Selected biotic vectors transmitting beech bark necrotic disease in Central and South-Eastern Europe

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Abstract

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The authors mapped occurrence of three biotic vectors of beech (*Fagus sylvatica* L.) bark necrotic disease: beech lice *Cryptococcus fagi* Bärensp. and moths *Bucculatrix ulmella* Zeller and *Ectoedemia liebwerdella* Zim. in several countries in Central and South-Eastern Europe. The role of these species in European beech pathology is discussed. We have found a massive occurrence of *C. fagi* in all the localities, with frequency values reaching up to 100%. The occurrence of beech lice was not limited by the locality altitude. The butterfly *E. liebwerdella* generally occurred in most localities, with exception of Poland and Romania. In contrast to *C. fagi*, occurrence of *E. liebwerdella* was limited by altitude. The upper occurrence limit in Slovakia was 800 m a.s.l., in Bulgaria it was 1,220 m a.s.l. (32%) and infrequent in 1,380 m a.s.l. (only 4%). The butterfly *B. ulmella* occurred everywhere, apart from Poland. Its frequency was always lower than that of *C. fagi* and *E. liebwerdella*. The maximum value (91%) was found in Slovakia in a beech stand strongly affected with airborne pollutants in the past. Our results show that the upper occurrence limit for this species was 900 m a.s.l. in Slovakia and 1,250 m a.s.l. (4%) in Bulgaria.

Keywords

beech bark disease, biotic vectors, Central Europe, *Fagus sylvatica* L., insects, South-Eastern Europe

Introduction

Over the last three decades, an increasing occurrence of beech bark necrotic disease has been documented in Central and South-Eastern Europe (Cicák and Mihál, 2002; Jančařík, 1992; Rosnev and Petkov, 1996). This disease can be caused and spread by several biotic vectors – insects associated with the European beech (*Fagus sylvatica* L.). The insects transport on their bodies particles of mycelia and spores of various fungi species acting as beech bark disease causal agents: e.g. fungi from genera *Fusarium* Link., *Nectria* (Fr.) Fr., *Ophiostoma* Syd., *Phomopsis* Sacc., *Phytophthora* de Bary, *Valsa* Fr., *Verticillium* Nees. and others (e.g. Houston, 1994; Jančařík, 2000; Jung, 2009; Mihál et al., 2009; Perrin, 1984).

The issue of biotic vectors transmitting beech bark necrosis has been studied by many authors in Central and South-Eastern Europe. The problems of occurrence, spreading and phytopathological importance of *Cryptococcus fagi* has been studied by e.g. Cicák et al. (2006), Chira et al. (2003), Jurášek and Vacek (1983), Karadžić et al. (2003), Marinković and Karadžić (1985), Mihál and Cicák (2001), Mihál et al. (2009), Rojek (2005), Rosnev and Petkov (1996), Suvák (1998). Moreover, the role of moths *Ectoedemia liebwerdella* and *Bucculatrix ulmella* in beech bark disease complex is also studied by Borkowski and Konca (1991), Cicák et al. (2006), Csóka and Kovács (1999), Csóka and Szabóky (2005), Mihál and Cicák (2001), Mihál et al. (2009), Rojek (2005), Stolnicu (2007). Some mutual aspects between xylophagous Coleoptera and beech bark disease complex has been studied by e.g. JANČAŘÍK (1992) or SUROVEC and NOVOTNÝ (1985).

The aim of our work was to map the occurrence of three selected biotic vectors (*Cryptococcus fagi*, *Bucculatrix ulmella* and *Ectoedemia liebwerdella*) for beech bark necrotic disease in countries of Central and South-Eastern Europe (Czech Republic, Poland, Slovakia, Hungary, Romania, Bulgaria and Serbia).

Materials and methods

Together with assessment of degree of necrotic beech bark disease, we recorded occurrence of biotic vectors transmitting this disease – beech lice *Cryptococcus fagi* Bärensp. (Fig. 1) and moths *Bucculatrix ulmella* Zeller (Fig. 2) and *Ectoedemia liebwerdella* Zim. (Fig. 3). The research ran (April–May or October–November) in selected localities in Slovakia in the years 1995–2007. In the years 2001–2013, we also monitored occurrence of these species in several localities in the Czech Republic, Poland, Hungary, Romania, Serbia and Bulgaria.

Fig. 1. *Cryptococcus fagi* Bärensp. – adult colonies on beech bark (photo A. Cicák).

Fig. 2. *Bucculatrix ulmella* Zeller – pupae on beech bark (photo A. Cicák).

Fig. 3. *Ectoedemia liebwerdella* Zim.– the relict traces (galleries in bark) after the mining (photo A. Cicák).

