

Estimating the abundance of the typographer bark beetle in the spruce forests of the Republic of Tatarstan

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Abstract. The article provides an estimation of abundance the typographer bark beetle using barrier traps in the spruce forests of the Republic of Tatarstan. For the last 10 years, there has been the shrinkage of spruce forests throughout the Russian Federation due to adverse factors, primarily the weather. In the forests of the Republic of Tatarstan, the main reasons for the unsatisfactory condition of forest stands are forest diseases – 20,276.7 ha and weather conditions – 16,824.1 ha, corresponding to 51.7% and 42.9% of the area of all plantations with disrupted and lost stability. The research studies were carried out in the "Sabinskiy Forestry Enterprise" and "Lubyanskiy Forestry Enterprise" of the Republic of Tatarstan. According to our observations for the whole growing season, the largest number of beetles is concentrated on a site of pure plantings at the age of 40 years and is estimated at 1,645 pcs. On all three sites, the peak number of beetles takes place on July 5, 2019 corresponding to 3,684 pcs. In 2019, there was damping of some foci of this pest on 330.1 ha. At the same time, the new foci were identified, which accounted for 9.5% of the total area of bark beetle foci. As a result, at the end of 2019, the total area of foci of this pest in the forests of the Republic of Tatarstan was 1,018.9 ha, which is 28% less than the same indicator last year.

1 Introduction

One of the main forest-forming species in the northern regions of the Republic of Tatarstan is spruce. The key pest of the tree species is the typographer bark beetle, which is a common inhabitant of spruce forests. It settles on individual trees weakened by rot rose and other conditions, individual wind-damaged decayed trees that serve as reservations where the bark beetle population survives and remains in extremely low abundance [4].

The rapid growth of the typographer bark beetle population is facilitated by its ability to form sister and second generations in a single season. In years of sufficient moisture and lack of heat, the reproduction foci of the typographer bark beetles retain a local character and are connected directly to the places of wind damage to spruce forests and damp over 2-3 years after the occurrence.

However, in the zone of coniferous and broad-leaved forests, spruce forests are relative of the same age, so their damage by rotting diseases, wind damage, and weakening by droughts, which are aggravated by mass reproduction of the typographer bark beetles, are especially destructive. In this regard, numerous authors think that this zone is considered to be a zone of periodical pandemic breeding activity of bark beetles and associated with catastrophic drying of spruce [1–3, 5, 6, 11, 12].

The forests of the Sabinskiy and Lubyanskiy forestries belong to the zone of coniferous and broad-leaved forests. Therefore, monitoring the condition of spruce forests in the Republic of Tatarstan is considered relevant.

2 Objects and methods of research

The research studies were carried out in "Sabinskiy Forestry Enterprise" and "Lubyanskiy Forestry Enterprise" of the Republic of Tatarstan.

Barrier traps were used to catch bark beetles (The Guidelines for organizing and conducting forest pathology monitoring in Russian forests, 2000). In the region, forest areas where there is a real or potential threat of mass reproduction of bark beetles are selected for pheromone surveillance. In each point of accounting, 3 traps are set up; thus, it is enough to have up to 9-15 forest sites per region, and only up to 30 traps [7, 8, 10].

The objects of research were selected the areas of spruce plantations located in divisions N 99, 89, 19 of Lubyanskiy Forestry and N 79, 77 of Shemordanskiy Forestry. As objects of supervision in spruce stands the areas with spruce in the stand of at least 5 -6 units and 1-2 bonitets were selected. The object characteristics are presented in table 1 and Fig. 1.

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During the investigations, the traps were set up within the boundaries of the "Sabinskiy Forestry Enterprise" and "Lubyanskiy Forestry Enterprise".

