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INTRAPOPULATION CONTROL MECHANISMS IN POPULATION DYNAMICS OF EIGHT-TOOTHED BARK BEETLE

Entomological analysis of model trees that are inhabited by bark beetle *Ips typographus* L. in forest pest center of drying spruce in the Orsha-Mogilev forest growing region allowed us to determine population figures of the bark beetle and to analyze the dependence of some indicators from population density. It was found that population density can be alimiting regulator of the number of bark beetle among intrapopulation regulatory mechanisms in the population dynamics.

Introduction. Variation in population size in this or that extent is typical for xylophage insects and it is a self-regulated process which is controlled by natural mechanisms. In this connection, there are two groups of such mechanisms – modifying and regulating [1–3]. Modifying factors are not connected with population density, they usually provoke accidental difference in number and in general belong to abiotic. Control factors which actions depend on population density smooth arising variations and provide stability of population level. Control factors are biotic factors.

Xylophages belong to cryptic species of insects whose population level is first of all limited by the availability of feed supplies. That is why in the system of population control of such species intrapopulation control mechanisms predominate. Natural enemies at this play considerably lesser role [1, 2].

In Orsha-Mogilev forest area in 2012 further deterioration of sanitary condition of spruce plants took place as well as increase of xylophages influence on their weakness and drying off. In this connection we continued our research in this region [4, 5].

Revealing of peculiarities of the development and dynamics of trunk injurious organisms can lead to improvement of forest management methods and development of measures on health improvement of weakened spruce forests, increase of their resistance, improvement of sanitation condition, decrease of negative consequence of drying off.

Main part. In 2012 forest pathologic research of spruce stands of the III age class and older in four forest estate lands of SLHE "Orsha forestry" was carried out, the total area of which consisted of 12,000 ha. The results of the research showed that 56.9% of spruce stands preserve biological resistance, 35.0% of spruce forests belong to plantation with disordered resistance and 42% – to the plantation with lost resistance. In total, during the research it was revealed 235,270 m^3 of dead trees. 46.4% out of this figure is a current mortality, 43.0% – old dry wood, 10.6% – merchantable debris. The main reason of drying off is the influence of the complex "trunk injurious organisms – plant pathogenic fungi". Among trunk injurious organisms eight-toothed bark beetle has a dominant place. In total 10,211.4 ha of pest harborage area was revealed among which trunk injurious organisms area consisting mainly of eight-toothed bark beetle constitutes of 37.7%.

For characteristics of eight-toothed bark beetle population entomologic analysis of the trees inhabited by bark beetle was carried out [6, 7]. As a model brood spruce trees were used. Totally ten model trees inhabited by the first generation of eight-toothed bark beetle were tested. Model trees were selected in different by origin areas. The first area of trunk injurious organisms (No. 1) appeared as a result of unfavorable weather conditions and the second (No. 2) – across the fulfilled forest cutting, i. e. it may be said, it was created as a result of business activity. Population index of an eight-toothed bark beetle in areas is in table 1.

It should be pointed out that index of settlement density and production of a bark beetle in the area across the fulfilled forest cutting is much higher. Here settlement density of males, females and general is considered [6, 7] as "high" (correspondently 3.26 ± 0.67; 6.76 ± 1.52 and 10.03 ± 2.17 numb./dm^2). In the area of a bark beetle in spruce forests weakened under the influence of weather conditions index of density settlement of females and general – "medium" (correspondently 5.19 ± 1.50 and 7.79 ± 2.40 numb./dm^2). Index of production in the area across the fulfilled forest cutting is 1.5 times higher (23.32 ± 2.13 numb./dm^2 in comparison with 15.79 ± 7,85 numb./dm^2).

Thus, bark beetle areas forming in plantations as a result of business activity can differ even by higher index of population.

During the study of the peculiarities of the bark beetles development study of the intrapopulation mechanisms action in regulation of their population is very important. Action of these mechanisms at the significant extend is determined by the density of population of the current generation [1, 2].

