Cambioxylophagous fauna developing on logging residues of blue spruce (*Picea pungens* Engelmann)

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ABSTRACT: Cutting down 20- to 30-years-old trees of blue spruce (*Picea pungens* Engelm.) (October, May) and cross-cutting them to sections of different volume (0.5–75 dm^3) under conditions of half-shade × open area resulted in a potential food offer for cambiophages. *Ips amitinus* (Eichh.) and *Pityogenes chalcographus* (L.) reached the higher frequency of occurrence on sections placed in the open area than in half-shade and on stems felled in the autumn season than in the spring season. *Dryocoetes autographus* (Ratz.) was markedly profiled on sections in half-shade with the gradual desiccation of phloem. *P. chalcographus* preferring open areas occurred on branches being accompanied by *Cryphalus abietis* (Ratz.), which attacked branches located in half-shade. On stems of sections from both autumn and spring felling, one generation of *I. amitinus* developed, however, on autumn sections, the 2nd generation developed unsuccessfully on the original nutritive material. *P. chalcographus* completed the development of one generation on stems and branches from autumn felling. On the spring material, the invasion was delayed and a part of wintering larvae did not complete their development. Logging residues of *P. pungens* were available for the development of *I. amitinus* and *P. chalcographus* during one growing season only.

Keywords: cambiophages; *Cryphalus abietis*; *Ips amitinus*; Krušné hory Mts.; *Picea pungens*; *Pityogenes chalcographus*

Clear-cut areas induced by air pollution that originated in the mountain areas of the Krušné hory, Jizerské hory and Orlické hory Mts. at the beginning of the 80s of the 20th century were afforested by woody species resistant to the effect of air pollution and tolerating soil acidification. In the Krušné hory Mts., some 33 thousand ha of stands of substitute species (*Betula* 18%, *Alnus* 1.2%, *Larix* 7.7%, *Sorbus* 5.9%) were established, blue spruce (*Picea pungens* Engelm.) being represented by 13.2% (Smejkal 1994; Balcar, Navrátil 2006). Blue spruce as an introduced species proved decreased requirements for the soil environment, high tolerance to the air pollution stress caused by sulphur oxides and minimum threat by ungulate game (Šika 1976; Tesař 1981; Jirgle et al. 1983; Balcar 1986; Kubelka et al. 1992). Blue spruce stands fulfilled their covering and soil-protection function. However, their wood-producing function has been insignificant and their wood is not attractive for the wood-processing industry (Pearson 1931). As compared with other tree species its soil-reclamation function is reduced (Podrázský 1997). In blue spruce monocultures aged 20–30 years, symptoms of damage and worsening of the health condition occur particularly due to fungal pathogens (*Gemmamyces piceae* Borthw., *Lophodermium piceae* [Fuckel] Hohn., *Armillaria ostoyae* [Romagn.] Herink etc.) (Soukup, Pešková 2009). Local dieback of blue spruce intensely attacked by *Dendroctonus micans* (Kug.) in the Krušné hory Mts. is interesting (Kula et al. 2009, 2010). On standing blue spruce trees attacked by bark beetles eight species were noted while economically important *Pityogenes chalcographus* (L.), *Ips amitinus* (Eichh.), *D. micans, Cryphalus abietis* (Ratz.) (Kula et al. 2009) showed a dominant position. Kula et

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al. (2010) reported a threat of the reproduction of *I. amitinus* on logging residues of blue spruce. This species is able to attack also blue spruce trees killed by Roundup at chemical treatment (Pop et al. 2010). After inevitable tending measures (cleaning) or after the removal of whole blue spruce stands by reason of the introduction of target species, considerable amounts of unprocessed logging residues remain in stands. The aim of the present paper is to determine the rate of attractiveness and to evaluate this available material as the environment for the potential reproduction of cambioxylophagous fauna.

METHODS AND MATERIAL

Our inspection was focused on blue spruce stands (aged 25–30 years) in the area of Děčín Forest District (Management-Plan Area [MPA] Sněžník), Děčínská vrchovina Upland (Sněžník locality, 50°46'53"N and 14°03'58" E, altitude 620 m); Litvínov Forest District (MPA Lom) (Dlouhá louka locality, 50°38'57"N and 13°37'43"E, altitude 863 m) and Jirkov Forest District (Boleboř locality, 50°32'58"N and 13°23'03"E, altitude 794 m, the eastern Krušné hory Mts.). The Dlouhá louka locality is situated 30 km and Boleboř 54 km west of Sněžník.

