CZECH MYCOL. 63(1): 39–53, 2011

Ecology and incidence of *Polyporus umbellatus* in Slovakia

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Kunca V. (2011): Ecology and incidence of *Polyporus umbellatus* in Slovakia. – Czech Mycol. 63(1): 39–53.

Research of the incidence of *Polyporus umbellatus* (Pers.) Fr. was carried out in 37 plots covering a diverse range of conditions in Slovakia. Based on measurements of soil pH values, this fungal species prefers acid soils. The highest number of sporocarps per plot during the three years of monitoring was detected every July. The majority of localities with incidence of *P. umbellatus* were located in hilly terrain, fewer in lowlands and very occasionally in uplands. Sclerotium and sporocarps predominantly occur at a specific distance from colonised beech, hornbeam and oak trees, with fewer individuals found in the vicinity of the host trees. Data from the research confirm that this species is well represented in Slovakia, nevertheless published data on its incidence and habitat are still rare.

Key words: *Polyporus umbellatus*, ecology, pH values, incidence, Slovakia.

Kunca V. (2011): Ekológia a výskyt *Polyporus umbellatus* na Slovensku. – Czech Mycol. 63(1): 39–53.

Výskum trúdnika klobúčkatého – *Polyporus umbellatus* (Pers.) Fr. prebiehal na 37 plochách v rôznych častiach Slovenska. Na základe meraní pH hodnôt pôdy je zrejmé, že táto huba uprednostňuje kyslé pôdy. Najväčší a úhrnný počet plodníc počas trojročného monitoringu sme v rámci roka našli v mesiaci júl. Najviac lokalít sa nachádza v pahorkatinách, menej v nížinách a niektoré sú aj v podhorí. Sklerócium a plodnice sa väčšinou vyskytujú v určitej vzdialenosti od stromov, menej na ich báze, pod bukmi, hrabmi a dubmi. Nie je to vzácna huba, no publikovaných údajov o jej výskyte je stále málo.

INTRODUCTION

Polyporus umbellatus (Pers.) Fr. is well known for its medicinal effects and is one of the most widely used fungi in traditional Chinese medicine, especially its sclerotium (Zhao & Zhang 1992). Its cultivation is however still not dependable (Huang & Liu 2007). In certain regions of Slovakia, the fungus is well known and rather popular for its edibility. The areas occupied by the species are well defined by common ecological characteristics. Generally, it occupies relatively warm regions and grows in broadleaved forests. In the wider European context, this native fungus is considered a rare but widespread species. Similarly, in Slovakia it is not a common fungus, but in some regions – such as Šariš and Zemplín in the east of the country – it is reasonably widespread. Pilát (1942) compiled one of the first papers summarising historical data, distribution and incidence of *P. umbellatus*, and presents two localities from Slovakia. Kotlaba (1984) provides general information on 11 localities but only two more detailed descriptions. Finds of this fungus are still published only rarely and it is apparent that current estimates of its frequency based on available data are likely to be too low. The systematic bias often introduced by mycologists because of not collecting samples of easily noticeable and identifiable species, should not be underestimated and probably contributes to the scarcity of data.

Gáper (1998) did not find *P. umbellatus* to be a phytopathologically important parasite of broadleaved trees and Kotlaba et al. (2006) regard it as a lignicolous saproparasite. However, in Europe it is often protected, e.g. in Poland (Kujawa & Gierczyk 2010), Hungary (Fodor 2006), and Estonia (Sell 2010), or redlisted, for example in the Czech Republic (Holec & Beran 2006), Ukraine (Hayova 2010), Austria (Austrian Mycological Society 2009), and Bulgaria (Gyosheva et al. 2006).

The aim of this paper is to present new findings on the ecology of the species and to summarise the data on the incidence of *P. umbellatus* in the Slovak Republic.

MATERIAL AND METHODS

Methods

Surveys of forested areas were concentrated in Eastern Slovakia, more specifically in the Ondavská vrchovina highlands and in several regions of central Slovakia, namely in the Stolické vrchy hills, Zvolenská kotlina basin, Kremnické vrchy hills, Štiavnické vrchy hills and Javorie hills. The initial survey including identification of potential new localities of *P. umbellatus* started in 1997 in the Ondavská vrchovina highlands. Intensive monitoring and regular visits of some localities were carried out in 2008–2010, every year. The period from the end of May to the end of September was found to be the most suitable. Selected sites were visited during this entire period in 5– to 15-day intervals. When weather conditions seemed more favourable for the growth of sporocarps, the frequency of visits was increased. The exact locations of sampling sites are not presented in this paper in order to avoid excessive human pressure on the species, mainly due to the medicinal qualities of its sclerotium.

