

## Diversity of *Russulaceae* in the Vihorlatské vrchy Mts. (Slovakia)

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*Russulaceae* taxa were studied in selected (nine) localities in the Vihorlatské vrchy Mts. (Slovakia) in the years 2001–2003. The study was focused on their diversity, ecology and distribution. A total of 75 species were identified, from which four species, *Lactarius romagnesii*, *Russula odorata*, *R. sericatula* and *R. zvaraе*, were not published from Slovakia before, and another eleven species are rare.

**Key words:** *Russula*, *Lactarius*, distribution, biodiversity, Slovakia, fungi.

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V rokoch 2001–2003 sme študovali taxóny čelede *Russulaceae* na vybraných (deviatich) lokalitách vo Vihorlatských vrchoch (na Slovensku). Počas výskumu sme sa zamerali na zistenie ich diverzity, ekológie a rozšírenia. Celkovo sme determinovali 75 druhov, z ktorých štyri, *Lactarius romagnesii*, *Russula odorata*, *R. sericatula* a *R. zvaraе*, dosiaľ neboli publikované na Slovensku a ďalších jedenásť druhov je vzácnych.

### INTRODUCTION

In Europe, most *Russulaceae* taxa are members of two agaricoid genera *Lactarius* and *Russula*. The *Russulaceae* family is one of the groups of mycorrhizal fungi with the highest diversity – the real number of taxa (species and infraspecific taxa) is not exactly known. Only few authors of monographic studies mentioned the number of accepted taxa for a delimited area, e.g. Einhellinger (1994) listed 153 taxa of the genus *Russula* in Germany, and Heilmann-Clausen et al. (1998) described 97 species of the genus *Lactarius* in the area of Northern Europe. Moreover, numerous taxa are taxonomically and nomenclaturally problematic and their taxonomic treatment differs in recent literature, e.g. Sarnari (1998, 2005) and Reumaux et al. (1996).

Our paper has two basic aims: (1) to study the diversity of *Russulaceae* in the Vihorlatské vrchy Mts. and (2) to estimate the frequency of the studied species in well-defined habitat types.

(1) Research of *Russulaceae* does not have a tradition in Slovakia. During the past years we have compiled some comprehensive works on the diversity of fungi in Slovakia (Lizoň and Bacigálová 1998, Adamčík et al. 2003). Lizoň and Bacigálová (1998) treat 118 taxa of the genus *Russula* and 71 of *Lactarius* published from the area of Slovakia. According to our knowledge of published data, the distribution of *Russulaceae* in most areas of Slovakia is insufficiently known and based often on dubious identifications and various taxonomical concepts (personal observations on herbarium material). Identifications of taxa in our paper follow recent taxonomical studies and several inconsistencies between our observations and current taxonomical concepts are discussed in chapter Taxonomic remarks.

(2) Published data on *Russulaceae* from the ecological aspect are sparse and insufficient. Sarnari (1998) included the ecology of the *Russula* species on several sites in Italy in his monograph. However, he characterised these sites only by the dominance of a simple host tree (e.g. beech forest or spruce forest) to which he added brief information about altitude and soil conditions. Other recent monographic studies on *Russula*, e.g. Einhellinger (1994), Van Vuure (1992), Hallingbäck and Aronsson (1998), Romagnesi (1967) generally lack data on the occurrence of *Russulaceae* in sufficiently defined habitats.

Sufficient information about the ecology of fungi in defined habitats should be given by coenological studies. Methods in phytocoenology are in comparison with mycocoenology better thoughtout, more established and used uniformly by most scientists. Whereas most phytocoenologists use methods of Zürich-Montpellier's school (Braun-Blanquet 1964, Westhoff and van der Maarel 1978), mycocoenologists use various methods, e.g. Keizer and Arnolds (1994), Šmarda (1968), Fellner (1987, 1988), Winterhoff (1992), Väre et al. (1996), which cause incomparability of data on fungal communities. For example, Keizer and Arnolds (1994) counted numbers of sporocarps per 1000 m<sup>2</sup> and Väre et al. (1996) measured grams of dried mass of sporocarps from 600 m<sup>2</sup>. Unfortunately, methods in mycocoenology are mostly not so effective as in phytocoenology. It requires a lot of field and laboratory work to count and pick sporocarps or to measure its biomass, but it cannot reflect the real proportion of mycelium in the biotope. Moreover, mycorrhizal fungi do not occur in compact populations such as vascular plants. Simple mycelia are often scattered in the forest. According to our knowledge, enlarging of studied sites (in a phytocoenologically homogeneous area) could mean an increase in diversity of mycorrhizal fungi. We do not know any comprehensive statistical studies recommending appropriately defined areas of sites for research of biodiversity of mycorrhizal fungi. For this reasons we collected our data from defined habitats of

various size and we provided our collections with estimated frequency degrees, as defined in the chapter Material and methods below.

## MATERIAL AND METHODS

We have collected and studied taxa of *Russulaceae* in nine selected localities in the Vihorlatské vrchy Mts. in the years 2001–2003 (Fig. 1; for detailed characteristics of the localities see text below). The localities represent four main types of habitat: (1) forests with dominance of *Fagus sylvatica* (the Nature Reserve of Machnatý vrch, the National Nature Reserve of Morské oko, the Nature Reserve of Jedlinka), (2) forests with dominance of *Carpinus betulus* and *Quercus* sp. div. (the locality of Hlivištia, the valley of the Dielový potok stream, the National Nature Reserve of Jovsianska hrabina, the Nature Reserve of Drieň), (3) abandoned pastures under succession (the locality of Strihovce), (4) peat-bog (the National Nature Reserve of Postávka).

The Vihorlatské vrchy Mts. (Eastern Slovakia, 166.5 km<sup>2</sup> of forest area) are located in the temperate belt of central Europe with a continental climate. The mean annual rainfall near the National Nature Reserve of Jovsianska hrabina (Fig. 1) is 788 mm, and mean annual temperature varies from 8.7 to 4.8 °C in higher altitudes (Ambros 1987). Most of the studied localities are situated in volcanic areas formed by andesites and tuffs, except for the locality of Strihovce with bedrock of sandstones, microconglomerates, and less claystones.

The diversity of *Russulaceae* taxa in the Vihorlatské vrchy Mts. has been compared with their diversity in the nearby areas of the Bukovské vrchy Mts. and the Ondavská vrchovina Hills (Tab. 1). Both are situated in the flysch belt (mostly sandstone or claystone in bedrock) and they are the only Slovak areas with sufficient *Russulaceae* data to compare. In the Bukovské vrchy Mts., research was carried out in 1992–1995 by J. Kuthan and S. Adamčík and the results concerning macrofungi (including *Russulaceae*) as well as information on localities were published in the book *Fungi in the National Park of Poloniny* (Kuthan et al. 1999). In the Ondavská vrchovina Hills, a survey was carried out in 1987–1995 by S. Adamčík. The localities are situated in the vicinity of Kvakovce village and they represent abandoned pastures in several types of succession (towards mixed forests) and beech forest (often with a few *Carpinus* or *Quercus* trees). Their altitude is c. 200 ± 50 m and exposition mostly south. The results of the survey on *Russulaceae* taxa in the Ondavská vrchovina Hills have not been published yet.

The position of the collecting sites is presented as geographical coordinates and the quadrant (Q) of the Central European grid mapping system (MTB). Coordinates are situated approximately in the centre of the locality. Categories of threat of vascular plants follow Feráková et al. (2001). Nomenclature and abbreviations of biotopes are according to Stanová and Valachovič (2002). Nomenclature

of vascular plants is according to Marhold and Hindák (1998). Names of orographic regions follow Adamčík et al. (2003).

Taxa of the genus *Lactarius* were identified according to the monograph by Heilmann-Clausen et al. (1998). For the identification of taxa of the genus *Russula* we used several publications, in most cases books by Romagnesi (1967) and Sarnari (1998, 2005). Due to several taxonomical problems, uncertain identifications are discussed.

Specimens are deposited in the herbaria of SAV and SLO. The abbreviations of the herbaria are cited in accordance with the Index Herbariorum (Holmgren et al. 1990).

Species are listed according to their mycorrhizal hosts. In case we did not know which of the present trees was the host, we mentioned all trees the species was associated with.

Species frequency is estimated in accordance with the following scale:

- 1 – one collecting site with few basidiocarps (five and less).
- 2 – one collecting site with numerous basidiocarps (more than five) or two or more collecting sites with few basidiocarps.
- 3 – two or more collecting sites, at least one of them with numerous basidiocarps.