In October 2008 and in May 2009, some 50 blue spruce trees were felled at each of the localities in the open area and simultaneously 50 trees in the stand half-shade. Each of the trees was cross-cut to sections roughly 1.5–2.5 m long which were not trimmed. In June, August and October 2009, checking the cambioxylophages was carried out. Stems and branches of each of the sections were debarked and on the basis of occurring feeding marks (or imagoes and larvae) the bark beetle species, developmental stage and intensity of attack were determined according to the methodology of Kula and Zabecki (1996). At each of the sections, its length was determined and diameter was measured in the middle of the section. The condition of phloem desiccation was described visually with respect to changes in its mechanical properties and structure:

0% – living phloem, after incision scalable in long strips, white colour; the wood surface after phloem peeling was glossy and moist; 10% – small loss of water, at cutting the phloem its fibres occur sporadically on the knife edge; 30% – phloem always scalable, the length of peeled bark strips shortened; 80–90% – phloem largely darkly coloured, fibrous structure preserved, the content of water is sufficient for the survival of larvae and pupae of bark beetles. The progress of the section defoliation (October 2008) was > 70% after eight months (July 2009) being, however, balanced between the half-shade site and open area. Under these conditions, the phloem desiccation showed differentiated character (Table 1). Defoliation of spring sections (May 2009) was faster in the open area, but at the end of the growing season (October 2009) the condition was balanced. The phloem desiccation was more gradual and of different rate at the end of the growing season (Table 1).

In total, 356 blue spruce trees of mean dbh 80–136 mm and mean height 5.52–6.78 m (Table 2) were felled and cross-cut to sections. 1,085 sections were analyzed. To evaluate the cambioxylophagous fauna under comparable conditions the criterion of section volume was selected and nine volume categories were created (0–0.99; 1–2.49; 2.5–4.99; 5–7.49; 7.5–9.99; 10–14.99; 15–24.99; 25–34.99; over 35 dm^3).

Because there was a simultaneous occurrence of even several species of cambioxylophages in particular sections, dominance was not used to express a preference but the frequency of occurrence was applied in the population of checked sections of different volume.

RESULTS

At sections of the blue spruce stem, nine species of the family Scolytidae were noted and sporadical-

Table 1. The progress of defoliation and wilting the phloem of sections of *Picea pungens* (%)

	Felling	Defoliation				Phloem			
		autumn 2008		spring 2009		autumn 2008		spring 2009	
		half-shade	open area	half-shade	open area	half-shade	open area	half-shade	open area
Control	VII	69.3	73.1	0.0	16.0	21.9	60.9	0.0	15.0
	VIII	85.8	89.5	23.6	42.6	54.7	84.4	25.4	49.4
	X	89.9	92.9	75.4	72.4	86.8	91.9	55.9	70.4

Table 2. Characteristics of blue spruce stands

Localities	Location	*N*-trees	Tree height (m)		dbh (cm)		Crown height (m)	
			average	SD	average	SD	average	SD
Sněžník	half-shade	61	582.48	166.72	79.87	25.08	164.75	51.17
	open area	76	615.53	148.69	104.11	32.49	132.24	44.74
Dlouhá louka	half-shade	49	612.14	126.49	116.39	32.27	151.22	34.50
	open area	62	678.15	124.26	136.21	32.81	123.87	43.93
Boleboř	half-shade	68	597.06	151.68	90.51	30.98	157.06	63.41
	open area	40	552.00	162.40	101.08	45.19	101.50	43.10

dbh – diameter at breast height (cm), SD – standard deviation

ly also the ants *Camponotus herculeanus* (L.) and *Hylecoetus dermestoides* (L.). Larvae of the family Cerambycidae [*Isarthron castaneum* (L.) and *Rhagium inquisitor* (L.)] were an important decomposition component of the blue spruce stem. Their proportion was affected by the season of felling and insolation of sections. Generally higher preferences of laying eggs occurred at trees situated in half-shade compared to the open area, viz. both at felling trees in autumn (18.56 × 10.24%) and in spring (27.15 × 19.83%). At the same time, there was a higher invasion of bark beetles to stems felled in spring (Table 3).

Although the synusia of bark beetles of blue spruce from autumn felling was more numerous (9 species) than from spring felling (6 species), it was possible to state that only two economically important species reached general representation (*P. chalcographus, I. amitinus*) and temporally secondary (*Dryocoetes autographus* [Ratz.]). As for other species, *D. micans* did not attack felled trees but occurred on standing trees. *C. abietis* showed sporadic occurrence on sections of smaller volume usually in the terminal part of a tree. The development of *Hylurgops palliatus* (Gyll.) is interesting, namely only on stems felled in autumn. In spite of the sporadic occurrence of *Ips typographus* (L.) and *Xyloterus lineatus* (Oliv.) corroborating food relationships it is possible to rank these species among potential pests of blue spruce with its increasing age.