Occurrence of these biovectors was recorded in each locality on a sample set consisting of 100 trees selected from the local beech parent stand. The sample size in localities with status of a permanent research plot (Prolaz, Troyan, Shipka, Balkanets, Tri Buki) was conformed according to the number of the numbered trees (in general less than 100 trees). We evaluated trees representing all the tree classes (according to Kraft). Occurrence of biotic vectors was recorded on the tree bark, around the whole stem perimeter, from root buttresses up to 2 m above the ground. In case of *C. fagi* we evaluated occurrence of adults, in case of *B. ulmella* occurrence of pupae on beech bark and in case of *E. liebwerdella* the relict traces (galleries in bark) after the mining. Also, isolated occurrence of a target species was considered as a recorded finding. The results were interpreted in percents – expressing frequency occurrence of the target species. A short description of the Slovak localities is in Table 1, the foreign localities in Central and South-Eastern Europe are summarised in Table 2.

Results and discussion

The information about frequency occurrence of the studied biotic vectors in Slovakia is in Table 3, the data for the other countries of Central and South-Eastern Europe are in Table 4.

According to our observations, *Cryptococcus fagi* had the highest frequency occurrence. Almost 80% of Slovak localities showed frequency occurrence values for this biovector exceeding 70%. In Bulgaria, these values were found lower, but also 68% of Bulgarian localities exceeded the value of 70%. In the other lands of Central and South-Eastern Europe the frequency values of this vector were higher than 90%. The only exception was the locality Crucea in Romania where

Table 1. Basic characteristics of research localities in Slovakia

Orographic unit	Locality	Altitude [m a.s.l.]	Exposition	Age of stand [years]	Beech [%] composition
Kremnické vrchy Mts	Boky	370	NW	70–120	55.0
	Kováčová	450	W	90	98.0
	Badínsky prales	760	N	20–150	95.0
	Mláčik	850	SE	95	60.0
Spišsko-gemerský kras karst	Javorníčková	600	SE	90	30.0
	Veľká Stožka	880	NE	65	90.0
	Nemecké lúčky	950	SE	80	70.0
	Vyšná Roveň	1,000	NE	105	95.0
	Červená Skala	1,050	NE	70	60.0
Bukovské vrchy Mts	Havešová	520	SE	120	100.0
	Udava	620	W	120	60.0
	Stužica	800	N	20–180	95.0
	Riaba skala	980	E	160	30.0
Štiavnické vrchy Mts	Žiar nad Hronom	470	NW	70	95.0
	Jalná	610	NW	75	100.0
	Sitno	900	NW	90	70.0
Malé Karpaty Mts	Kačín	320	NE	90	100.0
	Havrania skala	400	N	90	98.0
Nízke Tatry Mts	Korytnica	960	SW	80	88.0
	Lomnistá dolina	1,200	SE	140	50.0
Vihorlatské vrchy Mts	Sninský kameň	560	N	90	100.0
	Kyjov	800	N	20–250	100.0
Krupinská planina plain	Litava	300	NW	90	75.0
Slovenský kras karst	Brzotínske skaly	450	NW	70	65.0
Považský Inovec Mts	Hrádocká dolina	460	NE	60	100.0
Volovské vrchy Mts	Volovec	540	S	70	55.0
Laborecká vrchovina highlands	Výrava	550	SW	40–100	100.0
Ondavská vrchovina highlands	Kačalová	640	SW	60	60.0
Pieniny Mts	Bukový les	660	NW	90	99.0
Revúcka vrchovina highlands	Železník	660	NW	60	98.0
Stolické vrchy Mts	Kohút	680	W	100	95.0
Malá Fatra Mts	Valčianska dolina	680	NE	100	90.0
Slánske vrchy Mts	Oblík	700	SW	170–250	95.0
Pohronský Inovec Mts	Veľký Inovec	720	NE	45	100.0
Tríbeč Mts	Veľký Tríbeč	770	SW	80	50.0
Belianske Tatry Mts	Belianska jaskyňa	780	NE	30	55.0
Čierna Hora Mts	Vysoký vrch	780	NE	90	100.0
Ostrôžky Mts	Bralce	790	E	90	100.0
Biele Karpaty Mts	Veľká Javorina	940	E	80	80.0
Poľana Mts	Hrončecký grúň	950	SE	20–150	40.0
Strážovské vrchy Mts	Strážov	950	SW	80	100.0
Veporské vrchy Mts	Dobročský prales	950	NW	20–250	25.0
Veľká Fatra Mts	Veľká Skalná	1,000	S	60	80.0
Vtáčnik Mts	Škurátka	1,025	SE	100	95.0
Moravsko-sliezske Beskydy Mts	Malý Polom	1,060	NW	90	45.0

