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Use of anti-attractants in specific conditions of protected areas

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Abstract
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Tests for protection of spruce forest stands against spruce bark beetle (*Ips typographus*) by using anti-attractants were performed in specific conditions of protected areas in which standard sanitary cutting is not allowed. The experiments have shown that application of anti-attractants in a no-cutting zone can significantly reduce bark beetle attacks on the standing trees. In case when the trees at stand edges are not damaged by wind, there is possible to reduce the tree mortality by up to 73%, even in case of large bark beetle populations and even in living green trees growing immediately next to trees attacked by spruce bark beetle. On the other hand, anti-attractants are ineffective at stand edge segments either damaged by freshly wind-thrown or broken trees or wedged with wind-thrown areas, as it was shown in semi-application tests in the NP šumava.

Key words
anti-attractants, *Ips typographus*, Norway spruce

Introduction

Protection of spruce stands edges against attacks of spruce bark beetle *Ips typographus* L. (Coleoptera: Scolytidae) is a serious problem in managed forests. Beside cutting and sanation of infested trees, barriers of pheromone traps can considerably reduce tree mortality in such areas (Jakuš, 1998). Jakuš and Dudová (1999), Jakuš et al. (2003) and Schiebe et al. (2011) demonstrated a significant reduction of bark beetle attacks after applying one dose of a complex blend of NHV (non-host volatiles) and verbenone on protected trees in combination with pheromone trap barrier (push and pull system). Bark beetle outbreaks represent a serious problem in protected areas where only limited interventions are allowed, and, in many cases, tree mortality requires to be reduced without sanitary cutting (Jakuš et al., 2009).

Practical application of new methods for bark beetle control based on anti-attractants has been pioneered in N. America, mostly for pine bark beetles of the genus *Dendroctonus*. Salom et al. (1998) and Clarke et al. (1999) elaborated a reliable anti-attractant (verbenone) based technique for the protection of standing pine trees against the southern pine beetle (*Dendroctonus frontalis* Zimm., Coleoptera, Scolytidae) in conditions of North America. This technique includes protections of forest stands without sanitary cutting.

The aim of this paper is to show the results of an experiment and semi application tests for spruce forest edges protection by applying anti-attractants in specific conditions of protected areas, where standard sanitary cutting is not allowed.

Material and methods

1. Experiment – lokality Žerucha
(the Tatra National Park, Slovakia)

We established five pairs of experimental plots in the Tatra National Park (TANAP), the locality "Žerucha" (GPS 49°09‘02“ N, 19°53‘29“ E) at altitudes ranging from 1,100 to 1,200 m above the see level (a.s.l.) in early spring 2008. The plots were situated at stand edges created by a wind storm in November 2004.

The downed trees were removed. The sanitary cutting of standing trees was not allowed. There was a large source of migrating bark beetles from the neighbouring spruce stands where neither sanitary cutting nor removing of the downed trees was allowed. Each pair of experimental plots consisting of a treated and a control segment (zone). The two segments were separated with a non-evaluated strip, min 10 m in wide. Each segment comprised 10 dominant or codominant spruce trees in the first line and 10 trees of the same status in the second tree line from the stand edge (Fig. 1). Experimental stands were 70–100 years old and forest edges were oriented to the south-east. The trees attacked one year earlier had not been removed. The experimental plots were established in an area affected by a bark beetle outbreak in the no-management zone of the National Park. The whole forest edge was protected with a barrier of pheromone traps (Jakuš, 1998). Three coupled pheromone traps ECOTRAP (Fytofarm, Ltd.) were used in one position. The distance between the positions was approximately 20 m. Pheromone dispensers IT ECOLURE Extra (Fytofarm, Ltd.) containing primary attractants were used.

In the treated zones, the stems of dominant or codominant trees at the active stand edge (together 20, see above) were provided with dispensers of anti-attractants IT-REP (Fytofarm, Ltd.) (Fig. 1). The IT-REP is a wick dispenser (Varkonda, 1996) with a combination of NHV; racemic trans-conophthorin (tC), GLV (1-hexanol) and bark C8 alcohols (1-octen-3-ol, 1-octanol), and the old-host bark compound (S)-(–)-verbenone (Vn). The estimated dispenser performance was 8 weeks. Each treated tree had two dispensers attached to the trunk at the shadow side, one at 2 m and the other at 6 m above the ground. The dispensers had been installed before the bark beetles attacked the stand edge. After the end of the growing period, all dispensers were removed from the tree stems.

