

## ON THE USE OF EXPERIMENTAL PLOTS WHEN STUDYING FOREST INSECTS.

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The problems of how to obtain accurate records of the infestation of injurious insects has during recent years received considerable attention; and when we take into consideration that it is quite as impossible to study the course of an outbreak during its different stages as it is to compare two outbreaks occurring in different localities or at different times, without possessing methods of recording in an accurate way the degree of infestation and injury, it is evident that every effort must be made to solve this difficulty and devise means of obtaining accurate records in these respects.

In the case of the insects injurious to forest trees this need of accurate information is, for various reasons, perhaps still more urgent than in the case of herbivorous insects, but at the same time the problem seems to present fewer difficulties. The necessity for possessing accurate methods of recording the infestation and the injury done is obvious, because the attacks made on the trees by injurious insects often continue for several years, which means that the degree of infestation and the amount of injury done must be continually observed and accurately recorded during several years, if we are to obtain a reliable idea of the course of the outbreak and to be able to predict the probable seriousness of the attack during a succeeding year. It is also, in the case of forest insects, necessary to investigate the consequence of the injury to the health of the trees and to observe the infestation of secondary insects following upon the primary ones, in order to know what measures are to be adopted to prevent the spreading of an outbreak or the deteriorating of the timber if the trees are killed.

But on the other hand, trees undoubtedly present fewer difficulties to such investigations than do herbaceous plants, because, at least in many instances, the degree of infestation may easily be fairly estimated without in the least interfering with the trees or causing any disturbance in the prevailing conditions at the period when the insects have temporarily migrated from the trees and are hibernating in the ground.

When investigating an outbreak of the pine-tree looper (*Bupalus piniarius*, L.), for instance, the degree of infestation is comparatively easy to ascertain by counting the pupae in the ground in May in different parts of the forest; all that is required being a sufficient number of girls or boys to examine the ground thoroughly. The amount of injury done, viz., the degree of defoliation, on the other hand, is more difficult to estimate, especially when the same trees are to be examined during several years, which makes it impossible to fell them and count the number of devoured or half-devoured needles.

During the recent outbreak of *Bupalus piniarius* in Sweden in 1916-1917 the author had occasion to devote some time to the studying of these problems, and in the following paragraphs the method employed will be briefly described.

We find in the literature regarding *Bupalus piniarius* the statement that the trees are able to withstand a defoliation, provided it is not repeated and does not occur early in the autumn. If, on the other hand, the defoliation is repeated during two years in succession the trees are said to be past recovery. As this conclusion was based on observations made chiefly in Germany and as it did not seem safe to assume its applicability in Sweden, investigations on the state of health of pine-trees after a defoliation repeated during two years were carried on in 1917 and 1918.

At Sörby in Södermanland the degree of infestation in May 1917 was found to be 97·8 pupae per square metre, 18 per cent. of which were parasitised. By counting the needles it was found that the average defoliation at the top of the trees was 75%, the injury decreasing gradually downwards, so that in the lower part of the crown about 60% of the needles were intact.

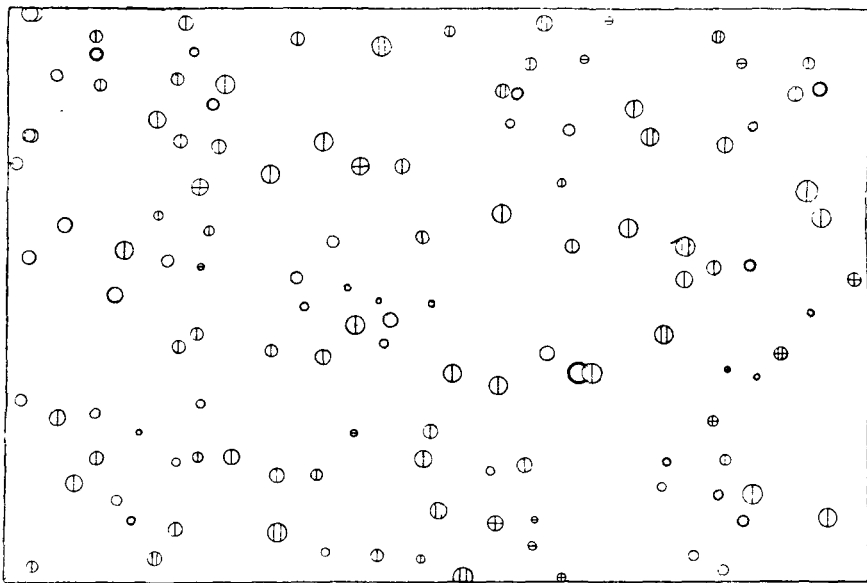


Fig. 1. Map of experimental plot in pine forest attacked by *Bupalus piniarius*, L., at Sörby, Sweden; 0 = felled trees, | = average defoliation, ⊕ = severe defoliation, — = attack by the pine beetle.