Phytogeographical units used to describe the sites follow the classification of Futák (1966), while the vegetation altitudinal zones originate from Holub & Jirásek (1967) ex Kotlaba (1984). General geological conditions were taken from available geological maps (ŠGÚDŠ on-line) and, where possible, visually confirmed at the site. At some of the sites sclerotia were found to be intertwined, thus limiting our ability to identify the number of individual fungi. In such cases we presumed that the sclerotia originated from the same organism and thus we refer to one individual fungus and locality.

Soil samples were taken from plots with living sclerotia to cover the full variability of ecological conditions, with the exception of locations identified late in the period of observation. The samples were taken in the vicinity of the sclerotia from mineral soil at a depth of approximately 10 cm. Soil sampling was carried out from June to October 2010. The soil samples were analysed in the laboratory of Technical University in Zvolen, Faculty of Ecology and Environmental Sciences, Department of Applied Ecology. Soil pH values were determined in water suspension (HANNA HI 9321).

Localities and ecological conditions

In the following description of 37 distinct plots, we present data on geology, exposition, slope inclination, position on the slope, altitude, forest characteristics and position of living sclerotia in relation to the closest living tree or tree part (Tab. 1). The plots were included into our intensive three-year monitoring to ascertain equal length of observation for each plot, except for the newly found ones. These plots are specified by the abbreviation NIM. The following tree species were found to be associated with *P. umbellatus*: European hornbeam (*Carpinus betulus*), Pedunculate oak (*Quercus robur*), European beech (*Fagus sylvatica*), Sessile oak (*Quercus petraea*) and Norway spruce (*Picea abies*).

The location of the sclerotia to the nearest living tree in distance categories is presented for each fungal organism. Plots where several visible “nests” of sclerotia were found in an area of approximately 100 square metres were assumed to contain a single organism.

Tab. 1. Characteristics of natural and landscape conditions of plots with *Polyporus umbellatus* ('scl.' stands for sclerotium).

locality /plot	**exposition**	**slope inclination**	**position on the slope**	**altitude (m)**	**forest characteristics**	**position of sclerotium**
OV1	SW	20°	central part of the longer slope	170	old hornbeam forest with dispersed young pedunculate oaks	between base of old hornbeam and small hornbeam stump
OV2	W	2°	plain base of slope	165	old beech forest with hornbeam	close (less than 1 m) to stem of old beech
OV3	S	3°	plain base of slope	170	middle-aged part of mixed forest with dominance of hornbeam and beech	more than 1 m from middle-aged hornbeam
OV4	S	15°	middle part of 80 m long slope	185	old beech forest	1st scl. more than 3 m from old beech, 2nd scl. 2 m from old beech, 3rd scl. 1 m from middle-aged beech, 4th scl. at the base of old beech
OV5	S	5°	plain part in centre of gentle slope	180	old beech forest	scl. more than 3 m from old beech
OV6	S	5°	small ridge of 80 m long slope	200	all-aged beech forest	1st scl. at the base of young beech, 2nd scl. between three old beeches – 1 m from stem (NIM)
OV7	S	3°	plain part of flat ridge	210	all-aged beech forest	1st scl. more than 1 m from old beech, 2nd scl. more than 1 m from young beech, 3rd scl. more than 1 m from middle-aged beeches