The experiment was evaluated by comparing the bark-beetle-caused tree mortality between the treated and control zones of experimental plots (Jakuš et al. 2003, Schiebe et al., 2011). For statistical evaluation, assumptions for use of parametric statistics were tested (Shapiro-Wilk test and Levene test; Underwood 2001). The data that did not comply with the assumptions were processed with the nonparametric Kruskal-Wallis test followed by Mann-Whitney U test. All statistical calculations were done using the Statistica 5.5 software.

2. Semi application tests
(NP Šumava, the Czech Republic)

In 2008 we tested anti-attractants in two localities situated in the National Park Šumava (Czech Republic). It was not possible to establish control (untreated) plots in these localities.

a) Description of experimental localities:
   – Locality "Prameny Vltavy" (springs of the Vltava river, GPS 48°58‘29“ N, 13°33‘34“ E): 400 treated trees at a south-facing mature spruce forest edge created by a windstorm (Kyril) and partially by sanitary cuttings at altitudes ranging from 1,200 to 1,260 m asl. The locality is situated on a mountain plateau. Most of forest edges are adjacent to the windblown area. Bark beetles colonized the wind blown spruces in the previous year. In 2008 bark beetles started to attack the standing trees. In all accessible areas, barrier of pheromone traps was installed. The distance between the traps was approximately 20 m. There were used pheromone traps of a "Theysohn" type.
   – Locality "Kalamitní svážnice" (a calamity skidding road, 48°47‘18“ N, 13°49‘31“ E): 350 treated trees at a west-south-facing mature spruce forest edge resulted from sanitary cuttings in previ-

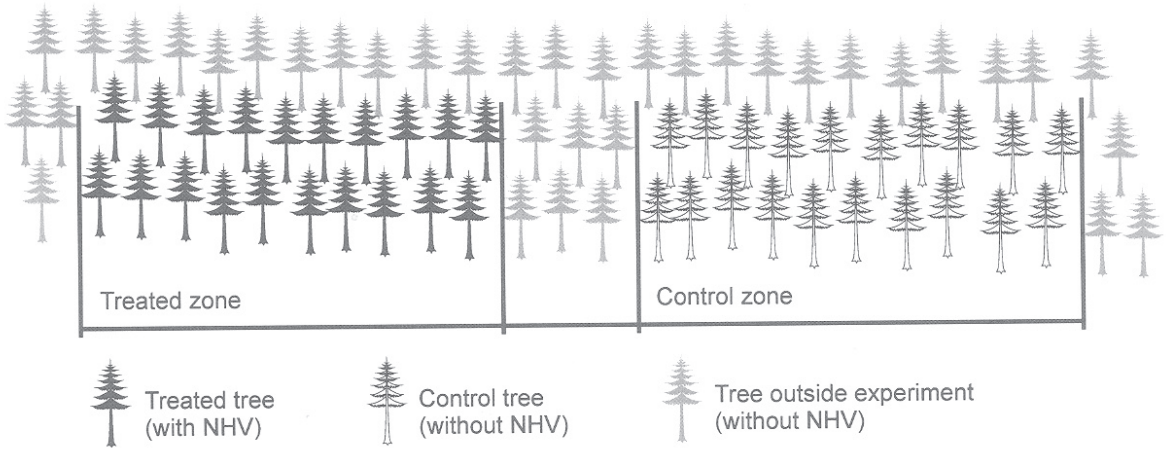

Fig. 1. Experimental design for testing of anti-attractants.

ous years, at altitudes ranging from 1,050 to 1,120 m a.s.l. The locality is situated on a north-facing slope close by a gale disaster area at a distance of 100 m. Bark beetles colonized wind blown spruce trees in the previous year. In 2008, bark beetles started a massive attack to standing trees.

b) Methods of application
Dispensers with anti-attractants were installed in the same way as in the locality Žerucha. Unlike in the test in the locality "Žerucha", there were treated the entire stand edges. Considering the results of the preceding experiments, the line (zone) of treated trees avoided freshly windthrown and broken trees (Fig. 2). The treatment of trees situated immediately by the windthrown and broken trees had no protective effect against attacks of spruce bark beetle.