Table 1. The characteristics of research objects

Object No., Division No.	Name of Forestry	Distinctive characteristic
No. 1 Division 99	Lubyanskiy Forestry Enterprise	the composition is 10E, the fullness is 0.9, the average age is 40 years, the average diameter is 18 cm, the average height is 16 m.
No. 2 Division 89	Lubyanskiy Forestry Enterprise	the composition is 9E1B, the fullness is 0.7, the average age is 33 years, the average diameter is 14 cm, the average height is 13 m.
No. 3 Division 19	Lubyanskiy Forestry Enterprise	the composition is 7E2B1Lp, the fullness is 0.8, the average age is 17 years, the average diameter is 8 cm, the average height is 8 m.
No. 4 Division 79	Shemordanskiy Forestry Enterprise	the composition is 3E2E3B2LP, the fullness is 0.7, the average age is 70 years, the average diameter is 28 cm, the average height is 24 m.
No. 5 Division 77	Shemordanskiy Forestry Enterprise	the composition is 2E1P1E1P3B2LP+OS, the fullness is 0.7, the average age is 90 years, the average diameter is 23 cm, the average height is 26 m.



Fig. 1. Object No. 2 Division 89

3 Results and discussion

For the last 10 years, there has been the shrinkage of spruce forests throughout the Russian Federation due to adverse factors, primarily the weather.

In the forests of the Republic of Tatarstan, the main reasons for the unsatisfactory condition of forest stands are forest diseases – 20,276.7 ha and weather conditions – 16,824.1 ha, corresponding to 51.7% and 42.9% of the area of all plantations with disrupted and lost stability.

In 2018 in the Republic of Tatarstan, the areas of pre-existing foci of the typographer bark beetle have decreased in some forestries, especially in "Arskiy Forestry Enterprise", "Mamadyshskiy Forestry Enterprise", "Sabinskiy Forestry Enterprise", mainly as a result of sanitary and recreational activities on a total area of 435,8 ha. Besides, there was damping of some foci of this pest on 228.9 ha. At the same time, the new foci were identified, the share of which in the total area of the foci of the typographer bark beetle was 5.5%. As a result, at the end of 2018, the total area of foci of this pest in the forests of the Republic of Tatarstan was 1,414.9 ha, which is 29.3% less than the same indicator last year.

The 2010 drought contributed to the emergence of primary foci of the typographer bark beetle and the development of an outbreak of its mass reproduction. At present, almost all foci of the typographer bark beetle are in the phase of crisis with partial damping in areas of fully developed plantations.

Table 2. The distribution of the areas of forest stands with the focal number of the typographer bark beetle by the degree of settling plantations in 2018

Name of Forestry	The degree of settling plantations, ha			Total
	11...20%	21...30%	more	

			than 30%	
Agryzskiy Forestry		131.0	77.3	208.3
Arskiy Forestry	153.2	172.7		325.9
Elabuzhskiy Forestry	8.4	113.1	212.4	333.9
Kamskiy Forestry	2.7	3.6	2.6	8.9
Kzyl-Yulduzskiy Forestry	4.1	1.7		5.8
Lubyanskiy Forestry	117.0	80.9	1.0	198.9
Mamadyskii Forestry	5.6	133.3	0.5	139.4
Sabinskiy Forestry	9.1	167.6		176.7
Total	300.1	803.9	293.8	1,397.8

Most of all foci (57.5% of the area) are characterized by an average degree of settlement and damage to plantings. 21.0% of foci are strongly abundant, while 21.4% are weakly abundant.

The well-timed and high-quality sampling of newly populated trees is the most effective way of destroying bark beetles. New perspectives in the fight against the typographer bark beetle were opened with the appearance of synthesized pheromones of this species and accompanying it the graver bark beetle, conifer ambrosia beetles.

The great experience in the practical application of pheromones to protect spruce stands from the typographer bark beetle was obtained during a prolonged outbreak of its mass reproduction (1971-1982) in Norway, Sweden, Finland, Germany, Denmark and France. On average, 4,800 pieces were caught per trap in 1979, 6,000 pcs – in 1980, 1,900 pcs – in 1981, 1,900 pcs – in 1982.

During the season, from 8 to 100,000 pieces of beetles were caught for 1 trap; the individual traps caught more than 20,000 the typographer bark beetles a day. In Russia, large-scale protective measures against the typographer bark beetle were not carried out by trapping beetles for pheromone, but there is some positive experience in the supervision and protection of some local areas of spruce plantations by T.P. Sadovnikov [9].

