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ACTUAL STATUS OF BEECH BARK NECROTIC DISEASE IN SOUTH-WEST BULGARIA

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Abstract: Data of beech bark necrotic disease on beech stems are expressed through necrotisation index (I_{SN}) values from 15 selected localities in the Rhodopes, 4 ones in Pirin and one locality in Maleshevska planina. The values of I_{SN} varied from 0.22 to 0.80 in the Rhodopes, from 0.38 to 0.88 in Pirin and 0.38 in the Maleshevska planina. Six species from the genus *Nectria* s. l. were determined in the Rhodopes and only one species in Pirin. Five out of six species were identified from living trees and dead beech wood, and one species was identified from declining silver fir.

Among potential vectors of beech bark disease (*Cryptococcus fagisuga* Lindinger, *Bucculatrix ulmella* Zeller and *Ectoedemia liebwerdella* Zimm.), were have recorded high frequency values in *C. fagisuga*. The frequency values of *C. fagisuga* varied from 34.0% to 100.0%, values of *B. ulmella* varied from 2.0% to 46.0% and values of *E. liebwerdella* from 2.0% to 100.0%.

Key words: beech, *Fagus sylvatica* L., necrotic disease, South-West Bulgaria

INTRODUCTION

In recent decades, the beech necrotic disease in Europe has become a serious problem in forest pathology, forest management and landscape ecology. In some localities in Central and South-Eastern Europe, the disease manifests nature of an epiphytocia. The beech necrotic disease symptoms can be divided, from the diagnostic position, into two general groups. The first one is represented by visually observable symptoms. Here belong necroses, deramification and occurrence of fruit bodies of parasitic fungi causing the necrotic disease. The second involves the symptoms non visible with the naked eye only. In the group of hidden symptoms of infection the following ones can be included: tyloses of vessels in the proximity of the attacked stem or bark segment visible only with the aid of a special apparatus, i.e. scanning electron microscope. These symptoms can be observed even in advance to the occurrence of visible necroses entailing in several cases considerable deformations of branch or stem segments. There exists a hidden

symptom that can be considered as a very significant beech bark disease indicator: relic traces of cambium injury, known under the name T-disease (Butin, 1995). This symptom is visible only on the stem cross-section at the place of necrosis occurrence and has an important share on low quality of round wood assortment production. The symptoms from both groups can be observed on beech stems, except deramification – typical only for the crown parts (branches) of the trees (Mihál, Cicák, 2003).

To date, the beech necrotic disease has been studied by several authors: Metzler et al. (2002), Schütt, Summerer (1983) in Germany, Schimitschek (1980) in Austria, Rykowski et al. (1989) in Poland, Jančařík (2000a, 2000b) in Czech Republic, Cicák, Mihál (2002), Jarčuška et al. (2013) and Mihál, Cicák (2001) in Slovakia, Mihál, Cicák (2005) in Hungary, Lazarev (1985) in Bosnia, Karadžić (2012), Karadžić et al. (2003, 2012), Mihál et al. (2009) in Serbia and Republic of Srpska, Chira, Chira (1997), Chira et al. (1996) and Mihál, Cicák (2007) in Romania, Cicák et al. (2006), Jarčuška et al. (2013), Tsakov, Cicák (2010), Tsakov et al. (2008) and Rossnev, Petkov (1996) in Bulgaria.

In this work are presented the latest results of our assessment of necrotic damage to beech trees in 15 localities in the Rhodopes, 4 ones in Pirin and one locality in the Maleshevska planina in South-West Bulgaria. These results are the first contribution to assessment of the state-of-art in beech necrotic disease in South-West Bulgaria, and they are a part of an extensive study of this problem in South-Eastern Europe.

MATERIAL AND METHODS

The study was performed between 21. 04. 2010 and 28. 04. 2014 in beech forest stands in 20 selected localities in South-West Bulgaria, orographic units the Rhodopes, Pirin and Maleshevska planina (Table 1). One stand per each locality was selected and 50 trees per stand, belonging to the 1–5 Kraft tree classes to, were assessed in order to represent the whole vertical profile of the stand. The degree of beech bark necrotic disease was estimated according to Cicák, Mihál (1997), and used evaluation scale is shown in Table 2.

To obtain a simplification of interpretation of the results, the evaluation has been performed using the so-called bark necrosis index (I_{SN}) (Cicák, Mihál, 1998). Data represents the mean degree of the injury (computed as the weighed arithmetical mean) for each individual tree class. During of assessment process of the degree of necrotic damage to beech stems, the fruiting bodies of the genus *Nectria* s. l. fungi were acquired on the beech bark in the teleomorpha form. The sampled of fungal fruiting bodies were determined in a laboratory according to the determination keys provided by authors Breitenbach, Kränzlin (1986) and Rossman et al. (1999).

