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Cambioxylophagous fauna of young spruce stands damaged by snow in the Beskids

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ABSTRACT: In 25 to 40-years-old stands damaged by snow in the Beskids, the fauna of cambioxylophages was analyzed both on standing breaks and lying break-off stems. Breaks are characterized by the gradually drying phloem, watered phloem and secondary fauna (*Hylurgops palliatus*, *Hylocoetes dermestoides*, *Dryocoetes* sp., *Monochamus* sp.), which does not represent any danger to spruce stands. The phloem on lying breaks withered and died till the end of the growing season. The competing species *Pityogenes chalcographus* (L.) (46–52% cover) and species of the genus *Dryocoetes* (20% cover) colonized the breaks in particular. The upper and the lower side of the lying breaks-off differ in the intensity of attack and the degree of cover of these species. In young broken and open stands with the unprocessed wood of lying breaks-off there occurs a risk of the creation of bark beetle circles in the subsequent year after the damage.

Keywords: Norway spruce; the Beskids; cambioxylophages; snowbreaks; young stands

In winter 2005–2006, snowbreaks of disaster character occurred and in consequence, salvage felling wood was processed amounting to 3 million m^3 (spruce 74.5%, pine 23.3%) in stands aged over 40 years in the Czech Republic. In stands up to 40 years, 321 thousand m^3 wood were felled (spruce 79.8%, pine 18.1%). In the basin of the Šance water-supply reservoir in the Moravian-Silesian Beskids, stands of the 1st and 2nd age classes were mostly damaged. With the increasing age of stands the danger decreased (Křístek et al. 2006). Existing records on the volume of disaster salvage felling from young stands do not reflect the whole extent and rate of the disturbance of stands because a considerable part of damaged wood remains in stands (due to uneconomic processing) and so conditions are created for the reproduction of bark beetles.

The cambioxylophagous fauna of break-off stems and lying breaks-off in stands aged > 60 years represented by the fauna of *Ips typographus* (L.) reflects specific conditions, changes in the position of particular species and the degree of threat to stands (Capecki 1978; Gilbert et al. 2005; Göthlin et al. 2005; Gründwal 1986; Jakuš 1998; Kula, Ząbecki 2005, 2006a,b,c). Similarly, the colonization of felling debris from spring cleanings confirmed a possibility of reproduction of bark beetles, particularly of *Pityogenes chalcographus* (L.) (Kula, Kajfosz 2006). Breaks, crown and undercrown breaks-off in stands of the 2nd age class are characterized by thin bark which wilts gradually in the microclimate of pole-stage stands at the various degree of shading. Thus, the phloem is filled with water, which affects not only the species spectrum but also the progress and extent of the attack by cambioxylophagous species.

The aim of the present paper was to determine the species spectrum of cambioxylophages of the damaged wood in stands of the 2nd age class, intensity of attack, cover, competition relations and the level of

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the potential threat of *P. chalcographus* reproduction.

METHODS

The study was carried out in young spruce stands (20–40 years old), Forest Ranges Kavalčanky, Samčanka and Bílá, Forest District Ostravice, which were heavily damaged by snow in winter 2005–2006 (windfalls and snowbreaks). Our analysis was concentrated only on broken trees where the standing part (snowbreak) and the lying part (break-off) were described separately. Windfalls showing a limited attack by bark beetles were excluded from the study in the 1st year after the snowbreak.

At the first inspection (mid-August), 60 trees were analyzed in order to obtain basic information on the progress of cambiophage invasion on the wood of windfalls. At the subsequent inspection, the group of 216 trees in 8 stands was analyzed. At the same time, the basal area (G) of (crown and undercrown) breaks, windfalls and standing trees was determined there. Circular sample plots (200 and 500 m^2), the area of which amounted to at least 10% of the stand area, were used. The proportion of undercrown (9.8%) and crown (10.1%) breaks was balanced (Table 1).

Breaks and respective lying breaks (break-off stems) were barked in the whole profile (lying breaks on the upper and lower side) and the rate of wilting or excessive amounts of water filling the phloem were determined in one-meter sections on the stem, and in the crown part the level of defoliation was also determined (registered and evaluated from the break-off top because of the comparability of sections at the uneven length of broken parts). For easier interpretation the degrees of phloem wilting were assigned to the particular categories (0% – live, 10–30%, 40–60%, 70–90% and dead).

Description of the species spectrum of cambioxylophagous fauna (according to feeding marks), conditions of its development and the degree of attack in the whole stem profile in one-meter sections are based on procedures used by Kula and Ząbecki (1996).