The period of felling and the position of sections differentiated the frequency of attack of blue spruce by *D. autographus*. Unambiguously, conditions in half-shade were preferred compared to those in the open area (autumn 2008: 47.03 × 6.83% and spring 2009: 15.89 × 3.38%) and the higher frequency of occurrence was observed under comparable conditions on stems felled in the autumn season (Table 3).

I. amitinus is the most important bark beetle, which preferred sections placed in the open area to sections in half-shade (autumn 2008: 65.19 × 31.68% and spring 2009: 42.26 × 4.64%) and the higher frequency of occurrence was observed on stems felled in the autumn season (Table 3). The same behaviour was noted in *P. chalcographus* (autumn 65.5 × 43.6% and spring 2009: 56.54 × 22.52%) (Table 3).

The total attractiveness of sections to particular species in the monitored period was evaluated in relation to their volume. Although *P. chalcographus* preferred sections of a smaller volume, its frequencies of occurrence were also higher at larger sections. The trend of recession from small-diameter to large-diameter sections became evident particularly in wood felled in autumn (Figs. 1 and 2). An opposite trend was noted in *I. amitinus,* which occurred even at very small sections preferring, however, sections of medium and large volume (> 5 dm^3). In the open area from autumn felling it focussed on large-diameter sections (Figs. 1 and 2). *D. autographus* showed a generally balanced occurrence with the fall of frequency at very large sections. It attacked sections at shaded localities (Figs. 1 and 2). Other noted species showed a balanced proportion at the particular sections (Fig. 1; Table 3). The development of *I. amitinus* was differentiated not only by the season of the origin of sections but also by their place in the open or half-shade area. The fastest development occurred at sections of the open area from autumn felling because 74% of pupae were already recorded in July. In August, young beetles occurred in insect galleries (25%) and emergence holes (25%). At the end of the growing season, the beetles no longer occurred in insect galleries but the presence of dried larval and mother galleries was evident. It is of interest that also in half-shade, the development was identical in the autumn

Table 3. The cambioxylophagous fauna of sections of a blue spruce stem felled in the spring and autum aspect (%)

	Volume of section (dm^3)									
Species	0–0.99	1–2.49	2.5–4.99	5–7.49	7.5–9.99	10–14.99	15–24.99	25–34.99	35+	Sum
Spring (2009, half-shade)										
No attack	71.43	50.00	43.75	60.87	50.00	23.33	33.33	0.00	33.33	41.06
Cerambycidae	0.00	0.00	9.38	8.70	16.67	43.33	66.67	75.00	66.67	27.15
Cryphalus abietis (Ratz.)	14.29	8.33	6.25	4.35	0.00	0.00	0.00	0.00	0.00	3.31
Dendroctonus micans (Kug.)	0.00	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	0.66
Dryocoetes autographus (Ratz.)	0.00	16.67	15.63	13.04	16.67	10.00	22.22	50.00	0.00	15.89
Ips amitinus (Eichh.)	0.00	0.00	0.00	8.70	11.11	3.33	11.11	0.00	0.00	4.64
Pityogenes chalcographus (L.)	14.29	41.67	34.38	21.74	16.67	30.00	0.00	0.00	0.00	22.52
N-sections	7	12	32	23	18	30	18	8	3	151
Spring (2009, open area)										
No attack	0.00	13.04	14.29	15.38	21.74	11.43	18.18	14.81	18.18	15.19
Camponotus herculeanus (L.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.55	0.42
Cerambycidae	0.00	13.04	0.00	0.00	13.04	14.29	36.36	40.74	40.91	19.83
Dendroctonus micans (Kug.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.55	0.42
Dryocoetes autographus (Ratz.)	0.00	0.00	0.00	0.00	4.35	5.71	9.09	3.70	0.00	3.38
Ips amitinus (Eichh.)	44.44	43.48	60.71	50.00	43.48	54.29	43.18	40.74	40.91	47.26
Ips typographus (L.)	0.00	0.00	0.00	0.00	4.35	5.71	4.55	11.11	4.55	3.80
Pityogenes chalcographus (L.)	88.89	52.17	50.00	65.38	52.17	65.71	50.00	55.56	50.00	56.54
N-sections	9	23	28	26	23	35	44	27	22	237
Autumn (2008, half-shade)										
No attack	14.29	11.76	9.33	4.55	2.63	5.48	10.77	18.18	25.00	8.42
Cerambycidae	0.00	1.96	5.33	13.64	26.32	28.77	32.31	54.55	75.00	18.56
Cryphalus abietis (Ratz.)	4.76	5.88	6.67	1.52	2.63	1.37	0.00	0.00	0.00	2.97
Dryocoetes autographus (Ratz.)	14.29	35.29	41.33	48.48	55.26	61.64	55.38	27.27	25.00	47.03
Hylecoetus dermestoides (L.)	0.00	0.00	0.00	0.00	0.00	1.37	1.54	0.00	0.00	0.50
Hylurgops palliatus (Gyll.)	0.00	3.92	0.00	4.55	5.26	9.59	1.54	0.00	0.00	3.71
Ips amitinus (Eichh.)	14.29	17.65	20.00	50.00	47.37	30.14	36.92	27.27	25.00	31.68
Pityogenes chalcographus (L.)	76.19	70.59	56.00	45.45	42.11	28.77	18.46	27.27	0.00	43.56
Xyloterus lineatus (Oliv.)	0.00	0.00	0.00	1.52	0.00	1.37	4.62	0.00	0.00	1.24
N-sections	21	51	75	66	38	73	65	11	4	404
Autumn (2008, open area)										
No attack	0.00	0.00	2.44	3.13	6.25	2.08	3.28	7.41	5.26	3.41
Cerambycidae	0.00	3.57	0.00	6.25	9.38	8.33	21.31	11.11	21.05	10.24
Cryphalus abietis (Ratz.)	0.00	0.00	0.00	0.00	3.13	0.00	0.00	0.00	0.00	0.34
Dendroctonus micans (Kug.)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26	0.34
Dryocoetes autographus (Ratz.)	0.00	10.71	7.32	12.50	6.25	8.33	4.92	0.00	5.26	6.83
Hylurgops palliatus (Gyll.)	20.00	3.57	4.88	6.25	0.00	12.50	4.92	14.81	5.26	6.83
Ips amitinus (Eichh.)	0.00	42.86	43.90	50.00	50.00	77.08	85.25	88.89	84.21	65.19
Pityogenes chalcographus (L.)	100.00	89.29	87.80	78.13	81.25	70.83	42.62	37.04	42.11	66.55
Pityophthorus pityographus (Ratz.)	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
N-sections	5	28	41	32	32	48	61	27	19	293