Table 1

Population index of the first generation of an eight-toothed bark beetle depending on the origin of area in SLHE "Orsha forestry"

Index		Area No. 1		Area No. 2	
		n	$x_{cp} \pm t_{0,5}Sx_{cp}$	n	$x_{cp} \pm t_{0,5}Sx_{cp}$
Density of the settlement, num./dm^2	♂	6	2.60 ± 0.98	4	3.26 ±0.67
	♀	6	5.19 ± 1.50	4	6.76 ± 1.52
	general	6	7.79 ± 2.40	4	10.03 ± 2.17
Polygamy coefficient		6	2.05 ± 0.34	4	2.07± 0.11
Production, numb./dm^2		6	15.79 ± 7.85	4	23.32 ± 2.13
Bark beetles reserve, numb.		6	13.489 ± 7.246	4	16.879 ± 2.815
Bark beetles growth, numb.		6	26.347 ± 13.859	4	39.477 ± 6.676
Reproductive energy		6	2.05 ± 0.95	4	2.36 ± 0.51

For the analysis of interconnection of population index two forest estate lands were chosen: Mogilev [4, 5] and Orsha. Population indexes that were used for analysis are in table 2.

Dependence of production on settlement density of parents' generation of an eight-toothed bark beetle for Mogilev and Orsha forest estate lands is presented on figure 1 and 2.

In the SLHE "Mogilev forestry" index of production vary within wide limits (from 0.20 to 20.81 numb./dm^2). As it is seen dependence between the production and settlement density of parents' generation of the first life cycle of an eight-toothed bark beetle can be expressed by the power-function equation (fig.1).

That is at the increase of settlement, density increase of production is observed. Such dependence is observed at not high in general ("medium") density of settlement (6.35 numb./dm^2).

The different situation is in Orsha forestry (fig.2). Increase of production with settlement density growth goes to the point 6.64 numb./dm^2 (production constitutes 22.98 numb./dm^2), that is close to the maximal settlement density in Mogilev forestry (fig. 1), then its decrease is observed.

Reproductive energy is also closely connected with settlement density of parents' generation (Fig. 3 and 4).

So, dependence between reproductive energy and settlement density of parents' generation of the first life cycle of the bark beetle in Mogilev forestry can be expressed by the power-function equation, i. e. at the increase of settlement density (maximum 6.35 numb./dm^2) increase of reproductive energy is observed.

Connection of reproductive energy with settlement density in Orsha forestry can be expressed by the second degree spline. At the increase of settlement density to 5.79 numb./dm^2 increase of reproductive energy is observed. At this level of density reproductive energy is maximal and equals 2.57.

Then decrease of reproductive energy is observed. Thus, as in case of assessment of production dependence on settlement density, reproductive energy in population increases to certain indexes of settlement density (5.79–6.35 numb./dm^2), and the decreases.

At the stage of the beetles development under the bark intrapopulation regulation happens via females and namely due to variations of the length of the laying off collective feeding tunnels by females. Females activity is limited by the feed substrate availability.

Variations of the average length of collective feeding tunnels in connection with the density of females settlement in SLHE "Mogilev forestry" and SLHE "Orsha forestry" are presented in Fig. 5 and Fig. 6.

Table 2

Population index of the first generation of the eight-toothed bark beetle (SLHE "Mogilev forestry", 2011; SLHE "Orsha forestry", 2012)

Index		SLHE «Mogilev forestry»		SLHE «Orsha forestry»	
		n	$x_{cp} \pm t_{0,5}Sx_{cp}$	n	$x_{cp} \pm t_{0,5}Sx_{cp}$
Settlement density, num./dm^2	♂	19	1.99 ± 0.50	10	2.87 ± 0.58
	♀	19	3.21 ± 0.89	10	5.82 ± 1.04
	general	19	5.20 ± 1.33	10	8.68 ± 1.58
Polygamy coefficient		19	1.66 ± 0.24	10	2.06 ± 0.17
Production, numb./dm^2		19	6.60 ± 3.08	10	18.80 ± 4.89
Bark beetles reserve, numb.		19	5,644 ± 1,801	10	14,845 ± 3,957
Bark beetles growth, numb.		19	7,216 ± 4,322	10	31,599 ± 8,724
Reproductive energy		19	1.51 ± 0.81	10	2.17 ± 0.51

