the lowlands. *Russula cessans* and *R. silvestris* represent such examples of fungi associated primarily with *Pinus* and are therefore common in lowland temperate forests or parks growing together with *Pinus silvestris* as well as in the Mediterranean region, where they are associated with other South-European pines (Sarnari 2005, Knudsen *et al.* 2008). *Russula cavipes*, *R. laurocerasi*, *R. mairei*, *R. romellii*, *R. vesca* and *R. veternosa* seem to prefer lowland and colline forests and occur only at the lowest elevations of the lower montane belt in the study area (Tab. 1).

The Tatra Mountains are geologically heterogeneous and are built up of crystalline, metamorphic and sedimentary rocks. Diverse geological bedrock influences vegetation assemblages as well as fungal diversity. Many *Russulae* found in the calcareous part of the Tatra Mountains are considered calciphilous (Tab. 1). *Russula integra, R. firmula,* and *R. queletii* are thought to be characteristic of montane Norway spruce forests on calcareous bedrock in the Alps (Moser 2004); we also found them only in the calcareous area of the Tatra Mountains. Three other species, *R. decolorans, R. paludosa,* and *R. vinosa*, are considered to be characteristic of acidic montane spruce forests in the Alps (Moser 2004). The first two occurred exclusively in the granitic part of the Tatra Mountains, while the latter was common in the upper montane belt of the calcareous Tatra Mountains (Tab. 1). Most authors believe that *R. vinosa* prefers nutrient-poor, acidic soils (Einhellinger 1985, Kränzlin 2005, Sarnari 2005), but the species has also been reported from calcareous mountains (e.g. Schmid-Heckel 1985, 1988). Similarly, we found other

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primarily acidophilus species, *Russula albonigra*, *R. emetica, R. ochroleuca,* and *R. silvestris*, in the calcareous part of the massif (Tab. 1). *Russula favrei* has also been often reported from siliceous areas (Adamčík 2002), but our observations show that it is frequent in calcareous regions.

Members of the genus *Russula* are ectomycorrhizal and many of them have a wide range of ectomycorrhizal partners. *Russula ochroleuca*, for example, has been reported from localities with various accompanying tree species; its mycorrhizal symbiosis with all trees given in Tab. 1 has been confirmed (Agerer & Rambold 2004–2008). On the other hand, some fungi prefer to form symbiosis with trees belonging to one genus. Beech forests in the Tatra Mountains occur in some parts of the massif where ectomycorrhizal fungi associated with *Fagus* can be encountered, e.g. *R. fellea*, *R. laurocerasi*, *R. mairei*, *R. veternosa* (Tab. 1). However, *Picea abies* and *Abies alba* are also present in the montane beech forest as an admixture, thus the occurrence of fungi thought to be associated with these conifers is not surprising; e.g. we recorded *R. cavipes* in the montane beech forest. Thus, for example, *Russula cavipes*, considered to be mycorrhizal with *Abies* and *Picea* (Tab. 1), is probably associated with one of these trees in the study area. As Norway spruce is the most common tree occurring in the mountains from the lower montane belt to the subalpine shrubland (where it grows in a dwarfed form up to the krummholz zone), present at all our localities, it must be considered as the most probable mycorrhizal partner. *Russula roseipes*, a fungus thought to be preferably associated with *Pinus*, may have formed mycorrhizae with Norway spruce in the study area as no pine trees were noted at its locality.

A comparison of our results with those from some of the main European mountain ranges shows that many *Russulae* known from the montane and subalpine belts of the Tatra Mountains are also often encountered in similar altitudinal vegetation zones in other mountains of Europe (Tab. 2). Favre (1960) and Horak (1963) reported 52 species of *Russula* from the Swiss National Park and its vicinity, 37 of them in common with those reported from the Tatra massif (SI = 0.64), and, 35 species of 39 noted by Schmid-Heckel (1985, 1988) in the Berchtesgaden National Park in the German Alps are also known from the Tatra massif (SI = 0.69); similarity in species composition is highest for these two regions. Twenty-one of 23 *Russulae* reported from the Bulgarian massif of the Rila Mountains (Gyosheva & Denchev 2000) are also listed for the Tatra Mountains (SI = 0.49). Almost all species known from the Tatra Mountains (n = 57) have been reported also from the French Pyrenees (152 species; SI = 0.53) (Corriol *et al.* 2004). Thus, we are confident that the composition of *Russula* species known from the Tatra Mountains is

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similar to that in other mountain regions of Europe. Species previously published from the Tatra Mountains, but not found by us, may be added to the above list (Tab. 2): *R. adusta*, *R. azurea*, and *R. consobrina*. They are considered to prefer mountain forests by Einhellinger (1985), Sarnari (1998, 2005), and Kränzlin (2005).