Table 2. Basic characteristics of research localities in selected countries of Central and South-Eastern Europe

Country	Orographic unit	Locality	Altitude [m a.s.l.]	Exposition	Age of stand [years]	Beech [%] composition
Czech Republic	Moravsko-sliezske Beskydy Mts.	Hukvaldy	450	E	90	38.0
		Šance	650	SW	60	90.0
		Pustevny	680	SE	115	74.0
Poland	Beskid Sądecki Mts	Kiczera	600	W	65	80.0
	Bieszczady Mts	Przysłop	610	S	70	80.0
	Beskid Nizki Mts	Przełecz Zebrak	825	W	100	95.0
Hungary	Zempéni-Hegység Mts	Telkibánya	300	SE	65	50.0
	Börzöny Mts	Diosjenö	500	N	100	80.0
	Mátra Mts	Parád	600	E	90	100.0
	Bükk Mts	Öserdö	800	SW	20–200	92.0
Romania	Munţii Tibleş Mts	Telciu	420	E	70	90.0
	Munţii Bistriţei Mts	Holda	660	NE	30–120	95.0
	Munţii Stânişoarei Mts	Crucea	690	SW	30–100	90.0
	Munţii Bârgau Mts	Piatra Fântânele	1,020	E	80	98.0
Serbia	Kucheyske planine plain	Yavorak	720	NW	55	100.0
		Velka Brezovitsa	900	N	70	100.0
Bulgaria	Stara planina Mts	Prolaz	300	N	60	90.0
		Shumen	450	E	100	90.0
		Boaza	450	N	70	100.0
		Troyan	480	N	80	100.0
		Vrbitsa	500	W	80	90.0
		Shipkovo	650	NE	70	100.0
		Ichera	700	NW	80	100.0
		Pravets	700	N	50	100.0
		Kotel	700	N	120	100.0
		Etropole	720	NE	125	99.0
		Ticha	750	SW	70	90.0
		Vitinya	970	NE	90	97.0
		Karandila	1,000	SE	135	100.0
		Ribaritsa	1,100	NW	70	100.0
		Shipka	1,100	NE	65	90.0
		Barzia	1,150	NW	110	100.0
		Balkanets	1,250	N	110	100.0
		Govezhda	1,250	N	70	100.0
		Beklemeto	1,300	NE	60	100.0
		Petrohan	1,400	NE	110	100.0
		Dlgi Del	1,450	S	130	100.0
	Rodopi Mts	Debravitsa	550	N	65	50.0
		Semchinovo	700	NW	75	100.0
		Fotinski vodopadi	750	N	70	100.0
		Rozovo	900	NE	65	100.0
		Eleshnitsa	900	NW	65	100.0
		Dobra Voda	950	NW	80	100.0
		Chepino	1,100	E	90	98.0
		Grashevo	1,100	N	80	100.0
		Marino	1,150	E	100	100.0
		Ravnogor	1,200	N	90	100.0
		Ossenovo	1,220	NW	140	100.0

Table 2. Basic characteristics of research localities in selected countries of Central and South-Eastern Europe – continued

Country	Orographic unit	Locality	Altitude [m a.s.l.]	Exposition	Age of stand [years]	Beech [%] composition
Bulgaria	Rodopi Mts	Velingrad	1,250	E	75	100.0
		Rakitovo	1,380	SW	80	100.0
		Aposlovtchark	1,400	E	50	60.0
	Pirin Mts	Razlog	1,150	NW	70	100.0
		Yane Sandanski	1,200	NW	120	100.0
		Popovi livadi	1,350	N	35	95.0
	Rila Mts	Rilski monastir	975	S	90	100.0
		Raduil	1,060	E	90	100.0
		Chaira	1,150	N	90	100.0
		Borovets	1,500	NE	90	90.0
	Sredna Gora Mts	Oborishte	750	W	80	100.0
		Panagyurishte	1,000	S	90	100.0
	Strandzha Mts	Silkosia I	305	NE	56	90.0
		Silkosia II	305	N	100	98.0
	Kraisthe planina Mts	Breznik	975	S	70	100.0
	Ljulin planina Mts	Gorna Bania	900	NW	70	80.0
	Osogovo planina Mts	Tri Buki	1,550	NW	160	100.0
	Vitosha Mts	Dragalevski monastir	1,080	NE	70–130	100.0

Table 3. Occurrence frequency (%) of selected biotic vectors of beech necrotic disease in selected localities in Slovakia

