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Successful overwintering of Lepidoptera larvae and eggs on spruce trees uprooted by the wind

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Abstract

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Windstorm on November 19, 2004 seriously affected Norway spruce (*Picea abies*) forests in Tatra Mountains, Northern Slovakia. We studied as to whether moth larvae and eggs overwintered successfully on branches of uprooted spruce trees. Also, we evaluated differences in assemblage structure of overwintering developmental stages of moths between the upper and middle crown area of wind-felled spruce trees. In May 2005, we sampled branches from a total of 12 wind-felled trees in Tichá dolina valley in the altitudes between 1,020 and 1,050 m. From each tree, a total of 30 branches were collected from both its upper and middle crown area. In addition, a total of 400 cones were sampled from the wind-felled trees. Moth larvae or hatched adults were obtained from branches or cones through photoeclectors in the laboratory. Larvae of one species developing in cones (*Cydia strobilella*), 3 species of bud-borers (*Argyresthia glabratella, A. amiantella, A. bergiella*), 7 needle spinning species (*Batrachedra pinicolella, Chionodes electella, Syndemis musculana, Dichelia histrionana, Pseudohermenias abietana, Epinotia tedella, E. nanana*), one free living species (*Thera variata*) and one species feeding on lichens or algae (fam. Psychidae – Naryciinae, not identified) were recorded. The moth *Zeiraphera griseana* was the only species overwintering in the egg stage. Branches of uprooted spruce trees hosted all moth species common on living standing spruce trees in other mountain valleys of Tatra Mountains. Specimens of needle-spinning species overwintering in the larval stage were collected in significantly greater numbers on the upper crown than on the middle crown branches of the individual wind-felled trees ($p < 0.05$, Wilcoxon matched pairs test). In bud-borers, such significant differences were not found. The numbers of moth specimens belonging to the rest feeding groups were low. Successful development of all moth species overwintering on uprooted trees in the larval stage (13 species) was highly likely. Most larvae of *Z. griseana* emerging from eggs in spring, possibly, died because of the lack of opening buds and young needles on most fallen trees which were drying out gradually.

Key words

Lepidoptera, Norway spruce, middle crown, overwintering, *Picea abies*, upper crown, uprooted trees, wind disturbance

Introduction

Wind disturbances are frequently affecting spruce forests in Europe (Skuhravý, 2002). Windstorms influence insect populations in these forests in different way (cf. Bouget and Duelli, 2004). The insects dwelling in tree crowns may be affected directly by the strong wind currents (usually short lasting) and indirectly by modified abiotic and biotic conditions following windstorms. Uprooted spruce trees provide plant-eating insects with food, the quality of which is greatly changed. Drought-stressed Norway spruce becomes a better-matching food source for some insect species (Mattson and Haack, 1987; Björkman and Larsson, 1999) but

severe and prolonged drought can become debilitating to phytophagous insects (Mattson and Haack, 1987). Often, windstorms damage European spruce forests out of growing season (Skuhravý, 2002) and affect overwintering insects on spruce trees. Over that period of time, the insects are passive or almost passive. On spruce trees uprooted in autumn, the insects accelerate their activity several months later (in the spring).

Main objectives of this study were to find out as to whether:

1. The moth larvae and eggs on branches of Norway spruce (*Picea abies*) trees uprooted by the strong wind on November 19, 2004 overwinter and complete their development successfully
2. The wind-felled spruce trees host larvae of all moth species mostly occurring on living standing spruce trees
3. The assemblages of overwintering developmental stages of moths in the upper crown area differ from the assemblages on the middle crown area of the uprooted spruce trees.