locality /plot	exposi-tion	slope in-clination	position on the slope	altitude (m)	forest characteristics	position of sclerotium
OV8	S	1°	plain base of short slope	160	mixed forest with dominance of hornbeam and beech	more than 1 m from old beech
OV9	SW	10°	central part of relatively long slope	180-185	old beech forest	1st scl. beside big beech stump and less than 1 m from old beech, 2nd scl. under old beeches more than 1 m from stems
OV10	SW	15°	upper part of relatively long slope	225	old beech forest	at the base of old beech
OV11	NW	5°	small valley at the base of relatively long slope	185	all-aged part of beech forest	1st scl. among young beeches, 2nd scl. less than 1 m from old beech (NIM)
OV12	S	2°	small plain on gentle slope	212	middle-aged mixed deciduous forest	scl. less than 1 m from young hornbeams (NIM)
SV1	E	15°	small plain at lower part of long slope	485	open area in old mixed forest with dominance of beech	at the base of spruce with transition to part of forest with young natural reproduction of beech (NIM)
SV2	SW	20°	lower part of relatively steep slope	510-525	young mixed broadleaved forest with dominance of hornbeam and beech	1st scl. at the base of middle-aged hornbeam, 2nd scl. among young beeches, less than 1 m from them (NIM)
ZK1	W	15°	plain part in the centre of short slope	360	edge of old hornbeam forest	sclerotium up to 3 m from old hornbeam
ZK2	N	3°	plain base of long gentle slope	420-425	mixed all-aged forest with dominance of hornbeam	1st scl. less than 1 m from old sessile oak and hornbeam, more than 1 m from stems, 2nd scl. at the base of relatively young hornbeam, 3rd scl. at the base of old hornbeam (NIM)
KV1	SE	3°	middle of the gentle slope	370-375	all-aged sessile oak forest	1st scl. more than 1 m from young oak, 2nd scl. more than 1 m from young oaks
KV2	S	0°	large plain area	518	old pedunculate and sessile oak forest with hornbeam	more than 1 m from young hornbeam (NIM)
ŠV1	SW	8°	base of the gentle slope	529	old deciduous forest with dominance of oak and beech close to depression of ephemeral brook	at the base and close to old sessile oak
ŠV2	S	1°	large plain area	541	relatively old hornbeam forest with sessile oak	less than 1 m from oak and hornbeam

locality /plot	exposi-tion	slope in-clination	position on the slope	altitude (m)	forest characteristics	position of sclerotium
ŠV3	W	1°	relatively large plain area	525	all-aged mixed forest with dominance of hornbeam	1st scl. less than 1 m from old spruce, closest deciduous species being hornbeam at a distance of 2 m (NIM), 2nd scl. less than 1 m from young hornbeam (NIM), 3rd scl. less than 1 m from hornbeam seedlings (NIM), 4th scl. less than 3 m from middle-aged sessile oak and hornbeam
J1	W	20°	upper part of long slope	480	deciduous forest with dominance of beech, sessile oak and hornbeam	sclerotium less than 1 m from middle-aged hornbeam (NIM)

The plots in the Ondavská vrchovina highlands (OV) are localised in its southern part, in the surroundings of the village of Holčíkovce, apart from OV12, which is situated in the territory of Kvakovce, northern part of the district of Vranov nad Topľou. The geological conditions are identical for all of these plots, featuring flysch as a mixture of sandstones, pudding stones and claystones. Phytogeographical unit: Východné Beskydy, subunit Nízke Beskydy. Plots OV2–OV11 occur in a single area of approximately four hectares.

Relative localisation of the plots in the Ondavská vrchovina highlands (OV): plot OV2 is 1.5 km N of OV1, plot OV3 100 m N of OV2, plot OV4 40 m N of OV3, plot OV5 100 m SE of OV4, plot OV6 20 m N of OV4, plot OV7 100 m E of OV6 (Fig. 1, Fig. 2), plot OV8 200 m W of OV3, plot OV9 150 m N of OV6, plot OV10 300 m NE of OV9, plot OV11 150 m SW of OV10.

The localities in the Stolické vrchy hills (SV) are situated in the district of Revúca, its northern part, more accurately N of Revúca close to Revúčka (SV1) and SW of Revúca close to Muránska Lehota (SV2), and were found in 2010. The geological bedrock of both localities consist of metamorphic rocks such as migmatites and orthogneiss. Phytogeographical unit: Slovenské rudohorie.

In the Zvolenská kotlina basin (ZK) the localities are situated between Zvolen and Banská Bystrica (ZK1 at the outskirts of the town of Zvolen, ZK2 near the village of Iliaš) where volcanic rock deposits prevail: volcanic sandstones and tuffs at ZK1, clay sands and gravel with volcanic influence at ZK2. Phytogeographical unit: Slovenské stredohorie, subunit: Poľana.

Localities in the Kremnické vrchy hills (KV) are located in the SE part of the hills, near Zvolen. The geological bedrock near Kováčová consists of clay sands and gravel under volcanic influence at KV1 and epiclastic volcanic breccias of andesites at KV2 near Budča. Phytogeographical unit: Slovenské stredohorie, subunit: Kremnické vrchy.

In the Štiavnické vrchy hills (ŠV) localities of *P. umbellatus* are known from the NE part of the area, SW of Zvolen near of village of Dubové, occurring in a relatively large complex of a few hectares on epiclastic volcanic breccias of andesites. Phytogeographical unit: Slovenské stredohorie, subunit: Štiavnické vrchy. Plot ŠV2 is 400 m SW of ŠV1 (Fig. 3), plot ŠV3 600 m N of ŠV2.

