Insects Infesting Norway Spruce (*Picea abies* Karst.) Branches in Clear-cuts and Adjacent Stands

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Abstract

For the determination of forest entomofauna migration, the assessment of its distribution is very important. The investigation was carried out in 2004-2006 in in the clear-cuts of Norway spruce (*Picea abies* Karst.) in Dubrava Experimental and Training Forest Enterprise. The aim of the present work was to estimate the distribution of xylobiont insects breeding under the bark of spruce branches in the clear-cuts and adjacent spruce stands.

The assessment of underbark xylobiont insects was made using a method of sample branches and eclector traps. During the research, 1272 spruce branches were examined. A total of 32 insect species in spruce branches were found. The number of phytophagous and entomophagous species was 19 and 11, respectively. The Coleoptera order dominated comprising 93.7% of all xylobiont insects in spruce branches. *Pityogenes chalcographus* was the most abundant species (75.6% of beetles in total) among the coleopterans. The mean number of phytophages and entomophages was significantly ($p \leq 0.05$) 3 times less in the clear-cuts, than in the adjacent stands. Shannon‘s index showed poor species diversity, and was 0.3 (in the clear-cuts) and 1.34 (in adjacent stands). The difference was statistically significant ($t \geq 1.96$, $p \leq 0.05$). Sorenson‘s similarity measure of xylobiont insects species was 0.51 in the clear-cuts and adjacent stands.

Key words: clear-cut, spruce stand, spruce branches, xylobiont insects, trophic group

Introduction

Dangerous insect pests such as *Pityogenes chalcographus* (L.) and *Ips typographus* (L.) can breed in spruce branches. With increasing abundance, bark beetles are able to make mass outbreaks and attack even healthy spruces in Lithuania. (Pileckis et al. 1968, Валента и др. 1974). In stable ecosystems, this forest entomofauna serve as a mechanism providing long-term ecological stability. In unstable ecosystems, their activities are essentially negative and cause ecosystem degradation (Yanovskii 2005). Human activities, like logging, modify the dynamics and composition of virgin forest, affecting the equilibrium between the natural species (Mazur et al. 1996, Spagarino et al. 2001, Seidl et al. 2007). Ecological and phenological aspects of coniferous trees' xylofauna have been examined in Scandinavia, in America as well as in Russia (Schlyter 1985, Lindhe and Lindelöw 2004, Eriksson et al. 2005, Jurc et al. 2006, Маслов 2008). The peculiarities of xylobiont insects biology are well known. In Lithuania, until now, the main efforts have been oriented toward insects' biology and ecology, insect-related damage and forest protection (Pileckis et al. 1968, Pileckis 1976, Valenta and Gedminas 1999, Zolubas et al. 2009).

Assesing species diversity, the Shannon, Berger-Parker and Sorenson diversity indexes are widely in use. According to diversity indexes scientists examined diversity of xylobiont insects in Mexico, species of entomofauna occurring in different biotopes in Poland and species of litter entomofauna in Switzerland (Duelli et al. 1999, Skalski and Pospiech 2006, Noguera et al. 2007) as well as in Lithuania (Lynikienė and Zolubas 2003, Lynikienė 2006, Gedminas et al. 2007). Non-target insect species diversity in pheromone traps for *I. typographus* has also been examined (Zolubas 2000). However, the data on species diversity of xylobiont insects of coniferous trees are just poor in Lithuania.

According to tree height and diameter, the volume of Norway spruce branches comprises 14–26% of the total tree volume (Валента и др. 1974, Repšys 1994). The branches are a sufficient base for the bark and wood boring beetles. Coniferous species cover 1,155.1 thousand ha (58.1% of the total area of forest land) including 21.8% of the spruce stands (Anonymous 2005). The area of spruce stands decreased strongly in the period 1993–1998. Due to damages of bark beetle, the area of sanitary fellings reached 515.9 thousand ha of spruce stands, remaining the clear-cuts with spruce branches (Valenta and Povilonis 2003). Bark and wood boring insect pests concentrate in spruce branches in the clear-cuts, threatening the surrounding forest stands. Left branches are attractive substance for the bark beetles. The chemical composition of such active compounds and the dependence of their dissemination intensity from environmental conditions is already described (Byers et al. 1988, Führer et al. 1991, Niemeyer and Watzek 1996, Baier and Bader 1997). Using auditory and taste receptors, bark beetles can find a timber suitable for them (McMullen and Atkins 1962, Hietz et al. 2005).

Pityogenes chalcographus is one of the main insect pest damaging spruce in Lithuania (Валента и др. 1974, Valenta 2000, Valenta and Povilonis 2003). About 93.2% of these beetles accommodate under the bark of spruce by lenticels (Rosner and Führer 2002). The abundance of pests is regulated by natural enemies – entomophages, which can enter under the spruce bark through the holes of bark beetles (Харитонова 1972). Entomophages can respond to odors, which are emitted by pests attacking the tree (Byers and Wood 1981).

By now, no studies have been conducted in Lithuania about the species diversity of xylobiont insects and its distribution in clear-cut and adjacent spruce stand. The hypothesis was posed that the xylobiont insects distribute not randomly in spruce clear-cuts and adjacent stands. The aim of this study was to determine species diversity and distribution of xylobiont insects infesting spruce branches in Norway spruce clear-cuts and adjacent stands.

