Pests of Oriental Spruce Picea orientalis (Link) and measures to combat them

ABSTRACT:

The article addresses current issues related to the sanitary condition of fir (Abies) stands in Adjara affected by certain bark beetle pests, as well as the planning of control measures aimed at reducing their populations or achieving their complete eradication. For the purpose of conducting detailed and reconnaissance studies, permanent and temporary sample plots were established in various ecotopes of coniferous forests in Adjara, at different elevations above sea level, with varying stand density, age structure, productivity, and in pure as well as mixed forest stands, based on preliminary monitoring.

Long-term studies have shown that the deterioration of the sanitary condition of fir stands is mainly caused by stem pests belonging to the bark beetle family (Ipidae), namely the great spruce bark beetle *Dendroctonus micans* (Kug.), the European spruce bark beetle *Ips typographus* (L.), and the sharp-dentated bark beetle *Ips acuminatus* Gyll., as well as by wood-decaying pathogenic fungi, such as *Phellinus pini* var. *abietis* Karst (the causative agent of red heart rot of fir), the capped fungus honey fungus *Armillaria mellea*, and others.

The pathological condition of trees recorded on the selected sample plots was assessed in accordance with rules accepted in Georgia and international practice.

Model trees were selected within the sample plots, on which the following parameters were recorded: maternal entrance holes, nuptial chambers, number of young beetles, settlement density of males and females, production of *Dendroctonus* in cases of tree colonization, reserves, increment, reproductive energy, coefficient of polygamy, and other indicators. The data are presented in a table (Table 4).

The study revealed that effective results in fir stands against the European spruce bark beetle (*Ips typographus* (L.)), the sharp-dentated bark beetle (*Ips acuminatus* Gyll.), and the six-toothed bark beetle (*Ips sexdentatus* Boern., also known as the stenographer) are achieved through the implementation of biological and integrated control measures, including the installation of pheromone traps, the introduction of entomophagous insects—checkered beetles (*Thanasimus formicarius*)—and the application of sanitary cuttings. Against the great **spruce bark beetle** (*Dendroctonus micans*), effective measures include the introduction of entomophagous **insects—checkered beetles** (*Thanasimus formicarius*) and the great spruce rhizophagous beetle *Rhizophagus grandis*—as well as the implementation of sanitary cuttings.

Keywords: Entomophages, bark beetles (Ipini), signal pheromone, dieback gradient, bark beetle stock.

INTRODUCTION

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Eastern spruce *(Picea orientalis Link)* is endemic to Georgia. It is mainly widespread in Western Georgia, Samtskhe-Javakheti and Shida Kartli (in the Liakhvi Gorge). The general area of distribution includes the Western Caucasus and Asia Minor. According to the vertical distribution, it reaches the alpine border of the forest (2300 m). It is a mesophilic species that tolerates moisture, shade and cold. It forms both pure and mixed groves - together with fir, beech, pine, birch, poplar, hornbeam.

Within such a distribution range, the commercial value, taxonomic indicators (frequency, age class, stratification, quality class, order, etc.) and biological stability of spruce forests often change due to the influence of biotic and abiotic factors.

The deterioration of the sanitary condition of Eastern spruce stands, including the dieback of individual trees, group foci, or entire stands, is often caused not only by the infestation and impact of the great spruce bark beetle *(Dendroctonus micans Kugel.),* but also by the involvement of a wide range of secondary stem pests. These include: *Ips* +

MATERIALS AND METHODS

Permanent and temporary sample plots were established in natural-origin, structurally diverse forest stands of varying species composition, density, thickness, and productivity, located at different altitudes above sea level. To attract insects, pheromone-baited traps and insect-attracting trees were installed within these plots. Monitoring and observation of forest pests and diseases were conducted using approved and widely practiced forestry methodologies.

The study included analysis of:
– species composition,
– distribution range,
– settlement intensity on trees,
– damage caused by pest activity,
– dieback gradient,
– bark beetle stock and population growth,
– reproductive potential, and
– settlement density.

Certain bioecological traits and taxonomic identification of insect species were investigated under laboratory conditions.

The pathological condition of the inventoried trees within the selected plots was assessed according to standards accepted both in Georgia and in international forestry practice, using the following vitality classes:

I – Resistant (healthy);

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II – Decreased resistance (reduced vitality);
III – Lost resistance (non-vital).