One locality of *P. umbellatus* is known from the Javorie hills (J), S of Zvolen in the area of Pustý hrad, situated on acid andesites. It was found in 2010. Phytogeographical unit: Slovenské stredohorie, subunit: Javorie.

Specimens and collections

Herbarium collections are listed in chronological order and are mostly based on specimens from official herbaria, such as BRA and PRM. Abbreviations of the herbaria are cited in accordance with the Index Herbariorum (Holmgren et al. 1990). The abbreviation LDM represents the Forestry and Timber Museum Zvolen, Slovakia. Voucher specimens of sporocarps and sclerotia from research plots are deposited in the author's private herbarium (PVK). Specimens consisting of one sclerotium are specified as (scl.).

Field collections

Ondavská vrchovina highlands (OV): Q6996: OV3, 7 July 2010; OV11, 8 July 2010; OV1, 9 July 2010; OV8, 18 Aug. 2010. – Stolické vrchy hills (SV): Q7286: SV1, 27 July 2010; SV2, 31 July 2010 (scl.). – Zvolenská kotlina basin (ZK): Q7380: ZK2, 18 June 2010 (scl.); Q7480: ZK1, 30 June 2010 (scl.); ZK2, 1 July 2010 (specimens from two plots). – Kremnické vrchy hills (KV): Q7480: KV2, 18 July 2010, Q7480: KV1, 14 March 2011. – Štiavnické vrchy hills (ŠV): Q7480: ŠV3, 23 June 2010; ŠV1, 1 July 2010; ŠV2, 16 July 2010; ŠV3, 16 July 2010; ŠV2, 4 Sept. 2010. – Javorie hills (J): Q7480: J1, 20 July 2010.

Herbarium collections

Collections are listed in chronological order.

Štiavnické vrchy hills: Q7679: Prenčov, Čierne Blatá, alt. c. 600 m, broadleaved forest, 10 July 1888, leg. A. Kmeť (BRA CR4169). – Malé Karpaty hills: Q7868: Bratislava – Koliba, alt. 250 m, 15 Aug. 1955, leg. et det. I. Fábry (Kotlaba 1984); ibid. 29 June 1969, leg. et det. L. Opold (herb. Ponitrianske Múzeum Nitra, Slovakia). – Považský Inovec hills: Q7274: Zlatníky, Kulháň, alt. 350 m, *Quercus*, 18 Sept. 1969, leg. J. Kuthan (BRA CR4167) – Kováčovské kopce hills: Q8178: Štúrovo, alt. 400 m, *Quercus* and *Fagus*, 15 Aug. 1970, leg. J. Kuthan (BRA CR4164). – Slánske vrchy hills: Q7094: Zlatá Baňa, *Quercus*, 6 July 1971, leg. P. Hauser, det. A. Pilát (PRM 712680). – Záhorská nížina lowland: Q7368: Čáry, alt. c. 200 m, *Quercus*, 11 June 1972, leg. A. Dermek as *Grifola umbellata* (BRA CR4165). – Hornonitrianska kotlina basin: Q7177: Šutovce, alt. 450 m, *Quercus*, 25 Aug. 1974, leg. J. Kuthan (BRA CR4166). – Malá Fatra Mts.: Q6880: Turany, alt. 500 m, mixed forest, under *Fagus*, 22 Sept. 1974, leg. M. Šeděnko (BRA CR4182). – Strážovské vrchy hills: Q7177: Malá Magura, Šútovce, alt. 550 m, broadleaved forest, under *Quercus*, 6 Sept. 1975. leg. J. Kuthan (BRA CR4181). – Malé Karpaty hills: Q7868: Bratislava, Lamač, *Quercus*, 2 July 1978, leg. F. Kelbek (BRA CR4180). – Malé Karpaty hills: Q7768: Bratislava, Kačín, alt. c. 330 m, 2 July 1979, leg. J. Šeba (BRA CR4174). – Hornonitrianska kotlina basin: Q7277: part Rudnianska kotlina basin, Diviaky nad Nitricou, Máčov, alt. 420 m, broadleaved forest, under *Quercus*, 20 July 1980, leg. J. Kuthan (BRA CR4183). – Tríbeč hills: Q7575: Kostoľany pod Tríbečom, Jedliny, alt. 400 m, broadleaved forest, under *Quercus*, 13 Sept. 1980, leg. J. Kuthan (BRA CR4179). – Pohronský Inovec hills: Q7677: Čaradice, alt. 400 m, *Quercus*, 15 July 1984, leg. J. Kuthan (BRA CR4175). – Malé Karpaty hills: Q7868: Bratislava, Dúbravka, young *Quercus* trees, 30 June 1987, leg. J. Bernadič (BRA CR4178). – Krupinská planina plateau: Q7780: Čabradský Vrbovok, Veľký háj, alt. 300 m, broadleaved forest, under *Quercus*, 17 June 1988, leg. J. Sand (BRA CR4176). – Malé Karpaty hills: Q7768: Marianka, Svätý vrch, alt. 270 m, *Carpinus betulus*, 5 July 1990, leg. J. Sand (BRA CR4173). – Veľká Fatra Mts.: Q6880: Stankovany, Dierová, alt. 540 m, beech forest, 22 Sept. 1990, leg. L. Hagara (herb. Ladislav Hagara). – Malé Karpaty hills: Q7868: Bratislava, Železná Studnička, alt. c. 500 m, mixed broadleaved forest, 24 June 1993, leg. Dluhoš (BRA CR417); 7 Aug. 1999, leg. A. Urbanová (BRA CR4171). – Šarišská vrchovina highlands: Q7093: Prešov, Cemjata, alt. c. 350 m, oak and beech, 23 June 1998, leg. V. Kabát (herb. Vin-

