Spruce Bark Beetle (*Ips typographus* L.) Risk Based on Individual Tree Parameters

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Abstract – Spruce bark beetle (*Ips typographus* L.) under normal population conditions prefer to colonize dominant (Kraft class 2), larger (taller, of bigger diameter, with thicker bark) and undamaged (except for root rot) Norway spruce trees (*Picea abies* Karst.).

I. Introduction

Damage by spruce bark beetle is recorded, on average, on a few thousand ha of spruce forests every year in Lithuania, with heavy outbreaks repeating every 8-10 years. The last large outbreaks were recorded in 1970-73 (with 6000-6500 ha annual damage) and in 1984-85 (5000-5300 ha/year). Heavy wind throws in 1993 (about 3 million m^3) and climate anomalies (droughts) provoked the heaviest epidemics of spruce bark beetle (*Ips typographus* L.) in 380 thousand ha and resulted in the harvesting of 8 million m^3 of dead trees. Nearly 20 thousand ha were clear-cut by the end of outbreak in 1997 [1]. It is clearly seen that sporadic (situational) forest protection measures, applied to control pests and diseases, have been insufficient and could not effectively improve forest health in Lithuania. Recent pest and disease management appear to be inadequate, and therefore modern forest health management strategies should be developed, with monitoring and predicting disease/pest occurrence and impact on forest ecosystems the objectives of highest priority. Although the spruce beetle *Ips typographus* (L.) is the most important secondary pest of Norway spruce (*Picea abies* Karst.) in Lithuania [2] and in most of Europe, no methods of predicting tree or stand susceptibility and outbreak risk have been developed for this species.

II. Methods

A ”network,” consisting of 106 test plots, scattered all over the country in pure mid-aged (ca 80 years old) spruce stands, was established in 2000-2002. Test plots represented fixed radius 0.02 ha plots, established to enclose at least one bark beetle freshly attacked tree. All spruce trees in the plot, belonging to main store, were sampled for status (live, freshly attacked, damaged by other agents, etc.), height, diameter at breast height, bark thickness, and tree social position in the stand (Kraft class – superior, dominant, co-dominant, intermediate, overtopped). All *Ips typographus* infested and selected representatives of all tree social classes were sampled with an increment borer for phloem, sapwood thickness and stem rot presence. Significance of differences in measured variables between attacked and healthy trees was evaluated using Student-t, for quantitative data, and chi^2 statistics for qualitative variables [3].

III. Results and discussion

Three-hundred-forty-three of 925 spruce trees (37.1%) sampled in 106 test plots, were colonized by *Ips typographus*. However, distribution by social position class was different among successfully attacked and healthy trees (table 1). Approximately 10% of *Ips* attacked and healthy trees were categorized as uperior trees (table 1). In contrast, approximately 70% of *Ips* attacked trees were dominant (Kraft class 2) trees whereas trees in this class comprised only 48.6 ±2.1% of healthy trees. Co-dominant tree (Kraft class 3) accounted for approximately only 18% and 39% of attacked and healthy trees, respectively (table 1). Even though test plots were established on managed forests where there were few intermediate and overtopped spruce trees (Kraft class 4 and 5) , our data suggests that a lower proportion of these trees are attacked by *Ips* (table 1).

On average,attacked trees were taller, had a larger diameter (DBH) and thicker bark than healthy trees (table 2). Phloem thickness and sapwood areas had no effect on spruce tree preference by *Ips typographus*. However, trees damaged by root rot were more susceptible to bark beetle attacks; all other damage (broken or dry top, defoliation, etc.) seems to decrease spruce suitability to *Ips typographus* (table 2).

TABLE 1
Distribution of spruce by tree social position in the stand

Tree status	*Ips* attacked		healthy trees		
superior	35	10,2 ±1,6%	58	10,0±1,2%	n.s.
dominant	240	70,0 ±2,5%	283	48,6±2,1%	***
co-dominant	61	17,8 ±2,1%	225	38,7±2,0%	***
intermediate	4	1,2 ±0,6%	16	2,7±0,7%	*
overtopped	3	0,9 ±0,5%			n.s.
Total	343	100,0 %	582	100,0%	

significance of difference: * – chi^2

It is universally agreed that endemic spruce bark beetle populations attack and successfully colonize only weak and/or suppressed trees [4]. Distribution of colonized trees by social position in our research does not support this idea. Although a similar percentage of attacked and healthy trees were in the superior tree class, dominant trees were more frequently attacked, and co-dominant trees were definitely less attractive (or more resistant) to *Ips typographus*. The trend of lower attractiveness of suppressed trees was also evident.

TABLE 2
Characteristic of *Ips* attacked and healthy spruce trees

	Ips attacked	healthy	
Tree height, m	31.9±0.6	23.9±0.4	***
Tree diameter, cm	23.0±0.3	19.2±0.3	***
Bark thickness, mm	8.7±0.2	7.9±0.1	***
Phloem thickness, mm	3.5±0.2	3.8±0.1	n.s.
Sapwood thickness, mm	57.7±3.2	49.7±2.8	*
Top damage frequency, %	2.3±0.8	8.2±1.5	##
Stem rot frequency, %	5.5±1.2	2.0±0.5	###
Other damage frequency, %	3.5±1.0	5.3±0.9	#

significance of difference: * – Student-t, # – chi^2

Beetle preference for larger (i.e. higher and thicker), undamaged (except root rot) spruce trees also contradicts conventional understanding of spruce susceptibility to bark beetles. The exception of root rot damaged trees is understandable, as pioneer beetles respond to tree volatiles. Nevertheless, it should be noted that the frequency of root rot and other kinds of damage was too low to allow one to make definite conclusions.

IV. Conclusions

Trees with dominant crowns (Kraft class 2) comprised 70.0 ±2.5% *Ips typographus* colonized spruce, but only 48.6±2.1 of non-attacked trees. Co-dominant trees (Kraft class 3) comprised 17,8±2,1% of trees colonized by *Ips* and 38,7±2,0% of healthy trees.

Attacked trees were larger (average height 31.9±0.6 m, diameter – 23.0 ±0.3 cm, bark thickness – 8.7±0.2) than healthy trees (average height 23.9±0.4 m, diameter – 19.2±0.3 cm bark thickness – 7.9±0.1 mm). Spruce trees damaged by root rot accounted for 5.5±1.2% of trees attacked by *Ips*, compared to 2.0±0.5% of healthy trees. Trees with other kinds of damage were less frequently attacked by spruce bark beetle.

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