Based on meteorological data of the weather conditions in 2019 in the territory of the Republic of Tatarstan, the following conclusions can be drawn. In the winter of 2018-2019, there was an increased temperature regime, in general by 1-3° warmer than usual. The sum of effective temperatures above +5°C (since the beginning of the vegetation period) reached 320-400° by May, 31 at the normal

rate of 250-300°C. Last year, by the end of May, it was accumulated to 250-330°C. This indicates the favourable weather conditions for the beginning of the development of harmful insects. In general, during the summer of 2019, the average air temperature in most areas was about normal or below normal.

The sum of effective temperatures above +5°C (since the beginning of vegetation) on August, 31 was 1,360-1,580°C at the norm of 1,375-1,480°C (last year, 1,435-1,655°C), and 750-925 above +10°C at a rate of 755-835°C. In the autumn of 2019, the temperature regime was about normal or above normal (in November). In general, the weather conditions in 2019 were quite favourable for the development of insect pests.

The beginning of spring-summer of bark beetles can also be assessed by phenological signals that are similar for different geographical areas: budding of birch, spruce, rowan, raspberry, honeysuckle, red elderberry, the flowering of sour cherry and goat willow [5, 6].

The observations on the number of the typographer bark beetles were carried out from 25.04.2019 to 09.09.2019. The results are presented in Table 3.

Analyzing the data obtained for the "Lubyanskiy Forestry Enterprise", we can make a conclusion that for the first period of observations (including May and June), only in one section the level of pathological decline is 30-40% - object No. 1. At this site, it is already possible to predict the selective sanitary felling. The other two sites require continued supervision of the typographer bark beetle.

According to our observations for the whole growing season, the largest number of beetles is concentrated on a site of pure plantings at the age of 40 years and is estimated at 1,645 pcs. For all three sites, the peak number of beetles takes place on July 5, 2019 corresponding to 3,684 pcs. Fig. 1.

Table 3. The results of the typographer bark beetle counting over five sites

Object No.	Composition	Date of observation	Abundance
1	10E	05.05.2019	46
		15.05.2019	78
		25.05.2019	30
		05.06.2019	1,365
		16.06.2019	101
		15.08.2019	15

		09.09.2019	10
Total			1,645
2	9E1B	05.05.2019	0
		15.05.2019	0
		25.05.2019	26
		05.06.2019	1,195
		16.06.2019	56
		15.08.2019	19
		09.09.2019	10
Total			1,306
3	7E2B1lp	05.05.2019	102
		15.05.2019	233
		25.05.2019	27
		05.06.2019	1,124
		16.06.2019	49
		15.08.2019	18
		09.09.2019	3
Total			1,556
4	3E2E3B2LP	05.05.2019	0
		15.05.2019	15
		25.05.2019	11
		05.06.2019	0
		16.06.2019	1
		15.08.2019	1
		09.09.2019	0
Total			28
5	2E1P1E1P3B 2LP+OS	05.05.2019	3
		15.05.2019	10
		25.05.2019	0
		05.06.2019	0
		16.06.2019	1

		15.08.2019	0
		09.09.2019	0
			14

In the second period of investigations, the level of pathological decline increases in the other two objects, therefore, the selective sanitary felling is required.

Comparing the data obtained for all five sites, it can be concluded that the typographer bark beetle is attracted to plantations of pure composition and younger age from 17 to 40 years. And in plantings of older age 70-90 years, the number of imago decreases sharply. So, at objects No. 4 and 5, for the whole period of investigations, the number of bark beetles varied from 14 to 28 pcs. In these areas, no selective sanitary felling is required, and the pathological falling off is within the normal range of up to 50 pcs.



