EFFECTS OF FIR SAWYER BEETLE ON SPATIAL STRUCTURE OF SIBERIAN FIR STANDS

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INTRODUCTION

Insects not only use plants for food and habitat; they also change plant populations by influencing their structure and dynamics. This influence is evidenced in the alteration of the spatial structure of a stand.

The fir sawyer, *Monochamus urussovi* Fisch. (Coleoptera: Cerambycidae), is the most abundant xylophagous insect injuring siberian fir, *Abies sibirica* Ledeb. It dominates both in outbreak and non-outbreak areas. The beetles influence the structure and dynamics of fir stands by damaging tree crowns during adult feeding. At high population density this damage eventually determines the spatial structure of the fir stands.

METHODS

We sampled plots on a western slope in the taiga zone of the Western Sayan mountains, South Siberia, U.S.S.R. In this habitat, siberian fir is a climax species that successfully reproduces under its own canopy.

To estimate the spatial pattern of fir stands, we used two sample plots (1 and 1.5 ha), with 1,000 and 2,000 fir trees, respectively. The first plot was an all-aged fir stand with an age distribution described by a rather smooth, inverse J-shaped curve. The second plot was an uneven-aged fir stand with a bimodal curve of age distribution. The first plot was inhabited by sparse populations of *M. urussovi* and the second by a very dense population.

We obtained coordinates of all fir trunks within the plots as well as their parameters and used the radial distribution function to interpret the data statistically. We used a version of the technique and computer programs modified by Dr. O.P. Sekretenko (Buzykin et al. 1985). Radial function of distribution $G(r)$ characterizes probability in order to find a point at a distance from r to $r + dr$ away from a randomly chosen point on a plot map. A simple modification of $G(r)$ allows us to study mutual arrangement of trees classified into two groups. This technique is known as partial radial distribution function. This function characterizes the probability of detecting an object of one class at a distance from r to $r + dr$ away from a randomly chosen object of the other class.

We have obtained the partial radial function of distribution of 40- to 60-year-old fir trees in relation to dead, standing trees damaged by the fir sawyer and vigorous trees of the crown layer. The radial distribution function of the young trees over the plots has also been calculated.

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RESULTS AND DISCUSSION

To date no direct observations have been made of the behavior of adult fir sawyers during colonization of a forest stand. We have assumed that adults normally fly a short distance away from the place of emergence.

In the stands we examined, the fir sawyer damages mature, but not young trees. This critical feature of host selection allows a self-replacement process in the fir population. The pattern of establishment and growth of seedlings and the mortality of mature trees determine the structure of a fir stand. In the all-aged fir population a low asynchronous mortality is observed. Under these conditions, the micropopulations of the sawyer colonizing the dying trees appear to be spatially separated. Hence tree crowns neighboring the infested ones are damaged rather lightly and the trees are not weakened sufficiently to allow for egg laying. Since the fir sawyer attacks only the naturally dying trees or occasionally those weakened by other factors, sparse populations of fir sawyer are maintained.

In the second fir stand, old trees predominate, which results in increased mortality of mature fir trees and a higher density of fir sawyer population. There is some evidence of beetle concentration on weakened trees and of localized insect distribution for adult feeding and oviposition (Vetrova 1986, 1987). Intensive crown damage (5 to 9 grazing wounds per 1 m of first-order branches) resulted in irreversible tree weakening. The damaged trees were then attacked by ovipositing females. High colonization density (up to 7 eggs per 1 sq dm) is observed. We believe that beetle activity explains the patchy distribution of infested fir trees that we observed (Fig. 1).

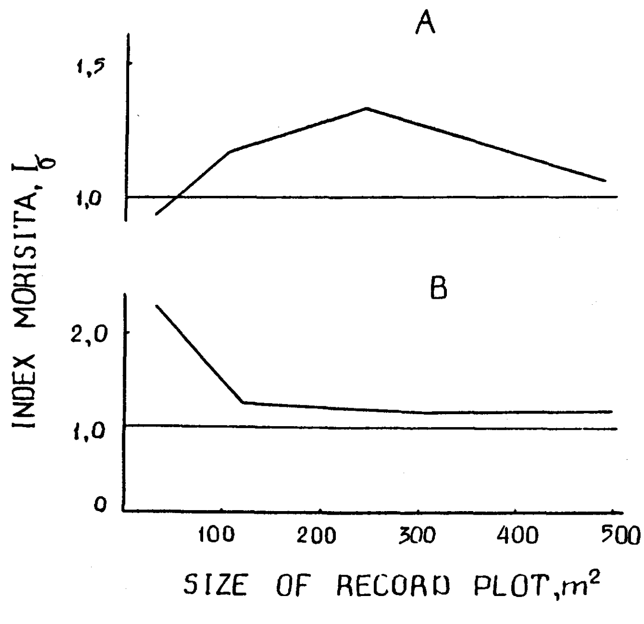

Figure 1. Spatial distribution of infested trees on the sample plots. $I_\delta = q\left[\frac{\Sigma n_i\,(n_i - 1)}{N\,(N - 1)}\right]$, where q = number of record plots, n_i = number of trees on a record plot, N = number of all trees on a sample plot, A and B = habitats of the beetle populations (A = dense population, B = sparse one).