Material and methods

In May 2005, branches were sampled from a total of 12 spruce trees uprooted by the wind in November 2004 in the bottom of the Tichá dolina valley, Tatra Mountains, northern Slovakia, at 1,020–1,050 m a.s.l. (49°10'27.39" N, 19°55'3.29" E). From each sample tree, a total of 30 branches were collected from the upper crown area (top section of a tree, 5 m long), and a total of 30 branches were collected from the middle crown area (middle section of a tree, 7–12 m apart from the top). Sample branches were 0.5 m long each. Only the branches not touching the ground were collected from tree crowns. The sample trees were 60–80 years old and 25–30 m high. In addition, a total of 400 cones were sampled from the wind-felled spruce trees. The sample branches and cones were placed in photoeclectors in the laboratory. Moth larvae or hatched adults of moth species were collected from the eclectors regularly. Material examined consisted of a total of 92 moth specimens obtained from the upper and a total of 69 moth specimens gathered from the middle crown area, and a total of 135 moth specimens collected from spruce cones.

Moth larvae overwintering on branches of living standing trees aged 60–80 years were monitored in the bottom of Tichá dolina valley in the altitude of some 1,030 m. In April or May (depending on weather), a total of 10 terminal parts of branches, 1 m long each, were sampled from the lower parts of spruce crowns, in this particular case 2–3 m above the ground. Moth larvae or emerged adults were obtained using eclectors. A total of 18, 19 and 7 moth specimens were collected in 1998, 1999 and 2000.

The spruce forests in Tichá dolina valley are the habitats of Community interest – NATURA 2000 No. 9410: Acidophilous *Picea* forests of the montane to alpine levels (Vaccinio-Piceetea). However, they were managed in the past.

Results and discussion

In total, 13 moth species overwintering as larvae or eggs were recorded on branches of the uprooted spruce trees (Table 1). Most of them overwinter in the larval stage – as larvae or prepupae; only a single species *Zeiraphera griseana* overwinters in the egg stage. Number of specimens differed greatly among the individual sample trees (Fig. 1). According to behaviour and food requirements of particular species moth larvae were classified into four feeding guilds: (1) needle-spinning species, (2) bud-borers, (3) free-living species feeding on needles and (4) species feeding on lichens or algae (Table 1). Abundance of all species was low (latency period – no outbreak). The average density of moths (larvae or adults), expressed as the number of specimens on 100 branches (0.5 m long each), was the following: needle-spinning larvae – 6.9 specimens in the upper crown area against 5.6 specimens in the middle crown area; bud-borers – 18.3 specimens in the upper crown area against 12.8 specimens in the middle crown area; free-living larvae feeding on needles – 0.8 specimens in the middle crown area; species feeding on lichens or algae – 0.3 specimens in the upper crown area. The larvae of *Argyresthia* spp. overwintering in buds were predominant (Fig. 2).

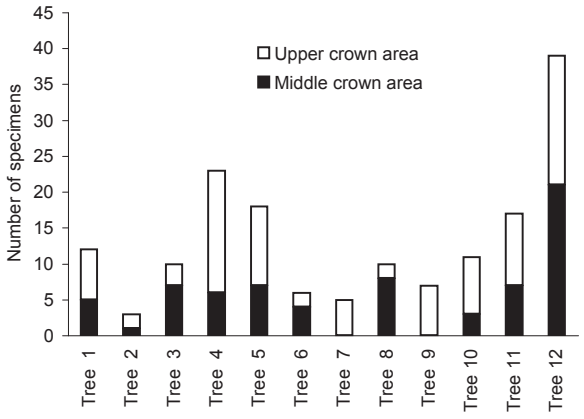


Fig. 1. Number of moth specimens recorded on sample branches in two crown areas of wind-uprooted Norway spruce trees (n = 12) in Tichá dolina valley, Tatra Mountains, in 2005.