material with a high proportion of dried larval and mother galleries (Table 4). In sections from spring felling, one generation of *I. amitinus* was developed but a relatively high proportion of pupae occurred in the galleries (20%) at the end of the growing season The locality with spring felling in half-shade showed decreased attractiveness to *I. amitinus*. A markedly lower proportion of dried mother and larval galleries occurred on stems of blue spruce from spring felling (Table 4). *P. chalcographus* was profiled in its

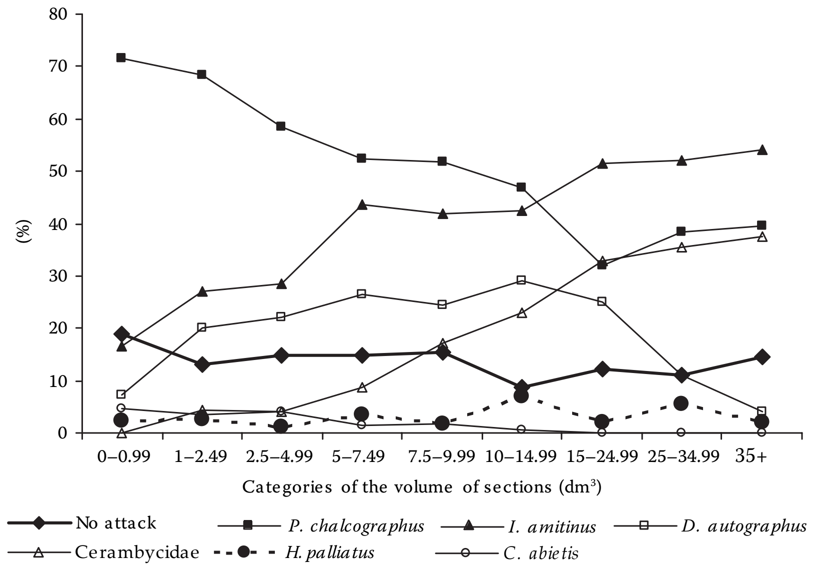

Fig. 1. The frequency of occurrence of cambiophages on sections of blue spruce

development more markedly than *I. amitinus*. In the open area from autumn felling, 75% of beetles already pupated in July and 100% abandoned the place of their development until the end of the growing season. In the same material located in half-shade, its development was markedly delayed (in July, only mother galleries [83.3%] occurred), but the development was successfully completed with the insignificant proportion of dried mother and larval galleries. In sections created in spring, the invasion was