Materials and methods

The investigations were conducted at Dubrava Experimental and Training Forest Enterprise, Kaunas district, in 2004 – 2006. We selected two clear-cuts of Norway spruce (*Picea abies* L. Karst.) that have been felled because of the bark beetle infestations (outbreak plots). One of these clear-cuts was fresh (cuttings of the running year), and the other – old (cuttings were done one year before). Following the same principles, we selected another two (fresh and old) clear-cuts that have been felled in the planned order, not for sanitary reasons (control plots). Four research plots were established in the selected clear-cuts. In order to bait xylobiont insects including spruce bark beetles, sample branches were used in each plot. (Gedminas et al. 2007). Sample branches with medium diameter of 2.8 cm and length of 1.75 m were collected from healthy and living spruces, without removing small twigs and needles. Small piles of the sample branches were shaped. Totally five piles (3 sample branches in each pile) were installed in the centre of each clear-cut before the swarming of bark beetles (in April). Similar piles of spruce branches were exposed in surrounding spruce stands, at the distance of 5 m, 50 m and 100 m from the edge of each clear-cut. Total number of piles was 53 in each plot (Fig. 1).

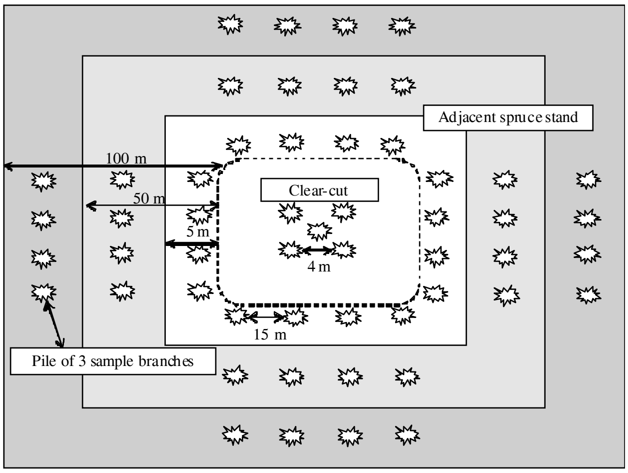

Figure 1. The design of sample branches in spruce clear-cuts and adjacent stands

Every year, in July – August before the emergence of adults, the samples from the branches were collected. Samples – thick cutoff 40 cm long - were selected from each sample branch. These samples were placed into special eclectors. Eclector was the polyethylen bag (50 l volume) with small holes for the aeration. The samples of the branches from the same pile were placed in the same eclector and were kept under laboratory conditions for one year. Afterwards, branch samples were inspected by removing the bark and the emerged insects were collected at all stages of their developent: imagines, pupae and larvae. The number of collected xylobiont insects was recalculated per 1,000 cm² of the bark surface. During the study, 1,272 of spruce branches were examined.

The data have been analysed using elementary statistical methods (Songailienė and Ženkauskas 1985, Čekanavičius and Murauskas 2001). Diversity of xylobiont insect species has been assessed using: Shannon (*H'*) diversity index, measure of evenness (*E*), Simpson (*D*) and Berger-Parker (*d*) species domination indexes and Sorenson (*Cs*) species similarity measure (Magurran 1988).

Shannon (*H'*) species diversity index:

$$H' = -\Sigma p_i \ln p_i, \quad (1)$$

where

$p_i = n_i / N$,

n_i – number of individuals of *i*th species;

N – total number of individuals.

Measure of evenness (E):

$$E=H/\ln S, \quad (2)$$

where

H – index of diversity;

S – total number of species.

Simpson's index (D):

$$D=\Sigma p_i^2, \quad (3)$$

where

$p_i= n_i /N$;

n_i – number of individuals of ith species;

N – total number of individuals.

Berger-Parker index:

$$d=N_{max}/N, \quad (4)$$

where

N_{max} – number of individuals of the most abundant species;

N – total number of individuals.

Sorenson index:

$$C_s=2j /(a+b), \quad (5)$$

where

j – the number of species found in both sites;

a – the number of species in site A;

b – the number of species in site B.

Dispersion analysis was conducted in order to estimate the influence of distance from the edge of clear-cut on the distribution of xylobiont insects.

Results

The relative abundance of xylobiont insects was realiably different between spruce branches selected in the clear-cuts and in adjacent stands (Table 1). Mean number of individuals (per 1,000 cm² of spruce branch bark) was 443.3±14.8 in fresh outbreak plot, 420.29±11.69 – in the fresh control plot, 478.86±14.41 – in old outbreak plot and 516.01±26.19 – in the old control plot. The difference of xylobiont insect abundance was significant ($p≤0.05$) only in fresh and old control plots.

Table 1. Xylobiont insects abundance (number of individuals/1,000 cm²) under the bark of spruce branches in clear-cuts and adjacent stands

	Variant	Clear-cut	Adjacent stand	t *	P*
Entomophages	Fresh control	6.18±0.31	23.59±2.04	8.39	0.001
	Fresh outbreak	4.34±0.47	15.34±1.16	8.85	0.002
	Old control	1.66±0.21	22.31±2.62	7.87	0.001
	Old outbreak	1.22±0.08	58.82±5.63	10.22	0.001
Phytophages	Fresh control	124.72±7.94	387.02±16.46	14.35	0.001
	Fresh outbreak	165.31±23.71	423.29±17.09	8.83	0.001
	Old control	92.88±28.59	491.81±28.21	9.93	0.001
	Old outbreak	175.76±22.20	410.23±16.66	8.45	0.001

Note: xylobiont insects from other trophic groups (saprophages) are not included in the Table, because abundance was only 2.17±1.28 in spruce stand near the fresh outbreak and 1.22±0.11 in spruce stand near the fresh control.
Note: *significance of differences (t>1.96, when p<0.05)

In total, 32 insect species belonging to Coleoptera, Diptera, Hemiptera, Hymenoptera and Raphidioptera orders were detected (Table 2). Beetles dominated in all research plots and comprised 93.7% of the collected insects in total. *Pityogenes chalcographus* was markedly abundant (75.6% of individuals) among the beetles collected in spruce branches.