Degrees of frequency in the parenthesis follow each taxon in the chapter Results.

Frequency and distribution of some species of special interest (considered to be rare in the literature or with lack of distribution data in Slovakia) are also discussed in Tab. 2.

## RESULTS

### Locality Strihovec

**Coordinates:** 48°53'52"N; 22°15'31"E; **Q:** 7099d; **altitude:** 470–720 m a.s.l.; **area:** apr. 22 ha; **bedrock:** sandstones, microconglomerates, rarely claystones; **soil:** Eutric Cambisol (Haplic Cambisol).

**Brief description.** Abandoned pasture in several succession stages, besides a few old solitary trees most of the area is covered by *Betula pendula*, *Populus tremula* and *Salix caprea*, groups of young trees are often interspersed with meadows.

**Biotope:** Difficult to specify. We suggest leaving it on the uppermost Kr level of thickets and shrub communities. It is closely related to the Kr7 biotope Blackthorn-hazel thickets or to the Kr3 biotope succession stages with *Juniperus communis* formations. This was a pasture area in the past, which has gradually been covered with woody species.

**Vegetation:**

**E<sub>3</sub>:** The fragmentary tree layer is dominated by *Betula pendula* (often damaged by cutting), *Populus tremula*, and *Salix caprea*. *Carpinus betulus*, *Cerasus avium*, *Fagus sylvatica*, *Pyrus communis*, and *Quercus petraea* also occur.

**E<sub>2</sub>:** The shrub layer is exceptionally well-developed and species-rich. It is formed by self-sown juveniles of the woody species *Betula pendula*, *Carpinus betulus*, *Frangula alnus*, *Populus tremula*, and



**Fig. 1.** Slovakia: A: Ondavská vrchovina hills, B: Bukovské vrchy Mts., C: Vihorlatské vrchy Mts.

Studied localities in the Vihorlatské vrchy Mts.: 1 – Postávka National Nature Reserve, 2 – Jedlinka Nature Reserve, 3 – Morské oko National Nature Reserve, 4 – Strihovce, 5 – Jovsianska hrabina National Nature Reserve, 6 – Machnatý vrch Nature Reserve, 7 – Drieň Nature Reserve, 8 – Hlivišťa, 9 –valley of Dielový potok stream.

*Quercus petraea* and by the shrubs *Corylus avellana*, *Crataegus* sp. div., *Juniperus communis*, and *Prunus spinosa*.

E<sub>1</sub>: The herb layer is mainly represented by the meadow species *Achillea millefolium*, *Acetosa pratensis*, *Carex flava*, *C. nigra*, *C. tomentosa*, *Cruciata glabra*, *Deschampsia cespitosa*, *Festuca pratensis*, *Fragaria vesca*, *Galium verum*, *Hypericum perforatum*, *Jacea pratensis*, *Lysimachia vulgaris*, *Luzula multiflora*, *Prunella vulgaris*, *Pteridium aquilinum*, *Tithymalus cyparissias* and *Viola canina*.

Data of field research: 12. VI. 2002, 16. X. 2002, 12. VI. 2003, 18. IX. 2003.

#### **Russulaceae species**

*Betula pendula*: *Lactarius glyciosmus* (1), *Lactarius pubescens* (1), *Lactarius tabidus* (1), *Russula aeruginea* (2), *Russula brunneoviolacea* (1), *Russula gracillima* (1), *Russula versicolor* (2).

*Fagus sylvatica*: *Lactarius subdulcis* (1), *Russula cyanoxantha* (1).

*Pinus sylvestris*: *Lactarius hygginus* (1).

*Betula pendula*, *Populus tremula*, *Salix caprea*: *Russula atrorubens* (1), *Russula medullata* (3), *Russula subfoetens* (2).

*Fagus sylvatica*, *Betula pendula*, *Populus tremula*: *Lactarius piperatus* (2).

## Machnatý vrch Nature Reserve

Coordinates: 48°50'54"N; 22°11'24"E; Q: 7199c; altitude: 280–350 m a.s.l.; area: 3.18 ha; bedrock: andesite; soil: Dystric Cambisol, Gleyic Fluvisol.

Brief description: forest with dominance of beech on steep slope and acid soil, most *Russulaceae* were collected in exposed mossy places.

Biotopes: Ls5.2 – Acidophilous beech forests; Ls1.3 – Submontane ash-alder floodplain forests – a fragment.

Phytocoenology: Ls5.2 – the union *Luzulo-Fagion* Lohmeyer et R. Tx. in R. Tx. 1954; Ls1.3 – the union *Alnion incanae* Pawłowski in Pawłowski et al. 1928 – sub-union *Almenion glutinoso-incanae* Oberd. 1953.

Vegetation:

E<sub>3</sub>: The acidophilous beech forests of the Ls5.2 biotope are species-poor. The tree layer is primarily formed by *Fagus sylvatica* with admixed *Acer pseudoplatanus*, *Betula pendula*, *Carpinus betulus*, *Cerasus avium*, *Quercus robur*, and *Pinus sylvestris*; *Pinus nigra* and *Pseudotsuga menziesii* are planted. The Ls1.3 submontane ash-alder floodplain forests create only a fragment nearby the stream with *Alnus glutinosa*, *Fraxinus excelsior*, and *Populus tremula*.

E<sub>2</sub>: The Ls5.2 shrub layer is especially developed in the northern and north-western part of the study area and is predominantly formed by juveniles of the main woody species. The Ls1.3 shrub layer is mainly represented by *Lonicera nigra*, *Prunus spinosa*, and *Salix caprea*.

E<sub>1</sub>: The Ls5.2 herb layer is primarily formed by acidophilous and oligotrophic species, such as *Carex pilulifera*, *Luzula luzuloides*, *Hieracium murorum*, *Pyrola minor*, and *Solidago virgaurea*. The endangered (EN) *Chimaphila umbellata* is abundant. Of the other species typical of beech forests, *Carex pilosa*, *Galium schultesii*, *Hieracium sabaudum*, *Maianthemum bifolium*, *Prenanthes purpurea*, *Salvia glutinosa*, and *Veronica officinalis* occur. The Ls1.3 herb layer is mostly formed by nitrophilous and hygrophilous species, such as *Aegopodium podagraria*, *Alliaria petiolata*, *Campánula trachelium*, *Carex sylvatica*, *Festuca gigantea*, *Ficaria bulbifera*, *Milium effusum*, *Telekia speciosa*, and *Rubus caesius*.

Data of field research: 12. VII. 2001, 19. IX. 2001, 13. VI. 2002, 20. X. 2002, 11. VI. 2003, 20. IX. 2003.

### **Russulaceae species**

*Fagus sylvatica*: *Lactarius blennius* (2), *Lactarius pallidus* (1), *Lactarius piperatus* (2), *Lactarius romagnesii* (1), *Lactarius serifulvus* (1), *Lactarius subdulcis* (2), *Lactarius volemus* (1), *Russula amoena* (2), *Russula cyanoxantha* (3), *Russula densifolia* (2), *Russula fellea* (2), *Russula grisea* (1), *Russula mairei* (2), *Russula nigricans* (3), *Russula pseudointegra* (1), *Russula raoultii* (1), *Russula risigallina* (1), *Russula rubra* (1), *Russula velenovskyi* (2), *Russula vetermosa* (1), *Russula virescens* (1).

## Morské oko National Nature Reserve

Coordinates: 48°54'54"N; 22°12'06"E; Q: 7099c; altitude: 550–750 m a.s.l.; area: 108.48 ha; bedrock: andesite; soil: Haplic Andosol to Skeleti-Leptic Andosol, Andi-Skeletal Leptosol to Skeletal Leptosol.

Brief description: old-growth forest with dominance of beech on steep slope.

Biotope: Ls5.1 – Beech and fir-beech forests with forb-rich undergrowth (the prevailing biotope);

Ls4 – Lime-maple forests on slopes, screes, and in ravines (in restricted area only).

Phytocoenology: Ls5.1 – the union *Fagion* Luquet 1926, sub-union *Eu-Fagenion* Oberd. 1957;

Ls4 – the union *Tilio-Acerion* Klika 1955.

Vegetation:

E<sub>3</sub>: *Fagus sylvatica* dominates the Ls5.1 tree layer, with admixed *Abies alba*, *Betula pendula*, *Picea abies*, and *Populus tremula*. The Ls4 treelayer is formed by *Acer pseudoplatanus*, *Fraxinus excelsior*, *Sorbus aucuparia*, and *Ulmus glabra*.