The group of analyzed trees (275) with breaks at the stem base (39), in the crown (113) and under the crown (123) is characterized by the mean original height (15 m) of trees, diameter at breast height (dbh) (15.5 cm), length of breaks-off (10 m), height of breaks (5 m) and diameter at the place of break (12.8 cm).

RESULTS

Wilting of the phloem of breaks

Qualitative changes in the phloem on standing breaks were affected by their height and by the presence of living branches. In mid-August, 58% of the sections of crown breaks with remains of living branches where the phloem partly fulfilled its function and 42% of the sections of undercrown breaks were registered. The phloem of undercrown breaks more often contained excessive amounts of water, max. up to a height of 6 m with the highest frequency in the stem base section (17%) and a subsequent section (8.5%) (Fig. 1). Living phloem occurred in 68% of the break length, wilting phloem (10–30%) in 15.3% and dead phloem in 4% of sections (Table 2).

At the end of the growing season, the proportion of crown standing break sections (59.1%) and undercrown sections (40.1%) was identical. Sections

Table 1. Characteristics of stands damaged by snow (the Beskids, 2006)

Forest stand	Live			Undercrown breaks			Crown breaks			Windfalls		
	G	trees		G	trees		G	trees		G	trees	
	(%)	*N*	(%)	(%)	*N*	(%)	(%)	*N*	(%)	(%)	*N*	(%)
$332B_3$	79.0	107	81.7	4.7	5	3.8	11.6	15	11.5	4.2	4	3.1
$537F_3$	81.3	130	89.0	2.6	1	0.7	7.2	7	4.8	5.7	7	4.8
$343D_3$	84.2	741	77.8	5.8	90	9.5	7.5	81	8.5	2.4	40	4.2
$350C_3$	68.6	352	58.8	9.3	77	12.9	16.9	126	21.0	5.2	44	7.3
$420A_3$	94.1	377	91.3	4.0	22	5.3	0.7	4	1.0	0.9	7	1.7
$545D_3$	82.0	115	68.9	2.3	7	4.2	4.5	10	6.0	6.1	15	9.0
$327C_3$	88.2	395	80.0	4.5	38	7.7	4.2	32	6.5	2.8	28	5.7
$439D_3$	69.0	283	56.4	13.0	94	18.7	10.9	70	13.9	5.3	44	8.8
Sum	80.8	2,500	73.4	5.8	334	9.8	7.9	345	10.1	4.1	189	5.6

G – basal area

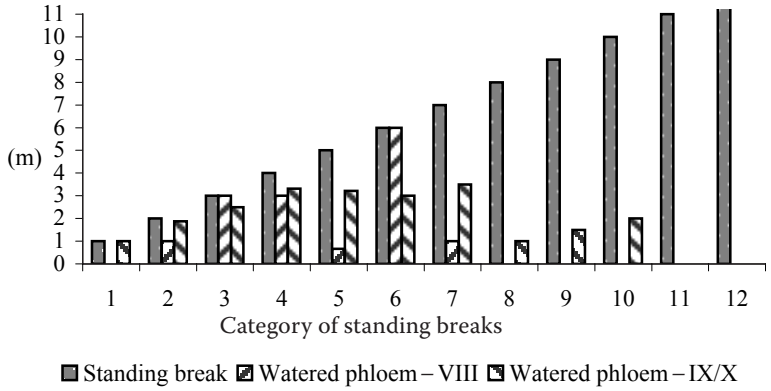

Fig. 1. The mean proportion of sections with water-filled phloem on standing breaks (the Beskids, VIII and IX/X)

containing the water-filled phloem occurred in the break profile even at a height of 7 m but their frequency decreased from the stem base section (35.7%) to the 4th section (27.9–18.8–13.3%). Living phloem occurred in 37% of sections, wilting phloem (10–30%) in 29.3% of sections and dead phloem in 8.8% of sections (Table 4).

After 6 weeks, the proportion of sections with water-filled phloem increased from 6.4 to 19.1% and that of sections with living phloem decreased by a half, the proportion of wilting phloem increased in the categories 10–30% and 70–90%. Only a partial increase occurred in the proportion of sections with quite dead phloem. On the basis of the findings mentioned above it is to state that a gradual wilting of breaks was taking place, and at the end of the growing season, there occurred some 60–70% sections available for the invasion of cambioxylophages.