Table 2. Percentage of collected individuals in spruce branches

Taxonomic group	Fresh clear-cut		Old clear-cut	
	Control	Outbreak	Control	Outbreak
Coleoptera				
Buprestidae	1.21	0.26	0.35	0.28
Cerambycidae	0.76	1.76	0.77	1.81
Cleridae	0.85	1.18	0.58	2.52
Cucujidae	-	-	0.77	1.19
Curculionidae[1]	1.11	0.45	-	1.8
Scolytinae	87.15	92.87	92.38	79.66
Elateridae	0.30	0.25	-	-
Nitidulidae	-	0.22	-	-
Salpingidae	0.35	0.44	-	1.44
Trogositidae	0.23	0.21	-	1.04
Diptera				
Diptera spp.	0.28	0.40	-	-
Dolichopodidae	-	-	-	0.59
Hemiptera				
Anthocoridae	0.83	-	-	-
Hymenoptera				
Braconidae	1.35	1.04	4.30	5.70
Pteromalidae	5.58	0.66	0.48	1.07
Raphidioptera				
Raphidiidae	-	0.26	0.38	0.40

[1]without *Scolytinae*

A total of 25 species of spruce xylobiont insects have been identified in fresh outbreak and 22 – in the fresh control plot. The number of species in old outbreak and control plot was 19 and 14, respectively. A small number insect from the families Cerambycidae and Curculionidae caused the low species richness in old spruce clear-cuts (Fig. 2).

Generally, only 10 species were the same in all research plots: 3 species of them were enthomophages (*Thanasimus formicarius, Coeloides* sp., *Rhopalicus* sp.), 6 ones – phytophages (*Anthaxia quadripunctata, Dryocoetes autographus, Hylastes cunicularius, P. chalcographus, Pogonocherus fasciculatus, Polygraphus polygraphus*) and one – oligophagy (*Crypturgus cinereus*). According to species richness, Scolytinae subfamily was most abundant (9 species in total). Some of entomophages such as *Medetera* sp. and *Pityophagus ferrugineus* occurred in the spruce branches selected only from outbreak clear-cuts. Parasitoids *Coeloides* sp. *and Rhopalicus* sp. (Hymenoptera) were the most abundant species (respectively 3.4% and 3.03% of the xylobiont insects collected in spruce branches). The number of individuals of the last species was 4 times larger in old outbreak plot than

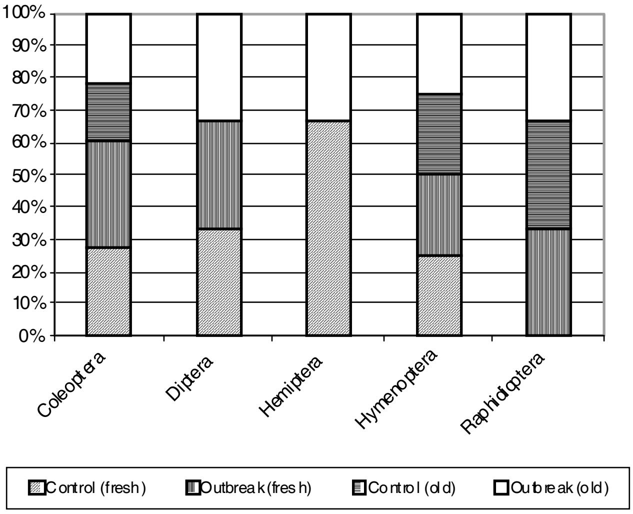

Figure 2. Percentage of xylobiont insect species

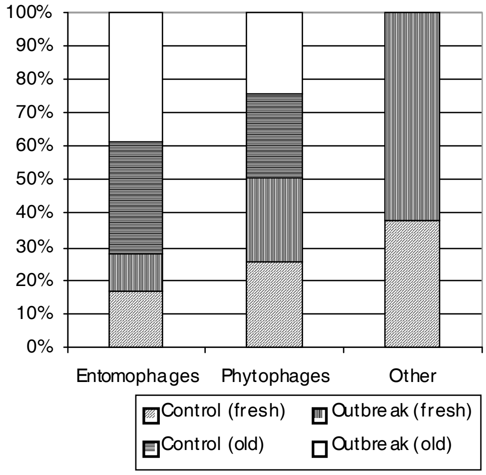

Figure 4. Percentage of xylobiont insect individuals by trophic groups in spruce branches

in the rest of plots. The abundance of entomophages is higher in old outbreak, comparing with other plots: 4.5 times in *Nemosoma elongatum* and 2.7 times in *Cryptolestes* sp. and *Rhinosimus* sp. Some species of *Cerambycidae* family – *Callidium aeneum, Molorchus minor, Pogonocherus fasciculatus* – were present under the bark of spruce branches, but not commonly.

Phytophagous species dominated in the fresh, as well as in old spruce clear-cuts (Fig. 3). The number of phytophagous species was 16 in fresh outbreak, while in old outbreak – only 9: 13 and 8 species of phytophages occured in fresh and old control clear-cut, respectively.

According to the number of individuals, in all plots phytophages constituted 93.6% and entomophages – only 5.8% of the collected xylobiont insects in total. Insects belonging to other trophic groups were saprophages (Fig. 4).