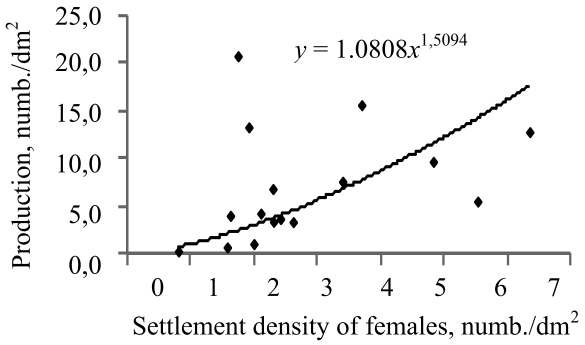

Fig. 1. Influence of settlement density on the production of the eight-toothed bark beetle (SLHE "Mogilev forestry")

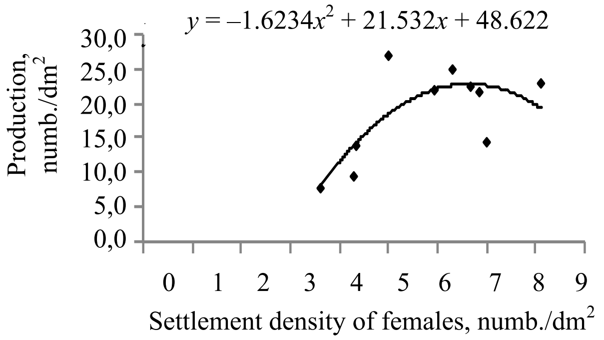

Fig. 2. Influence of settlement density on the production of the eight-toothed bark beetle (SLHE "Orsha forestry")

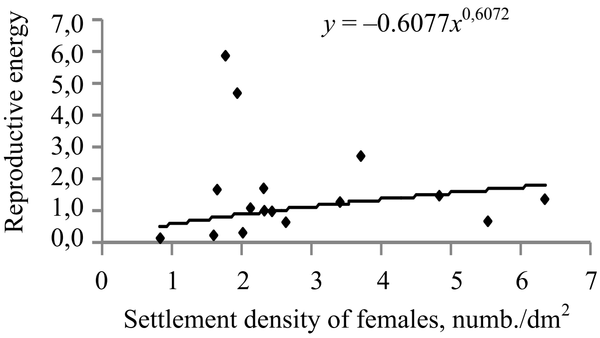

Fig. 3. Dependence of reproductive energy of bark beetle on settlement density (SLHE "Mogilev forestry")

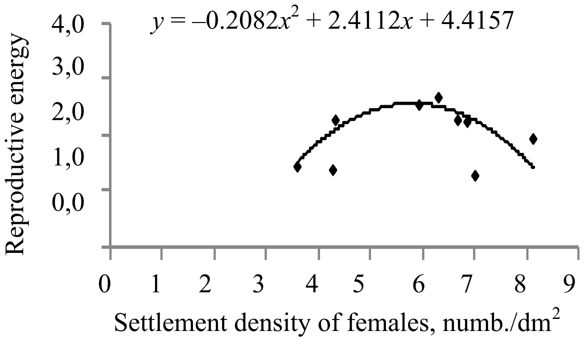

Fig. 4. Dependence of reproductive energy of the bark beetle on settlement density (SLHE "Orsha forestry")

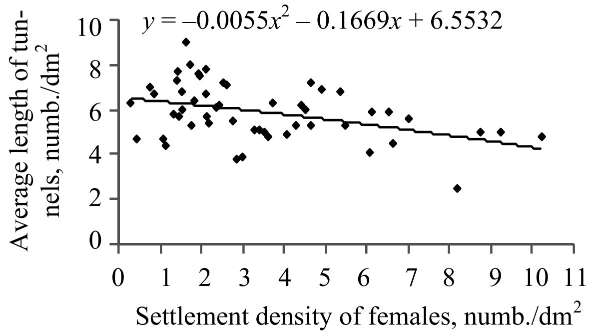

Fig. 5. Connection of average length of feeding tunnels and settlement density (SLHE "Mogilev forestry")