E<sub>2</sub>: Vegetation of the Ls5.1 shrub layer is poor. The shrub layer is mainly formed by sporadically occurring juveniles of *Fagus sylvatica* and some other species from E<sub>3</sub>. In the Ls4 biotope, the shrub layer is well-developed and represented by juveniles of *Acer pseudoplatanus*, *Sambucus racemosa*, *Corylus avellana* and some other species.

E<sub>1</sub>: The herb layer of the Ls5.1 beech and fir-beech forests with forb-rich undergrowth is relatively species-poor, although only in the central part of the study area. Species diversity is higher in the open stands at the study area edges being represented by *Athyrium filix-femina*, *Anemone nemorosa*, *Aegopodium podagraria*, *Carex pilosa*, *C. sylvatica*, *Circaea lutetiana*, *Doronicum austriacum*, *Dentaria bulbifera*, *D. glandulosa* (a Carpathian sub-endemit), *Dryopteris filix-mas*, *Gymnocarpium dryopteris*, *Hieracium sabaudum*, *Prenanthes purpurea*, *Salvia glutinosa*, and others. In the Ls4 lime-maple forests on slopes, screes, and in ravines, besides the herb species typical of beech forests, mainly nitrophilous and heminitrophilous herb species such as *Alliaria petiolata*, *Actaea spicata*, *Campanula rapunculoides*, *Dentaria bulbifera*, *Galium odoratum*, *Glechoma hirsuta*, *Lamium maculatum*, *Lunaria rediviva* and *Mercurialis perennis* occur.

Data of field research: 12. VII. 2001, 19. IX. 2001, 11. VI. 2002, 10. VI. 2003, 19. IX. 2003.

#### **Russulaceae species**

*Fagus sylvatica*: *Russula cyanoxantha* (3), *Russula faginea* (1), *Russula nigricans* (1), *Russula ochroleuca* (2), *Russula romellii* (2).

### **Jedlinka Nature Reserve**

Coordinates: 48°54'59"N; 22°10'51"E; Q: 7099c; altitude: 750–860 m a.s.l.; area: 32.89 ha; bedrock: hyperstene-augitic andesite; soil: Eutric Cambisol (Haplic Cambisol).

Brief description: old-growth forest with dominance of beech on steep slope.

Biotope: Ls5.1 – Beech and fir-beech forests with forb-rich undergrowth; Ls4 – Lime-maple forests on slopes, screes, and in ravines.

Phytocoenology: Ls5.1 – the union *Fagion* Luquet 1926, sub-union *Eu-Fagion* Oberd. 1957; Ls4 – the union *Tilio-Acerion* Klika 1955.

Vegetation:

E<sub>3</sub>: The Ls5.1 tree layer is mainly formed by *Fagus sylvatica*, less by *Acer pseudoplatanus*, *Fraxinus excelsior*, *Ulmus glabra*, and by the coniferous trees *Abies alba* and *Picea abies*. The Ls4 tree layer is mainly represented by the maples *Acer platanoides* and *A. pseudoplatanus*, also by *Fagus sylvatica*, *Fraxinus excelsior*, *Sorbus aucuparia*, and by some species from Ls5.1.

E<sub>2</sub>: The shrub layer is well-developed, especially in the central part. In the Ls5.1 biotope, it is formed by juveniles from the E<sub>3</sub> tree layer, e.g. *Fagus sylvatica*, *Fraxinus excelsior*, *Picea abies*, and *Abies alba*. Besides young trees from the E<sub>3</sub> layer, Ls4 is also formed by shrubs, such as *Lonicera nigra*, *Ribes wacrispa*, *Rosa pendulina*, *Sambucus racemosa* and *Salix* sp. div.

E<sub>1</sub>: The Ls5.1 beech and fir-beech forests with forb-rich undergrowth are distinguished for the multi-layered herb vegetation that includes typical forest sciophytes with high nutrient demands. The vegetation is composed of *Asarum europaeum*, *Calamagrostis arundinacea*, *Dentaria bulbifera*, *Doronicum austriacum*, *Dryopteris carthusiana*, *D. dilatata*, *D. filix-mas*, *Galium odoratum*, *Gentiana asclepiadea*, *Luzula sylvatica*, *Prenanthes purpurea*, *Rubus hirtus*, *Solidago virgaurea* and *Vaccinium myrtillus*. The herb layer of the Ls4 lime-maple forests on slopes, screes, and in ravines is represented by *Alliaria petiolata*, *Actaea spicata*, *Aruncus vulgaris*, *Campanula rapunculoides*, *Dentaria bulbifera*, *Galium odoratum*, *Glechoma hirsuta*, *Lamium maculatum*, *Lunaria rediviva*, *Lycopodium annotinum* (LR:nt), *Matteuccia struthiopteris* (VU), *Mercurialis perennis*, and some other species from the Ls5.1 biotope.

Data of field research: 11. VI. 2002, 18. X. 2002, 10. VI. 2003, 19. IX. 2003.

**Russulaceae species**

*Fagus sylvatica*: *Lactarius blennius* (2), *Lactarius romagnesii* (1), *Lactarius subdulcis* (3), *Russula cyanoxantha* (2), *Russula delica* (1), *Russula fellea* (1), *Russula grisea* (1), *Russula laurocerasi* (2), *Russula nigricans* (1), *Russula ochroleuca* (2), *Russula veternosa* (1).

**Locality Hlivištia**

Coordinates: 48°48'19"N; 22°13'53"E; Q: 7199c; altitude: 280–300 m a.s.l.; area: apr. 36 ha; bedrock: andesite; soil: Eutric Cambisol (Haplic Cambisol).

Brief description: ca. 60–80 years-old deciduous forest with dominance of *Carpinus betulus* and *Quercus* sp. div. on relatively flat relief.

Biotope: Ls2.1 – Carpathian oak-hornbeam woods.

Phytocoenology: The union *Carpinion* Issler 1931, sub-union *Carici pilosae-Carpinenion* J. et M. Michalko.

Vegetation:

E<sub>3</sub>: The vegetation-forming wood species of the tree layer are represented by *Acer campestre*, *Carpinus betulus*, *Quercus robur*, *Q. petraea*, and *Tilia cordata*. *Fagus sylvatica* is relatively abundant; *Cerasus avium* also occurs.

E<sub>2</sub>: The shrub layer is species-rich at the stand edges getting poor towards the middle of the stand. It is formed by *Carpinus betulus* juveniles, and the shrub species *Crataegus* sp. div., *Ligustrum vulgare*, *Prunus spinosa*, *Salix caprea*, *Sambucus nigra*, etc.

E<sub>1</sub>: The herb layer is markedly dominated by *Carex pilosa*, followed by mesophilous species typical of beech and oak forests, such as *Anemone nemorosa*, *Ajuga reptans*, *Asarum europaeum*, *Carex sylvatica*, *Cruciata glabra*, *Fragaria vesca*, *Galium schultesii*, *Genista tinctoria*, *Lathyrus niger*, *L. vernus*, *Melica nutans*, *M. uniflora*, *Melittis melissophyllum*, *Polygonatum odoratum*, *Sanicula europaea*, *Salvia glutinosa*, *Urtica dioica*, and *Viola reichenbachiana*. The Carpathian endemit *Dentaria glandulosa* is also present, along with the scarce lower risk (LR:nt) species *Lilium martagon*.

Data of field research: 13. VII. 2001, 13. VI. 2002, 11. VI. 2003, 20. IX. 2003.

**Russulaceae species**

*Quercus* sp. div.: *Russula* cf. *pseudoromellii* (1), *Russula graveolens* (1).

*Fagus sylvatica*: *Lactarius pallidus* (1), *Russula cyanoxantha* (3), *Russula mairei* (1), *Russula solaris* (2), *Russula veternosa* (1).

*Carpinus betulus*: *Lactarius circellatus* (1), *Russula sericatula* (1).

*Quercus* sp. div., *Fagus sylvatica*, *Carpinus betulus*: *Lactarius flavidus* (1), *Lactarius piperatus* (3), *Russula acrifolia* (2), *Russula heterophylla* (3), *Russula aurea* (2), *Russula laurocerasi* (1), *Russula lepida* (1), *Russula meliolens* (1), *Russula pectinatoides* (3), *Russula risigallina* (1), *Russula romellii* (2), *Russula vesca* (3).