Tab. 2. – Representatives of the genus Russula known from the montane and subalpine belts of the Tatra Mountains (literature data and present study) and from other mountain regions of Europe: P – the Pyrenees, France (Corriol *et al.* 2004), SNP – Swiss National Park and its vicinity, Switzerland (Favre 1960, Horak 1963), BNP – Berchtesgaden National Park, Germany (Schmid-Heckel 1985, 1988), RNP – Rila National Park, Bulgaria (Gyosheva & Denchev 2000).

N°	**Species known from the Tatra Mountains**	**Reported from other mountain regions of Europe**			
		P	SNP	BNP	RNP
1.	*R. acrifolia*	+		+	
2.	*R. adusta*	+	+	+	
3.	*R. aeruginea*	+	+		+
4.	*R. albonigra*	+		+	
5.	*R. amethystina*	+		+	
6.	*R. anthracina*	+			
7.	*R. aquosa*	+	+		
8.	*R. atrorubens*	+	+		
9.	*R. aurea*	+	+	+	
10.	*R. aurora*	+			
11.	*R. azurea*	+	+		+
12.	*R. badia*	+		+	
13.	*R. betularum*	+			
14.	*R. cavipes*	+		+	
15.	*R. cessans*	+		+	
16.	*R. chloroides*	+		+	
17.	*R. claroflava*	+			
18.	*R. clavipes*	+			
19.	*R. consobrina*	+	+	+	
20.	*R. cyanoxantha*	+	+	+	+
21.	*R. decolorans*	+	+	+	
22.	*R. delica*	+	+	+	+
23.	*R. emetica*	+	+	+	+
24.	*R. emeticolor*	+			
25.	*R. exalbicans*	+	+		
26.	*R. farinipes*	+			
27.	*R. favrei*	+	+		
28.	*R. fellea*	+		+	
29.	*R. firmula*	+	+	+	+
30.	*R. foetens*	+	+		+
31.	*R. font-queri*	+			
32.	*R. fragilis*	+	+		+
33.	*R. griseascens*			+	
34.	*R. integra*	+	+	+	+
35.	*R. laurocerasi*	+			
36.	*R. mairei*			+	

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Tab. 2. – continued.

N°	Species known from the Tatra Mountains	Reported from other mountain regions of Europe			
		P	SNP	BNP	RNP
37.	*R. mustelina*	+	+	+	+
38	*R. nana*			+	
39.	*R. nauseosa*	+	+	+	+
40.	*R. nigricans*	+	+	+	+
41.	*R. nitida*	+	+		
42.	*R. ochroleuca*	+	+	+	+
43.	*R. olivacea*	+	+	+	
44.	*R. paludosa*	+	+	+	+
45.	*R. postiana*	+	+	+	
46.	*R. puellaris*	+	+		+
47.	*R. queletii*	+	+	+	+
48.	*R. rhodopoda*	+	+	+	
49.	*R. risigallina*	+	+		+
50.	*R. romellii*	+		+	
51.	*R. roseipes*	+	+		
52.	*R. sanguinea*		+	+	+
53.	*R. sapinea*				
54.	*R. silvestris*	+			
55.	*R. subfoetens*	+			
56.	*R. subrubens*				
57.	*R. turci*	+	+		+
58.	*R. vesca*	+	+		
59.	*R. veternosa*	+	+		
60.	*R. vinosa*	+	+	+	+
61.	*R. virescens*	+		+	
62.	*R. viscida*	+	+	+	
63.	*R. xerampelina*	+	+	+	+
No. of species in common:		**57**	**37**	**35**	**21**

Although a comparison of the results from the above-mentioned European areas with ours (Tab. 2) suffers from divergent research methods (e.g. number of observations, length of the study period), similarities in the species composition are obvious. Notably, either mountain species (*R. adusta*, *R. azurea*, *R. consobrina*, *R. delica*, *R. emetica*, *R. firmula*, *R. integra, R. mustelina*, *R. paludosa*, *R. queletii*, *R. vinosa*) or common and ubiquitous species (*R. chloroides*, *R. cyanoxantha*, *R, nigricans*, *R. ochroleuca*, *R. vesca*) have been reported from all or almost all mountainous regions of Europe compared here. Moser (2004), who analysed the composition of fungi in the montane forests of the Alps, Altai, and the Rocky mountains, concluded that the presence of similar kinds of ectomycorrhizal trees in these regions may explain similar diversity patterns of ectomycorrhizal fungi.

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