Locality	Altitude [m a.s.l.]	*Cryptococcus fagi*	*Bucculatrix ulmella*	*Ectoedemia liebwerdella*
Litava	300	88.0	62.0	35.0
Kačín	320	76.0	51.0	97.0
Boky	370	74.0	22.0	59.0
Havrania skala	400	79.0	0.0	70.0
Brzotínske skaly	450	85.0	0.0	59.0
Kováčová	450	94.0	8.0	60.0
Hrádocká dolina	460	91.0	12.0	71.0
Žiar nad Hronom	470	100.0	91.0	100
Havešová	520	100.0	3.0	70.0
Volovec	540	90.0	9.0	0.0
Výrava	550	89.0	6.0	80.0
Sninský kameň	560	3.0	0.0	29.0
Javorníčková	600	94.0	5.0	9.0
Jalná	610	89.0	0.0	96.0
Udava	620	88.0	3.0	0.0
Kačalová	640	100.0	11.0	70.0
Bukový les	660	48.0	0.0	0.0
Železník	660	86.0	13.0	92.0
Valčianska dolina	680	98.0	5.0	84.0
Kohút	680	88.0	7.0	44.0
Oblík	700	99.0	8.0	77.0

Table 3. Occurrence frequency (%) of selected biotic vectors of beech necrotic disease in selected localities in Slovakia – continued

Locality	Altitude [m a.s.l.]	*Cryptococcus fagi*	*Bucculatrix ulmella*	*Ectoedemia liebwerdella*
Veľký Inovec	720	99.0	14.0	91.0
Badínsky prales	760	99.0	15.0	3.0
Veľký Tríbeč	770	99.0	14.0	100.0
Belianska jaskyňa	780	39.0	5.0	0.0
Vysoký vrch	780	97.0	2.0	2.0
Bralce	790	99.0	5.0	89.0
Kyjov	800	99.0	4.0	0.0
Stužica	800	93.0	5.0	0.0
Mláčik	850	80.0	0.0	0.0
Veľká Stožka	880	95.0	11.0	0.0
Sitno	900	94.0	2.0	12.0
Veľká Javorina	940	87.0	0.0	0.0
Strážov	950	47.0	0.0	17.0
Hrončecký grúň	950	33.0	0.0	0.0
Dobročský prales	950	52.0	1.0	1.0
Nemecké lúčky	950	75.0	1.0	0.0
Korytnica	960	79.0	2.0	0.0
Riaba skala	980	2.0	0.0	3.0
Vyšná Roveň	1,000	83.0	0.0	0.0
Veľká Skalná	1,000	13.0	5.0	0.0
Škurátka	1,025	10.0	1.0	0.0
Červená skala	1,050	83.0	0.0	0.0
Malý Polom	1,060	25.0	2.0	0.0
Lomnistá dolina	1,200	93.0	0.0	0.0

Table 4. Occurrence frequency (%) of selected biotic vectors of beech necrotic disease in selected countries of Central and South-Eastern Europe

Country	Locality	Altitude [m a.s.l.]	*Cryptococcus fagi*	*Bucculatrix ulmella*	*Ectoedemia liebwerdella*
Czech Republic	Hukvaldy	450	100.0	17.0	95.0
	Šance	650	100.0	2.0	14.0
	Pustevny	680	99.0	2.0	22.0
Poland	Kiczera	600	100.0	0.0	0.0
	Przysłup	610	99.0	0.0	0.0
	Przelecz Zebrak	825	100.0	0.0	0.0
Hungary	Telkibánya	300	97.0	27.0	52.0
	Diosjenö	500	100.0	19.0	63.0
	Parád	600	99.0	18.0	60.0
	Öserdö	800	100.0	3.0	4.0
Romania	Telciu	420	98.0	0.0	0.0
	Holda	660	90.0	2.0	0.0
	Crucea	690	77.0	3.0	0.0
	Piatra Fântânele	1,020	99.0	1.0	0.0

Table 4. Occurrence frequency (%) of selected biotic vectors of beech necrotic disease in selected countries of Central and South-Eastern Europe – continued