*Quercus* sp. div., *Carpinus betulus*: *Lactarius pterosporus* (1), *Russula sororia* (1).

*Fagus sylvatica*, *Carpinus betulus*: *Lactarius volemus* (1), *Russula nigricans* (2), *Russula virescens* (1).

**Valley of the Dielový potok stream**

Coordinates: 48°48'17"N; 22°15'56"E; Q: 7199d; altitude: 280–350 m a.s.l.; area: apr. 22 ha; bedrock: pyroxenic and pyroxene-amphibolic andesites; soil: Eutric Cambisol (Haplic Cambisol).

Brief description: ca. 60–80 years-old forest with dominance of *Carpinus betulus* and *Quercus* sp. div. on steep slope.



Biotope: Ls3.1 – Sub-mediterranean thermophilous oak woods.

Phytocoenology: The union *Quercion pubescenti-petraeae* Br.-Bl. 1932.

Vegetation:

E<sub>3</sub>: In the tree layer, *Carpinus betulus* and *Quercus petraea* are most abundant. Besides them, *Acer campestre*, *Fagus sylvatica*, and *Cerasus avium* also occur. *Alnus glutinosa* grows at the edge of the stand, close to the stream.

E<sub>2</sub>: The shrub layer is species-rich at the study area edges and is mainly represented by *Acer campestre*, *Cornus mas*, *Corylus avellana*, *Crataegus laevigata*, *Ligustrum vulgare*, *Sorbus torminalis*, *Prunus spinosa*, *Pyrus communis*, and lower risk (LR:nt) species *Swida australis*.

E<sub>1</sub>: The herb layer is formed by *Asarum europaeum*, *Brachypodium sylvaticum*, *Carex digitata*, *C. pilosa*, *Clinopodium vulgare*, *Cruciata glabra*, *Dactylis polygama*, *Galium schultesii*, *Glechoma hirsuta*, *Melampyrum nemorosum*, *Melica uniflora*, *Melittis melissophyllum*, *Lamium maculatum*, *Lathyrus nigra*, *Poa nemoralis*, *Pulmonaria officinalis*, *Veronica chamaedrys*, and some other species.

Data of field research: 12. VI. 2002, 19. X. 2002, 12. VI. 2003.

#### **Russulaceae species**

*Carpinus betulus*: *Lactarius circellatus* (1), *Russula aurea* (1), *Russula carpini* (1).

*Quercus* sp. div., *Fagus sylvatica*, *Carpinus betulus*: *Russula cyanoxantha* (2), *Russula vesca* (2).

*Quercus* sp. div., *Carpinus betulus*: *Russula anthracina* (1), *Russula fragilis* (1), *Russula pectinatooides* (1).

*Fagus sylvatica*, *Quercus* sp. div.: *Russula heterophylla* (2), *Russula solaris* (1).

*Fagus sylvatica*, *Carpinus betulus*: *Russula medullata* (1).

### **Jovsianska hrabina National Nature Reserve**

Coordinates: 48°49'24"N; 22°06'44"E; Q: 7198d; altitude: 150–180 m a.s.l.; area: 257.58 ha; bedrock: andesites and tuffs, loess in the outer boundary; soil: Stagnic Cambisol, Gleyic Fluvisol. Brief description: old-growth forest with dominance of *Carpinus betulus* and *Quercus* sp. div. on almost flat relief, in eastern part with humid depression.

Biotope: Ls1.2 – Oak-elm-ash floodplain forests (JH2); Ls2.1 – Carpathian oak-hornbeam woods (JH1).

Phytocoenology: Ls1.2 – the union *Alnion incanae* Pawłowski in Pawłowski et al. 1928; Ls2.1 – the union *Carpinion* Issler 1931.

Vegetation:

E<sub>3</sub>: The Ls1.2 tree layer is mainly formed by *Alnus glutinosa*, *Fraxinus angustifolia*, *F. excelsior*, and *Quercus robur*, less by *Acer campestre*, *A. platanoides*, *Cerasus avium*, and *Populus tremula*. The Ls2.1 tree layer is predominantly occupied by *Carpinus betulus*, *Quercus petraea*, and *Q. robur*, and less by *Acer campestre*, *Cerasus avium*, *Fagus sylvatica*, *Populus tremula*, and *Sorbus torminalis*.

E<sub>2</sub>: The shrub layer is mostly developed at the study area edges. The Ls1.2 shrub layer is represented by *Frangula alnus*, *Ligustrum vulgare*, *Swida sanguinea*, *Viburnum opulus*, and some other species. In the Ls2.1 shrub layer, besides rejuvenated woody species, the shrub species *Crataegus laevigata*, *Staphylea pinnata*, and some other occur.

E<sub>1</sub>: The Ls1.2 herb layer has typically three spring aspects. At first, the aspect with *Anemone nemorosa*, *Corydalis cava*, and *Ficaria bulbifera* occurs, later the aspect with *Leucojum vernum* subsp. *carpathicum* develops at humid sites, and finally the aspect with almost monotypic stands of *Allium ursinum* dominates. *Aegopodium podagraria*, *Alliaria petiolata*, *Galium aparina*, *Urtica dioica* and some other species are characteristic of the summer aspect. The occurrence of rare and endangered species such as *Carex strigosa* (VU), *Fritillaria meleagris* (CR), and *Gagea spathacea* (VU) is also important. Besides species frequently occurring in the Carpathian oak-hornbeam woods, the

Ls2.1 biotope is relevant for notable presence of rare and endangered species, such as *Aconitum moldavicum* (VU), *Lathyrus laevigatus* (EN), *Iris graminea* subsp. *pseudocyperus* (VU), and *Waldsteinia geoides* (LR:nt).

Data of field research: 11. VII. 2001, 18. IX. 2001, 10. VI. 2002, 15. X. 2002, 26. IV. 2003, 11. VI. 2003, 20. IX. 2003

**Russulaceae species in Ls2.1 – Carpathian oak-hornbeam woods (JH1)**

*Quercus* sp. div.: *Lactarius camphoratus* (1), *Lactarius quietus* (2), *Russula atropurpurea* (3), *Russula graveolens* (2), *Russula odorata* (1).

*Quercus* sp. div., *Carpinus betulus*: *Lactarius fulvissimus* (1), *Lactarius glaucescens* (2), *Lactarius piperatus* (2), *Lactarius serifluus* (1), *Lactarius vellereus* (1), *Lactarius volemus* (2), *Russula cyanoxantha* (3), *Russula densifolia* (2), *Russula fragilis* (1), *Russula heterophylla* (3), *Russula illota* (1), *Russula lilacea* (1), *Russula nigricans* (2), *Russula ochroleuca* (1), *Russula pectinatoides* (1), *Russula risigallina* (2), *Russula subfoetens* (1), *Russula vesca* (3), *Russula virescens* (2), *Russula* cf. *poikilochroa* (2), *Russula zvarae* (1).

*Carpinus betulus*: *Russula sericatula* (1).

**Russulaceae species in Ls1.2 – Oak-elm-ash floodplain forests (JH2)**

*Populus tremula*: *Russula violacea* (1), *Russula persicina* (1).

*Betula pendula*: *Russula versicolor* (1).

## Drieň Nature Reserve

Coordinates: 48°49'09"N; 22°12'46"E; Q: 7199c; altitude: 300–345 m a.s.l.; area: 11.25 ha; bed-rock: pyroxenic and pyroxene-amphibolic andesites; soil: Eutric Cambisol (Haplic Cambisol), Haplic Andosol to Skeleti-Leptic Andosol.

Brief description: old-growth forest with dominance of *Carpinus betulus* and *Quercus* sp. div. on steep slope.

Biotope: Ls3.1 – Sub-mediterranean thermophilous oak woods.

Phytocoenology: The union *Quercion pubescenti-petraeae* Br.-Bl. 1932.

Vegetation:

E<sub>3</sub>: The tree layer is primarily occupied by *Fagus sylvatica*, followed by *Acer campestre*, *A. platanoides*, *Carpinus betulus*, *Cerasus avium*, *Fraxinus excelsior*, *Tilia cordata*, and *Quercus petraea* agg.

E<sub>2</sub>: The shrub layer is wholly dominated by the thermophilic and heliophilic to halfshade-loving woody species *Cornus mas*, which flowers before the developing of the beech foliage. The other shrub species, i.e. *Crataegus* sp. div., *Ligustrum vulgare*, *Prunus spinosa*, and *Salix caprea*, are poorly represented.