Table 1
Basic characteristics of the research localities

Orographic unit	Locality	Altitude (m a.s.l.)	Location	Exp.	Age of stand (years) / Beech structure (%)	Date of research
The Rhodopes	Debravitsa	550	42°05′N 24°15′E	N	65 / 50	26.04.2012
	Semchinovo	700	42°09′N 24°05′E	NW	75 / 100	22.04.2011
	Fotinski vodopadi	750	41°53′N 24°23′E	N	70 / 100	24.04.2013
	Eleshnitsa	900	41°53′N 23°40′E	NW	65 / 100	25.04.2013
	Rozovo	900	41°59′N 24°23′E	NE	65 / 100	27.04.2012
	Dobra Voda	950	42°03′N 24°15′E	NW	80 / 100	26.04.2012
	Chepino	1100	41°57′N 23°99′E	E	90 / 98	22.04.2011
	Grashevo	1100	41°58′N 23°54′E	N	80 / 100	28.04.2012
	Koldanovi nivi	1100	41°36′N 23°57′E	NW	70 / 99	27.04.2014
	Marino	1150	41°59′N 24°13′E	E	100 / 100	22.04.2010
	Ravnogor	1200	41°58′N 24°22′E	N	90 / 100	27.04.2012
	Ossenovo	1220	41°45′N 23°44′E	NW	140 / 100	25.04.2013
	Velingrad	1250	42°04′N 23°58′E	E	75 / 100	23.04.2010
	Rakitovo	1380	42°04′N 24°11′E	SW	80 / 100	21.04.2010
	Apostolov chark	1400	41°42′N 23°58′E	E	50 / 60	26.04.2012
Pirin	Popina laka	1150	41°40′N 23°23′E	W	70 / 100	28.04.2014
	Razlog	1150	41°53′N 23°21′E	NW	70 / 100	23.04.2011
	Yane Sandanski	1200	41°32′N 23°36′E	NW	120 / 100	27.04.2013
	Popovi livadi	1350	41°33′N 23°38′E	N	35 / 95	27.04.2013
Maleshevska planina	Dobri laki	1300	41°37′N 23°59′E	NE	120 / 100	28.04.2014

Exp. – exposition

Table 2
Classification scale for bark necrosis evaluation on beech stems

Degree	Characteristics
0	without any necrotic wounds on the bark
1	small necrotic wounds (bark fissures, cracks) occurring singularly or in individual groups, visible only with closer examination of the stem
2	small necrotic wounds (as for the degree 1) accompanied by occurrence of larger necrotic wounds (larger fissures, rugged bark) visibly under ordinary examination of the stem
3	larger necrotic wounds denuding the xylem and partly deforming the stem, bark cracking and shedding, visible already from a larger distance
4	large necrotic wounds deforming the stem heavily or leading to "bark necrosis", rugged bark and bark shedding, visible also from greater distance

Notes: A stem, from buttresses to the crown setting, in an evaluated part of the tree. It is necessary to consistently distinguish in the process of evaluation occlusions after bark injury from logging, after game browsing and frost cracks from necrosis. Neither the number of necrotic lesions nor the size of the stem bark area covered with necroses in taken as the main indicator during evaluation. Destructive effects of necrotic disease are manifested mainly by the stages of necrosis development precised in the classification scale description.

It is necessary to add, that the necrotic damage of beech bark tissues is associated with activity or interaction among various fungal and insect pathogens, mainly fungi of the genus *Anthostoma* Nitschke, *Cytospora* Ehr.: Fr., *Diatrype* Fr., *Fusarium* Link, *Nectria* (Fr.) Fr., *Neonectria* Wollenw., *Ophiostoma* Syd., fungal-like organisms P*hytophthora* de Bary, also *Phomopsis* Sacc., *Valsa* Fr., *Verticillium* Nees, etc. (e.g. Houston 1994; Jančařík 2000b; Jung 2009; Mihál et al. 2009; Perrin 1984; Rossman et al., 1999).

Together with the assessment of the degree of necrotic damage the occurrence of biotic vectors of the necrotic disease were also recorded: *Cryptococcus fagisuga* Lindinger, *Bucculatrix ulmella* Zeller and *Ectoedemia liebwerdella* Zim. The presence was identified from the buttresses to a height of 2 m around the whole stem perimeter (Mihál, Cicák, 2001).