Within and around the sample plots, the sanitary condition of recorded trees was categorized into six classes:

I – Healthy, without signs of weakening;
II – Weakened;
III – Severely weakened;
IV – Dying;
V – Recently dead (new snags);
VI – Old dead trees (from previous years).

Tree damage in the forest stand was evaluated according to the following severity scale:
– **Minor damage** – up to 10% of trees affected by pests;
– **Moderate damage** – 11–30% of trees affected;
– **Severe damage** – more than 31% of trees affected.

RESULTS AND DISCUSSION

Many years of research have shown that one of the main reasons for the spread of pests and diseases is abiotic factors, including climate change, atmospheric temperature, humidity, precipitation, prolonged droughts, excessive rains, etc., while biotic factors include human unintended agricultural activities, deforestation, thinning, damage and weakening of trees, and the illegal transportation of planting material, seeds, and timber from country to country, region to region, etc., which contributes to the spread of foreign, invasive pests and diseases as well as the expansion and multiplication of the area of pests and diseases existing within the country. There are frequent cases where the climatic environment of our country is very favorable for insects introduced from other countries, which is why they acclimatize and multiply quickly, as is clear evidence of the spread of the large spruce leafhopper and various bark beetles in the past, and today theevergreen Colchian boxwood borer, chestnut borer, etc.

In order to study the sanitary condition of spruce forests in 1999-2023, we have obtained significant material on forest pests and diseases, their bioecological characteristics, distribution area, settlement intensity on trees, and damage caused by their impact, as a result of monitoring carried out in the forests of Adjara in permanent and temporary sample areas allocated by us, in groves of natural origin, variety, different composition, frequency, thickness, and productivity, at different times of the year, at different heights above sea level, in permanent and temporary sample areas allocated by us to study the sanitary condition of spruce forests. In order to identify pests and diseases and study some biological features, studies were conducted in laboratory conditions.

The forest taxonomy indicators presented in the table below (Table №1, sample area №19) show that in the sample area and the adjacent forest area, spruce and fir form a

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two-story grove of high productivity I-II, rarely III quality, 0.6-(0.7) frequency, complex structure, where the settlement of pests and diseases and their harmfulness are not yet clearly manifested by symptoms. Symptoms of transition from healthy category I to weakened category II are observed in the sample area and its adjacent territory, spruce needles are slightly twisted and small branches seem to have lost their vitality, water content is slightly limited, which is enough to consider that the weakening of individual trees in the grove has already begun and stability is gradually being violated. The height of the first floor for the fir tree is 30.07 meters, the height of the second floor is 22.0 meters, the height of the first floor for fir is 29.24 meters, the height of the second floor is 28.90 meters, the average diameter of the fir tree is 38.22 cm, fir is 41.32 cm, the age of the fir tree is 104 years, fir is 102 years, the cross-sectional area of the fir tree is 29 $m^2$and the stock is 380 m^3, while fir's stock is 8,44 $m^2$and 105,89 m^3..