Fig. 1. Young sporocarp of *Polyporus umbellatus* at plot OV7 (17 July 2009; photo: V. Kunca).

Fig. 2. Beech ecosystem – typical biotope of *Polyporus umbellatus* at plot OV7 (29 October 2010; photo: V. Kunca).

Fig. 3. Hornbeam ecosystem with oak – typical biotope of *Polyporus umbellatus* at plot ŠV2 (25 June 2010; photo: V. Kunca).

Fig. 4. Living sclerotium in the soil (on the left side) and dead sclerotium of *Polyporus umbellatus* at plot SV1 (19 June 2010; photo: V. Kunca).

cent Kabát). – Malé Karpaty hills: Q7768: Bratislava, Biely Kríž, alt. c. 600 m, mixed forest (*Quercus*, *Fagus*, *Picea*), 24 June 1999, leg. I. Kubáň (BRA CR4172). – Zvolenská kotlina basin: Q7480: Zvolen, Borová Hora, alt. 355 m, *Carpinus betulus*, 30 June 1998, 21 July 1999, leg. S. Glejdura (LDM M-000385, M-001034) [compatible with our research plot ZK1]. – Kremnické vrchy hills: Q7480: Kováčová, alt. 370 m, *Quercus* sp., 5 July 2002, leg. S. Glejdura (herb. S. Glejdura, PSG 319) [compatible with our research plot KV1]. – Nízke Beskydy hills: Q7099: Beskydské predhorie foothill, Snina, Konské, alt. c. 400 m, beech forest, 11 July 2008, leg. M. Saksun, det. J. Pavlík (PVK). – Slánske vrchy hills: Q6994: Pavlovce, Stravný potok, alt. 420 m, *Fagus*, 10 Sept. 2008, leg. O. Jindřich, det. J. Holec (PRM 914983).