RESULTS AND DISCUSSION

The data of necrotic damage of beech trees – frequency values of necroses according to the individual damage degrees and necrotisation index values (I_{SN}) have been summarised in Table 3. The values of I_{SN} varied from 0.22 to 0.80 in the Rhodopes, from 0.38 to 0.88 in Pirin and 0.38 in the Maleshevska planina. The high frequency values of necrotic damage in degree 0 (without necrotic damage) were recorded in the localities Debravitsa (78.0%) and Rozovo (76.0% of evaluated trees) in the Rhodopes. The least values 30.0% (locality Velingrad) and 36.0% (Rakitovo) of evaluated

Table 3
Frequency of necrotisation and index of beech bark stem necrotisation (I_{SN}) in selected localities

Localities	Frequency of necrotisation in individual necrotisation degrees (%)								I_{SN} (mean ± standard error)
	0	1	2	3	4	1-4	2-4	3-4	
Debravitsa	78.0	22.0	0.0	0.0	0.0	22.0	0.0	0.0	0.22 ± 0.06
Semchinovo	66.0	32.0	2.0	0.0	0.0	34.0	2.0	0.0	0.46 ± 0.09
Fotinski vodopadi	54.0	36.0	10.0	0.0	0.0	46.0	10.0	0.0	0.56 ± 0.10
Eleshnitsa	78.0	32.0	0.0	0.0	0.0	32.0	0.0	0.0	0.32 ± 0.07
Rozovo	76.0	22.0	2.0	0.0	0.0	24.0	2.0	0.0	0.26 ± 0.07
Dobra Voda	44.0	46.0	6.0	2.0	2.0	56.0	10.0	4.0	0.72 ± 0.12
Chepino	70.0	28.0	2.0	0.0	0.0	30.0	2.0	0.0	0.32 ± 0.07
Grashevo	70.0	30.0	0.0	0.0	0.0	30.0	0.0	0.0	0.32 ± 0.07
Koldanovi nivi	42.5	50.0	7.5	0.0	0.0	57.5	7.5	0.0	0.65 ± 0.10
Marino	68.0	32.0	0.0	0.0	0.0	32.0	0.0	0.0	0.32 ± 0.07
Ravnogor	44.0	54.0	2.0	0.0	0.0	56.0	2.0	0.0	0.58 ± 0.08
Ossenovo	52.0	42.0	4.0	2.0	0.0	48.0	6.0	2.0	0.56 ± 0.10
Velingrad	30.0	60.0	10.0	0.0	0.0	70.0	10.0	0.0	0.80 ± 0.09
Rakitovo	36.0	60.0	4.0	0.0	0.0	64.0	4.0	4.0	0.68 ± 0.08
Apostolov chark	62.0	38.0	0.0	0.0	0.0	38.0	0.0	0.0	0.38 ± 0.07
Popina laka	62.5	37.5	0.0	0.0	0.0	37.5	0.0	0.0	0.38 ± 0.08
Razlog	20.0	75.0	2.5	2.5	0.0	80.0	5.0	2.5	0.88 ± 0.09
Yane Sandanski	46.0	52.0	2.0	0.0	0.0	54.0	2.0	0.0	0.56 ± 0.08
Popovi livadi	64.0	34.0	2.0	0.0	0.0	36.0	2.0	0.0	0.38 ± 0.07
Dobri laki	62.5	37.5	0.0	0.0	0.0	37.5	0.0	0.0	0.38 ± 0.08

trees belonged to the evaluation degree 0 (without necrotic damage) in the Rhodopes and only 20.0% (locality Razlog) in Pirin.

The values of I_{SN} obtained on selected localities in the Rhodopes, in Pirin and in Maleshevska planina are measurably comparable with the values of I_{SN} obtained in selected countries of Central and South-Eastern Europe. The I_{SN} values from 0.53 to 1.97 were obtained by the same methods in 54 localities in Slovakia (Cicák, Mihál, 2002), and almost equal to the values obtained in four localities in northern part of Romania – from 0.83 to 1.31 (Mihál, Cicák, 2007). The resulting values of necrotic disease expressed through I_{SN} ranged from 0.72 to 1.12 in north-west part of Bulgaria, in Vitosha and Stara planina (Cicák et al., 2006). The values of index necrotisation obtained from two localities in South-Eastern Serbia were 0.80 and 0.88, respectively (Mihál et al., 2009). The higher values of I_{SN} were obtained from four localities in northern part of Hungary – from 1.14 to 1.18 (Mihál, Cicák, 2005).