At the same time an experimental plot was laid out in the part of the forest most seriously injured. In this plot the trees were marked with numbers; their height, diameter at breast height, and the distances between them were measured; and a map was drawn (fig. 1), the scale used for the plot being 1 : 100 and for the trees 1 : 400. Further, the degree of defoliation of each tree was recorded, only three degrees being distinguished, viz., no injury, average injury, severe injury. The plot was re-examined in May 1918, when also the degree of infestation was ascertained, the number of pupae being found to have been then reduced to 8·8 per square metre, 60% of which were parasitised.

The examination made in 1918 revealed the fact—as astonishing as it was satisfactory—that in spite of the attacks during the two previous years not a single tree had yet succumbed. In 4% of the trees, however, pine-beetles were breeding

and in 10% they had in vain attempted to enter. The supposition at once presents itself that the primary cause of the attack of the pine-beetle was the defoliation brought about by *Bupalus piniarius*, which had weakened the trees to such an extent as to render them appetising to the beetles. A closer examinations of the trees on the experimental plot showed, however, that this cannot be the case in this instance, at least not to any great extent.

According to the estimates made in 1917, 71 of the 126 trees of the plot had an average injury, 14 being severely defoliated and the rest having escaped any visible damage. Only one of the 14 severely injured trees had in the spring of 1918 been attacked by the pine-beetle, and that in vain. Moreover, we notice that one of the trees in which the pine-beetle was breeding had not previously been attacked by *Bupalus*, nor had five other trees into which the beetle had in vain tried to enter been previously injured by the moth. Fig. 2 shows how the attacks of the moth

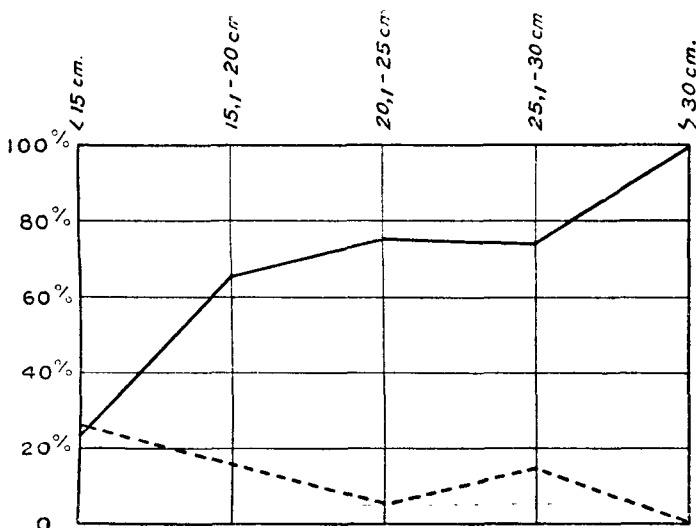


Fig. 2. Diagram showing the distribution of attacks of *Bupalus piniarius* (solid line) and the pine beetle (dotted line) on trees of different dimensions.

and beetle are distributed in trees of different dimensions, from which it is evident how little the attack of the pine-beetle is connected with that of *Bupalus*. We notice that only 24% of the trees measuring less than 15 cm. at breast height have suffered from the moth, whereas all trees measuring more than 30 cm. have been attacked. The pine-beetle, on the other hand has preferred the smaller trees, those exceeding 30 cm. not being attacked at all.

From this it is evident that the two insects, the pine-tree looper and the pine-beetle, work on two different lines, one selecting the largest trees, the other preferring the smaller ones. The investigation has also revealed the fact that during the outbreak in 1916-1917 the forest was able to withstand the defoliation and that the subsequent attack of the pine-beetles was in no way the consequence of the previous defoliation, but would have happened in any case.

It is of course impossible to draw any conclusions from these data as to what is likely to happen during other outbreaks, among other things, because we have no data regarding the parasites of the eggs and the younger larval stages: but if other outbreaks are studied in the same way, it seems likely that we shall by degrees be able to prognosticate after the first year the fate of forests attacked by *Bupalus*.

During such investigations, as well as others when special attention is paid to the influence of the attack on the health of the trees, I venture to think that the use of experimental plots as outlined above will be found very expedient or even indispensable.

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