Fig. 2. Accounting for the bark beetles in laboratory conditions

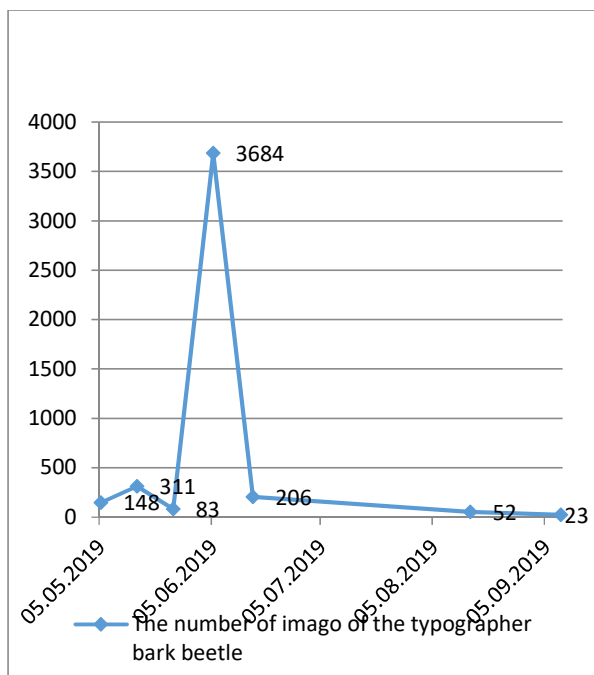


Fig. 3. The number of imago of the typographer bark beetle

In 2019 in the Republic of Tatarstan, the areas of pre-existing foci of the typographer bark beetle have decreased in some forestries, especially in the "Arskiy Forestry Enterprise", "Elabuzhskiy Forestry Enterprise", "Mamadyshskiy Forestry Enterprise", "Sabinskiy Forestry Enterprise", mainly as a result of sanitary and recreational activities conducted on a total area of 163,2 ha.

Besides, there was damping of some foci of this pest on 330.1 ha. At the same time, the new foci were identified, which accounted for 9.5% of the total area of bark beetle foci. As a result, at the end of 2019, the total area of foci of this pest in the forests of the Republic of Tatarstan was 1,018.9 ha, which is 28% less than the same indicator last year.

Table 4. Dynamics of the areas of foci of the typographer bark beetle for 2019

Name of Forestry	at the beginning of the year	identified	destroyed by the activities carried out	disappeared due to natural factors	at the end of the current year
1	2	3	5	6	7
Agryzskiy Forestry	208.3		23.4	7.1	177.8
Aznakaevskiy Forestry	12.1			12.1	0
Almetyevskiy Forestry	1.4				1.4
Arskiy Forestry	325.9		5.4	129.2	191.3
Bugulminskiy Forestry	2.8				2.8
Buinskiy Forestry	0.8				0.8

Elabuzhskiy Forestry	333.9		64.0	17.7	252.2
Kaybitskiy Forestry	0	3.5	1.5		2.0
Kamskiy Forestry	8.9		4.4		4.5
Kzyl-Yulduzskiy Forestry	5.8	18.8		5.7	18.9
Lubyanskiy Forestry	198.9	3.7	3.2	62.0	137.4
Mamadyshskiy Forestry	139.4		22.7	32.1	84.6
Sabinskiy Forestry	176.7	71.3	38.6	64.2	145.2
Total	1,414.9	97.3	163.2	330.1	1,018.9

4 Conclusion

The consequences of mass reproduction of the typographer bark beetle and the resulting in a catastrophic shrinkage of spruce forests have not been fully studied. As a result, the structure of forests is disrupted, sometimes in large territories. The climate-regulating and water-protecting role of forests are decreasing, and their age structure is deteriorating. The spatial continuity of forestland is disrupted that reduces the resistance of trees to mass windfalls and windbreaks, contributes to the spread of sunburn, etc. There are large areas and territories, often not covered with forest vegetation for a long time, where it is necessary to carry out reforestation activities to create new mixed forests of different ages and structures.

To improve the condition of spruce forests, it is advisable to use a set of protective measures. These include forestry measures, sanitary prevention, forest pathology monitoring and sanitary and recreation activities.

Forestry measures are considered to be preventive and are aimed at growing resistant to adverse factors and high-performance spruce stands. These include the creation of mixed plantings (with birch, oak, pine), timely thinning of dense plantings, reducing the felling age in complex plantings, etc.

It is a high-quality cleaning of felling residues in wood cutting areas among the sanitary activities for timely cleaning of spruce forests to remove the litter. Sanitary and recreational activities should also be timely, taking into account the weather conditions. The positive effect gives a selection of the trees freshly attacked by insects into a sanitary felling, lining the trap trees, and using pheromone traps.

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