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D	H	Spruce								H	Fir								D	H	Spruce in 2016							
		Number of trees				Cross-sectional area m2	Total cross-sectional area m2	Stock m3	Total stock m3		Number of trees				Cross-sectional area m2	Total cross-sectional area m2	Stock m3	Total stock m3			Number of trees				Cross-sectional area m2	Total cross-sectional area m2	Stock m3	Total stock m3
		lumber	Half lumber	Firewood	Total						lumber	Half lumber	Firewood	Total							lumber	Half lumber	Firewood	Total				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
12	12	3	2	1	6	0,01	0,07	0,07	0,40	-	-	-	-	-	-	-	-	-	4	3,5	-	-	28	28	0,001	0,04	0,01	0,25
16	14,5	1	2		3	0,02	0,06	0,15	0,45	-	-	-	-	-	-	-	-	-	6	5,8	-	-	19	19	0,003	0,05	0,01	0,19
20	17	3	1	1	5	0,03	0,16	0,27	1,35	-	-	-	-	-	-	-	-	-	8	10,5	7	5	2	14	0,005	0,07	0,01	0,18
24	19	5	1	3	9	0,05	0,41	0,44	3,96	20,5	4		1	5	0,045	0,226	0,42	2,10	12	12	1	2	1	4	0,011	0,05	0,07	0,27
28	21	30	2	3	35	0,06	2,15	0,64	22,40	22,5	5			5	0,062	0,308	0,66	3,30	16	14,5	5	-	6	11	0,020	0,22	0,15	1,64
32	23	48	2	5	55	0,08	4,42	0,89	48,95	24	8	1	1	10	0,080	0,804	0,92	9,20	20	17	-	1	14	15	0,031	0,47	0,27	4,05
36	25	51	2	7	60	0,10	6,10	1,18	70,80	25,5	6	1	1	8	0,102	0,814	1,22	9,76	24	19	2	2	18	22	0,045	0,99	0,44	9,68
40	27	22	3	4	29	0,13	3,64	1,51	43,79	26,5	3			3	0,126	0,377	1,56	4,68	28	21	-	3	10	13	0,062	0,80	0,64	8,32
44	28,5	7	1	2	10	0,15	1,52	1,95	19,50	28	8	1	1	10	0,152	1,520	1,93	19,30	32	23	-	1	1	2	0,080	0,16	0,89	1,78
48	30,5	6	2	2	10	0,18	1,81	2,54	25,40	29	12	-	-	12	0,181	2,170	2,34	28,08	36	25	-	-	3	3	0,102	0,31	1,18	3,54
52	32	8			8	0,21	1,70	3,22	25,76	30	6	-	1	7	0,212	1,486	2,80	19,60	40	27	1	-	1	2	0,126	0,25	1,51	3,02
56	33,5	3		1	4	0,25	0,98	3,96	15,84	31	2	-	1	3	0,246	0,739	3,29	9,87	-	-	-	-	-	-	-	-	-	-
60	35	6	1	1	8	0,28	2,26	4,75	38,00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64	36,5	8		1	9	0,32	2,89	5,46	49,14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72	39	2	-	-	2	0,41	0,81	7,29	14,58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Σ		203	19	31	253	2,28	28,99	34,32	380	-	54	3	6	63	1,21	8,44	15,4	105,89	Σ		16	14	103	133	0,49	3,41	5,18	32.92

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Shuakhevi Forestry Administration, Oladauri Forest District. Composition: 8 spruce (Picea) : 2 fir (Abies);Young growth: 5 spruce : 4 fir : 1 Caucasian elm (Zelkova carpinifolia).Stand density (canopy closure): 0.6–0.7.Site quality class: I–II, occasionally III.Exposure: northeast (NE).Slope inclination: 11°–20° and steeper.Stand structure: multistoried, age 100–120 years.Elevation: 1550 m above sea level.Soil depth: medium, 31–60**cm.**

In 2007-2008, the sanitary situation in the sample area and its surrounding area changed. Although we still do not have any dead trees, out of 253 spruce trees, 60 trees (24%) of various ages belong to

Classification of healthy and damaged trees in the sample area

Table №2

Species	Total number of trees recorded	Healthy and damaged trees By category						Total IV+V+VI	Inhabited by insects and fungi, among others	Among them				
										Name of a harmful insect%		Beneficial insect.%		Populated by mushrooms
		I-Health. No signs of weakness.	II-weakened	III-Severely weakened	IV-withered	V-new bone dry	VI –last year's none dry			ge spruce leafhopper-%	Ips typographus%	Rhizophagus	Formicarius	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Spruce	253	100	42	45	27	26	13	66	153	150	3	3	-	15
%	100 %	39%	17%	18%	11%	10%	4%	26%	60%	99%	1%	2%	-	6%
Fir	63	40	9	2	2	5	5	12	-	-	-	-	-	5
%	%	63%	14%	3%	3%	8%	8%	19%	-	-	-	-	-	8%
total	316	140	51	47	29	31	18	78	153	150	3	3	-	20
	100%	44	16	15	9	10	6	31%	60%	99%	1%	2%	-	6%

III-IV (II)-category, the bark is heavily openwork, the needles are light green or yellowish-green, it is compacted and needle loss is observed, the spruce leafhopper is inhabited, and here and there a weak settlement of other pests and mushroom fruiting bodies are observed.