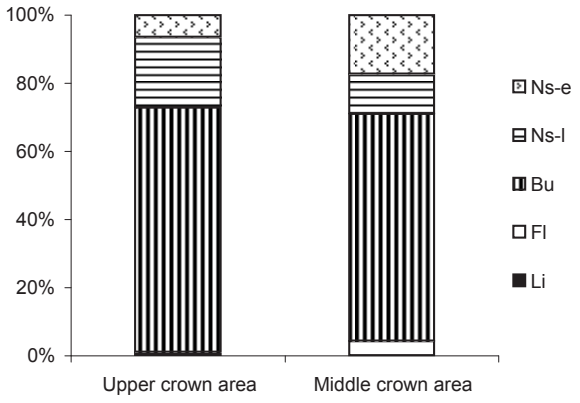
Needle-spinning overwintering larvae were significantly more in the upper crown than on the middle crown area of the individual uprooted trees (Wilcoxon matched pairs test, $N = 12$, $Z = 2.03$, $p < 0.05$). In

Table 1. Dominance (in %) of moth taxa recorded in two crown areas of wind-uprooted Norway spruce trees in Tichá dolina valley, Tatra Mountains, in 2005

Guild	Taxon	Upper crown area	Middle crown area	Upper + middle area
Li	Naryciinae sp.	1.1		0.6
Bu	*Argyresthia glabratella* (Zeller, 1847)	16.3	13.0	14.9
Bu	*Argyresthia amiantella* (Zeller, 1847)	41.3	30.4	36.6
Bu	*Argyresthia bergiella* (Ratzeburg, 1840)	14.1	23.2	18.0
Ns-l	*Batrachedra pinicolella* (Zeller, 1839)	2.2		1.2
Ns-l	*Chionodes electella* (Zeller, 1839)	4.3	2.9	3.7
Ns-l	*Syndemis musculana* (Hübner, 1799)	1.1		0.6
Ns-l	*Dichelia histrionana* (Frölich, 1828)	2.2		1.2
Ns-l	*Pseudohermenias abietana* (Fabricius, 1787)	5.4	1.4	3.7
Ns-l	*Epinotia tedella* (Clerck, 1759)		1.4	0.6
Ns-l	*Epinotia nanana* (Treitschke, 1835)	5.4	5.8	5.6
Ns-e	*Zeiraphera griseana* (Hübner, 1799)	6.5	17.4	11.2
Fl	*Thera variata* (Denis & Schiffermüller, 1775)		4.3	1.9
Total		100	100	100

Larval guilds: Li, species feeding on lichens or algae; Bu, bud-borers; Ns-l, needle-spinning species overwintering as larvae; Ns-e, needle-spinning species overwintering in the egg stage; Fl, free-living species feeding on needles.

bud-borers, such significant differences were not found (Wilcoxon test, $N = 12$, $p > 0.05$). The numbers of specimens belonging to the rest feeding groups were too low to test for statistical significance.



Larval guilds: Ns-e, needle-spinning species overwintering in egg stage; Ns-l, needle-spinning species overwintering in larval stage; Bu, bud-borers; Fl, free-living species feeding on needles; Li, species feeding on lichens or algae

Fig. 2. Proportion of moth guilds overwintering as larvae or eggs on branches of uprooted spruce trees in Tichá dolina valley, Tatra Mountains, in 2005.

All moth specimens collected from spruce cones belonged to a single species, *Cydia strobilella* (Linnaeus, 1758).

The larvae obtained from the branches of living standing trees in 1998, 1999 and 2000 were represented by a total of 6 species (Table 2). Their abundance was low (latency). All these species were also found to be developing on the branches of spruce trees uprooted in May 2005.

Table 2. Dominance (in %) of moth taxa recorded on branches of living spruce trees in Tichá dolina valley, Tatra Mountains, before windstorm in November 2004 (data from 1998, 1999, 2000)

		Year		
Guild	Taxon	1998	1999	2000
Li	Naryciinae sp.		15.8	
Bu	*Argyresthia glabratella* (Zeller, 1847)	11.1	42.1	14.3
Bu	*Argyresthia amiantella* (Zeller, 1847)	16.7	5.3	14.3
Ns-l	*Chionodes electella* (Zeller, 1839)	16.7		28.6
Ns-l	*Epinotia nanana* (Treitschke, 1835)	22.2	31.6	14.3
Fl	*Thera variata* (Denis & Schiffermüller, 1775)	33.3	5.3	28.6
Total		100	100	100

Larval guilds: Li, species feeding on lichens or algae; Bu, bud-borers; Ns-l, needle-spinning species overwintering in larval stage; Fl, free-living species feeding on needles.