Country	Locality	Altitude [m a.s.l.]	*Cryptococcus fagi*	*Bucculatrix ulmella*	*Ectoedemia liebwerdella*
Serbia	Yavorak	720	100.0	6.0	88.0
	Velka Brezovitsa	900	82.0	4.0	44.0
Bulgaria	Prolaz	300	97.5	10.0	0.0
	Silkosia I	305	62.0	14.0	16.0
	Silkosia II	305	96.0	2.0	56.0
	Boaza	450	65.0	5.0	0.0
	Shumen	450	100.0	12.0	98.0
	Troyan	480	40.0	10.0	97.5
	Vrbitsa	500	100.0	14.0	56.0
	Debravitsa	550	98.0	6.0	2.0
	Shipkovo	650	30.0	10.0	55.0
	Ichera	700	100.0	12.0	90.0
	Kotel	700	100.0	0.0	75.0
	Pravets	700	49.0	62.0	7.0
	Semchinovo	700	98.0	46.0	100.0
	Etropole	720	83.0	25.0	17.0
	Ticha	750	96.0	0.0	92.0
	Oborishte	750	96.0	22.0	68.0
	Fotinski vodopadi	750	56.0	2.0	8.0
	Gorna Bania	900	62.0	2.0	5.0
	Rozovo	900	98.0	4.0	94.0
	Eleshnitsa	900	34.0	0.0	0.0
	Dobra Voda	950	100.0	5.0	98.0
	Vitinya	970	75.0	22.0	97.0
	Breznik	975	44.0	1.0	2.0
	Rilski monastir	975	36.0	0.0	1.0
	Karandila	1,000	100.0	23.0	100.0
	Panagyurishte	1,000	100.0	0.0	100.0
	Shipka	1,000	87.5	0.0	100.0
	Chepino	1,000	68.0	0.0	0.0
	Grashevo	1,000	92.0	0.0	42.0
	Raduil	1,060	78.0	8.0	0.0
	Dragalevski monastir	1,080	50.0	6.0	0.0
	Ribaritsa	1,100	12.0	2.0	2.0
	Barzia	1,150	20.0	0.0	4.0
	Marino	1,150	96.0	4.0	42.0
	Razlog	1,150	97.0	0.0	97.0
	Chaira	1,150	84.0	0.0	0.0
	Ravnogor	1,200	100.0	0.0	38.0
	Yane Sandanski	1,200	100.0	0.0	0.0
	Ossenovo	1,220	86.0	0.0	32.0
	Balkanets	1,250	87.5	0.0	0.0
	Govezhda	1,250	92.0	0.0	0.0
	Velingrad	1,250	94.0	4.0	2.0

Table 4. Occurrence frequency (%) of selected biotic vectors of beech necrotic disease in selected countries of Central and South-Eastern Europe – continued

Country	Locality	Altitude [m a.s.l.]	*Cryptococcus fagi*	*Bucculatrix ulmella*	*Ectoedemia liebwerdella*
Bulgaria	Beklemeto	1,300	88.0	0.0	0.0
	Popovi livadi	1,350	54.0	0.0	0.0
	Rakitovo	1,380	100.0	0.0	4.0
	Aposlovtchark	1,400	66.0	0.0	0.0
	Petrohan	1,400	84.0	0.0	0.0
	Dlgi Del	1,450	8.0	0.0	0.0
	Borovets	1,500	78.0	0.0	0.0
	Tri Buki	1,550	12.5	0.0	0.0

we observed *C. fagi* occurring with a 77% frequency. On the other hand, not in a single locality from the studied ones in Central and South-Eastern Europe, *C. fagi* was absent. This result corresponds well to the fact that several authors consider *C. fagi* as the most important and widest spread species acting as a biotic vector transmitting beech bark necrotic disease.

Bionomy, distribution and importance of *C. fagi* in European forests have been documented by Pfeffer (1954). Lonsdale and Sherriff (1982) isolated from colonies of *C. fagi* conidia of the fungi *Nectria coccinea* (Pers.) Fr., *Nectria viridescens* C. Booth and *Verticillium lecanii* Viegas that may cause beech bark necrosis. Spores of the fungi belonging to the genera *Nectria*, *Alternaria* Nees and *Verticillium* on bodies of *C. fagi* in conditions in vitro were determined by Suvák (1998). Rojek (2005) refers to *C. fagi* as a biotic vector of beech bark necrotic disease in Poland and Karadžić et al. (2003), Marinković and Karadžić (1985) in Serbia. Chira et al. (2003) describe *C. fagi* in the Romanian Carpathians as the primary vector of beech bark necrotic disease.