Phloem wilting and the progress of defoliation of lying breaks-off

The degree of dying and the rate of phloem wilting and dying as well as needle fall characterize the potential volume of breaks available for colonization by cambioxylophages. Qualitative changes in the phloem, which were not specially dealt with, show undoubtedly a decisive effect on differentiation of the species spectrum.

The group of 60 lying breaks-off (mid-August) showed only 5% sections with living phloem and 27% sections were wilted to 30%. Sections wilted to 70–90% (42%) and sections with dead phloem (16% sections) accounted for a decisive proportion. An insignificant difference in the quality of phloem on the upper and lower side of a lying break-off was noted only in the category of 70–90% wilting when 8% more sections occurred on the upper side (Table 3).

The group of 216 lying breaks off is characterized by the low proportion of living sections and sections wilted to 60% (11%) in the autumn aspect. Sections with the phloem in the stage of 70–90% wilting (37%) and dead sections (52%) show a decisive proportion. No differences in quality were observed between the upper and the lower side (Table 3).

Obviously, the wilting of the phloem reached a favourable degree for colonization by cambiophages in July. The degree of wilting at the end of the growing season eliminates a possibility of the repeated attack of lying breaks by the spring generation of *P. chalcographus*.

Needle fall was more progressive than phloem wilting because in mid-August the defoliation reached 70–90% in 39% of sections and there were 50% of sections with 100% needle fall. In the autumn aspect (IX/X), 76% sections were totally defoliated (Table 4).

Cambioxylophagous fauna of standing breaks

Some secondary species not endangering healthy trees (*Hylurgops palliatus* [Gyll.], *Hylocoetes dermestoides* [L.], *Dryocoetes* sp., *Monochamus* sp.)

Table 2. The progress of phloem wilting in the profile of the break (the Beskids, 2006)

Control	Phloem wilting (%)										Σ (m)
	0		10–30		40–60		70–90		100		
	N	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	
VIII	245	68	55	15	36	10	9	3	14	4	359
IX/X	403	37	319	29	155	14	115	11	96	9	1,088

Table 3. The progress of phloem wilting in the profile of the break-off stem (the Beskids, 2006)

Side	Control	Phloem wilting (%)										Σ (m)
		0		10–30		40–60		70–90		100		
		N	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	
Upper	VIII	29	5	130	21	78	13	280	46	91	15	608
Lower	VIII	29	5	143	24	98	16	230	38	108	18	608
Sum	VIII	58	5	273	22	176	14	510	42	199	16	1,216
Upper	IX/X	25	1	101	5	124	6	788	35	1,200	54	2,238
Lower	IX/X	30	1	57	3	126	6	878	39	1,147	51	2,238
Sum	IX/X	55	1	158	4	250	6	1,666	37	2,347	52	4,476

occurred in the spectrum of cambioxylophages of spruce standing breaks.

The phloem with an excessive content of water substantially affected the occurrence of cambioxylophages, particularly of *H. palliatus*, which developed in 44% of sections with water-filled phloem and in 23.5% sections with water-free phloem, which occurred, however, in breaks with water-filled phloem. In trees not showing the water-filled phloem its proportion was insignificant (14%). *H. dermestoides* also preferred breaks with water-filled phloem and attacked them exclusively (23%). Similarly like *H. palliatus* the *Dryocoetes* sp. colonized 36% of sections with water-filled phloem and another 25.5% of sections with water-free phloem in breaks with the excessive content of water. Breaks which were not filled with water were attacked only sporadically (Table 5). *H. palliatus* developed faster in the water-free phloem. In the species spectrum of breaks *Xyloterus lineatus* Ol. was also found in the autumn aspect.

Preference to the water-filled phloem mentioned above corresponds to the general preference of these species to the lower part of stems where the higher content of water is most common being related to the necessary wood moisture. Although the frequency of occurrence of the particular species of cambioxylophagous fauna, namely of *H. palliatus* (7.4–85.2%), *Dryocoetes* sp. (3.7–63%), *H. dermestoides* (11.1 to 55.6%), *X. lineatus* (0–40.7%), was differentiated in breaks of the studied stands, no causal relationship to FTG (forest type groups 5B, 5H, 5S), altitude (600–780 m a.s.l.) or slope orientation was found.