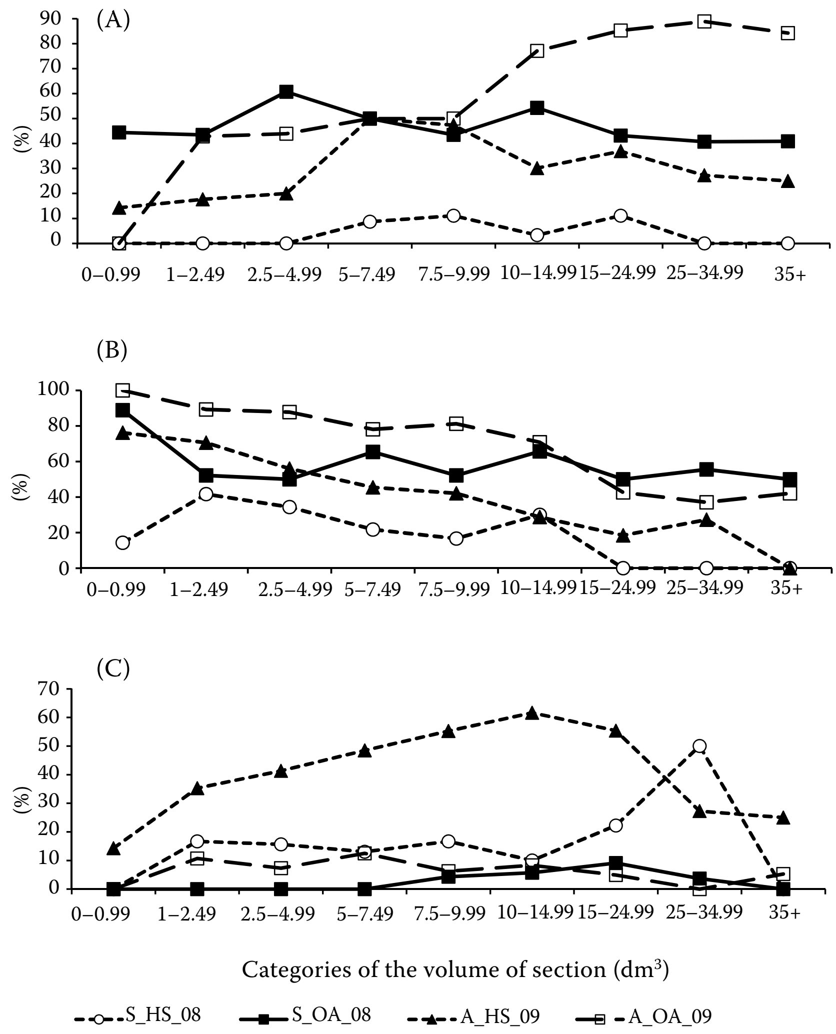

Fig. 2. The frequency of occurrence of (A) *Ips amitinus*, (B) *Pityogenes chalcographus* and (C) *Dryocoetes autographus* on sections of blue spruce S – spring, A – autumn, HS – half-shade, OA – open area

Table 4. The dynamics of the development of *Dryocoetes autographus* on a stem of *Picea pungens* under differentiated conditions

Aspect-Year	Location	Development stadium												
		Month	EH	NCh	MG	L	P	I	EmH	DNCh	DMG	DL	DP	Sum
S-2009	half-shade	8	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
S-2009	half-shade	10	0.0	0.0	4.5	54.5	22.7	0.0	13.6	0.0	0.0	4.5	0.0	22
S-2009	open area	8	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	4
S-2009	open area	10	0.0	0.0	25.0	50.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	4
A-2008	half-shade	7	0.0	0.0	60.0	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	10
A-2008	half-shade	8	2.9	0.0	52.4	35.9	0.0	1.0	1.9	0.0	3.9	1.9	0.0	103
A-2008	half-shade	10	0.0	0.0	0.0	58.4	1.3	0.0	39.0	0.0	1.3	0.0	0.0	77
A-2008	open area	7	0.0	15.4	76.9	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13
A-2008	open area	8	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
A-2008	open area	10	0.0	0.0	0.0	0.0	0.0	0.0	75.0	0.0	25.0	0.0	0.0	4

EH – entrance hole, NCh – nuptial chamber, MG – mother gallery, L – larva, P – pupa, I (YI) – imago (young), EmH – emergence hole, DNCh, DMG, DL, DP means dry NCh, MG, L, P, S – spring, A – autumn

delayed and 29.5 and 37.9% imagoes abandoned their galleries till the end of the growing season, nevertheless, 21–25% of eating larvae (Table 5) always occurred in the galleries. The development of *D. autographus* preferring half-shade conditions took place identically at sections felled both in autumn and in spring. However, more than 50% of eating larvae (Table 6) occurred in insect galleries at the end of the growing season.