The distance from the clear-cut had the influence on the distribution of phytophagous species: in fresh outbreak (F=20.27, p=0.0001), as well as in fresh

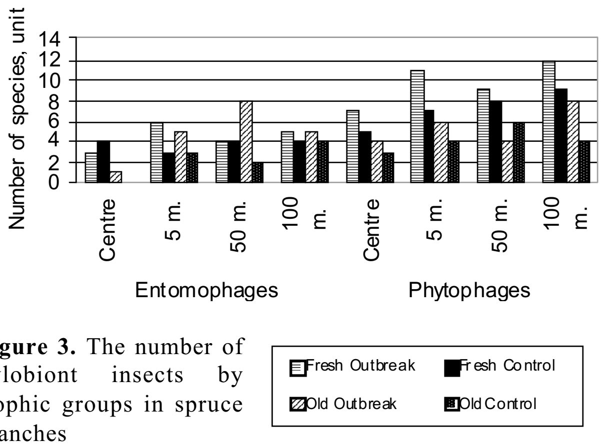

Figure 3. The number of xylobiont insects by trophic groups in spruce branches

(F=3.97, p=0.0275), and in old (F=4.15, p=0.0281) control clear-cuts (Table 3). The distribution of entomophagous species was not effected by the distance from the clear-cut.

The mean number of phytophages and entomophages was significantly (t=8.7, $p \leq 0.05$) 3 times less in the centre of the clear-cuts than in adjacent spruce stands. The abundance of phytophages and entomophages was highest in spruce branches, located in the spruce stands at the distance of 100 m from the edge of the fresh, old outbreak and old control clear-cuts (Fig. 5, 6).

Table 3. Dispersional analysis (with 0.95 probability) of phytophages species distribution, according to the distance from the edge of the clear-cut

	Sum of squares	df	Mean square	*F**	*p*-level*
			Fresh control		
Effect	16.62	2	8.31	3.97	0.0275
Error	75.25	36	2.09	-	-
			Fresh outbreak		
Effect	92.37	2	46.18	20.27	0.0001
Error	82	36	2.27	-	-
			Old control		
Effect	7.38	2	3.69	4.15	0.0281
Error	21.33	24	0.88	-	-
			Old outbreak		
Effect	1.5	2	0.75	0.47	0.6284
Error	38	24	1.58	-	-

* Was used one-way ANOVA, when significance level p<0.05

Pityogenes chalcographus prevailed in all research plots (Table 4).

The differences of species diversity were signif-

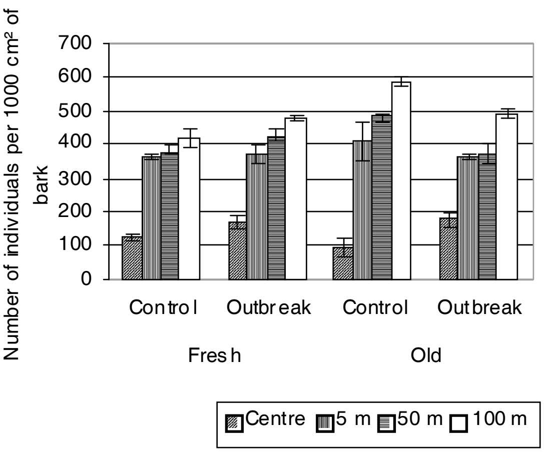

Figure 5. The distribution of phytophages at different distance from the clear-cuts

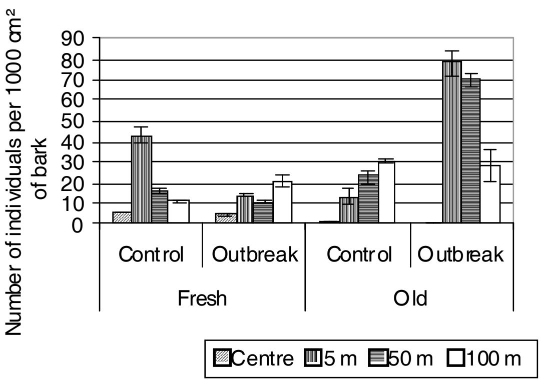

Figure 6. The distribution of entomophages at different distance from the clear-cuts

Table 4. The number of *Ips typographus* and *Pityogenes chalcographus* individuals (% of all xylobiont insects) in spruce branches

		Fresh		Old	
		Outbreak	Control	Outbreak	Control
Centre	*Ips typographus*	0	0	0	0
	Pityogenes chalcographus	94.67	83.92	94.75	82.18
5 m.	*Ips typographus*	0.26	0.67	0	0
	Pityogenes chalcographus	92.72	89.8	81.19	91.46
50 m.	*Ips typographus*	0.41	0	0	0
	Pityogenes chalcographus	92.55	90.8	84.3	87.54
100 m.	*Ips typographus*	0.5	0.22	0	0
	Pityogenes chalcographus	88.98	89.24	82.34	89.97

Table 5. The index of Shannon species diversity *H* and evenness *E* of species distribution at different distances from the clear-cuts ($t \geq 1.96$, $p \leq 0.05$)

Distance from clear-cut		Fresh outbreak		Fresh control		Old outbreak		Old control	
	Nr.	*H*	*E*	*H*	*E*	*H*	*E*	*H*	*E*
Centre	4	0.49[1]	0.20	0.85[2]	0.37	0.3[3]	0.19	0.65°	0.47
5m	1	0.62[1]	0.22	0.87[2]	0.35	1.34[3]	0.54	0.52°	0.25
50m	2	0.56[1]	0.21	0.63[2]	0.25	1.27[3]	0.49	0.75°	0.34
100m	3	0.73[1]	0.25	0.64[2]	0.24	0.99[3]	0.38	0.70°	0.32