Table 4. The progress of defoliation of crown sections of break-off stems (the Beskids, 2006)

Control	Defoliation (%)										Σ (m)
	0		10–30		40–60		70–90		100		
	N	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	
VIII	1	0	11	2	34	6	221	39	283	50	608
IX/X	3	0	25	1	73	4	384	19	1,570	76	4,476

Table 5. The cambioxylophagous fauna of breaks with different phloem quality (the Beskids, 2006)

Quality of phloem	Species	*Dryocoetes* sp.	*Hylocoetes dermestoides*	*Hylurgops palliatus*	*Monochamus* sp.	*Xyloterus lineatus*	Σ (m)
Water-filled sections	*N*	84	53	101	11	23	231
	(%)	36.36	22.94	43.72	4.76	9.96	
Water-free sections – 1	*N*	39	6	36	1	3	153
	(%)	25.49	3.92	23.53	0.65	1.96	
Water-free section – 2	*N*	60	27	151	0	27	1,063
	(%)	5.64	2.54	14.21	0.00	2.54	

1 – sections with water-free phloem in breaks with the excessive content of water, 2 – trees not showing the water-filled phloem

Table 6. The degree of the break-off stem cover by cambioxylophages (the Beskids, 2006)

Control	Species	*P. chalcographus*		*Dryocoetes*		*P. pityographus*		*C. abietis*		*Monochamus*		*H. palliatus*		*I. typopgraphus*		*I. amitinus*	
	Side	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)
VIII	Upper	334	54.93	63	10.36	6	0.99	9	1.48	14	2.30	3	0.49				
	Lower	223	36.68	177	29.11	11	1.81	6	0.99	34	5.59	10	1.60				
	Sum	557	45.81	240	19.70	17	1.40	15	1.23	48	3.95	13	1.07				
IX/X	Upper	1,305	58.31	310	13.85	30	1.34	3	0.13	144	6.43	7	0.31	1	0.04	33	1.47
	Lower	1,030	46.02	683	30.52	22	0.98	0	0.00	330	14.75	34	1.52	3	0.13	29	1.30
	Sum	2,335	52.17	993	22.18	52	1.16	3	0.07	474	10.59	41	1.83	4	0.18	62	2.77

Cambioxylophagous fauna of lying breaks-off

The occurrence of *P. chalcographus, Pityophthorus pityographus* (Rtzb.), *Dryocoetes* sp., *Cryphalus abietis* (Rtzb.), *H. palliatus* and *Monochamus* sp. was determined by the analysis of lying breaks (break-off parts) carried out in August. The proportion of the pine bark beetle (*P. chalcographus*) reaching 45.8% of the stem cover was critical. The upper side of lying breaks-off was invaded to a larger extent (54.9%) than the lower side (36.7%). The increased cover characterized the members of the genus *Dryocoetes* (19.7%) in such a way that the lower side of a break-off was attacked more often (29.1%) than the upper side (10.4%). In this period, the other components of cambioxylophagous fauna did not account for a marked proportion or conclusive differences between the upper and the lower part of the stem (Table 6).

At the end of the growing season, *I. typographus* (accidental insignificant occurrence – 0.18%) and *Ips amitinus* (Eichh.) (2.8%) occurred in the spectrum of cambioxylophages. For the latter species, this small-diameter material was not attractive although in old trees the species occupies the crown part of the stem, sometimes up to the top or large-diameter branches. *P. chalcographus* with 52.2% mean cover showed a decisive proportion. The species preferred the upper side of a lying break (58.3%) to the lower side (46%). Also in members of the genus *Dryocoetes*, increased attractiveness and cover of the lower side of the stem were confirmed (30.5%) compared to the upper side (13.9%). Species of the genus *Monochamus* with 10.6% cover and partial preference to the lower side of a break-off (14.8 × 6.4%) should be ranked among significantly occurring species. Economically important species occurred only sporadically (*P. pityographus, C. abietis*) as well as the secondary species *H. palliatus* (Table 6). Lying breaks of 8–11 m in length (max. 17 m) were invaded by bark beetles in the whole profile, however, differently. In the summer aspect (mid-August), no species attacked the top section probably due to fast drying. *P. chalcographus* covered the whole profile of a break-off with increased frequency between the 3rd and 11th sections from the top. The same space of a break-off was occupied by the species of the genus *Dryocoetes*, but the competition "fight" on the upper side resulted in favour of *P. chalcographus*. On the lower side they show the same frequency of occurrence. *H. palliatus* used the breaks sporadically, as a rule in their lower part close to the place of break. Species of the genus *Monochamus* occupied nearly the whole profile of a lying break showing the relatively balanced level of cover (Table 7).