Several authors suggest that there is evident increase in beech necrotic disease in Central and South-Eastern Europe caused by the parasitic fungi of the genus *Nectria* and *Neonectria* (Cicák, Mihál, 2001; Chira et al., 1996; Karadžić 2012; Karadžić et al., 2003; 2012, Rossnev, Petkov, 1996). The most important factors initiating the disease are, among others, unsuitable soil conditions, immissions, pests, slope, exposition of stands, improper age structure and species composition as well as unfavourable climate, e.g. soil moisture deficit and spring frosts (Chira, Chira, 1997; Kunca et al., 2000). These conditions promote spreading of fungi of the genus *Nectria*. During this research in South-West Bulgaria 6 species of the genus *Nectria* in the Rhodopes and only one species in Pirin were determined. All species have been found in the teleomorpha form. The species *Cosmospora purtonii* (Grev.) Rossman & Samuels, *C. coccinea* Rabenh., *Nectria cinnabarina* (Tode: Fr.) Fr., *Neonectria fuckeliana* (C. Booth) Rossman & Samuels, *N. galligena* (Bres.) Rossman & Samuels and *N. punicea* (J. C. Schmidt) Castl. & Rossman have been identified on living beech trees (as the parasites) and beech dead-wood (as a saproparasites and saprotrophs) from the Rhodopes. Only the species *Neonectria fuckeliana* was identified on decline silver fir trees. The species *Neonectria coccinea* (Pers.: Fr.) Rossman & Samuels was found on beech dead-wood in Pirin (Mihál et al., 2014a).

The results of the monitoring of three selected biotic vectors of beech necrotic disease are reported in Table 4. Among these vectors, the highest frequency was observed in *Cryptococcus fagisuga*. The high frequency values of *C. fagisuga* are comparable with those obtained in Central (Slovakia, Hungary, Poland, Czech Republic) and South-Eastern Europe (Bulgaria, Romania). No of either Central or South-Eastern European localities have been found having zero occurrence (absence) of *C. fagisuga* (Mihál et al., 2014b). This is one of causes why several authors consider *C. fagisuga* as the most important and widest distributed species acting as a biotic vector of beech bark necrotic disease (Lonsdale, Sherriff, 1982; Rojek, 2005; Mihalciuc et al., 2001). The negative influence of *C. fagisuga* on the beech bark necrotic disease in evidently. It was been documented also by Zúbrik et al. (1999) on 8 beech research plots situated in Central Slovakia. Authors found the 74% presence of *C. fagisuga* and 52% common presence of *C. fagisuga* and bark necrosis on 550 monitored beeches. In referring to the results of Zúbrik et al. (1999), it is necessary to add, that our paper presents only basic and actual data about occurrence of the mentioned biotic vectors but no specifically evaluations of mutual interaction among biotic vectors, fungi of the genus *Nectria* s.l. or *Neonectria* and degree of necrotic disease. The concrete research of these mutual interaction requires long-term monitoring and frequent fieldwork.

From Lepidoptera the focus was on two species: *Bucculatrix ulmella* and *Ectoedemia liebwerdella.* Low frequency values of *B. ulmella* (except the

Table 4
Frequency occurrence (%) of biotic vectors of beech necrotic disease on selected localities

Localities	Altitude (m a.s.l.)	*Cryptococcus fagisuga*	*Bucculatrix ulmella*	*Ectoedemia liebwerdella*
Debravitsa	550	98.0	6.0	2.0
Semchinovo	700	98.0	46.0	100
Fotinski vodopadi	750	56.0	2.0	8.0
Eleshnitsa	900	34.0	0.0	0.0
Rozovo	900	98.0	4.0	94.0
Dobra Voda	950	100	5.0	98.0
Chepino	1000	68.0	0.0	0.0
Grashevo	1000	92.0	0.0	42.0
Koldanovi nivi	1100	70.0	0.0	0.0
Marino	1150	96.0	4.0	42.0
Ravnogor	1200	100	0.0	38.0
Ossenovo	1220	86.0	0.0	32.0
Velingrad	1250	94.0	4.0	2.0
Rakitovo	1380	100	0.0	4.0
Apostolov chark	1400	66.0	0.0	0.0
Popina laka	1150	90.0	0.0	0.0
Razlog	1150	97.0	0.0	97.0
Yane Sandanski	1200	100	0.0	0.0
Popovi livadi	1350	54.0	0.0	0.0
Dobri laki	1300	90.0	0.0	12.5