E<sub>1</sub>: The herb layer is well-developed, covering the study area more or less regularly. The spring aspect is characteristic by *Dentaria bulbifera*, *Lathyrus niger*, *L. vernus*, and the Carpathian endemit *Dentaria glandulosa*. The early summer aspect is formed by *Asarum europaeum*, *Athyrium filix-femina*, *Carex pilosa*, *C. sylvatica*, *Cystopteris fragilis*, *Galium schultesii*, *Genista tinctoria*, *Geranium robertianum*, *Luzula luzuloides*, *Melittis melissophyllum*, *Polygonatum odoratum*, *Rubus caesius*, *R. idaeus*, *Stellaria holostea*, etc., among which rare and endangered species, such as *Asplenium adiantum-nigrum* (EN), *Cephalanthera longifolia* (VU) and *Waldsteinia geoides* (LR:nt) are also present.

Date of field research: 13. VII. 2001.

**Russulaceae species**

(frequency is not given because we have visited the locality only once)

*Quercus* sp. div.: *Lactarius volemus*, *Russula virescens*, *Russula heterophylla*, *Russula lepida*, *Russula decipiens*, *Russula graveolens*.

*Quercus* sp. div., *Carpinus betulus*, *Crataegus* sp.: *Russula chloroides*, *Russula pectinatoides*, *Russula violipes*.

**Tab. 1.** (1) Frequency of *Russulaceae* species collected at the selected localities in the Vihorlatské vrchy Mts. The numbers for localities of the Vihorlatské vrchy Mts. (with the exception of Drieň) represent degrees of frequency (see chapter Material and Methods).

(2) Comparison of occurrence of *Russulaceae* species in the Vihorlatské vrchy Mts., the Ondavská vrchovina hills and the Bukovské vrchy Mts. The cross mark (for Drieň and Ondavská vrchovina hills) indicates presence of the species. The numbers of published collections from the Bukovské vrchy Mts. are in parenthesis.

Taxa / The studied localities and areas	Vihorlatské vrchy									Ondavská vrchovina	Bukovské vrchy
	Strihovce	Machnatý vrch	Morské oko	Jedlinka	Hlivštitia	Dielový potok	Jovsianska hrabina	Drieň	Postávka		
<i>Lactarius blennius</i>		2		2						+	(17)
<i>Lactarius camphoratus</i>							1				(1)
<i>Lactarius circellatus</i>					1	1				+	(8)
<i>Lactarius flavidus</i>					1						
<i>Lactarius fulvissimus</i>							1				
<i>Lactarius glaucescens</i>							2				(4)
<i>Lactarius glycosmus</i>	1									+	(4)
<i>Lactarius hygginus</i>	1										(4)
<i>Lactarius lacunarum</i>									2		(1)
<i>Lactarius pallidus</i>		1			1					+	(22)
<i>Lactarius piperatus</i>	2	2			3		2			+	(26)
<i>Lactarius pterosporus</i>					1					+	(2)
<i>Lactarius pubescens</i>	1									+	
<i>Lactarius quietus</i>							2			+	(4)
<i>Lactarius romagnesii</i>		1		1							
<i>Lactarius rufus</i>									1		(1)
<i>Lactarius seriffuus</i>		1					1				(2)
<i>Lactarius subdulcis</i>	1	2		3						+	(33)
<i>Lactarius tabidus</i>	1									+	(2)
<i>Lactarius torminosus</i>									3	+	(8)
<i>Lactarius vellereus</i>							1			+	(11)
<i>Lactarius volemus</i>		1			1		2	+		+	(7)
<i>Russula acrifolia</i>					2						
<i>Russula aeruginea</i>	2									+	(18)
<i>Russula amoena</i>		2									
<i>Russula anthracina</i>						1				+	(1)
<i>Russula atropurpurea</i>							3			+	(2)
<i>Russula atrorubens</i>	1									+	(4)
<i>Russula aurea</i>					2	1				+	(6)
<i>Russula brunneoviolacea</i>	1									+	(3)
<i>Russula carpini</i>						1				+	(2)
<i>Russula chloroides</i>								+		+	(12)
<i>Russula cyanoxantha</i>	1	3	3	2	3	2	3			+	(45)
<i>Russula decipiens</i>								+			
<i>Russula delicata</i>				1							(3)

Tab. 1. Continuation.

Taxa / The studied localities and areas	Vihorlatské vrchy									Ondavská vrchovina	Bukovské vrchy
	Strihovec	Machnatý vrch	Morské oko	Jedlička	Hlivštitia	Dielový potok	Jovsianska hrabina	Drieň	Postávka		
<i>Russula densifolia</i>		2					2				(1)
<i>Russula emetica</i>									1		(1)
<i>Russula faginea</i>			1							+	(6)
<i>Russula fellea</i>		2		1						+	(24)
<i>Russula fragilis</i>						1	1			+	(6)
<i>Russula gracillima</i>	1									+	(6)
<i>Russula graveolens</i>					1		2	+			
<i>Russula grisea</i>		1		1							
<i>Russula heterophylla</i>					3	2	3	+		+	(10)
<i>Russula illota</i>							1				
<i>Russula laurocerasi</i>				2	1					+	(15)
<i>Russula lepida</i>					1			+			(6)
<i>Russula lilacea</i>							1			+	(6)
<i>Russula mairei</i>		2			1					+	(24)
<i>Russula medullata</i>	3					1				+	(3)
<i>Russula melliolens</i>					1					+	(1)
<i>Russula nigricans</i>		3	1	1	2		2			+	(21)
<i>Russula odorata</i>							1				
<i>Russula ochroleuca</i>			2	2			1			+	(18)
<i>Russula pectinatoides</i>					3	1	1	+		+	(4)
<i>Russula persicina</i>							1				
<i>Russula cf. poikilochroa</i>							2				
<i>Russula pseudointegra</i>		1									
<i>Russula cf. pseudoromellii</i>					1						
<i>Russula raoultii</i>		1								+	(9)
<i>Russula risigallina</i>		1			1		2			+	(5)
<i>Russula romellii</i>			2		2					+	(6)
<i>Russula rubra</i>		1									
<i>Russula sericatulata</i>					1		1				
<i>Russula solaris</i>					2	1				+	(4)
<i>Russula sororia</i>					1						(1)
<i>Russula subfoetens</i>	2						1				
<i>Russula velenovskyi</i>		2								+	(14)
<i>Russula versicolor</i>	2						1			+	(3)
<i>Russula vesca</i>					3	2	3			+	(12)
<i>Russula veternosa</i>		1		1	1					+	(2)
<i>Russula violacea</i>							1				(4)
<i>Russula violeipes</i>								+		+	(14)
<i>Russula virescens</i>		1			1		2	+		+	(3)
<i>Russula zvaraе</i>							1				
No. of species	14	21	5	11	26	11	30	9	4	45	56

## Postávka National Nature Reserve

Coordinates: 48°55'24"N; 22°09'25"E; Q: 7098d; altitude: 760 m a.s.l.; raised bog area: 1.59 ha, average depth of peat 12.4 m, max. depth of peat 21 m; bedrock: andesite; soil: Fibri-Dystric Histosol.

Brief description: peat bog with solitaires of *Populus tremula*, *Picea abies* and *Betula pendula*.  
Biotope: Ra1 – Active raised bogs.

Phytocoenology: the unions *Oxycocco-Empetrium hermaphroditi* Nordhagen ex Hadač et Váňa 1967, and *Sphagnion cuspidati* Krajina 1933.

Vegetation:

E<sub>3</sub>: The peatbog already misses a tree layer; only the middle part is occupied by some solitaires of *Populus tremula*, *Picea abies*, and *Betula pendula*.

E<sub>2</sub>: the shrub layer is developed only at the peatbog edges and mainly formed by *Salix* sp. div., *Frangula alnus*, and *Fagus sylvatica* rejuvenates.

E<sub>1</sub>: An important habitat for herbs! Its herb layer is formed by numerous rare and endangered species, out of which *Carex limosa*, *Lycopodiella inundata*, *Oxycoccus palustris*, and *Scheuchzeria palustris* are critically endangered (CR), *Drosera rotundifolia* and *Menyanthes trifoliata* endangered (EN), *Carex lasiocarpa* and *Eriophorum vaginatum* vulnerable (VU), and *Trientalis europaea* is at lower risk (LR:nt). Other species are *Aposeris foetida*, *Campanula rapunculoides*, *Carex echinata*, *C. rostrata*, *C. vesicaria*, *Crepis paludosa*, *Doronicum austriacum*, *Equisetum palustre*, *Pteridium aquilinum*, *Senecio rivularis*, etc. As grasses clumps of the vulnerable species (VU) *Molinia caerulea* prevail.