Note:

[1]- H_{1-2}=0.02; H_{1-3}=0.01; H_{2-3}=0.001; H_{2-4}=0.05; H_{1-4}=0.01; H_{3-4}=0.001

[2]- H_{1-2}=0.001; H_{1-3}=0.001; H_{2-3}=n.s.; H_{2-4}=0.01; H_{1-4}=n.s.; H_{3-4}=0.01

[3]- H_{1-2}=0.01; H_{1-3}=0.001; H_{2-3}=0.001; H_{2-4}=0.001; H_{1-4}=0.001; H_{3-4}=0.001

°- H_{1-2}=0.001; H_{1-3}=0.001; H_{2-3}=0.01; H_{2-4}=0.01; H_{1-4}=0.01; H_{3-4}=0.05

n.s.- not significant

icant ($t \geq 1.96$, $p \leq 0.05$) in all research plots. In significant differences were noted only in the fresh control between centre-5m., and 50-100m. Results showed poor overall species diversity in all research plots. The mean values of Shannon index *H'* was 0.3 (in the clear-cuts) and 1.34 (in the adjacent spruce stands). According to the Shannon species diversity index, the maximum diversity was 1.61 in the clear-cuts and – 2.49 in the adjacent spruce stands (H_{max}=ln(S), where *S* – total number of species). The difference of species diversity was significant in the clear-cuts and adjacent stands (Table 5).

The highest species diversity was found in spruce branches collected from the fresh outbreak at the distance of 100 m from the clear-cut. Therefore, the highest diversity in old outbreak and the control was at the distance of 5 m and 50 m from the edge of the clear-cuts. Species distribution was uneven (*E* was aproximately 0.3) in all research plots (*E* is constrained between 0 and 1.0, where 1.0 representing a situation in which all species are equally abundant). According to the Sorenson species similarity measure, species of xylobiont insects occurring in the centre of the clear-cut was medium similar (C_s =0.51) to the species in adjacent spruce stand.

Discussion

In earlier investigations, 15 species of xylobiont insects breeding under the bark of spruce branches were found in Lithuania (Валента и др. 1974), while 22 xylobiont insects species were indentified by Gedminas et al. (2007). During our study in total 32 species were collected. Fresh spruce branches, due to their resin, are first attacked by bark beetles and afterwards, by other insects. The susceptibility and defense mechanisms of host trees are crucial for a successful attack by bark beetles (Wermelinger 2004). Experimental studies in the Pacific Northwest and southeast U.S.A. and in Norway revealed, that tree resistance to attack may be closely related to the amount of current and stored photosynthate that is available for defense (Christiansen 1987). *Ips typographus* and *Pityogenes chalcographus* have specific body structure: hard cuticula and shards, strong mandibulae. These characteristics help the beetle to overcome tree self protection mechanisms (Duelli et al. 1986, Zuber and Benz 1992, Lietuvos fauna 1995, Franceschi et al. 2005). Simpson‘s and Berger-Parker‘s species dominance indexes in our study show, that *Pityogenes chalcographus* was the main dominant in spruce branches (D=0.65; d=0.79). Risk of attack seems to be mainly related to the exposition, age, and nutrient and water supply of the trees. In this case, bark beatles can be like natural indicators of forest ecosystems conditions (Wermelinger 2004). As biological indicator *Ips typographus* can show changes in the microclimates conditions, especially in light and temperature (Slobodyan, Slobodyan 2001). Grodzki (1997) recommends to monitor *Pityogenes chalcographus* as an indicator species in the forests, however, it is still under discussion. Interspecific competition mechanism has influence on colonizing trees. For example, *Ips typographus* males avoided colonizing areas with higher densities of attack, where intraspecific competition would be more intense, and chose sites relatively free of competitors (Byers 1993). Species richness of beetles was constrained from 21 to 14 species in old outbreak and from 17 to 11 species – in old control plot. The dynamics of outbreaks largely depends on insect abundance (Wermelinger 2004). The decrease in species population density is strongly connected with forest fellings and afterwads – with changes in environmental and microclimate conditions: light activity, humidity and temperature (Deans et al. 2005, Bouget and Duelli 2004, Gandhi et al. 2007).

Predatory beetles are important natural enemies of cambium feeding beetles and knowledge about their ecology is important for biological control and sustainable forest management (Johansson et al. 2007). In Lithuania 13 entomophagous species were known from spruce branches (Валента и др. 1974). In our study, 11 species were identified. The most abundant of entomophages were *Rhopalicus* sp. and *Coeloides* sp. comprising 25.4% and 16.2% of all collected entomophages. These entomophagous genera regulate the abundance of bark beetles population (Харитонова 1972). Our results showed that the distance from the clear-cut had no effect on the distribution of entomophagous species (p>0.05). However, it would be the reason that the attractive reaction of entomophages to the pheromones of bark beetles helps them to find the places where the pests occur. According to our results, the highest abundance of phytophages and entomophages occurred in spruce stands at the distance of 100 m from the fresh and old outbreak and old control clear-cuts. Mills (1985), Bakke and Kvamme (1981) supossed, that the Thanasimus formicarius (9.8% of found entomophages in total), a predator is able to kill bark beetles at different stages of their developement, is baited by the bark beetles pheromones (ipsenol, ipsdienol, cis-verbenol). *Medetera* sp. (1.6% of all found entomophages) reacts positively to *I. typographus* or *P. chalcographus pheromones* (Hulcr et al. 2006). The importance of Raphidioptera is not very significant for the regulation of bark beetle population density, and is not common under the bark of spruce branches (Харитонова 1972). Our results confirmed this fact and showed a low abundance of Raphidioptera insects (1.8% of all entomophages). We also assesed significantly higher abundance of entomophages in spruce stands (58.82±5.63 individuals/1000 cm²) than in the centre of the clear-cuts (1.22±0.08 individuals/1000 cm²). Weslien and Schroeder (1999) indicate that predators of the spruce bark beetle may be more sensitive to certain forestry operations than their prey and suggest complex relationships with their prey and the environment