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Photo.1. Spruce-pine forests 2006 Photo.2. Spruce-pine forests 2013 Photo.3. Spruce-pine forests 2023

The number of bark beetles on different parts of the tree trunk varies. The number of large spruce leafhopper on the roots and from the root collar to a height of 3 meters of the trunk is 45.5%, from 3 to 5 meters 25.5%; from 5 to 10 meters 11.4%; from 10 to 15 meters 4.8%; from 15 to 20 meters 3.4%; from 20 to 25 meters 1.1%; from 25 to 30 meters 0.3%;

The high intensity of insect infestation on the roots is dangerous in terms of reinvasion, as it is difficult to control.





a b c





d e f

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Photo. 3. Symptoms of infestation and impact on a large spruce tree: a) bark lesions, b) funnel-shaped formation of resin, c) floury gnawing at the root neck, d) leafhopper worm and beetle, e) leafhopperbeetles burrowing into the resin, f) mother lode

To recognize a pest infestation on a tree, it is enough to observe the tree trunk (or exposed roots), where we will definitely notice variously shaped entrance holes and signal passages, as well as variously colored bark and sapwood (Photo 3.c.), the color of which depends on the species of insect and its location in the tree trunk.

For example, if the spruce leafhopper has just started to make an entrance hole and is still in the bark, then the color of the spray is dark brown or yellowish brown, and if part of the bark is finished and in the bark, then the spray is already white or yellowish white, often the entire pyramidal shape of the spray is smeared with resin and hardened and is located near the hole (photo.3.b.). The entrance holes of the beetles on the bark of the tree trunk from the outside, measuring 3-5 mm (often more or less), are slightly inclined from bottom to top, which is convenient for the insect to expel the gnawed bark outside and to improve aeration inside the bark. The entrance holes of the beetles on the bark from the outside are often grouped close to each other (photo.3.a.). And inside the bark there are groove-like passages of various lengths and widths (photo 3.f.). With excrement, a small mixture of finely ground tree bark and sawdust, they are directed to the opposite side.

A model tree was selected in the sample area, the surface area of each individual cotyledon was determined according to the formulas (Table №3), on which the number of maternal entrances, nuptial chambers, number of young beetles, etc. were recorded, the data of which are given in the table (Table №4).

The results of the census of the spruce leafhopper and other harmful insects on the model tree

Table №3

H_0	1	3	5	7	9	11	13	15	17	19	21	23	25
D Barkless	35,32	32,89	30,89	28,84	26,82	24,51	21,80	18,50	16,49	14,20	11,85	9,39	8,12
b/s.a. M^2	222	207	194	181	168	154	137	116	104	89	74	59	18
Total area 1723 dm^2													

The number of young beetles on the corresponding section of the tree trunk is:

№1 young beetles - 90 and 16 pupa;

№2 young beetles - 72 flight holes 5 pcs;

№3 young beetles - 48 pcs.

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A 0.25 cm section was measured on both sides and the number of maternal entrances and nuptial chambers was recorded, which amounted to:

№1 32.89 cm 15 and 12 pcs.

The density of the settlement of males and females, as a weighted average value on the model tree, is: 3,71 $pcs./dm^2$.

List of spruce leafhoppers and other harmful insects on a model tree

Table №15

Insect settlement area, m	Length of the cotter pin m	Section of the settlement of the insect, m	Average diameter without bark	Palette №	Palette size				Quantity of pieces	
					Length in dm	Width, dm	Areadm²	Name of indicators	On the palette	dm²
1	2	3	4	5	6	7	8	9	10	11
	4,34	2,17	32,89	1	3	2	6	mating chamber	15	2,5
								maternal gallery	12	2
								Young beetle	90	15
								pupa	16	2,67
								Sick insect	**17**	**2,83**
13∂	4,34	6,5	26,82	2	3	3	3	mating chamber	11	1,83
								maternal gallery	9	1,5
								Young beetle	72	12
								Flying holes	5	0,83
								Sick insect	**14**	**2,33**
	4,34	10,83	21,80	3	3	3	3	mating chamber	9	1,5
								maternal gallery	6	1
								Young beetle	48	8
								Sick insect	**9**	**1,5**

The settlement density of young beetles (progeny) per palette amounts to:

Ppr = (90 + 16) / 6 = 17.7 individuals/dm².