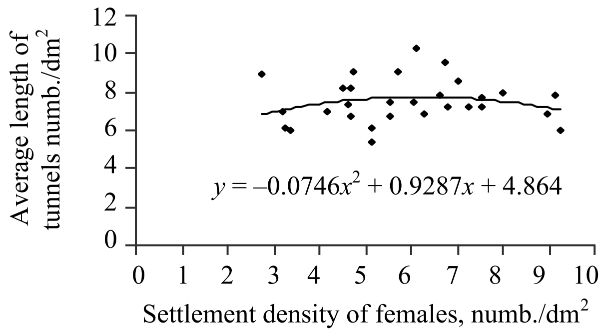

Fig. 6. Connection of the average length of collective feeding tunnels and population density (SLHE "Orsha forestry")

According to the diagram the average length of collective feeding tunnels decreases with the increase of settlement density of females. In Mogilev forestry an average length of the tunnels gradually decreases with the increase of settlement density of females. In Orsha forestry an average length of the tunnels increases to the settlement density of 6.2 numb./dm^2, i. e. to the density index, that plays a certain border role in the dynamics of the bark beetle population. Then length of the tunnels decreases.

As was mentioned earlier [4], a bark beetle inhabits trees of different diameters from 16 to 40 cm. Variability of settlement density of parents' generation of the bark beetle from the diameter of the inhabited tree is represented in Fig. 7 and 8.

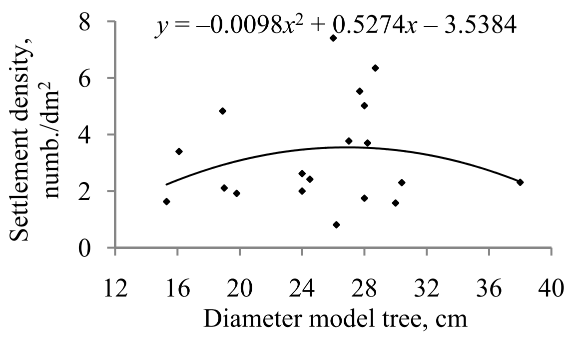

Fig. 7. Variability of settlement density of parents' generation beetles from the diameter of the tree (SLHE "Mogilev forestry")

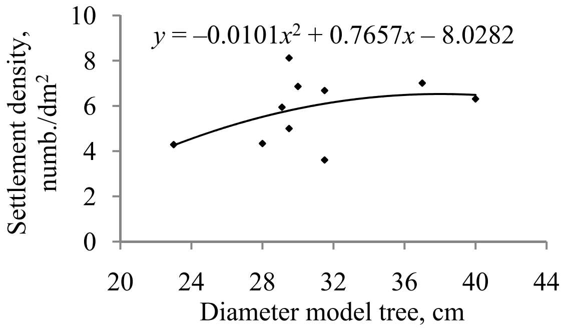

Fig. 8. Connection of settlement density of parents' generation beetles and diameter of a tree (SLHE "Orsha forestry")

Thus, in Mogilev as well as in Orsha forestry settlement density increases to a certain value of the tree diameter. In Mogilev forestry the maximal value of density was observed at infestation of the tree with the diameter of 27 cm and constituted 3.56 numb./dm^2. In Orsha forestry maximal density is 6.48 numb./dm^2 at the diameter of the tree of 38 cm. This permits to optimize the size (diameters) of trees while choosing of newly planted trees.

Conclusion. During the development of secondary insects population level is limited by the availability of food reserve. Thus, intrapopulation mechanisms play a basic role in population control. Depending on the settlement density intrapopulation control mechanisms provide optimal balance between population level and the amount of food resources. Assessment of the variability of a number of population indexes (production, reproduction power, average length of feeding tunnels) from settlement density helped to reveal that optimal conditions for the development of the bark beetle take place at the settlement density of females of 6–6.5 numb./dm^2, that simultaneously serves as border population control.

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