E<sub>0</sub>: A well-developed layer of bryophytes is dominated by numerous species of the genus *Sphagnum*: *S. contortum* (VU), *S. magellanicum*, *S. rubellum*, *S. subnitens* (DD) and *S. subsecundum*. From the other species, *Campylium stellatum*, *Polytrichum strictum*, and *Warnstorfia exannulata* occur (Háberová et al. 2002).

Data of field research: 20.IX.2001, 17.IX.2003.

### **Russulaceae species**

*Betula pendula*: *Lactarius torminosus* (3).

*Picea abies*: *Lactarius rufus* (1), *Russula emetica* (1).

*Betula pendula*, *Populus tremula*, *Salix* sp.: *Lactarius lacunarum* (2).

## DISCUSSION

We have identified 75 species of *Russulaceae* (22 species of *Lactarius* and 53 species of *Russula*) in the Vihorlatské vrchy Mts.

Nearly half of all identified species (39) are common in a wide range of habitats (according to published data and our experiences), and their distribution area is probably identical to their host tree distribution area. Such common species associated exclusively with *Fagus sylvatica* in the Vihorlatské vrchy Mts. are *Lactarius blennius*, *L. pallidus*, *L. subdulcis*, *Russula fellea*, *R. grisea* and *R. mairei*. Common species preferring associations with *Quercus* sp. div. are *Lactarius camphoratus*, *L. quietus*, *Russula atropurpurea*, *R. graveolens* and *R. lepida*. Common species associated exclusively with *Betula* sp. div. are *L. glyciosmus*, *L. torminosus*, *Russula aeruginosa*, *R. gracillima* and *R. versicolor* and common

species associated exclusively with *Carpinus betulus* is *Lactarius circellatus*. Many of the common and/or widely distributed species collected in the Vihorlatské vrchy Mts. have no preference for a host tree species or genus and grow under a wide range of deciduous trees and sometimes also under conifers: *Lactarius piperatus*, *L. serifuluus*, *L. volemus*, *Russula atrorubens*, *R. aurea*, *R. cyanoxantha*, *R. delica*, *R. fragilis*, *R. heterophylla*, *R. chloroides*, *R. laurocerasi*, *R. melliolens*, *R. nigricans*, *R. ochroleuca*, *R. pectinatoides*, *R. risigallina*, *R. romellii*, *R. sororia*, *R. vesca*, *R. violeipes*, *R. virescens*.

The rest of the *Russulaceae* species are considered to be rare or less frequent in literature or we have insufficient data about their distribution in Slovakia.

Four species have not been reported from Slovakia before: *L. romagnesii* Bon (Machnatý vrch, 12.VII.2001, S. Adamčík, SAV; Jedlinka, 19.IX.2003, J. Vataha, SAV), *Russula odorata* Romagn. (Jovsianska hrabina, 10.VI.2002, V. Kučera, SAV), *Russula sericatula* Romagn. (Jovsianska hrabina, 11.VII.2001, 18.IX.2001, S. Adamčík and J. Terray, 3 specimens in SAV; Hlivištie, 13.VII.2001, S. Adamčík, SAV) and *Russula zvarae* Velen. (Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV). These species are considered to be rare or absent in other European countries (see Tab. 2).

*Lactarius fulvissimus* Romagn. (Jovsianska hrabina, 18.IX.2001, S. Ripková, SAV), a species hitherto unknown from Slovakia, was probably misidentified as *L. ichoratus*, because Kuthan et al. (1999) treated these two names as synonyms and they accepted the name *L. ichoratus*. Heilmann-Clausen et al. (1998) do not recommend using the name *L. ichoratus*, because the original description refers to *L. volemus*.

*Lactarius tabidus* Fr. (Strihovce, 18.IX.2003, S. Adamčík, SAV) and *Russula decipiens* (Singer) Kühner et Romagn. (Drieň, 13.VII.2001, S. Adamčík, SAV) represent species that were probably treated under different names or confused. Moreover, we have only few data on their distribution.

In Slovakia, *Lactarius tabidus* was known only from the Liptovská kotlina basin (Lizoň and Kautmanová 2004). Previous finds were probably identified as *L. thejogalus*, e.g. Kuthan et al. (1999). We have also found *L. tabidus* in similar habitats in the Ondavská vrchovina hills (near Kvakovce village, 5.IX.1993, S. Adamčík, SAV).

*Russula decipiens* is known as a relatively common species, but it was probably confused with *R. maculata* in Slovakia. It was hitherto known only from the Malé Karpaty Mts. (Dermek and Michalko 1975) and Strážovské vrchy Mts. (Kuthan 1984).

Eleven species are considered to be rare according to the literature: *Lactarius flavidus* Boud. (Hlivištia, 13.VII.2001, S. Adamčík, SAV), *Lactarius glaucescens* Crossl. (Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV), *Russula anthracina* Romagn. (Dielový potok, 12.VI.2002, S. Ripková, SAV), *Russula brunneoviolacea* Crawshay (Strihovce, 12.VI.2003, S. Adamčík, SAV), *Russula carpini* R. Girard et Heinem. (Dielový potok, 12.VI.2002, S. Ripková, SAV), *Russula lilacea* QuéL. (Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV), *Russula persicina* Krombh. (Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV), *Russula pseudointegra* Arnould et Goris (Machnatý vrch, 12.VII.2001, S. Adamčík, SAV), *Russula rubra* (Fr.) Fr. (Machnatý vrch, 19.IX.2001, S. Adamčík, SAV), *Russula veternosa* Fr. (Hlivištia, 13.VII.2001, S. Adamčík, SAV; Jedlinka, 19.IX.2003, V. Kučera, SAV; Machnatý vrch, 20.IX.2003, S. Ripková, SAV) and *Russula violacea* QuéL. (Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV).

Only four of these species were also published from the Bukovské vrchy Mts. (Kuthan et. al. 1999): *Lactarius glaucescens*, *Russula anthracina*, *R. carpini* and *R. lilacea*.

*L. flavidus* was hitherto known only from the Liptovská kotlina basin (Kuthan 1989), *Russula persicina* from the Záhorská nížina lowlands (Hagara 1992) and *R. rubra* from the Biele Karpaty Mts. (Lizoň 2004).

Adamčík (1998) re-examined all available Slovakian material of *Russula pseudointegra* (4 specimens in herbarium BRA) and only one specimen, which was collected in Šúr Natural Reserve near Bratislava, was identified correctly.

*Russula brunneoviolacea* was hitherto known from the Devínska Kobyla Mts. (Záhorovská and Lišková 1996) and Bukovské vrchy Mts. (Kuthan et. al. 1999, 3 specimens) in Slovakia.

*Russula veternosa* was hitherto published only from the Poľana Mts. (Adamčík 1994) and Bukovské vrchy Mts. (Kuthan et al. 1999).

Many authors consider *Russula violacea* a rare species (see Tab. 2). In Slovakia, the species was hitherto known from the Záhorská nížina lowlands (Dermek 1978), Trábeč Mts. (Janitor 1994), Západné Tatry Mts. (Škubla 1998), Malé Karpaty Mts. (Janitor 1997), Bukovské vrchy Mts. (Kuthan et. al. 1999, 4 specimens) and Kremnické vrchy Mts. (Mihál 2003). Regarding the relatively numerous publications containing data on occurrence of the species, we expect that *R. violacea* is not rare in Slovakia.

Some of the species were also collected in the adjacent Ondavská vrchovina hills: *Russula lilacea* (near Kvakovce village, 2.IX.1993, S. Adamčík, SAV), *R. carpini* (near Kvakovce village, 3.VII.1992, S. Adamčík, SAV), *R. anthracina* (near Kvakovce village, 28.VI.1993, S. Adamčík, SAV) and *R. veternosa* (near Kvakovce village, 24.IX.1994, S. Adamčík, SAV).

**Tab. 2.** Comparison of distribution of rare or interesting *Russula* species collected in the Vihorlatské vrchy Mts. (2001–2003) with data from recent European literature. Van Vuure (1992) indicates rarest fungi by 'ZZZ' and most common as 'AAA'. Numbers in Hallingbäck and Aronsson represent the number of regions in Sweden with occurrence of the species, a small dot means a rare and a big dot a frequent species.