The results obtained in European Norway spruce stands are relatively poor in case of insect biodiversity. Our results showed low overall species diversity of spruce underbark entomofauna (Shannon index from 1.34 in spruce stands to 0.3 in the clear-cuts), Magurran (1988) supposes, that high domination of one or few species leads to low overall diversity. The Simpson and Berger-Parker indices of species domination in this study were D=0.65; d=0.79 respectively.

The hypotesis that the distribution of the xylobiont insects is not random in the clear-cut and adjacent stands could, however, be validated by the following suggestions. First – species diversity was similar in the clear-cuts and in the the adjacent spruce stands (C_s=0.51). Second – the dispersion analysis revealed the dependance of the distribution of phytophage species from the distance from the clear-cut. Third – the difference of the number of phytophages and entomophages was significant in spruce clear-cuts and adjacent stands. Fourth – the differences between Shannon species diversity were significant in case of different distances from the clear-cut

In order to get more detailed data, the assessment of xylobiont insect diversity in the clear-cuts and adjacent stands should be continued.

Final statements

1. Under the bark of spruce branches 32 species of insects, belonging to the following orders: Coleoptera, Diptera, Hemiptera, Hymenoptera and Raphi-

dioptera were determined. The number of phytophagous species was 19, and 11 species were entomophages.

2. Coleoptera composed 93.7% of all collected insects and dominated under the bark of spruce branches. *Pityogenes chalcographus* was the most abundant species (75.6% of all collected beetles).

3. The mean number of phytophagous and entomophagous insects was 3 times lower in the clear-cuts, than in the adjacent stands.

4. The Shannon index showed poor species diversity, as it was 0.3 (in the clear-cut) and 1.34 (in adjacent stands). The difference was realiable ($t \geq 1.96$, $p \leq 0.05$).

5. The Sorenson similarity measure of xylobiont insect species reached 0.51 in the clear-cuts and adjacent stands, and it indicates medium similarity.

6. In order to conserve biodiversity of xylobiont insects we recommend leaving spruce branches in the clear-cut.

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References

Anonymous. 2005. Lietuvos miškų ūkio statistika. [Lithuanian statistical yearbook of forestry]. Valstybinė miškotvarkos tarnyba [State Forest Survey Service]. Kaunas Lututė, 112 p. (In Lithuanian)

Baier, P. and Bader, R. 1997. Gehalt und Emission von Monoterpenen der Fichtenrinde und deren Bedeutung für die Primärattraktion von Borkenkäfern (Coleoptera, Scolytidae). *Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie* 11 (1/6): 639-643.

Bakke, A. and Kvamme, T. 1981. Kairomone response in Thanasimus predators to pheromone components of Ips typographus. *Journal of Chemical Ecology* 7: 305-312.

Bouget, C. and Duelli, P. 2004. The effects of windthrow on forest insect communities: a literature review. *Biological Conservation* 118 (3): 281-299.

Byers, J. A. 1993. Avoidance of competition by spruce bark beetles, *Ips-typographus* and *Pityogenes chalcographus. Experientia* 49 (3): 272-275.

Byers, J. A. and Wood, D. L. 1981. Interspecific effects of pheromones on the attraction of the bark beetles, Dendroctonus brevicomis and Ips paraconfusus in the laboratory. *Journal of Chemical Ecology* 7: 9-18.

Byers, J. A., Birgersson, G., Löfqvist, J. and Bergström, G. 1988. Synergistic pheromones and monoterpenes enable aggregation and host recognition by a bark beetle. *Naturwissenschaften* 75: 153-155.

Čekanavičius, V. and Murauskas, G. 2001. Statistika ir jos taikymai. [Statistic's and its application] (I). TEV, Vilnius, 172-216 p. (In Lithuanian with English summary)

Christiansen E, Waring, H. and Berryman, A.A. 1987. Resistance of conifers to bark beetle attack: Searching for general relationships. *Forest Ecology and Management* 22: 89-106.

Deans, M., Malcolm, JR., Smith, SM. and Bellocq, MI. 2005. Edge effects and the responses of aerial insect assemblages to structural-retention harvesting in Canadian boreal peatland forests. *Forest Ecology and Management* 204 (2-3): 249-266.

Duelli, P., Obrist, M. K. and Schmatz, D. R. 1999. Biodiversity evaluation in agricultural landscapes: above-ground insects. *Ecosystems & Environment* 74 (1-3): 33-64.

Duelli, P., Studer, M. and Naef, W. 1986. The flight of bark beetles outside of forest areas. *Journal of Applied Entomology* 102 (2): 139-148.

Eriksson, M., Pouttu A., and Roininen H. 2005. The influence of windthrow area and timber characteristics on colonization of wind-felled spruces by *Ips typographus* (L.). *Forest Ecology and Management* 216:105-116.