Branches of the uprooted spruce trees hosted all moth species which are common in other mountain valleys of Tatra Mountains, e.g. in Skalnatá dolina and Velická dolina valley (Kulfan and Zach, 2004, 2005).

Larvae (or prepupae) of 13 moth species (*C. strobilella* and the species listed in Table 1 except for *Z. griseana*) overwintered on uprooted trees successfully. As the branches of uprooted trees are slowly drying out in nature, successful development of those larvae is likely. The larvae of *Z. griseana* emerge from eggs in spring and feed in opening buds, young needles and shoots (Kalina et al., 1985). This is why they are able to survive only on branches of living spruce trees. On trees uprooted by the wind they can only survive if the roots of these trees are covered with soil. All the wind-felled spruce trees in Tichá dolina valley were dying, producing no shoots in the spring. As a result, most larvae of *Z. griseana* dwelling on these trees, possibly, died. In contrast, overwintering needle-spinning larvae feeding on old needles could complete their development the following spring (Fig. 2).

Although the direct effect of wind (in November 2004) on the moth larvae was likely it was not documented. Endophagous larvae living in cones and buds (bud-borers) were well protected against the wind; some needle-spinning, and especially free-living larvae might be blown by the wind or injured by sharp needles of fast moving branches. Free living larvae are most sensitive to such events, as they overwinter unprotected, roosting on green twigs, stretched along a needle (Dvořáčková and Kulfan, 2009). Also, some larvae might be knocked from branches during the wind-felling. Some parts of crowns of uprooted trees were touching the ground. The larval mortality in these tree parts might be higher than that in the other parts of tree crowns.

The data obtained did not enable to quantify the proportion of larvae surviving the windstorm and successfully overwintering on the fallen trees. On the uprooted trees the number of overwintering needle-spinning, and especially free living larvae, was low compared to the number of the bud-borers (compare Ns-l and Fl against Bu, Fig. 2). In standing living trees in the Tichá dolina valley (this study), Skalnatá dolina valley (Kulfan and Zach, 2004) and Velická dolina valley (Kulfan and Zach, 2005), the proportion of needle-spinning and free living larvae in larval assemblages was higher. Thus, the impact of windstorm on unprotected or partly protected moth larvae overwintering on spruce branches might be much greater than that on well protected moth larvae living in buds (requires further study).

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References

Björkman, C., Larsson, S. 1999. Insects on drought-stressed trees: four feeding guild sin one experiment. In Lieutier, F., Mattson, W.J., Wagner, M.R. (eds). *Physiology and genetics of tree-phytophage interactions.* Paris: INRA editions, p. 323–335.

Bouget, C., Duelli, P. 2004. The effects of windthrow on forest insect communities: a literature review. *Biol. Conserv.*, 118: 281–299.

Dvořáčková, K., Kulfan, J. 2009. Caterpillars overwintering on spruce roost near their food. *Folia oecol.*, 36: 75–78.

Kalina, F., Skuhravý, V., Žďárek, J., Šrot, M., Vrkoč, J., Hochmut, R. 1985. *Obaleč modřínový* [The larch bud moth]. Praha: Státní zemědělské nakladatelství. 134 p.

Kulfan, J., Zach, P. 2004. Spoločenstvá motýľov na smreku obyčajnom (Picea abies) pozdĺž vertikálneho gradientu v Skalnatej doline [Lepidoptera assemblages on Norway spruce (Picea abies) along an altitudinal gradient in the Skalnatá dolina valley]. *Štúdie TANAP*, 40: 311–319.