The presence of five species of the family Scolytidae and larvae of the family Cerambycidae was noted on branches of blue spruce. *C. abietis* plays an important role on shaded branches without the effect of the season of felling (2008: 28.57%, 2009: 28.57%) whereas branches in open areas were hardly attacked (2008: 0.44%, 2009: 7.19%). In the tree profile, there is a balanced proportion as shown by sections of different volume (Tables 7 and 8).

P. chalcographus occurs on branches of sections of all volume categories preferring thicker branches of large sections. Unambiguously, it uses branches in the open area as compared to shaded branches where a difference in the colonization of branches from autumn 2008 and spring 2009 became evident

Table 5. The dynamics of the development of *Ips amitinus* on a stem of *Picea pungens* under differentiated conditions

Aspect-Year	Location	Development stadium												
		Month	EH	NCh	MG	L	P	I	EmH	DNCh	DMG	DL	DP	Sum
S-2009	half-shade	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
S-2009	half-shade	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
S-2009	half-shade	10	0.0	0.0	0.0	0.0	0.0	0.0	85.7	0.0	14.3	0.0	0.0	7
S-2009	open area	7	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
S-2009	open area	8	0.0	0.0	8.4	14.5	45.8	4.8	9.6	0.0	2.4	14.5	0.0	83
S-2009	open area	10	0.0	0.0	4.0	0.0	20.0	8.0	64.0	0.0	4.0	0.0	0.0	25
A-2008	half-shade	7	0.0	0.0	14.3	0.0	85.7	0.0	0.0	0.0	0.0	0.0	0.0	21
A-2008	half-shade	8	0.0	0.0	2.7	8.0	26.7	9.3	21.3	0.0	9.3	22.7	0.0	75
A-2008	half-shade	10	0.0	0.0	0.0	0.0	3.1	0.0	65.6	0.0	18.8	12.5	0.0	32
A-2008	open area	7	0.0	0.7	4.8	11.0	74.0	2.7	1.4	0.7	4.1	0.7	0.0	146
A-2008	open area	8	0.0	0.0	0.0	3.6	21.4	25.0	25.0	0.0	0.0	25.0	0.0	28
A-2008	open area	10	0.0	0.0	0.0	0.0	0.0	0.0	76.5	0.0	17.6	5.9	0.0	17

EH – entrance hole, NCh – nuptial chamber, MG – mother gallery, L – larva, P – pupa, I (YI) – imago (young), EmH – emergence hole, DNCh, DMG, DL, DP means dry NCh, MG, L, P, S – spring, A – autumn

Table 6. The dynamics of the development of *Pityogenes chalcographus* on a stem of *Picea pungens* under differentiated conditions

Aspect-Year	Location	Development stadium												
		Month	EH	NCh	MG	L	P	I	EmH	DNCh	DMG	DL	DP	Sum
S-2009	half-shade	7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
S-2009	half-shade	8	0.0	0.0	0.0	80.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	5
S-2009	half-shade	10	0.0	0.0	0.0	20.7	24.1	6.9	37.9	0.0	0.0	6.9	3.4	29
S-2009	open area	7	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
S-2009	open area	8	0.0	0.0	16.1	25.3	54.0	1.1	1.1	0.0	0.0	2.3	0.0	87
S-2009	open area	10	0.0	0.0	0.0	25.0	22.7	15.9	29.5	0.0	2.3	4.5	0.0	44
A-2008	half-shade	7	0.0	0.0	83.3	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	6
A-2008	half-shade	8	0.8	0.0	3.3	26.7	27.5	5.8	17.5	0.0	5.8	12.5	0.0	120
A-2008	half-shade	10	0.0	0.0	0.0	2.0	0.0	0.0	82.0	0.0	6.0	10.0	0.0	50
A-2008	open area	7	0.0	0.0	11.7	9.0	74.5	1.4	0.7	0.0	0.0	2.8	0.0	145
A-2008	open area	8	0.0	0.0	0.0	3.0	15.2	12.1	66.7	0.0	0.0	3.0	0.0	33
A-2008	open area	10	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	17

EH – entrance hole, NCh – nuptial chamber, MG – mother gallery, L – larva, P – pupa, I (YI) – imago (young), EmH – emergence hole, DNCh, DMG, DL, DP means dry NCh, MG, L, P, S – spring, A – autumn

(40.48 × 13.82%) (Tables 7 and 8). The development on branches was also affected by the time of the section origin. On branches from 2008, pupae occurred dominantly already in July and imagoes flew out till the end of the growing season. The development under half-shade conditions can be characterized in the same way. On branches from spring 2008, mother galleries were created in July and a marked proportion of larvae and pupae remained there at the end of the growing season (Table 9).

DISCUSSION

Uneconomic logging residues originating during cleanings in Norway spruce stands (*Picea abies* [L.]