From the Lepidoptera, we focussed on two species, *Bucculatrix ulmella* and *Ectoedemia liebwerdella.* The highest, 91% frequency value of *B. ulmella* was found in case of the Slovak locality Žiar nad Hronom. Up to the recent past, the beech stand in this locality was strongly influenced by airborne pollutants. The second highest – 62% frequency value of *B. ulmella* was also observed in Slovakia – locality Litava. The beech stand in this locality was the lowest-situated – at 300 m a.s.l., from all the Slovak localities. The same, 62% frequency, we also found in the submountain beech monoculture in the Bulgarian locality Pravets. From the total number of 45 Slovak localities, 13 were found without occurrence of *B. ulmella*. Most localities in which the butterfly is absent are situated at an altitude exceeding 900 m a.s.l. Situation was similar in Bulgaria where we did not record occurrence of *B. ulmella* in 24 localities from the total number of 50 ones. Most of these sites are situated above 1,100 m a.s.l. (except two localities situated in 1,150 and 1,250 m a.s.l. – identically 4% occurrence of *B. ulmella*). It seems that 900 m a.s.l. in Slovakia and about 1,000 m a.s.l. in Bulgaria are natural altitudinal limits for occurrence of *B. ulmella.* Relatively high frequency values of *B. ulmella* occurrence were also recorded in Hungarian localities. With exception of one locality (Öserdö), in which we observed a 3% frequency value, the other three localities showed values ranging from 18 to 27%. *B. ulmella* generally occurs in oak trees in Hungary (Csóka and Szabóky, 2005). Moreover, this species is also frequent in oak forests in Slovakia (Patočka et al., 1999). For two Czech localities, we obtained 2% and 17%, respectively. Very low frequency values (1 to 3%) were found in Romania. In Southern Poland we have not recorded presence of this moth. The interesting results about occurrence of *B. ulmella* in beech forest stand under strong immission impact in Central Slovakia have been presented by Kulfan et al. (2002).

In case of *E. liebwerdella* we found considerably higher frequency values in comparison with *B. ulmella*. Several values obtained in Slovakia and in Bulgaria reached 100%. Lower than 100% these values were in Czech, Serbian and Hungarian localities. We have found that the upper altitudinal limit for *E. liebwerdella* occurrence in Slovakia is 800 m a.s.l. From the total number of 18 localities situated at and above 800 m a.s.l., we identified four with presence of *E. liebwerdella*. The values obtained for these localities were incomparably lower (representing 1 to 17%) than the values obtained for the localities situated lower than at 800 m a.s.l. The upper altitudinal occurrence limit for this species in Bulgaria is shifted much higher, in comparison with Slovakia – up to the altitude of 1,250 m a.s.l. (32%) and infrequent 1,380 m a.s.l. (only 4% of *E. liebwerdella* occurrence). Relatively high values of *E. liebwerdella* occurrence have been recorded in Serbia – 44% and 88%. The general presence of *E. liebwerdella* in damaged Slovak beech forests attacked by necrosis has been referred by Kodrík and Suvák (1999). These authors implemented the method in vitro and found that this moth is a vector transporting spores of the fungi of the genus *Nectria* (Fr.) Fr. *E. liebwerdella* is considered to be a common species in beech forest stands in Hungary (Csóka and Kovács, 1999) and Slovakia (Kulfan et al., 2011). Without occurrence of *E. liebwerdella* the localities in Romania and in Poland were found. This, however, does not mean that this butterfly does not occur in these countries. This fact has also been confirmed with the most recent data about its occurrence in beech stands in boundary areas in the Polish Sudeten Mts (Borkowski and Konca, 1991). The former occurrence of *E. liebwerdella* in Poland has also been confirmed with an ancient finding determined in the locality Jesienia in 1947 by Adamczewski (in Schönherr, 1958). Rojek (2005) assigns to this butterfly a special importance in association with beech bark necrotic disease. Occurrence of the relative species *Ectoedemia albifasciella* (Heinemann) and *E. heringii* (Toll) has been reported by Stolnicu (2007) in Eastern Romania and from the near Moldavia.

It is evident, that the interval of altitudinal zone suitable for living and occurrence of particular Lepidoptera species is very important not only for conditions in Central Europe, as well as for ones in South-Eastern Europe. For example, Kulfan (1990) observed that highest index of species diversity of butterflies (4.96) has been recorded in the localities situated in the valleys and foothills of the Malé Karpaty Mts in western Slovakia. On the other hand, the lowest index of ones (2.91) has been recorded in the localities situated on higher altitudes on the mountain ridges. The vertical gradient is very important for composition of butterfly fauna. This fact was confirmed by Kulfan and Kulfan (1997), who observed that from 118 species of butterflies recorded in the Malá Fatra Mts in northern Slovakia, total 94 species of ones have been found on various biotopes situated up to 500 m a.s.l. On the contrary, in the mountain biotopes, from 1,000 m a.s.l., only 8 species of butterflies occurred steady. The decreasing of butterflies fauna on the biotopes situated in higher altitudes, opposite to the biotopes situated in lowest altitudes, is the native phenomenon, which is typical mainly for higher mountains.