Taxa / Recent European literature on <i>Russulaceae</i>	Einhellinger (1994)	Van Vuure (1992)	Hallingbäck and Aronsson (1998)	Sarnari (1998, 2005)	Romagnesi (1967)
	Germany	Netherlands	Sweden	Europe (mostly Italy)	Europe (mostly France)
<i>Russula acrifolia</i>	relatively rare	ZZZ	?4 1	widely distributed	not very rare
<i>Russula amoena</i>	absent	absent	absent	locally common	rather rare
<i>Russula anthracina</i>	rare	ZZ	3	absent	rather rare
<i>Russula brunneoviolacea</i>	rare	ZZ	3	locally not rare	common
<i>Russula carpini</i>	well distributed	recently found	1	not common	only three collecting sites in France
<i>Russula decipiens</i>	well distributed	Z	2	common	common
<i>Russula densifolia</i>	common	A	?4 1	locally common	locally common
<i>Russula faginea</i>	fairly common	ZZ	2	common	not rare
<i>Russula illota</i>	not rare	ZZZ	4	not common	common
<i>Russula lilacea</i>	rare	ZZZ	3	rare	not very rare
<i>Russula medullata</i>	rather rare	ZZZ	5	locally common	not rare
<i>Russula odorata</i>	very rare	Z	3	locally common	rather common
<i>Russula persicina</i>	distributed	Z	4	distributed	not rare
<i>Russula poikilochroa</i>	absent	absent	absent	locally common	absent
<i>Russula pseudointegra</i>	rather rare	Z	3	not common	rather common
<i>Russula pseudoromellii</i>	absent	absent	absent	very rare	not treated
<i>Russula raoultii</i>	distributed	ZZ	3	common	widely distributed but not very common
<i>Russula rubra</i>	not common	absent	absent	locally not rare	rather rare
<i>Russula sericatulata</i>	absent	absent	absent	locally not rare	rather common
<i>Russula solaris</i>	very distributed	Z	2	locally not rare	rather rare
<i>Russula subfoetens</i>	fairly common	ZZZ	4	locally common	rather common
<i>Russula velenovskyi</i>	rather distributed	AA	?5	locally not rare	common
<i>Russula veternosa</i>	rather rare	ZZ	2	not common	locally common
<i>Russula violacea</i>	rare	absent	4	absent	three sites of typical collections
<i>Russula violeipes</i>	locally distributed	ZZ	3	distributed	more or less common
<i>Russula zvarae</i>	absent	absent	absent	widely distributed	rather rare



Some species have been rarely recorded in Slovakia. However, according to our experience and European literature, they are probably overlooked or not distinguished in Slovakia: *Lactarius lacunarum* Hora (Postávka, 20.IX.2001, J. Teray, SAV), *L. pubescens* Fr. (Strihovce, 18.IX.2003, S. Ripková, SAV), *Russula acrifolia* Romagn. (Hlivišťa, 13.VI.2002, 11.VI.2003, S. Adamčík and J. Vataha, 2 specimens in SAV), *R. densifolia* Gillet (Machnatý vrch, 12.VII.2001, S. Adamčík, SAV; Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV) and *R. velenovskyi* Melzer et Zvára (Machnatý vrch, 12.VII.2001, 19.IX.2001, 20.IX.2003, S. Adamčík and M. Vašutová, 3 specimens in SAV).

*L. lacunarum* was hitherto published only from the Bukovské vrchy Mts. (Kuthan et al. 1999) and the Liptovská kotlina basin (Škubla 1996, Lizoň and Kautmanová 2004).

*L. pubescens* was known only from three orographic areas, but the related species *L. torminosus* at least from nine orographic areas. We assume that *L. pubescens* was not distinguished from *L. torminosus* in Slovakia, e.g. they were probably misidentified in the Bukovské vrchy Mts. (Kuthan et al. 1999). In Belgium, *L. pubescens* is at least as common as *L. torminosus* (Verbeken et al. 1998).

*R. acrifolia* was hitherto known from the Nízke Tatry Mts. (Kuthan 1989), *R. densifolia* from the Malé Karpaty Mts. (Dermek and Michalko 1975), Záhorská nížina lowlands (Lizoň 1977), Spišské kotliny basins (Kautmanová 1996) and Bukovské vrchy Mts. (Kuthan et al. 1999), and *Russula velenovskyi* from the Malá Fatra Mts. (Hagara 1993), Trábeč hills (Janitor 1994), Záhorská nížina lowlands (Záhorovská and Jančovičová 1997) and Bukovské vrchy Mts (Kuthan et al. 1999).

Some species are interesting because of their ecology: *Lactarius hygginus* (Fr.) Fr. (Strihovce, 18.IX.2003, M. Vašutová, SAV), *L. rufus* (Scop.) Fr. (Postávka, 20.IX.2001, J. Terray, SAV), *Russula emetica* (Schaeff.) Pers. (Postávka, 17.IX.2003, S. Adamčík, SAV) and *Russula medullata* Romagn. (Strihovce, 12.VI.2002, 12.VI.2003, S. Adamčík and V. Kučera, 3 specimens in SAV; Dielový potok, 12.VI.2003, S. Adamčík, SAV).

It is known that *Lactarius hygginus* is associated with coniferous trees on disturbed soil. Heilmann-Clausen et al. (1998) mention it only in association with *Picea*. We have collected *L. hygginus* at the locality of Strihovce under a solitary tree of *Pinus sylvestris* on the margin of path nearby with a dump of rotten sawdust. We have confirmed our identification with microscopical observations; the species has very small spores (length up to 6.5 µm) and the pileipellis is an ixotrichoderm. *L. hygginus* was also collected at similar sites under *Pinus sylvestris* and *Betula* in the Bukovské vrchy Mts. (Kuthan et al. 1999).

*Lactarius rufus* and *Russula emetica* are in general very common species in spruce forests. They were evidently associated with a small group of *Picea abies* trees in the peat-bog of Postávka in the Vihorlatské vrchy Mts.

*Russula medullata* grows in a very wide range of habitats in association with various hosts. It is known e.g. from the Mediterranean area in association with *Quercus suber* (Sarnari 1998); from the arctic areas in association with dwarf *Betula* (we have studied specimens deposited in herbarium C); and from the alpine belt of the French Alps associated with *Salix herbacea* and *Betula nana* (Kühner 1975). In Slovakia, the species is also known from old pastures with *Betula* and *Populus tremula* in the Bukovské vrchy Mts. (Kuthan et al. 1999) and the Ondavská vrchovina hills (near Kvakovce village, 24.IX.1994, S. Adamčík, SAV). It seems that the species prefers open grassy sites in association with *Betula* and/or *Populus tremula* in Slovakia.

Interesting are also related species growing in the similar type of habitats but more frequent in one of the studied areas in Eastern Slovakia.

In the Vihorlatské vrchy Mts., *Lactarius romagnesii* Bon has been collected in the Jedlinka (19.IX.2003, J. Vataha, SAV) and Machnatý vrch reserves (12.VII.2001, S. Adamčík, SAV), and its related species, *L. pterosporus* Romagn., at Hlivištia (13.VII.2001, S. Adamčík, SAV). *L. pterosporus* is known from the Bukovské vrchy Mts. (Kuthan et al. 1999), but *L. romagnesii* is not.

*Russula amoena* Quél. (Vihorlatské vrchy Mts., Machnatý vrch, 12.VII.2001, S. Adamčík, SAV) is unknown from the Bukovské vrchy Mts., whereas both related species, *R. amoenicolor* and *R. violeipes*, were reported from there (Kuthan et al. 1999). On the other hand, *R. amoenicolor* has not been collected in the Vihorlatské vrchy Mts. Sarnari (1993) considers this species locally common, but the other authors call it a rare species (see Tab. 2). *R. amoenicolor* is in Slovakia known also from the Malé Karpaty Mts. (Dermek and Lizoň 1980).

*Russula illota* Romagn. (Vihorlatské vrchy Mts., Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV), a rather rare species, was hitherto known only from the Strážovské vrchy Mts. (Hagara 1992) and the Spišské kotliny basins (Kult 1989) in Slovakia. A very similar species is the common *R. laurocerasi*, collected in the Vihorlatské vrchy Mts., too.