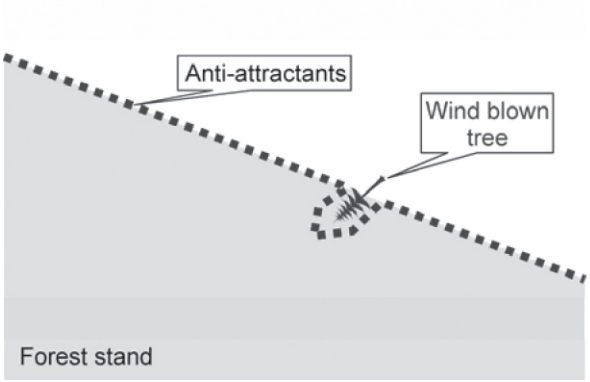

Fig. 2. Treatment of forest stand edge with anti-attractants (semi-application tests).

In some cases, the edge of forest stand was not regular, and the treatment would have required applying much more dispensers with anti-attractants. In these cases, we only treated compact stand parts without promontories (Fig. 3).

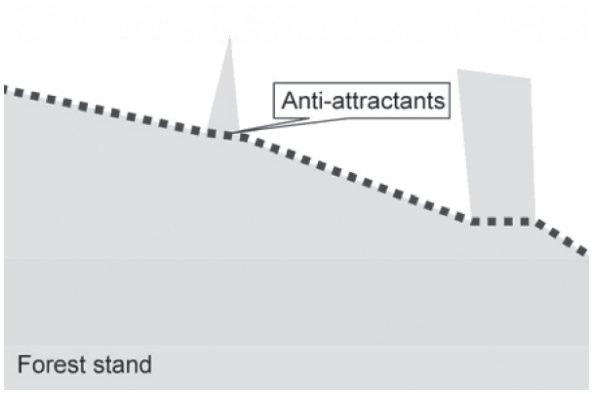

Fig. 3. Treatment of irregular forest stand edge with anti-attractants (semi-application tests).

Where it was possible, pheromone trap barriers were installed near the treated stand edges.

c) Methods used for detailed evaluation
Primary units for field observations were one-tree-narrow sections of the stand border perpendicular to the stand edge. The first and the second tree from the stand edge were treated with anti-attractants. The basic units were monitored for insect attack and for penetration of the attack inside the stand.

Results

1. Experiment – locality Žerucha

The bark beetle attack on the stand edges in the zones treated with anti-attractants was significantly reduced by up to 73% comparing to the control (Fig. 4). Population size of the spruce bark beetle as well as the history of its swarming in the locality "Žerucha" are characterised with data representing the average numbers of individuals collected from pheromone traps in the studied localities (Fig. 5).

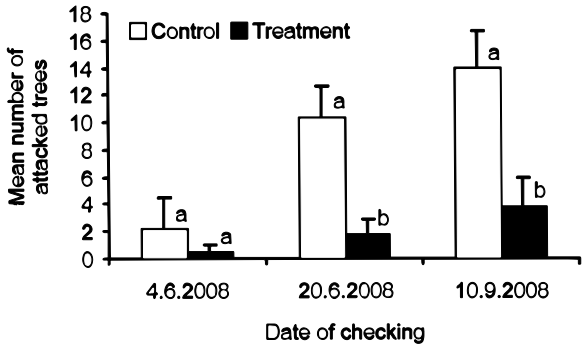

Fig. 4. Results (means and SEs) of experiment in locality "Žerucha". Bars with the same letter are not different according to the Mann-Whitney U-test.

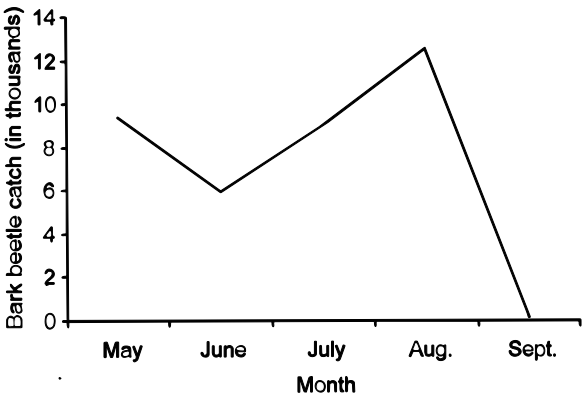

Fig. 5. Average trap catch of pheromone traps (142 traps) in the locality "Žerucha" (experiment).