Table 7. The frequency of occurrence of cambioxylophages on break-off stems (the Beskids, 2006)

Control		VIII		IX/X		VIII		IX/X		VIII		IX/X	
Side of stem	Sections	*P. chalcographus*				*Dryocoetes* sp.				*Monochamus* sp.			
		N	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)
Upper	1			7	3.24								
	2	13	21.67	48	22.22			2	0.93				
	3	31	51.67	114	52.78	2	3.33	12	5.56	8	3.70		
	4	35	58.33	140	64.81	5	8.33	20	9.26	16	7.41		
	5	4	6.67	153	70.83	7	11.67	31	14.35	27	12.50		
	6	38	63.33	160	74.07	6	10.00	41	18.98	27	12.50	3	5.00
	7	42	70.00	162	75.35	1	1.67	46	21.40	25	11.63	3	5.00
	8	42	72.41	153	74.63	8	13.79	35	17.07	16	7.80	1	1.72
	9	36	75.00	139	73.54	4	8.33	51	26.98	13	6.88	2	4.17
	10	22	62.86	98	69.50	7	20.00	32	22.70	4	2.84	3	8.57
	11	16	69.57	59	70.24	4	17.39	19	22.62	4	4.76	1	4.35
	12	1	8.33	33	66.00	4	33.33	9	18.00	2	4.00		
	13	4	80.00	19	65.52	1	20.00	4	13.79	1	3.45		
	14	2	50.00	12	66.67	2	50.00	5	27.78				
	15	1	100.00	6	75.00	1	100.00	2	25.00				
	16			2	66.67	1	100.00	1	33.33	1	33.33	1	100.00
Lower	1	1	1.67	4	1.85								
	2	7	11.67	43	19.91			3	1.39	2	0.93		
	3	17	28.33	104	48.15	3	5.00	14	6.48	13	6.02	1	1.67
	4	28	46.67	116	53.70	8	13.33	45	20.83	27	12.50	2	3.33
	5	27	45.00	128	59.26	18	30.00	62	28.70	43	19.91	5	8.33
	6	29	48.33	128	59.26	19	31.67	76	35.19	52	24.07	4	6.67
	7	3	5.00	127	59.07	26	43.33	91	42.33	46	21.40	7	11.67
	8	25	43.10	116	56.59	31	53.45	103	50.24	37	18.05	4	6.90
	9	25	52.08	107	56.61	25	52.08	104	55.03	45	23.81	2	4.17
	10	14	40.00	73	51.77	19	54.29	78	55.32	28	19.86	2	5.71
	11	11	47.83	40	47.62	12	52.17	41	48.81	13	15.48	3	13.04
	12	5	41.67	20	40.00	8	66.67	29	58.00	13	26.00	1	8.33
	13	2	40.00	14	48.28	3	60.00	19	65.52	4	13.79	2	40.00
	14			6	33.33	2	50.00	11	61.11	3	16.67		
	15	1	100.00	3	37.50	1	100.00	6	75.00	3	37.50	1	100.00
	16	1	100.00	1	33.33	1	100.00	1	33.33	1	33.33		

At the end of the growing season, resulting aggressiveness of *P. chalcographus*, which occupied the whole profile of the lying break (decreased intensity at the top only), was proved. From the 4th section up to the break, the cover in the upper position was high and balanced (64–75%). Obviously, this species is able to fully use the available space of a break-off for its development and to eliminate the competition pressure of the species of the genus *Dryocoetes*. The lower side of a break-off shows the high cover of both species mentioned above in the whole profile with moderate predominance of *Dryocoetes* sp. *I. amitinus* invaded sporadically lower and upper parts of the lying break centres. Neither at the end of the growing season was the population of *P. pityographus* so high to pose a threat. It concentrated on the 2nd section under the break top. Species of the genus *Monochamus* used intensively the whole profile

of a break-off, particularly on the lower side with the balanced frequency of attacked sections (Table 7).

The intensity of attack expressed by the cover of the stem section by feeding marks (Kula, Ząbecki 1996) completes the characteristics of significance of the particular species, their aggressiveness and competition environment. On the summer date of inspection (mid-August), *P. chalcographus* was already characterized by heavy feeding on 57% of invaded sections and only 18% of sections showed its scattered occurrence on the upper side. On the lower side, sections were occupied with the balanced intensity of attack in the scattered (37%), increased (34%) and heavy (30%) invasion category. At the end of the growing season, *P. chalcographus* occurred in the heavy degree of attack (64%) and balanced proportion of scattered and increased attack. Thus, it is evident that the invasion was not intensified on the upper side of a break-off in the course of the growing season. On the lower side of the stem, sections with heavier attack partly occurred. It is to note that the available space was not fully covered. It could be caused by the lower population level of *P. chalcographus* and partly by the competition environment of other cambiophages (*Dryocoetes* sp.).