Table 7. The cambioxylophagous fauna of sections of *Picea pungens* felled in the spring aspect (%) (2009, half–shade, open area)

	Categories of the volume of sections									
	0–0.99	1–2.49	2.5–4.99	5–7.49	7.5–9.99	10–14.99	15–24.99	25–34.99	35+	Sum
Species/Half–shade										
No attack	71.43	50.00	86.21	80.00	70.00	37.50	50.00	57.14	50.00	64.23
Cryphalus abietis (Ratz.)	28.57	33.33	6.90	15.00	20.00	41.67	25.00	42.86	0.00	23.58
Dryocoetes autographus (Ratz.)	0.00	0.00	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.81
Pityogenes chalcographus (L.)	0.00	16.67	6.90	5.00	10.00	20.83	25.00	28.57	50.00	13.82
N-sections	7	12	29	20	10	24	12	7	2	123
Species/Open area										
No attack	55.56	26.09	19.23	20.83	26.09	24.24	39.02	45.83	45.45	32.00
Cerambycidae	0.00	0.00	0.00	0.00	0.00	0.00	2.44	0.00	0.00	0.44
Cryphalus abietis (Ratz.)	0.00	0.00	0.00	0.00	0.00	0.00	2.44	0.00	0.00	0.44
Dryocoetes autographus (Ratz.)	0.00	4.35	3.85	0.00	0.00	0.00	0.00	0.00	0.00	0.89
Ips amitinus (Eichh.)	0.00	4.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
Pityogenes chalcographus (L.)	55.56	69.57	76.92	79.17	73.91	75.76	56.10	54.17	54.55	66.67
N-sections	9	23	26	24	23	33	41	24	22	225

Table 8. The cambioxylophagous fauna of sections of *Picea pungens* felled in the autumn aspect (%) (2009, half–shade, open area)

	Categories of the volume of sections									
	0–0.99	1–2.49	2.5–4.99	5–7.49	7.5–9.99	10–14.99	15–24.99	25–34.99	35+	Sum
Species/Half–shade										
No attack	61.90	44.00	43.66	31.03	27.59	37.74	45.45	42.86	33.33	40.48
Cryphalus abietis (Ratz.)	23.81	34.00	22.54	39.66	34.48	28.30	15.91	28.57	33.33	28.57
Dryocoetes autographus (Ratz.)	0.00	0.00	1.41	1.72	3.45	0.00	2.27	0.00	0.00	1.19
Pityogenes chalcographus (L.)	28.57	30.00	38.03	36.21	62.07	45.28	43.18	57.14	66.67	40.48
N-sections	21	50	71	58	29	53	44	7	3	336
Species/Open area										
No attack	80.00	53.57	17.07	43.33	16.67	10.64	19.23	14.81	22.22	24.10
Cerambycidae	0.00	0.00	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Cryphalus abietis (Ratz.)	20.00	10.71	12.20	3.33	0.00	8.51	9.62	3.70	0.00	7.19
Dryocoetes autographus (Ratz.)	0.00	0.00	0.00	0.00	3.33	0.00	0.00	0.00	0.00	0.36
Ips amitinus	0.00	0.00	2.44	0.00	0.00	0.00	3.85	0.00	0.00	1.08
Pityogenes chalcographus (L.)	20.00	35.71	73.17	56.67	83.33	85.11	75.00	85.19	77.78	71.58
Pityophthorus pityographus (Ratz.)	0.00	7.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
N-sections	5	28	41	30	30	47	52	27	18	278

Karst.) create differentiated space for the invasion and development of particularly *P. chalcographus, C. abietis, P. pityographus* (Pfeffer 1995a; Kula, Kajfosz 2006, 2007) depending on the season of their origin. Other species (*Dryocoetes* sp., *Hylurgops* sp., *Isarthron* sp.) occur on these residues as food competitors and subsequently they do not attack living trees. The species *X. lineatus* and *I. amitinus* (Kula, Kajfosz 2007) are not considered to be important. The progress of phloem desiccation was markedly modified by the invasion of cambioxylophages in the stem profile and their development (Kula, Kajfosz 2006). In snow damaged mountain spruce stands aged 25–40 years, breaks

Table 9. The dynamics of the development of *Pityogenes chalcographus* on branches of *Picea pungens* under differentiated conditions (%)