2. Semi application tests

a) Description – general
   i) Spruce bark beetle has neither attacked the treated trees nor crossed the defence line (barrier) at the stand edge distant more than 5 m from areas with attractive windthrown or broken trees.
   ii) Bark beetle has exceeded the defence line and penetrated 20 m inside the stand edge in areas:
      – directly adjacent to the windthrown area. In these areas, the windthrown trees (their crowns) did not cross forest edge or penetrate inside the stand (Fig. 6).
      – in areas around individual windthrown trees (their crowns), where their crowns crossed forest edge and penetrated inside the stand.
   iii) Spruce bark beetle attack has penetrated across the barrier up to several tens meters inward the stand in these cases:
      – windthrown trees from a calamity area were wedged into the protected stand edge. The trees have been attacked since 2007.
      – the stand edge was impaired by attractive windthrown or broken trees up to several tens meters inwards the stand.

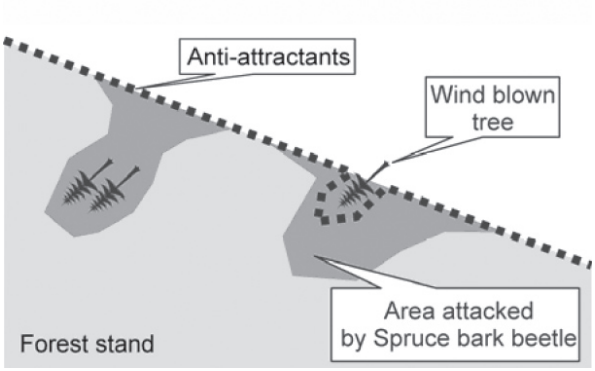

Fig. 6. Bark beetle attack at the forest stand edge with freshly wind thrown and broken trees treated with anti-attractants (semi-application tests).

b) Description – according to localities
   i) Locality: Prameny Vltavy
   Bark beetle has exceeded the defence barrier with anti-attractants in an area adjacent to a windthrow. In the lower part (by the road), the invasion reached to a 50 m distance from the stand edge, in the central, it was 15 m. In the upper quarter of the locality, the treated stand edge has not been exceeded.
   ii) Locality: Kalamitní svážnice
   Spruce bark beetle has crossed the barrier with anti-attractants and invaded the stand up to 50 m inwards close to attractive windthrown or broken trees (Fig. 6).

c) Analysis of the bark beetle attack
   Figures 7 and 8 present the results of analysis of invasion on stand edges treated with anti-attractants in spring 2008. There were monitored invasions up to the end of July 2008 – period of effective performance of the dispensers. The figures inform about percents of non-attacked stand edge, percents of stand edge with attacked treated trees in the first or in the second tree line and percents of treated line exceeded by the beetles inside the stand.

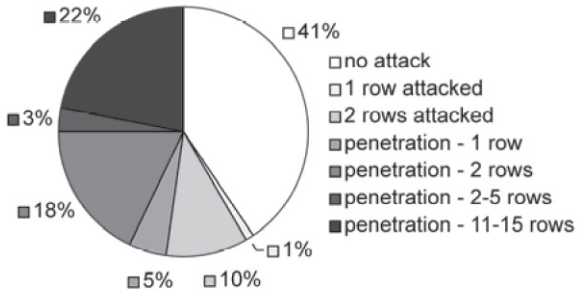

Fig. 7. Result of semi-application tests in locality "Prameny Vltavy".

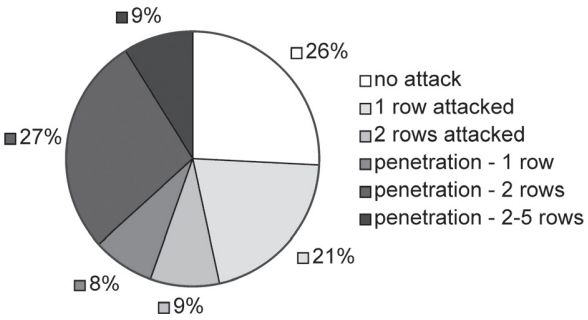

Fig. 8. Result of semi-application tests in locality "Kalamitní svážnice".

d) Population size in the localities
   Population size of the spruce bark beetle as well as history of its swarming in the NP Šumava are characterised with data representing average numbers of individuals collected from 5 randomly selected traps placed across the studied localities (Fig. 9).