Dryocoetes sp. occurred in the scattered degree of attack on the upper side of the stem (81%). The species showed scattered occurrence (62%) on the lower side described as more convenient, however, the degree of attack markedly increased (30%). At the end of the growing season, the intensity of attack was balanced. Another species *H. palliatus* can be characterized similarly. Members of the genus *Monochamus* showed the same intensity of attack of the upper and lower side of the stem. Sections with scattered occurrence predominated (Table 7).

In August, the development of *P. chalcographus* was partly delayed on the lower side of the stem, which was confirmed at the end of the growing season. On lying breaks the only generation of *P. chalcographus* developed that left the place of development (one half on the upper side and one third on the lower side of the stem) or remained at 38% of attacked sections in the stage of pupa or larva. Thus, it is possible to suppose that the development was completed considering the warm autumn weather and wintering imagoes. At present, the above-standard amounts of *P. chalcographus* imagoes winter in young spruce stands with unprocessed wood.

With the increasing degree of phloem wilting a heavy attack by *P. chalcographus* increased. In the lower part of the stem, the intensity of attack was balanced and differentiated only in the heavy degree depending on the phloem quality. The proportion of developmental stages corresponds to the findings mentioned above. Nuptial chambers were observed in the wilting phloem (10–30%) whereas mother galleries developed in the phloem with the degree of wilting up to 90%, however, with the increasing degree of wilting their proportion decreased. Larvae and pupae occurred particularly in the phloem in the stage of wilting exceeding 40%. In this period, we noted the occurrence of imagoes and emergence holes in the phloem with 70–90% wilting. The character of the structure of developmental stages was the same on the upper and lower side of the stem.

Table 8. The intensity of attack of break-off stems by *P. chalcographus* according to the degree of wilting of the break-off phloem (the Beskids, IX/X 2006)

Side	Degree of wilting (%)	Intensity of attack						Length of attack (m)	Length of break-off stems (m)
		scarce		increased		heavy			
		N	(%)	*N*	(%)	*N*	(%)		
Upper	0		0		0		0	0	25
	10–30	5	83	1	17		0	6	101
	40–60	15	68	6	27	1	5	22	124
	70–90	100	18	165	30	283	52	548	788
	100	71	10	107	15	551	76	729	1,200
	Sum	191	15	279	21	835	64	1,305	2,238
Lower	0		0		0		0	0	30
	10–30	4	67	2	33		0	6	57
	40–60	7	100		0		0	7	126
	70–90	154	36	169	40	101	24	424	878
	100	106	18	131	22	356	60	593	1,147
	Sum	271	26	302	29	457	44	1,030	2,238

Table 9. The rate of cover of the break-off stem in FTG (the Beskids, IX/X 2006)

FTG	*Dryocoetes*		*P. chalcographus*		*P. pityographus*		*C. abietis*		*I. amitinus*		*Monochamus*		*H. palliatus*		*I. typographus*		Sum
	N	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	
5B	516	23.04	890	39.73	10	0.45	3	0.13	4	0.18	158	7.05	17	0.76	2	0.09	2,240
5H	155	13.16	730	61.97	6	0.51		0.00	2	0.17	79	6.71	23	1.95	1	0.08	1,178
5S	180	32.61	339	61.41	27	4.89		0.00	32	5.80	151	27.36	1	0.18		0.00	552
6S	142	28.06	376	74.31	9	1.78		0.00	24	4.74	86	17.00	41	8.10	1	0.20	506

Table 10. The rate of cover of the break-off stem depending on coefficient K (the Beskids, IX/X 2006)

K	*Dryocoetes*		*P. chalcographus*		*P. pityographus*		*C. abietis*		*I. amitinus*		*Monochamus*		*H. palliatus*		*I. typographus*		Sum
	N	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	*N*	(%)	
618–670	1,395	80.64	1,069	61.79	33	1.91		0.00	34	1.97	230	13.29	24	1.39	1	0.06	1,730
742–763	1,244	74.40	622	37.20	10	0.60		0.00	2	0.12	138	8.25	1	0.06	2	0.12	1,672
835–959	844	78.58	644	59.96	9	0.84	3	0.28	26	2.42	106	9.87	16	1.49	1	0.09	1,074

K – coefficient of the relative insolation of the area in July (Vašků 1971)

After 4–5 weeks (September–October), the scattered occurrence of *P. chalcographus* was concentrated in the phloem with 10–60% wilting. An increased attack occurred in the phloem with more than 40% wilting and heavy intensity of attack was recorded in 70–100% wilted phloem (the upper and the lower side of the stem break-off) (Table 8). Based on the evaluation of *P. chalcographus*, the development of its first generation ended in this period because nuptial chambers and mother galleries occurred sporadically and the stage of larvae and pupae in the phloem characterized by 70–90% wilting showed a crucial position. Imagoes, but above all emergence holes occurred in sections with dead phloem. The identical situation was on the upper and lower side of the stem.