On the other hand, the situation of occurrence and spreading of butterflies within the conditions in South-Eastern Europe seems to be different from conditions in Central Europe. For example, van Swaay et al. (2007) have been studied lepidopterofauna in 9 various localities in eastern Serbia. Total 117 species of butterflies have been determined, only 25 species of ones have been recorded in the localities situated in 400–420 m a.s.l. in the Rtnaj Mts. On the contrary, the most species of butterflies (61) have been recorded in the locality situated from 980 up to 1,600 m a.s.l. in the Stara planina Mts. Moreover, in the Croatian Karst in Dalmacia the species diversity of butterflies has been investigated by Mihoci et al. (2011). The researched localities have been situated on vertical gradient, from coast of the Adriatic Sea to the elevated plateau in the inland. The authors found that in the localities situated from 0 up to 500 m a.s.l. the index of species diversity of butterflies was the lowest (0.84), in the localities situated from 500 up to 1,000 m a.s.l. the index of ones was 0.86 and within the zone up to 1,000 m a.s.l. index was the highest (0.92).

By the comparing these data obtained from Slovakia (Central Europe) and from Croatia and Serbia (Southern Europe) we can see that the climatic conditions in the continental Central Europe are supporting the declining of species diversity of butterflies towards the higher altitude biotopes. On the other hand, the butterflies occurred abundantly and steady also on the biotopes situated in higher altitudes in the climatic more suitable areas in South-Eastern Europe, in the Balkan Peninsula and Mediterranean area generally, probably due to high temperature and more suitable climatic conditions in the higher situated localities.

Other important and potential biotic vectors spreading beech bark necrotic disease are listed in the Table 5. The least investigated vectors include the species of the Acarina order. Other species from other groups, e.g. *Fagocyba cruenta* (Herrich-Schäffer), *Phyllapsis fagi* L. and *Mikiola fagi* (Hartig) have been indicated as important pests of beech by Hartmann et al. (1995) and Strout and Winter (1994). Butterflies and moths represent a significant group of biotic vectors for beech bark necrotic disease. Masarovičová et al. (1999) mention a massive occurrence of caterpillars of the butterfly *Calliteara pudibunda* (L.) in a beech stand seriously attacked by necroses. The stand has been, moreover, heavily loaded with airborne pollution of fluorine type. The high degree of necrotic damage to this stand has also been confirmed by Cicák and Mihál (2002). In the same stand, Šušlík and Kulfan (1993) observed a high abundance of caterpillars of the species *Ennomos quercinaria* (Hufnagel), *Agriopsis aurantiaria* (Hübn.) Regular at Kinloch and *Erannis defoliaria* Cl. Topp et al. (1998) mention a massive occurrence of the species *Operophthera fagata* Scharf. and *Erannis defoliaria* Cl. in beech forests in surroundings of the Rhine River in Germany. A potential vector from Lepidoptera can also be *Argyresthia semitestacella* Curt. Little known data on occurrence and bionomy of this species can be found in Patočka (1998). The author reports occurrence of this species in submountain beech stands. The species was locally abundant, and the author considers it to be a local pest and vector of fungal diseases of beech.

Another significant group of pests of beech and of biotic vectors of beech diseases consists of beetles. Table 5 gives a list of species living in tree bark or directly in tree wood mass, and can also be classified

Table 5. Overview of significant and potential biotic vectors of beech necrotic disease of tracheomycotic type by selected literary sources

Order	Family	Species	Literary source
Acarina	Eriophyidae	*Eriophyes stenaspis* Nal.	Hartmann et al. (1995), Pfeffer (1954), Szmidt (1990)
Homoptera	Cicadellidae	*Fagocyba cruenta* (Herrich-Schäffer)	Hartmann et al. (1995)
	Coccidae	*Cryptococcus fagi* Bärensp.	Chira et al. (2003), Hartmann et al. (1995), Jurášek and Vacek (1983), Krabel and Petercord (2000), Kulfan et al. (2011), Lonsdale and Sheriff (1982), Lunderstädt (1998), Pfeffer (1954), Rojek (2005), Strout and Winter (1994), Suvák (1998), Szmidt (1990)
Sternorrhyncha	Callophididae	*Phyllapsis fagi* L.	Hartmann et al. (1995), Kulfan et al. (2011), Strout and Winter (1994), Szmidt (1990)
Diptera	Cecidomyiidae	*Hartigiola annulipes* (Hartig)	Hartmann et al. (1995), Kulfan et al. (2011), Strout and Winter (1994)
		Mikiola fagi (Hartig)	Hartmann et al. (1995), Kulfan et al. (2011), Strout and Winter (1994), Szmidt (1990)
Lepidoptera	Bucculatricidae	*Bucculatrix ulmella* Zeller	Csóka and Szabóky (2005), Kulfan et al. (2002, 2011), Stolnicu (2007), Šušlík and Kulfan (1993), Topp et al. (1998)
	Geometridae	*Operophthera fagata* Scharf.	Kulfan et al. (2011), Szmidt (1990), Šušlík and Kulfan (1993), Topp et al. (1998)
	Lymantriidae	*Calliteara pudibunda* (L.)	Kulfan et al. (2011), Masarovičová et al. (1999), Šušlík and Kulfan (1993), Topp et al. (1998)
	Nepticulidae	*Ectoedemia liebwerdella* Zim.	Borkowski and Konca (1991), Csóka and Kovács (1999), Kodrík and Suvák (1999), Kulfan et al. (2011), Rojek (2005)
	Yponomentidae	*Argyresthia semitestacella* Curt.	Kulfan et al. (2011), Patočka (1998), Topp et al. (1998), Šušlík and Kulfan (1993)
Hymenoptera	Ichneumonidae	Erannis defoliaria Cl.	Hartmann et al. (1995), Kulfan et al. (2011), Pfeffer (1954), Šušlík and Kulfan (1993), Topp et al. (1998)
	Tenthredinidae	*Caliroa annulipes* (Klug.)	Kulfan et al. (2011), Strout and Winter (1994)
Coleoptera	Buprestidae	*Agrillus viridis* (L.)	Jančařík (1992), Surovec and Novotný (1985)
	Curculionidae	*Rhynchaenus fagi* L.	Hartmann et al. (1995), Innes (1992), Strout and Winter (1994), Szmidt (1990)
	Lymexylidae	*Hylecoetus dermestoides* L.	Hartmann et al. (1995), Surovec and Novotný (1985), Szmidt (1990)
	Scolytidae	*Ernoporicus fagi* (Fabr.)	Surovec and Novotný (1985)
		Taphrorychus bicolor (Herbst.)	Jančařík (1992), Surovec and Novotný (1985), Zach et al. (2002)
		Xylosterus domesticus L.	Carlier et al. (2006), Surovec and Novotný (1985), Szmidt (1990)