Note: *Bucculatrix ulmella* Zeller – pupae, *Cryptococcus fagisuga* Lindinger – colonies of adult individuals, *Ectoedemia liebwerdella* Zimm. – galleries in bark after mining

locality Semchinovo) are no surprise with respect to the high altitude. It was recorded, in generally, also by *E. liebwerdella*. Examining the relation between occurrence of *B. ulmella* and altitude of 85 localities in Central and South-Eastern Europe, Mihál et al. (2014b) came to conclusion that the occurrence of *B. ulmella* is limited by altitude. In Central Europe this limit represents 900 m a.s.l., in South-Eastern Europe it has been shifted to 1100 m. The *E. liebwerdella* showed much higher occurrence values (100.0% in locality Semchinovo and 97.0% in locality Razlog, respectively) than *B. ulmella* (46.0% in locality Semchinovo). In some cases, the frequency values in Slovakia and Bulgaria reached 100% (Mihál, Cicák, 2001). Occurrence of *E. liebwerdella* in Slovakia is limited by 800 m. In Bulgaria is this limit at 1150 m. Common occurrence of *E. liebwerdella* in Slovak beech stands with necroses has been reported by Kodrík, Suvák (1999) who have found, by *in vitro* cultivation, that this moth can distribute spores of fungi of the genus *Nectria*.

CONCLUSIONS

In this work are presented the latest results of assessment of necrotic damage to beech trees in 20 localities in South-West Bulgaria. These results are first contribution to assessment of state-of-art in beech necrotic disease in Bulgaria, and they are a part of an extensive study of this problem over South-Eastern Europe.

The data of necrotic damage of beech trees – frequency values of necroses according to the individual damage degrees and necrotisation index values (I_{SN}) have been summarised in Table 3. The values of I_{SN} varied from 0.22 to 0.80 in the Rhodopes, from 0.38 to 0.88 in Pirin and 0.38 in Maleshevska planina. The high frequency values of necrotic damage of degree 0 (without necrotic damage) were recorded in the localities Debravitsa (78.0%) and Rozovo (76.0% of evaluated trees) in the Rhodopes. The least values 30.0% (locality Velingrad) and 36.0% (Rakitovo) of evaluated trees belonged to the evaluation degree 0 (without necrotic damage) in the Rhodopes and only 20.0% of ones (locality Razlog) in Pirin. During the research in South-West Bulgaria, were determined 6 species of the genus *Nectria* (Fr.) Fr. in the Rhodopes and only one species in Pirin.

The results of the monitoring of three selected biotic vectors of beech necrotic disease are reported in Table 4. Among these vectors, the highest frequency was observed in *Cryptococcus fagisuga*. The high frequency values of *C. fagisuga* are comparable with those obtained in Central (Slovakia, Hungary, Poland, Czechia) and South-Eastern Europe (Bulgaria, Romania). Low frequency values of *B. ulmella* (except the locality Semchinovo) are no surprise with respect to the high altitude. It was recorded, in generally also by *E. liebwerdella*. The *E. liebwerdella* showed much higher occurrence values (100.0% in locality Semchinovo and 97.0% in locality Razlog, respectively) than *B. ulmella* (46.0% in locality Semchinovo).

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СЪСТОЯНИЕ НА НАКРОТИЧНИТЕ ЗАБОЛЯВАНИЯ ПО КОРАТА НА БУКА В ЮГОЗАПАДНА БЪЛГАРИЯ (РОДОПИ, ПИРИН, МАЛЕШЕВСКА ПЛАНИНА)

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В статията са представени резултати при оценка на некротичните повреди на буковите дървета чрез индекс на некротизация (I_{SN}) от 15 избрани местонахождения в Родопите, 4 в Пирин и 1 в Малешевска планина. Стойностите на I_{SN} варират от 0,22 до 0,80 в Родопите, от 0,38 до 0,88 в Пирин и 0,38 в Малешевска планина. Шест вида от род *Nectria* s. l. са установени в Родопите и само един в Пирин. Пет от шестте вида са изолирани от живи дървета и мъртва букова дървесина, и един върху паднало дърво обикновена ела.

Между възможните преносители на заболяването по кората на бука (*Cryptococcus fagisuga* Lindinger, *Bucculatrix ulmella* Zeller и *Ectoedemia liebwerdella* Zimm.), е установена висока честота на *C. fagisuga*. Честотата на *C. fagisuga* варира от 34% до 100%, стойностите за *B. ulmella* – от 2% до 46% и тези на *E. liebwerdella* от 2% до 100%.

Ключови думи: бук, *Fagus sylvatica* L., некротично заболяване, югозападна България

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