Franceschi, VR., Krokene, P., Christiansen, E. and Krekling, T. 2005. Anatomical and chemical defenses of conifer bark against bark beetles and other pests. *New Phytologist* 167 (2): 353-375.

Führer, E., Hausmman, B. and Wiener, L. 1991. Borkenkäferbefall (Col., Scolytidae) und Terpenmuster der Fichtenrinde (*Picea abies* Karst) an Fangbäumen. *Journal of Applied Entomology* 112 (2): 113-123.

Gandhi, K. J, K., Gilmore, D.W., Katovicų, S.A., Mattson, W.J., Spence, J.R. and Seybold, S.J. 2007. Physical effects of weather events on the abundance and diversity of insects in North American forests. *Environmental Reviews* 15: 113-152.

Gedminas, A., Lynikiene, J. and Zeniauskas, R. 2007. Cambio-xylofauna abundance and species diversity of cutting residues in Scots pine and Norway spruce clearcuts in Lithuania. *Biomass & Bioenergy* 31 (10): 733-738.

Grodzki, W. 1997. Pityogenes chalcographus (Coleoptera, Scolytidae) - an indicator of man-made changes in Norway spruce stands. *Biologia* 52 (2): 217–220.

Hietz, P., Baier, P., Offenthaler, I., Führer, E., Rosner, S. and Richter, H. 2005. Tree temperatures, volatile organic emissions, and primary attraction of bark beetles. *Phyton* 45 (3): 341-354.

Hulcr, J., Ubik, K. and Vrkoč, J. 2006. The role of semichemicals in tritrophic interactions between the spruce bark beetle *Ips typographus*, its predators and infested spruce. *Journal of Applied Entomology* 130 (5): 275-283.

Johansson, T., Gibb, H., Hjältén, J., Roger B., Pettersson, J.R., Hilszczański, J., Alinvi, O., Ball, J.P. and Danell, K. 2007. The effects of substrate manipulations and forest management on predators of saproxylic beetles. *Forest Ecology and Management* 242: 518-529.

Jurc, M., Perko, M., Džeroski, S., Demšar, D. and Hrašovec, B. 2006. Spruce bark beetles (*Ips typographus, Pityogenes chalcographus*, Col.: Scolytidae) in the Dinaric mountain forests of Slovenia: Monitoring and modelling. *Ecological Modelling* 194: 219-226.

Lindhe, A. and Lindelöw A. 2004. Cut high stumps of spruce, birch, aspen and oak as breeding substrates for saproxylic beetles. *Forest Ecology and Management* 203: 1-20.

Lynikienė, J. 2006. Effect of insecticide Arrivo on ground beetle (Coleoptera, Carabidae) species diversity in Scots pine stands. *Baltic Forestry* 12 (1): 39-45.

Lynikienė, J. and Zolubas, P. 2003. Effects of chemical and biological insecticides on the community and diversity of litter insects. Forest Insect Population, Dynamics and Host Influences. Proc. IUFRO WG, Kanazawa, September 14-19, p. 103-106.

Magurran, A. E. 1988. Ecological diversity and its measurement. Princeton Univ. Press, Princeton, 179 p.

Mazur, S., Borowski, J., Byk, A. and Mokrzycki T. 1996. The diversity of the predatory beetles complex living under spruce bark in the Białowieża Primeval Forest. Biodiversity protection of the Białowieża Primeval Forest. Warsaw, p. 115-125.

McMullen, L. H. and Atkins, M. D. 1962. On the flight and host selection of the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk. (Coleoptera: Scolytidae). *Canadian Entomologist* 94: 1309-1325.

Mills, N. J. 1985. Some observations on the role of predation in the natural of *Ips typographus* populations. Zeitschrift für Angewandte Entomologie 99 (3): 209-215.

Niemeyer, H. and Watzek, G. 1996. Test von Monoterpenen als Zusatz zu Pheroprax® bzw. Chalcoprax® in Pheromonfallen zum Fang des Buchdruckers, *Ips typographus* L bzw.des Kupferstechers, Pityogenes chalcographus L (Col, Scolytidae). *Anzeiger für Schädlingskunde, Pflanzenschutz, Umweltschutz* 69 (5): 109-110.

Noguera, FA., Chemsak, JA., Zaragoza-Caballero, S., Rodriguez-Palafox, Ramirez-Garcia, E., Gonzalez-Sorian, E. and Ayala, R. 2007. A faunal study of Cerambycidae (Coleoptera) from one region with Tropical Dry Forest in Mexico: San Buenaventura, Jalisco. Pan-Pacific *Entomologist* 83 (4): 296-314.

Pileckis, S. 1976. Lietuvos vabalai [Beetles of Lithuania]. Vilnius: Mokslas, 241 p. (in Lithuanian)

Pileckis, S. and Monkevičius, V. 1995. Vabalai (Coleoptera), Lietuvos fauna. [Beetles (Coleoptera) Fauna of Lithuania] Mokslo ir enciklopedijų l-kla, Vilnius, 304 p. (In Lithuanian with Russian summary)

Pileckis, S., Valenta, V., Vasiliauskas, A. and Žuklys, L. 1968. Svarbiausių miško medžių kenkėjai ir ligos [The pest insects and pathogens of the main forest trees]. Vilnius: Mintis, 268 p. (in Lithuanian)

Repšys, J. 1994. Miško taksacija [Forest survey]. Vilnius: Mokslo ir enciklopedijų l-kla, 352 p. (In Lithuanian)

Rosner, S. and Führer, E. 2002. The significance of lenticels for successful *Pityogenes chalcographus* (Coleoptera: Scolytidae) invasion of Norway spruce trees (*Picea abies* (Pinaceae)). *Trees - Structure and Function* 16 (7): 497-503.