The density of young beetles (production) on pallets 2 and 3 is determined in a similar way and all these data are entered into the table (Table No. 15, 16)

Dendrocton production in the case of settlement on a tree, as a weighted average value, is: 13,00 $pcs./dm^2$

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Dendrocton production is twice as high as the average (3,1-5pcs/dm^2) and is 13,06pcs/dm^2; **Stock**: 4114 pcs; **Increase** 14417 pcs;

Reproduction energy - 3.50

Polygamy coefficient 0.85

As for the bark-eating typographus, based on observations of model trees selected in the sample area, the population density of the female nest per 1 dm^2in the first phase of development was:

$Y_{settl.density\ ♂♀..} = 5,5$;

The number of nuptial chambers per 1 dm^2-2 is 2.9;

$P_{\text{pr}} = 22,3$; Reproduction energy 2.8.

In the second phase of development, the population density of males and females per 1 dm^2 of the female nest was:

$Y_{settl.density\ ♂♀..} = 2,9$;

The number of nuptial chambers per 1 dm^2 is 1.8;

$$P_{pr} = 11,3;$$

Reproduction energy 1.9.

CONCLUSION

Conclusion: Long-term research has determined that one of the main causes of the spread of pests and diseases is the abiotical and biotic factors, as well as the transport of planting materials, seeds, and timber without compliance with regulations.

The population density of bark beetles on tree trunks varies across different sections of the stem. For example, the population density of the large pine bark beetle is 71% on the roots and the root collar up to 5 meters in height of the trunk, while the remaining 29% are found above this height.

High infestation intensity on the roots is dangerous from the standpoint of reinvasion because it is difficult to control.

To identify bark beetle infestation on a tree, it is enough to observe the trunk (or exposed roots), where one will inevitably notice entrance holes of various shapes, tunnels inside, as well as different colored bark and resin debris, the color of which depends on the species of the insect and the location of the infestation on the trunk.

For example, in the case of the pine bark beetle, the entrance holes on the tree bark are 3-5 mm in size (often larger or smaller) and have a slightly slanted shape, from

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bottom to top. Inside the bark, there are tunnels of various lengths and widths, filled with excrement and a small mixture of fine-grained bark and resin, which extend in different directions.

The engraver beetle *(Ips typographus*) prefers smooth bark surfaces or bark cracks and begins creating an entrance hole vertically, from bottom to top. This hole is cylindrical and slightly tilted. Beneath the bark, the beetle creates a parental tunnel, the diameter of which is just slightly larger than the insect's body, so it only moves forward and ejects the sawdust with its tail.

The pine engraver beetle *(Ips acuminatus Fishh)*creates an entrance hole and a mating chamber. The male beetle moves from bottom to top and creates 2-mm wide and 40-cm long, star-shaped parental tunnels, filled with sawdust. The holes are deeply etched into the wood and bark.

The two-spined engraver beetle *(Pityogenes bidentatus Fabr)* creates 3-5 parental tunnels in a star-shaped pattern from the mating chamber, which are deeply etched into the bark. In the case of healthy and thick bark, the parental tunnels are weakly etched into the wood. The egg chambers on the sides of the parental tunnels are irregularly distributed. The exit tunnels are short, first heading into the bark, and then exiting through the wood.

The four-spined engraver beetle *(Pityogenes quadridens Hart)* – after mating, the female begins creating 3-5 parental tunnels, each 6 cm long, and digs out egg chambers, where she lays one egg per chamber, covering them with sawdust.

The six-spined engraver beetle, or stenographer *(Ips sexdentatus Boern*), also known as the large pine engraver beetle, has the male beetle create a wide mating chamber, from which the female beetle creates exit tunnels along the trunk. Typically, one tunnel leads up from the mating chamber, and two lead downward. Sometimes, the number of female exit tunnels reaches 4-5, with a length of 50 cm and a width of 3-4 mm. The beetle lays its eggs in the female exit tunnels, creating special egg chambers for them. The larvae that emerge from the eggs are whitish in color and create larval galleries along the trunk, which are short at first but widen toward the bottom (larval cavities). This is where the larvae pupate.

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