Aspect-Year	Location	Development stadium											
		Month	EH	NCh	MG	L	P	I	EmH	DNCh	DMG	DL	DP	Sum
S-2009	half-shade	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
S-2009	half-shade	8	0.00	20.00	60.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	5	5
S-2009	half-shade	10	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	50.00	0.00	12	29
S-2009	open area	7	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4	3
S-2009	open area	8	1.92	14.42	34.62	45.19	0.00	0.00	0.00	1.92	1.92	0.00	104	87
S-2009	open area	10	0.00	0.00	23.81	14.29	14.29	4.76	30.95	2.38	9.52	0.00	42	44
A-2008	half-shade	7	0.00	0.00	33.33	66.67	0.00	0.00	0.00	0.00	0.00	0.00	9	6
A-2008	half-shade	8	0.00	0.95	20.95	24.76	1.90	0.00	42.86	0.95	7.62	0.00	105	120
A-2008	half-shade	10	0.00	0.00	0.00	0.00	0.00	0.00	90.91	0.00	9.09	0.00	22	50
A-2008	open area	7	0.00	2.67	7.33	77.33	2.67	0.00	6.67	0.00	2.00	1.33	150	145
A-2008	open area	8	0.00	0.00	10.71	17.86	17.86	0.00	50.00	0.00	3.57	0.00	28	33
A-2008	open area	10	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	21	17

EH – entrance hole, NCh – nuptial chamber, MG – mother gallery, L – larva, P – pupa, I (YI) – imago (young), EmH – emergence hole, DNCh, DMG, DL, DP means dry NCh, MG, L, P, S – spring, A – autumn are characterized by secondary fauna (*H. palliatus, Hylocoetes dermestoides* L., *Dryocoetes* sp., *Monochamus* sp.) and fallen breaks by *P. chalcographus* and species of the genus *Dryocoetes* (Kula et al. 2007). In the spectrum of cambiophages, *I. amitinus* (Kula et al. 2007) occurred in the minority position. This material was not attractive to this species despite of the fact that in old trees it includes the crown part of the stem sometimes up to the tree top or large-diameter branches (Kula, Zabecki 2005). The cambiophagous fauna of blue spruce (*P. pungens*) was not presented by Pfeffer (1995b), but on logging residues it is consistent with the basic spectrum on Norway spruce with the exception of *I. amitinus*, which finds favourable conditions for its development on young blue spruce trees. The cambioxylophagous fauna of blue spruce (Kula et al. 2010) is consistent with the fauna of standing individuals in *I. amitinus, H. palliatus* and *C. abietis*. Logging residues of *P. pungens* are, similarly like in Norway spruce, preferred by *D. autographus*. This species evidently accepted sections placed in the shadow and felled already in autumn because it required a higher content of phloem moisture. Similarly, in the case of cleaning in the Norway spruce stand, it colonized particularly butt sections of trees lying in the stand and did not colonize logging residues in the open area (Kula, Kajfosz 2006). *P. chalcographus* flew more intensively to logging residues than to standing trees (Kula et al. 2009). *D. micans* does not attack felled trees with respect to its two-year development. On the basis of the analysis of logs, Kršiak et al. (2009) described the cambioxylophagous fauna of branches, which consisted of nine species with the dominant position of *P. chalcographus* and *P. pityographus*. On stems of blue spruce, the authors reported only six largely secondary species (*H. cunicularius*, *H. palliatus*, *D. autographus*).

The season of felling is important with respect to the occurrence of swarming imagoes and the origin of the required phloem quality, which appears to depend on climatic (microclimatic) conditions. Thus, the fauna is differentiated, and also the rate of development, on logging residues from autumn and spring felling as well as on logging residues placed in half-shade or in the open area. In *I. amitinus*, a marked proportion of dried mother and larval galleries was noted at the end of the growing season. It documents an unsuccessful attempt to establish the second generation on the original material of blue spruce. It is possible to suppose that hatched beetles look for oviposition places mostly outside logging residues where they developed. In connection with tending and logging measures in blue spruce stands the increased occurrence of *I. amitinus* expect should be expected, which can endanger existing Norway spruce stands aged over 60 years.

CONCLUSION

On logging residues resulting from tending or felling measures in 20- to 30-years-old blue spruce (*P. pungens*) stands, *I. amitinus* and *P. chalcographus* successfully developed on cross-cut and untrimmed sections 0.5–75 dm^3 in volume, namely with the higher frequency of occurrence on sections placed in the open area than in half-shade and on stems felled in the autumn season compared to the spring season. *D. autographus* was markedly profiled on sections in half-shade with the gradual desiccation of phloem. *P. chalcographus* preferring open areas occurred on branches being accompanied by *C. abietis*, which invaded branches of sections placed in half-shade. On sections from autumn and spring felling, one generation of *I. amitinus* was developed in such a way that on autumn sections the 2nd generation was established unsuccessfully. *P. chalcographus* completed the development of one generation on stems and branches of sections that originated in autumn. As for sections from spring felling, a delay occurred in the invasion and a part of larvae which wintered did not complete their development. Logging residues are available for the development of *I. amitinus* and *P. chalcographus* only within one growing season.

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