Records not documented by voucher specimens

Beskydské predhorie foothill: Q7097: Kamenica nad Cirochou, June 1961, leg. A. Janitor. – Východoslovenská nížina lowland: Q7596: Kráľovský Chlmec, Vakovec, alt. 200 m, *Quercus petraea*, 24 June 1965, leg., det. et not. F. Kotlaba (15/64-65:15) (Kotlaba 1984). – Volovské vrchy hills: Q7392: Malá Ida, Holička, oak and hornbeam forest, July 1971, leg. A. Janitor. – Štiavnické vrchy hills: Q7779: between Ladzany and Sebechleby, July 1973, leg. A. Janitor, K. Vaník. – Štiavnické vrchy hills: Q7579: Žibritov, July 1973, leg. A. Janitor, K. Vaník. – Nízke Beskydy hills: Q6795: Ondavská vrchovina highlands, beech-hornbeam forests, Stropkov (Lizoň 1981). – Malé Karpaty hills: Q7867: Devínska Kobyla, Jezuitský les, 1984, leg. Horváth, det. Záhorovská – not confirmed in herbarium of the Department of Botany, Comenius University Bratislava, Slovakia (Záhorovská 1997). – Štiavnické vrchy hills: Q7479: Sklenné Teplice, Teplá pri Podhorí, Aug. 1986, leg. A. Janitor, K. Vaník. – Šarišská vrchovina upland: Q7093: between Drienovská Nová Ves and Radatice, July 1986, leg. A. Janitor. – Bukovské vrchy hills: Q6999: Chotinka, alt. c. 300 m, *Carpinus*, *Quercus*, 28 June 1990, leg. J. Kuthan and others, det. J. Kuthan, not confirmed in the herbarium of the Slovak National Museum in Bratislava (Kuthan et al. 1999). – Tríbeč hills: Q7476: Skýcov, Zadné hony, Sept. 1994, leg. A. Janitor. – Tríbeč hills: Q7575: Čerešňová–Velčice, Panský diel, 21. Sept. 1994, leg. A. Janitor. – Vtáčnik hills: Q7577: Ostrý Grúň, Homôľka, Aug. 2001, leg. A. Janitor. – Vtáčnik hills: Q7477: Veľké Pole, Francov štál, Aug. 2001, leg. A. Janitor – Vtáčnik hills: Q7477: Kľak, Hlavatá, alt. 703 m, Aug. 2001, leg. A. Janitor. – Tríbeč hills: Q7577: Malá Lehota, Rajnohov štál, Brezový vrch, Aug. 2001, leg. A. Janitor. – Vtáčnik hills: Q7578: Horné Hámre, Maršková dolina, Aug. 2001, leg. A. Janitor. – Laborecká vrchovina upland: Q6999: water reservoir Starina, Sept. 2004, leg. A. Janitor.

RESULTS AND DISCUSSION

Habitats of *P. umbellatus*

Oak and hornbeam forests were the only two communities presented as the typical environment with documented incidence of *Polyporus umbellatus* (Kotlaba 1984). According to our observations, beech-dominated communities should be added to this list. Excluding plots with atypical tree species compositions, such as allochthonous spruce, more than half of the plots with the fungus in this study were located in beech forests (51 %). Hornbeam was the tree species closest to sclerotia in 32 % of the plots. No *P. umbellatus* was found under Turkey oak (*Quercus cerris*).

Conversely, data originating from other collections (see above) indicate that oak communities should be the most common host for this fungus, followed by beech. One of the explanations of this discrepancy is that most mycological research during the previous century was concentrated in oak forests around Bratislava, one of the warmest parts of Slovakia.

Our data suggest that most localities occur on gentle (from flat areas up to 10° inclination) and mainly on relatively warm, south-faced slopes. Smooth terrain is often typical of deep soils without or with just a low content of soil skeleton, rubble stone or rocks. *P. umbellatus*, according to the observations, seems to prefer such soils and conditions where soil parent material is not visible at the soil surface.

The presented findings indicate that the only environment where *P. umbellatus* can grow successfully is that of a forest ecosystem. Most of the forests where living sclerotia were observed were managed, some only superficially while others were under strict management. It seems likely that the only forest management practice which can stop *P. umbellatus* growth is clearcutting, however there is some evidence that the sclerotium is able to resume its growth after a few years of dormancy. These findings are supported by those of Gáper (1996), who did not find any evidence of *P. umbellatus* in an urban environment.

Soil pH provides valuable information on the chemical status of ecological conditions in an ecosystem. Our observations of pH values from the plots are listed in Table 2. The pH ranges from 4.1 to 5.75 and according to Šály (1996) can be characterised as very acidic to mildly acidic. *P. umbellatus* was not found on soils with limestone or dolomite mother rock, suggesting that the fungus probably cannot grow in alkaline soils. Pilát (1969) suggests that *P. umbellatus* is typical of acidophilous oak woodlands and oligotrophic oak woodlands with hornbeam.

Tab. 2. Soil pH of selected plots with confirmed presence of *Polyporus umbellatus*.

plot	OV1	OV2	OV3	OV6	OV10	OV12	SV1	SV2
pH value	4.82	4.15	4.1	4.36	4.35	4.91	5.75	5.21
plot	ZK1	ZK2	KV1	KV2	ŠV1	ŠV2	ŠV3	J1
pH value	5.03	4.86	5.24	4.89	4.73	4.61	4.7	4.62

OV – Ondavská vrchovina highlands, SV – Stolické vrchy hills, ZK – Zvolenská kotlina basin, KV – Kremnické vrchy hills, ŠV – Štiavnické vrchy hills, J – Javorie hills.