Kulfan, J., Zach, P. 2005. Spoločenstvá motýľov na smreku obyčajnom (Picea abies) pozdĺž vertikálneho gradientu vo Velickej doline [Lepidoptera assemblages on Norway spruce (Picea abies) along an altitudinal gradient in the Velická dolina valley]. *Folia faun. slov.*, 10: 29–34.

Mattson, W.J., Haack, R.A., 1987. The role of drought in outbreaks of plant-eating insects. *BioScience,* 37: 110–118.

Skuhravý, V. 2002. *Lýkožrout smrkový (Ips typographus L.) a jeho kalamity. Der Buchdrucker und seine Kalamitäten.* Praha: Agrospoj. 196 p.

Úspešné prezimovanie húseníc a vajíčok motýľov (Lepidoptera) na smrekoch vyvrátených víchricou

Súhrn

Víchrica z 19. novembra 2004 vážne poškodila smrekové lesy Tatier. Vyvrátené smreky postupne odumierali. Študovali sme, 1) či húsenice a vajíčka motýľov úspešne prezimujú na konároch smrekov vyvrátených touto

víchricou a či húsenice môžu na nich dokončiť svoj vývin; 2) či na vyvrátených smrekoch sú prítomné húsenice obvykle sa vyskytujúce na živých stojacich stromoch; 3) či sa spoločenstvá zimujúcich vývinových štádií motýľov na vyvrátených smrekoch v hornej časti koruny odlišujú od spoločenstiev v strednej časti koruny. V máji r. 2005 sme odobrali konáre z 12 vyvrátených dospelých smrekov v Tichej doline (1 020–1 050 m n. m.). Z každého stromu sme odrezali 30 polmetrových konárov z hornej a 30 polmetrových konárov zo strednej časti koruny. Okrem toho sme z konárov odobrali 400 šišiek. Konáre aj šišky sme umiestnili do fotoeklektorov v laboratóriu. Húsenice alebo imága vyliahnuté vo fotoeklektoroch sme z nich pravidelne odoberali. Takýmto spôsobom sme zistili prítomnosť húseníc jedného druhu vyvíjajúceho sa v šiškách (*Cydia strobilella*) a na vzorkových konároch 3 druhy žijúce v púčikoch (*Argyresthia glabratella, A. amiantella, A. bergiella*), 7 druhov spriadajúcich ihlice (*Batrachedra pinicolella, Chionodes electella, Syndemis musculana, Dichelia histrionana, Pseudohermenias abietana, Epinotia tedella, E. nanana*), jeden voľne žijúci druh živiaci sa ihlicami (*Thera variata*) a jeden druh živiaci sa lišajníkmi a riasami (bližšie neurčený, čeľaď Psychidae, podčeľaď Naryciinae). Motýle zimujúce v štádiu vajíčok reprezentoval na vzorkových konároch jediný druh – *Zeiraphera griseana*. Na vyvrátených smrekoch sme zistili všetky druhy motýľov, ktoré sa v jarnom období často vyskytujú aj na žijúcich stojacich smrekoch. Druhy spriadajúce ihlice zimujúce v larválnom štádiu boli prítomné vo väčšom počte jedincov na vzorkových vyvrátených stromoch v hornej časti korún v porovnaní so strednou časťou ($p < 0,05$, Wilcoxonov test). Pri húseniciach žijúcich v púčikoch sme takýto rozdiel nezistili. Počet jedincov ostatných potravných skupín bol nízky a neumožňoval štatistické porovnanie. Na vyvrátených stromoch s vysokou pravdepodobnosťou úspešne dokončili svoj vývin druhy zimujúce na konároch smrekov v larválnom štádiu (13 druhov). Naproti tomu väčšina lariev *Z. griseana*, ktoré sa vyliahli z vajíčok na jar, pravdepodobne zahynula pre nedostatok potravy na postupne usychajúcich vyvrátených smrekoch. Húsenice tohto druhu sa živia pletivami v otvárajúcich sa púčikoch, mladými ihlicami a výhonkami.

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