As other biotic vectors of beech necrotic disease can also be considered scale insects (*Pulvinaria* sp., *Phenacoccus aceris* Signoret), ants (Formicidae), birds (Certhiidae, Picidae, Sittidae), mammals (Rodentia, Artiodactyla) and, last but not least, the human itself too.

as important ones. Surovec and Novotný (1985) regard these species as important biotic vectors transmitting beech tracheomycoses in Slovakia. In a similar way, Jančařík (1992) discussing the species *Taphrorychus bicolor* (Herbst.) and *T. villifrons* Duffaeur, does not exclude the possibility of transport of spores of fungi belonging to the genus *Ophiostoma*. Potential vectors of beech bark necrotic disease can also be almost all the species of the family Scolytidae, whose life cycle is associated with wood (Zach et al., 2002). During our research on beech bark necrosis in Slovakia, we found occurrence of the species *Phyllobius argentatus* L. and *Xyloterus domesticus* L. attacking beech trees with severe necrotic symptoms. Carlier et al. (2006) observed in species *Xyloterus domesticus* and *X. signatus* transport of spores of *Ophiostoma arduennense* Carlier, Decock, K. Jacobs & Maraite, sp. nov.

Apart from xylophages, transmission of beech bark necrotic disease is also shared by phylophagous beetles. An important representative of this group is *Rhynchaenus fagi*, in outbreaks causing impaired health stand of beech stands. Innes (1992) suggests that there are links between changes in leaf colouring (chlorosis – yellowing) and leaf necrosis (browning) on one and synergic effect of *R. fagi* and fungus *Nectria ditissima* Tul. et C. Tul. on the other side. Probability of conidia transport of the species *Nectria galligena* Bres. sensu Strasser by leaf-eating insects, e.g. *R. fagi*, has been evaluated by Downing (1989).

The obtained results concerning occurrence of the discussed insect species suspected to act as biotic vectors of beech bark necrotic disease in selected countries of Central and South-East Europe reveal the following facts:

- Massive occurrence of the beech lice *Cryptococcus fagi*, in all the studied localities and countries, sometimes reaching frequency value of 100%. The occurrence of beech lice was not limited by altitude.
- Increased occurrence of *Ectoedemia liebwerdella*, except Poland and Romania. In several cases, the frequency reached 100%. In contrast to *C. fagi*, the occurrence of *E. liebwerdella* was limited by altitude. The upper limit in Slovakia is 800 m a.s.l., in Bulgaria it is 1,220 m a.s.l. (32%) and infrequent also in 1,380 m. a. s. l. (only 4%).
- Increased occurrence of *Bucculatrix ulmella*, except Poland. The maximum frequency value (91%) was obtained in Slovakia, in a locality strongly influenced by fluorine airborne pollutants in the past. The maximum frequency value of occurrence of *B. ulmella* in Bulgaria was 62%. The obtained frequency values show that the upper occurrence limit for this species is 900 m a.s.l. in Slovakia and 1,250 m a.s.l. in Bulgaria.

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