Due to the lack of data on the distribution and habitat of *P. umbellatus*, it is necessary to rely on incomplete or non-verifiable sources. For example, Janitor et al. (2006) claim that *P. umbellatus* is able to grow successfully on oak stumps, a claim that could not be justified in this study. During 13 years of observations not any sporocarp was recorded on a stump. Only on one occasion a sporocarp was seen growing close to a stump, but after careful examination it became evident that it was supported by nearby sclerotia which did not colonise the stump.

The positions of sclerotia and sporocarps in a forest stand vary significantly in relation to the positions of nearby trees. It is apparent from all measured plots and their descriptions that the sclerotia occur at the base of a tree only in 24 % of plots. The most common distance of sclerotia to trees was less than 1 m (38 %) and over 1 m (38 %). We recorded two cases where the sclerotia were located at around 3 m from the base of the stem, representing the upper limit of spatial distribution.

Incidence of sporocarps

Sporocarp production of *P. umbellatus* follows the patterns typical of most forest fungi – there are significant peaks and troughs in the frequency of sporocarp observation throughout the year, mostly driven by weather patterns. Numbers of sporocarps at localities of intensive monitoring are presented in Tab. 3. The highest number of sporocarps in one year was recorded at plot ŠV2 in 2010 (19 individuals) and the highest number of sporocarps over the 3-year observation was recorded at the same plot (a total of 47 individuals). During one year (2010) 52 sporocarps were found at 6 neighbouring plots in the Štiavnické vrchy hills (ŠV). It has to be remarked that the year 2010 was markedly rainy and wet. The largest sporocarp found during this period was 60 cm in diameter and 2.6 kg in weight.

Tab. 3. Numbers of *Polyporus umbellatus* sporocarps during 3 years of intensive monitoring.

	2008	2009	2010
OV	14	36	40
ZK	3	8	8
KV	2	4	3
ŠV	8	25	52

Kotlaba (1984) mentions that the fruitbody production of *Polyporus umbellatus* takes place from June to October, with maximum incidence of sporocarps in June (41 % of finds). Personal 13-years observations confirm this pattern, however no sporocarp was found in October. During intensive monitoring the highest total number of sporocarps was found in July (53 % of all finds – Tab. 4). On the other hand, a large, already decomposed sporocarp was found on 11th June 2007. This sporocarp must have started growing in May, which correlates with the assertion of Mikula (2008). The above-mentioned data from herbarium collections confirm that the majority of sporocarps appear in July, with about a third of the annual total. The rest of the finds are equally distributed over the remaining three months of the growing season.

Tab. 4. Number of *Polyporus umbellatus* sporocarps found during four sporocarp production months over 3 years of monitoring.

	June	July	August	September
OV	19	45	24	2
ZK	5	13	2	0
KV	3	4	2	0
ŠV	20	46	1	18
Σ	47	107	29	20

Kotlaba (1984) also describes the spatial arrangement of *P. umbellatus* in the landscape. A dominant incidence of sporocarps in the area of former Czechoslovakia was located in the hills (89 % of finds), with a minority in lowlands and uplands. The lowest locality was recorded at an altitude of 130 m and the highest at 750 m. The highest located long-term monitoring plot studied was at an altitude of 541 m. According to the altitudinal classification of vegetation zones by Holub & Jirásek (1967) ex Kotlaba (1984), 41 % of the studied plots are located in lowlands, 36 % in the hills and 23 % in uplands. Herbarium data confirm this conclusion: the dominance of finds from the hills (73 %) is clearly visible, but surprisingly there are no records of *P. umbellatus* from lowlands.

Interestingly, despite the fact that all plots in the Ondavská vrchovina highlands are in the northern part of Eastern Slovakia, they are situated at low altitudes (from 160 to 225 m). Environmental conditions at these sites are similar to localities of lower altitudes in southern parts of Slovakia despite their higher latitude.

The range of *P. umbellatus* covers most of the suitable habitats in Slovakia (Fig. 5). The map of the fungus finds shows that it is widespread over the southern half of Slovakia and in the non-mountainous parts of the eastern regions. This suggests that in the central European climate, the fungus is typical of phytogeographical units of warmer regions and of foothills and basins. In general, the incidence data of the fungus correspond with previously published ranges and localities, but several new cases were identified where the presence of the fungus had not been confirmed previously. These were mostly relatively warm localities in regions known as typically mountainous, the Malá Fatra Mts. and Veľká Fatra Mts. One locality, Turčianska kotlina basin may have been previously misclassified as a part of Malá Fatra Mts, which would explain the presence of the fungus in an ecosystem not normally associated with it and the low altitude of the location not corresponding with the height range of the mountains. An additional location was found in a karst region of the Veľká Fatra Mts., the alkaline soil conditions would normally exclude the presence of *P. umbellatus*. However, detailed examination of the site revealed that the warmer slopes are located in a non-calcareous rock belt consisting of granodiorite rocks emerging from the surrounding dolomites.