Schlyter, F. 1985. Aggregation pheromone system in the spruce bark beetle *Ips typographus.* Dissertation. Lund. Sweden. 157 p.

Seidl, R., Baier, P., Rammer, W., Schopf, A. and Lexer, M.J. 2007. Modelling tree mortality by bark beetle infestation in Norway spruce forests. *Ecological Modelling* 206 (3-4): 383-399.

Skalski, T. and Pospiech, N. 2006. Beetles community structures under different reclamation practices. *European Journal of Soil Biology* 42: S316-S320.

Slobodyan Y., Slobodyan P. 2001. *Ips typographus* (L.) as a biological indicator in the Eastern Carpathians (Ukrainiane). *Journal of Forest Science* 47: 159-160.

Songailienė, A. and Ženkauskas, K. 1985. Tyrimo duomenų biometrinis vertinimas. [Biometrical value of research data]. Vilnius: Mokslas, 55 p. (In Lithuanian)

Spagarino, C., Pastuk, G. M. and Peri, P. 2001. Changes in Nothofagus pumilio forest biodiversity during the forest management cycle. *Biodiversity and Conservation* 10 (12): 2077-2092.

Valenta, V. 2000. Miško apsaugos vadovas. [Forest Protection Manual]. Kaunas: Lututė, 351 p. (In Lithuanian with English Summary)

Valenta, V. and Gedminas A. 1999. Rezervatinių miškų bioįvairovė: būklė, raida, prognozė [Biodiversity of forests reserves: shape, progress, forecast]. Mokslinės-gamybinės konferencijos pranešimai. Vilniaus universitetas, Vilnius, 17-29 p.

Valenta, V. and Povilonis, R. 2003. Lietuvos miškų metraštis XX amžius. [The chronicle of Lithuanian forests XX century]. Vilnius: Mokslas, 277 p. (In Lithuanian)

Wermelinger B. 2004. Ecology and management of the spruce bark beetle *Ips typographus* – a review of recent research. *Forest Ecology and Management* 202: 67-82.

Weslien J. and Schroeder L.M. 1999. Population levels of bark beetles and associated insects in managed and unmanaged spruce stands. *Forest Ecology and Management* 115: 267-275.

Yanovskii, V. M. 2005. Role of the forest entomofauna in successional processes. *Russian Journal of Ecology* 36 (3): 205-208

Zolubas, P. 2000. Non-target insects in pheromone traps of *Ips typographus.* Development of environmentally friendly plant protection in the Baltic Region. Transactions of the Estonian Agricultural University, 209: 246-248.

Zolubas, P., Negron, J. and Munson, A.S. 2009. Modelling spruce bark beetle infestation probability. *Baltic Forestry* 15 (1): 23-27.

Zuber, M. and Benz, G. 1992. Investigations on the temporary sequence of the flight activities of *Ips typographus* (L.) and *Pityogenes chalcographus* (L.) (Col., Scolytidae) by means of the commercial pheromone preparations pheroprax and chalcoprax. *Journal of Applied Entomology* 113 (5): 430-436.

Валента, В. Т., Гавялис, В. М., Пусвашките, О. К. and Якаитис, Б. Ю. 1974. Применение энтомофагов в борьбе с вредителями сосны и ели [The use of entomophages against pests of spruce and pine]. Каунас. 27 с. (In Russian)

Маслов, А. Д. 2008. Влияние температуры и влажности на стволовых вредителей леса [Influence of temperature and humidity on the xylophagous insects]. Пушкино, ФГУ ВНИИЛМ, 26 с. (In Russian)

Харинтонова, Н. З. 1972. Энтомофаги короедов хвоиных пород. [Entomophages of bark beetles in conifer species]. Москва. 128 с. (In Russian)

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НАСЕКОМЫЕ КОЛОНИЗИРУЩИЕ ВЕТВИ ОБЫКНОВЕННОЙ ЕЛИ (*PICEA ABIES* KARST.) В ВЫРУБКАХ И ВБЛИЗИ СТОЯЩИХ ДРЕВОСТОЯХ

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Резюме

Исследования проводились в 2004-2006 гг. в Дубравос экспериментально-учебном лесничестве, в сплошных вырубках ели обыкновенной (*Picea abies* Karst.). Цель работы - установить распределение насекомых-ксилобионтов еловых ветвей на вырубках и в соседних к вырубкам древостоях.

Учлт насекомых-ксилобионтов производился по методу модельных ветвей при использовании эклекторов. Для опыта были использованы еловые свежо вырубленные 1272 ветви деревьев. В еловых ветвях выявленны 32 вида насекомых, из них 19 видов были фитофаги, а 11 – энтомофаги. Доминировали представители отряда жуков (Coleoptera*)*, они составили 93,7% всей найденной ентомофауны. Главный доминант среди жуков – короед – короед гравер (*Pityogenes chalcographus* L.) (75,6%). Число индивидов фитофагов и энтомофагов в вырубках в среднем было около 3-х раз меньше, чем в соседних к вырубкам древостоях ($p \leq 0.05$). Индекс видовова разнообразия (по Шенону) *H'* был 0.3 (в вырубках) и 1.34 (в соседних к вырубкам древостоях) ($t \geq 1.96, p \leq 0.05$). Индекс сходства биоценозов (по Соренсону) между вырубками и соседними к вырубкам древостоями был в среднем C_s=0.51.

Ключевые слова: вырубка, древостой, еловые ветви, насекомые-ксилобионты, трофические группы