*Russula raoultii* Quél. is fairly common in the Bukovské vrchy Mts. (Kuthan et al. 1999) and in the Ondavská vrchovina hills (near Kvakovce village, 16.VII.1993, S. Adamčík, SAV). However, we have collected *R. raoultii* in the Vihorlatské vrchy Mts. only in Machnatý vrch reserve (12.VII.2001, S. Adamčík, SAV). On the other hand, a more common species in the Vihorlatské vrchy Mts. seems to be the related species *Russula solaris* Ferd. et Winge (Hlivištia, 13.VII.2001, 13.VI.2002, S. Adamčík and V. Kučera, 3 specimens in SAV; Dielový potok, 12.VI.2002, V. Kučera, SAV), which is according to our observations less frequent in the Bukovské vrchy Mts. (Tab. 1) and in the Ondavská vrchovina hills (near Kvakovce village, 20.VII.1993, S. Adamčík, SAV).

*Russula pseudointegra* Arnould et Goris is rather rare in Slovakia. Our specimen from the Vihorlatské vrchy Mts. (Machnatý vrch, 12.VII.2001, S. Adamčík, SAV) is probably the second published find of the species. A similar species, *R. aurora*, which is common in the Bukovské vrchy Mts. (Kuthan et al. 1999) and also in the Ondavská vrchovina hills (specimen), has not been collected in the Vihorlatské vrchy Mts.

In Slovakia, *Russula subfoetens* W.G. Sm. was not found in the past – probably overlooked or confused with *R. foetens*. It was hitherto known only from the Záhorská nížina lowlands (Dermek 1978), Vysoké Tatry Mts. (Kuthan 1989) and Podunajská nížina lowlands (Hagara 1992). Specimens of *R. foetens* from the Bukovské vrchy Mts. (Kuthan et al. 1999) probably contain material of *R. subfoetens* and *R. illota*. We have not collected *R. foetens* in the Vihorlatské vrchy Mts., where we have found only *R. subfoetens* (Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV; Strihovce, 12.VI.2003, S. Ripková, SAV) and other related species such as *R. illota* and *R. laurocerasi*.

#### TAXONOMIC REMARKS

##### ***Lactarius glaucescens*** Crossl.

It is generally known that the milk of *L. glaucescens* turns indistinctly greenish. We have observed a similar discoloration also in the related species *Lactarius piperatus* (L.) Pers.; therefore we have verified our identification with microscopical observations. *L. glaucescens* has a thicker layer of filamentous hyphae in the pileipellis than *L. piperatus* (Heilmann-Clausen et al. 1998).

##### ***Lactarius serifluus*** (DC.) Fr.

We prefer the wide taxonomic concept of *L. serifluus* presented e.g. by Persson et al. (1992). We do not accept collections with a darker pileus as *Lactarius subumbonatus* Lindgr., because they are microscopically almost identical and differ mainly in the colour of basidiocarps.

##### ***Russula faginea*** Romagn. ex Adamčík

*R. faginea* is a rather rare species growing in beech forests often on exposed margins of forests. A single specimen has been collected only in the Vihorlatské vrchy Mts. (Morské oko, 19.IX.2001, J. Terray, SAV). This specimen has the same microscopic characters as the type, contrary to the specimen from the Ondavská vrchovina hills (Adamčík 2003) that has relatively small spores and longer and more constricted tips on terminal cells of hyphae in the pileipellis. The species is also known from the Bukovské vrchy Mts. (Kuthan et al. 1999). The distribution of *R. faginea* in Slovakia was published by Adamčík (2001).

***Russula graveolens*** Romell in Britzelm.

We accept the narrow taxonomic concept of *R. graveolens* presented by Romagnesi (1967) which is in accordance with our observation on the type specimen designated by Kärcher (2000). According to the revision of herbarium specimens from herbaria M, SAV, BRA, PRM and W, this is one of the most common species of *Russula* sect. *Xerampelinae* in central Europe. The majority of specimens identified as *R. graveolens* from Slovakia (Adamčík 2001) are probably identical with the taxon in the narrow concept.

***Russula pectinatoides*** Peck

Sarnari (1998) calls all European collections of *R. pectinatoides* (in sense of European authors) *R. praetervisa* Sarnari, because he observed warts on spores connected by lines on selected specimens from Europe. This is in contradiction to the original diagnosis and type of *R. pectinatoides*, which has isolated warts on spores. Sarnari (1998) believes that *R. pectinatoides* is restricted to North America, where it was described, and he distinguished European collections as a separate species. We have observed isolated warts on our material (Hlivištia, 13.VI.2002, 11. VI.2003, S. Ripková and S. Adamčík, 2 specimens in SAV; Dielový potok, 12.VI.2002, S. Ripková, SAV; Drieň, 13.VII.2001, S. Adamčík, SAV; Jovsianska hrabina, 11.VII.2001, S. Adamčík, SAV) and therefore we have used the name *R. pectinatoides* following the opinion of other European authors (e.g. Romagnesi 1967).

***Russula pseudoromellii*** J. Blum ex Bon

*R. pseudoromellii* was described by Blum (1954) and validated by Bon (1986). Both authors observed thin, 2–3 µm wide generative hyphae in the pileipellis. Blum (1962) distinguished this species from *R. romellii* according to its larger spores with more prominent, less reticulate spines, dense lamellae and vinaceous to carmine colours of pileus. Bon (1986) followed the original taxonomic concept. Galli (1996) published illustrations with pileus colours and spores similar to that described in the original diagnosis, but with a different pileipellis that contains hyphae 3.9–5.2 µm thick. Our specimen from Hlivištia (11.VI.2003, L. Palko, SAV) has more or less the same colour, spores and pileipellis structure as Galli (1996) described. Brighter red colours, the spore ornamentation and cylindrical, not attenuated and thicker terminal cells of hyphae in the pileipellis are characters that differentiate our specimen from *R. romellii*. *R. pseudoromellii* has been reported only from France and Italy (Blum 1962, Galli 1996).

***Russula risigallina*** (Batsch) Sacc.

Romagnesi (1967) distinguished two similar species: *Russula vitellina* (Pers.) Gray and *R. risigallina* [the second one under name *R. chamaeleontina* (Lasch)

Fr.]). The first one has acid smell and predominantly yellow pileus and the second one has fruity smell and pinkish to red tints of pileus. We have not observed relation between smell and pileus colour in our specimens from the Vihorlatské vrchy Mts., therefore we have treated wide concept of *R. risigallina* including both red and yellow coloured basidiocarps.

***Russula* aff. *poikilochroa* Sarnari**

We collected our 3 specimens of *R. aff. poikilochroa* in the Jovsianska hrabina reserve in association with *Carpinus betulus* and *Quercus* sp. (18.IX.2001, S. Adamčík, E. Jančovičová and V. Kučera, 3 specimens from one visit in SAV). They have a combination of characters that is typical of the group *Atropurpurinae* in the sense of Romagnesi (1967). The spore print is white, the taste acrid, the spores are reticulate. Subglobose spores resemble the spores of *R. fragilis*, but they are distinctly smaller, and the spores of *R. atrorubens*, but they are narrower. The colours of the pileus are similar to those of *R. fragilis*, in general variegated, but the margin is paler greenish and the centre is darker red-brown. *R. atrorubens* and *R. fragilis* grow on moist places in coniferous forests or under *Salix*, *Betula* or *Alnus* in the autumn. Our specimens are similar in several aspects (colours of pileipellis and spores) to *R. poikilochroa*, which was described from the Mediterranean in Italy (Sarnari 1990). The colour of the pileipellis is composed of purple and greenish tints and is often paler at the margin, which is demonstrated in illustrations by Sarnari (1997, 1998). The spores of *R. poikilochroa* are according to Sarnari (1997, 1998)  $6.6\text{--}8.8 \times (5.2\text{--}) 5.5\text{--}7 \mu\text{m}$  ( $8 \times 6.6 \mu\text{m}$  in average), our specimens have spores  $7.3\text{--}8.2 \times 6.3\text{--}7.1 \mu\text{m}$  ( $7.8 \times 6.7 \mu\text{m}$  in average). Sarnari (1997, 1998) considered a mild taste in the stipe and weakly acrid in the gills an important character. We have observed only a distinctly acrid taste in the lamellae of our specimens, not a taste in the stipe. The smell of our specimens was indistinctly fruity; Sarnari (1997, 1998) mentioned the same smell for *R. poikilochroa*. However, phenology and habitat of our specimens are different. All Sarnari's specimens were collected from October to December in dry mediterranean forests often accompanied by *R. fragilis* or *R. atropurpurea*. Our specimens grow in central European temperate forests and were collected in July and September. *R. fragilis* was collected at the same site, but in October. Final identification of our specimens requires more material and more observations.

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