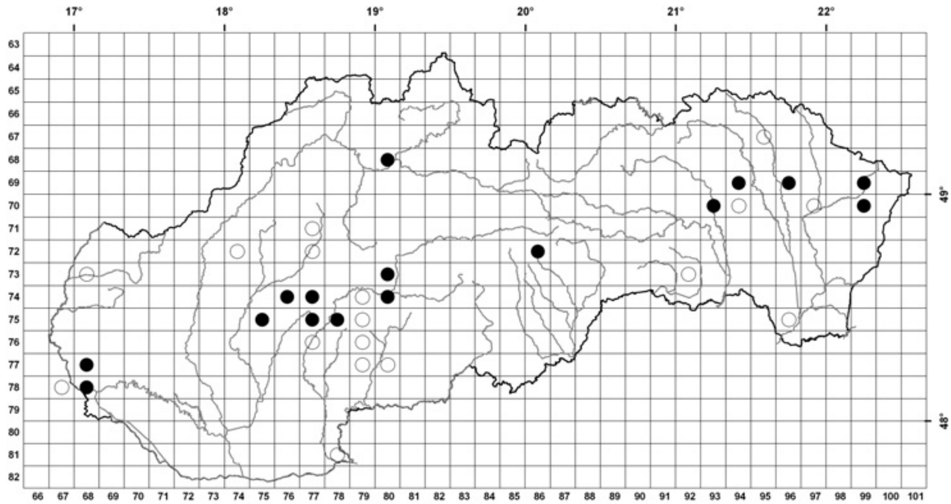

Fig. 5. Incidence of *Polyporus umbellatus* in Slovakia (○ – finds before 1990, ● – finds since 1990).

The list of known localities can be completed with published and deposited historical finds whose description and localisation is very general: Prešov: Hazslinsky, Veselský 1856 (not confirmed in the herbarium of the National Museum, Prague) (Pilát 1942), Spišské Vlachy, leg. F. Hazslinsky, 1880 (PRM 883705), Bratislava, July 1888 (BRA CR4170).

Some of the occurrences of *P. umbellatus* in this study were found by discovering exposed sclerotia, which are especially visible after heavy rains and summer storms. At locality OV5, a compact sclerotium covered an area of 2 × 3 m. In some plots no sporocarp production was observed for several years, despite a confirmed presence of a growing sclerotium in the soil. At plot OV8, the first sporocarp was found after 5 years of observations, suggesting that data based purely on sporocarp production may strongly underestimate the range and incidence of *P. umbellatus* in Slovakia.

Sclerotia of amorphous shape are very typical of *P. umbellatus* and often are visible at the soil surface. We monitored only living sclerotia which are characterised by hardened but elastic consistency and dark-coloured covering. The internal part of the sclerotium consists of a mass of white-coloured tissue which often exudes water when damaged. The micromorphology and ultrastructure of the sclerotium is given by Guo & Xu (1991). A dead sclerotium is greyish, lightweight and dry inside (Fig. 4). As a final note on the longevity of *P. umbellatus* sclerotia, it should be added that persistence of living sclerotia at one microlocality near Prešov has been confirmed after 55 years (pers. comm. by M. Jarkovský).

From field survey of the studied plots is apparent that at many of them sclerotia occur concentrated in small areas with suitable conditions. Only genetic tests can confirm whether some neighbouring sclerotia are one organism or not.

ACKNOWLEDGEMENTS

The paper was supported by the Slovak Grant Agency VEGA, grant No. 1/0557/10. Special thanks go out to Vladimír Kunca, Sr. for permanent monitoring of *P. umbellatus* in the Ondavská vrchovina hills. We wish to thank Nataša Kandová for laboratory analyses, Stanislav Glejdura for invaluable advice, Ján Červenka for help with specimens in the Slovak National Museum, Bratislava, Jan Holec for help with specimens in the National Museum, Prague, and Anton Janitor for providing information on many localities. We are also grateful to Peter Farárik, Roman Verkin, Anton Berdis and Vladimír Nemec for providing information on localities. We also thank Dušan Senko (Institute of Botany SAS, Bratislava) for technical assistance with the map and Martin Lukáč for advice and comments during the writing of the manuscript.

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