Attacks by *P. chalcographus* on break-off parts started from the stem top in a 3–5 m section and subsequently they moved to the central part.

At the end of the growing season (IX/X), the development of *Dryocoetes* sp. was evaluated together with *P. chalcographus*. The scattered degree of attack was related to the phloem wilted > 40%, increased and heavy degree of attack was noted in the phloem with 70–100% wilting. In this period, we observed the occurrence of mother galleries, larvae and pupae mainly in the phloem characterized by 40–100% wilting. The proportion of emergence holes in wilted or dead phloem was high (70–100%).

The frequency of occurrence of the particular species in monitored stands (IX/X) indicated high homogeneity for *P. chalcographus* because with the frequency of occurrence 81–100% only stand 343 D_3 (52%) differed and in members of the genus *Dryocoetes*, a difference from the frequency of 81–100% was found out in two stands, namely 350 C_3 (56%) and 439 D_3 (48%). Marked differences appeared in the frequency of occurrence in members of the genus *Monochamus* (7–85%) where the highest concentration was in stands 545 D_3 (85.2%), 420 A_3 (66.7%) and 537 F_3 (63%). As for other species characterized by the low frequency of occurrence, a parallel increase in *P. pityographus* and *I. amitinus* in stands 537 F_3 and 545 D_3 is of interest.

Assessing the cambioxylophages according to the level of the break-off cover the occurrence of species of the genus *Dryocoetes* in FTG 5H and of *P. chalcographus* in 5B was lower. On the other hand, the increased cover was observed in FTG 5S in members of the genus *Monochamus* (Table 9). Using the coefficient of relative insolation, fundamental differences were not found with the exception of *P. chalcographus,* where it was probably another effect causing this difference (Table 10).

DISCUSSION

Spruce standing breaks represent a specific space for the development of cambioxylophagous insects. The quality of phloem changes not only as a result of its gradual drying but also due to an increase in the content of water in the phloem. In stands aged over 60 years typical of *I. typographus*, the fauna typical of dying trees occurs in breaks (*X. lineatus, H. dermestoides, H. palliatus, Isarthron fuscum* [Fabr.]). As for the species endangering spruce only *Polygraphus polygraphus* (L.) developed markedly on breaks while the species typical of stems, such as *I. typographus* and *P. chalcographus*, do not attack standing breaks (Kula, Ząbecki 2005). The response of cambioxylophagous fauna on breaks in stands younger than 40 years was identical in the dominant position of secondary species *H. palliatus, Dryocoetes* sp., *H. dermestoides.* However, *P. polygraphus* was not found out. It can reproduce on breaks in older stands, but the phloem thickness is unambiguously insufficient for the species in pole-stage stands. *X. lineatus* sporadically attacked the stems of breaks of small dbh where, in addition, the intense competition environment with *H. dermestoides* was created.

The fauna of longhorn beetles on breaks of older trees was characterized by the species *I. fuscum*, the females of which laid eggs under scales of bark in May (Heyrovský, Sláma 1992). The species prefers standing dying trees and particularly thunderstruck trees with steamy phloem. On breaks in 20 to 40-year-old stands, members of the genus *Monochamus* occurred only sporadically. Larvae of the genus draw attention to their presence by small bore dust hillocks. Based on long-term studies, their higher proportion occurs on lying windfalls and large-diameter breaks-off, particularly at moist localities (Kula, Ząbecki 2006c). Although Heyrovský and Sláma (1992) reported them as rather a rare species in Bohemia, in the Moravian-Silesian Beskids and in the Beskid Zywiecki Mts. with salvage felling they create local large populations not only on breaks and breaks-off in young stands but also on windfalls and windbreaks in mature stands particularly at southern aspects (Kula, Ząbecki 2006c).