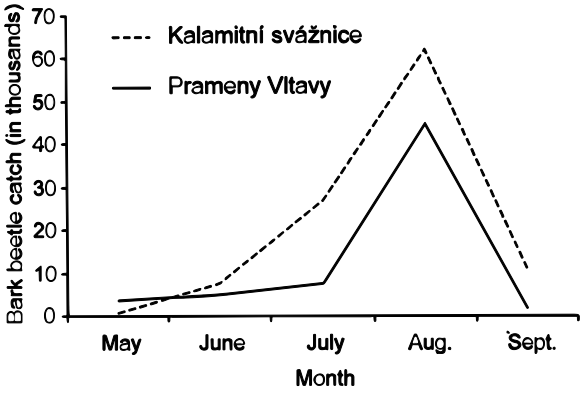

Fig. 9. Average trap catch in 5 randomly selected pheromone traps in the studied localities in NP Šumava (semi-application tests).

Discussion

The experiment in the locality "Žerucha" has shown that application of anti-attractants in a no-cutting zone can significantly reduce bark beetle attacks on the standing trees. In case when the trees at stand edges are not damaged by wind, there is possible to reduce the tree mortality by up to 73% even in case of large bark beetle populations and even in living green trees growing immediately next to trees attacked by spruce bark beetle in previous year. These results are comparable to the results of experiments in the managed forests (Jakuš and Dudová, 1999; Jakuš et al., 2003 and Schiebe et al., 2011). No total protection of the treated forest edges could be attained. However, no conventional method, except possibly massive insecticide applications, gives a total protection.

On the other hand, anti-attractants are ineffective at stand edge segments either damaged by freshly windthrown or broken trees or wedged with windthrown areas, as it was shown in semi-application tests in the NP Šumava. The semi-applied tests in the NP Šumava lack the data allowing us to hypothesize about development of situation in case without application of anti-attractants. The effect was only possible to estimate based on the size of the area inside the stand invaded by bark beetles through the protective barrier. The important factor influencing tree mortality was very high populations of bark beetles emerging from neighbouring or near situated wind blown trees. The bark beetle population in experiments localities in NP Šumava was much higher than in locality "Žerucha".

According to experience obtained during field experiments, the most suitable timing for installation of dispensers is before spring swarming of bark beetles. The effect of the method is the strongest during the spring swarming (Jakuš and Dudová, 1999). Installation in summer can cause problems. In this period, active attack trees can be just present at active stand edges. If such trees were neither cut and sanitized nor removed, the efficacy of the stand edge protection would not be guaranteed any longer. Some attacked trees could be not identified in time of anti-attractant application. Installation of anti-attractant dispensers on such trees could also cause inefficiency of forest edge protection.

Conclusions

Application of anti-attractants in localities with non-destructive management cannot give 100% protection against bark beetle attacks. Anti-attractants are ineffective at stand edge segments with either freshly windthrown or broken trees or wedged with windthrow areas. On the other hand, in case when the trees at stand edges are not damaged by wind, there is possible to reduce the tree mortality by up to 73% even in case of large bark beetle population and even in living green trees growing immediately next to trees attacked by spruce bark beetle.

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Aplikácia anti-atraktantov v špecifických podmienkach chránených území

Súhrn

V roku 2008 sme v bezťažbových zónach chránených území uskutočnili testy a poloprevádzkové pokusy aplikácií anti-atraktantov na ochranu okrajov smrekových porastov pred náletom lykožrúta smrekového (*Ips typographus*). Pokusy ukázali, že pomocou anti-atraktantov je možné znížiť nálet na porastové steny v bezťažbových zónach až o 73 % v porovnaní s plochami bez aplikácie anti-atraktantov. Aplikácie boli účinné aj v prípade veľmi veľkej populácie lykožrúta smrekového a aj v prípadoch, keď ošetrované stromy susedili so stromami obsadenými v predošlom roku. Na druhej strane, anti-atranktanty nefungujú v prípadoch, keď sa čerstvé vývraty alebo zlomy nachádzajú priamo v ošetrovanej porastovej stene.

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