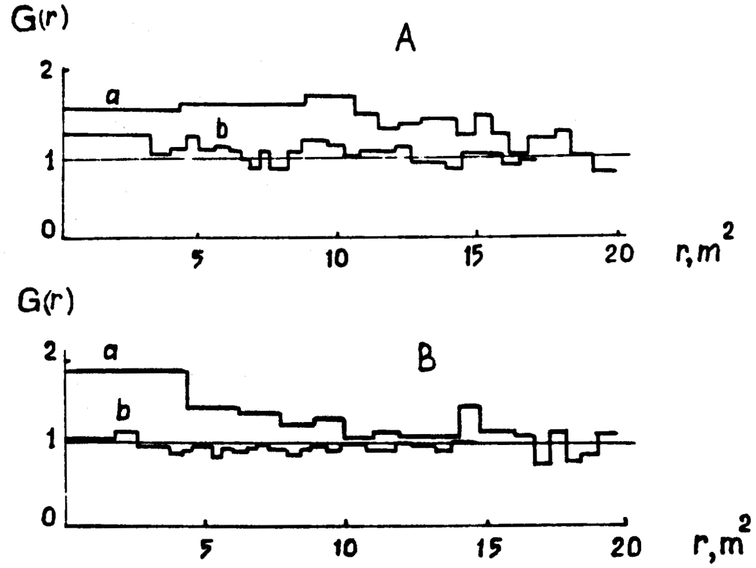

Figure 2. Spatial distribution of young fir trees in relation to standing dead trees (a) and undamaged old ones (b). G (r) - radial function of distribution (see text), r - radius of a record plot, A and B - quantities shown in Fig. 1.

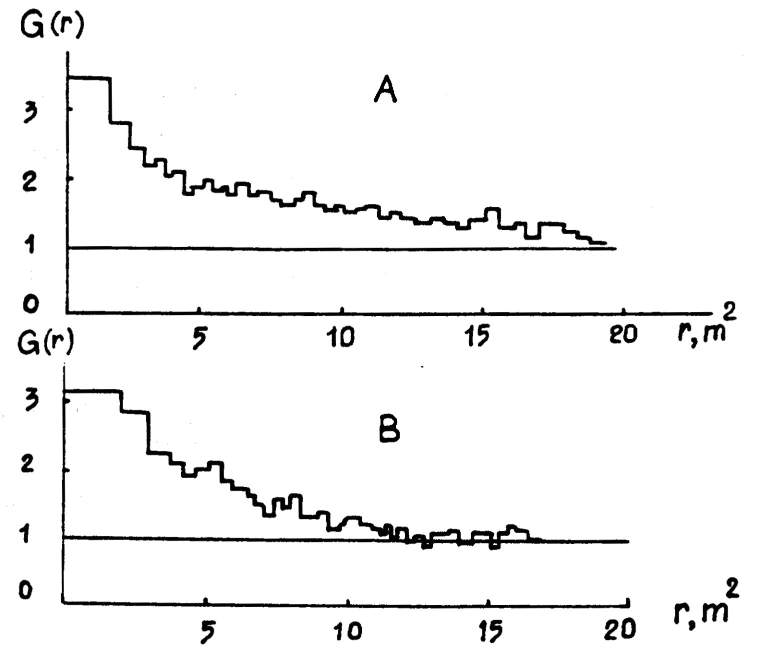

Figure 3. Histograms of radial function of distribution of young fir trees. G(r) - radial function of distribution (see text); other symbol codes as in Figs. 1 and 2.

A relation between the distribution of young (40- to 60-year-old) trees and standing dead trees exists such that the partial radial function of distribution shows a positive correlation in relative mutual arrangement of these two groups (Fig. 2). If so, we should expect different parameters of spatial distribution of young fir trees in the stands we examined. In fact, we observed more clustered distribution of young trees in the fir stand of the second type, as can be shown in Fig. 3.

In the habitat of the sparse sawyer population, the tree mortality pattern of mature trees results in rather small patches of young trees (not more than 50 sq m). Large patches of dying trees occur when the fir sawyer population are high and consequently cause larger patches of young tree (up to 200 sq m).

From the reports of other authors on the ecology of *M. urussovi*, it is clear that the case of outbreak populations of the beetle sharply differs from the above (Isaev et al. 1985, 1988). Usually, outbreak populations cause a constantly high mortality rate of mature trees. Spatial dynamics of fir stand damage look like the spreading of a single wave, comparable sometimes to that of fire.

CONCLUSION

M. urussovi F. is an important factor in the spatial and age dynamics of *A. sibirica* stands. Sparse beetle populations do not disturb the asynchronous, all-aged pattern of fir stand structure and do not prevent the fir population from achieving stability. On the other hand, high-density populations of the fir sawyer, accelerate the mortality rate of mature trees, giving rise to relatively widespread, local synchronization of fir tree development and decrease the stability of the whole system.

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