The fauna of cambioxylophages of the stem part of a break-off in mature stands is richer (17 species) (Kula, Ząbecki 2005) than that of a break-off in pole-stage stands (8). It is caused by the size of the break-off, which modifies the species spectrum in mature stands (Kula, Ząbecki 2005). If long stem breaks-off were invaded by *P. chalcographus* (96.3%) and *I. typographus* (77.8%) with the insignificant proportion of *I. amitinus* and *P. pityographus*, then crown breaks-off in mature stands were characterized by *P. polygraphus, P. chalcographus* and *P. pityographus. Monochamus* also showed a standard proportion (35%) (Kula, Ząbecki 2005). The fauna of break-off parts in pole-stage stands is characterized by *P. chalcographus* but differs markedly due to the proportion of species of the genus *Dryocoetes* sp. and *Monochamus* sp. The disastrous occurrence of break-off parts similarly like the concentration of logging debris arranged into piles endangers adjacent spruce stands by *P. chalcographus* (Hedgren et al. 2003).

Escherich (1923), Krämer (1953) and Postner (1974), Zumr (1984) described differences in the vertical distribution of bark beetles on stems of trees which correlated with the thickness of phloem and bark. Differences in their structure on standing trees, breaks and lying breaks should be related to changes induced by damage but also to the microclimate of a lying break in the stand. Breaks with the crown dry differently from a standing tree. Intensity and velocity of changes in the quality of phloem markedly affect the species and numerical proportion of cambiophages.

From the aspect of forest hygiene it is necessary to prevent the potential reproduction particularly of *P. chalcographus*, which is able to use the whole space of the stem break-off for its development, showing the high frequency of occurrence and cover and the heavy degree of attack. In case that it is not planned to process the wood of windfalls, it is necessary to carry out its treatment, at least through cutting aimed at faster drying. Nevertheless, the risk of damage to stands of the 2nd age class by *P. chalcographus* persists and the rate of hazard will be corrected only by weather conditions and actual population density of *P. chalcographus*.

CONCLUSION

The phloem wilting on lying breaks-off coming from winter 2005–2006 reached a suitable degree for the invasion of bark beetles at the turn of June/July and at the end of the growing season, 90% of phloem being heavily wilted or dead. On standing breaks, the progress of the phloem dying was gradual. At the end of the growing season, 66% of phloem remained live or in the first stage of wilting. There is available wood for the invasion of secondary cambiophages in the following growing season.

Standing breaks are characterized by the water-filled phloem particularly in the butt and adjacent

sections which are invaded particularly by secondary species (*H. palliatus, H. dermestoides*) together with *Dryocoetes* sp.

Lying breaks-off are dominantly colonized by *P. chalcographus* with the mean cover 46–52%, which is higher on the upper side of the stem while *Dryocoetes* with the mean cover 20% preferred the lower side of the stem. Members of the genus *Monochamus* showed a significant proportion, no other economically important species occurred on lying breaks-off.

The invasion of *P. chalcographus* reached first as far as the upper third of the breaks, and subsequently it descended to the central part with high intensity. It ascended with dominant heavy intensity of attack.

Conclusions for forest practice

Standing breaks in stands of the 2nd age class do not provide any available space for economically important cambioxylophages in the 1st year after snowbreak/windbreak. The lying breaks-off enable the development of minimally one generation of *P. chalcographus* (depending on the spring weather conditions). In young broken and open stands with the unprocessed volume of break-off stems there arises a risk of the formation of bark beetle circles in the next year after damage.

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Kambioxylofágní fauna mladých smrkových porostů poškozených sněhem v Beskydech

ABSTRAKT: Ve sněhem poškozených 25–40letých horských smrkových porostech (Beskydy) byla na stojících zlomech a ležících odlomech analyzována fauna kambioxylofágů. Zlomy charakterizuje pozvolné zasychání lýka, zavodnění lýka a sekundární fauna (*Hylurgops palliatus, Hylocoetes dermestoides, Dryocoetes* sp., *Monochamus* sp.), která pro smrkové porosty nepředstavuje žádné nebezpečí. Na odpadlých odlomech lýko do konce vegetačního období odumřelo. Dominantně byly odlomy osídleny potravně konkurenčním druhem *Pityogenes chalcographus* (L.) (46–52% pokryvnost) a zástupci rodu *Dryocoetes* (20% pokryvnost). Horní a spodní strana odlomu se intenzitou napadení a výší pokryvnosti těchto druhů liší. V mladých, rozlámaných a uvolněných porostech s nezpracovanou hmotou odlomů vzniká nebezpečí tvorby kůrovcových kol v následném roce po poškození.

Klíčová slova: smrk ztepilý; Beskydy; kambioxylofágové; sněhové polomy; mladé porosty

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