

# EFFECT OF NITROGEN FERTILIZATION AND INSECTICIDES ON THE POPULATION DENSITY OF THE PINE BARK BUG, *ARADUS CINNAMOMEUS* (HETEROPTERA, ARADIDAE)

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Seloste

TYPPILANNOITUKSEN JA ERÄIDEN HYÖNTEISMYRKKYJEN VAIKUTUS PUNALATIKAN ESIINTYMISRUNSAUTEEN

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The effect of nitrogen fertilization and two insecticides on the occurrence of the pine bark bug, *Aradus cinnamomeus* Panzer, was investigated in a young Scots pine stand (*Pinus sylvestris* L.) in southern Finland. Three years after the treatment the bug density was lowest in the trees treated with lindane or dimethoate. However, in spite of the increasing height growth of the trees, they did not grow significantly faster than the control trees. Nitrogen fertilization increased both the bug density and the height growth of the trees.

## 1. INTRODUCTION

Yellowish, short needles and decreased height growth of the trees are the typical symptoms of damage caused by the pine bark bug, *Aradus cinnamomeus* Panzer. This is especially true in open, even-aged pure stands on sandy soils, where the bug density is usually high. The bugs live in the bark crevices along the trunk and suck sap from the tree with their long stylets. In the worst cases the pines may die, but usually the bugs leave the affected host trees before they are too severely damaged and move to the neighbouring trees.

The condition of the trees can be improved by fertilization. Nitrogen fertilization affects the growth of the tree by increasing the needle mass (Gustavsen and Lipas 1975). The rate of photosynthesis per needle increases because the number and volume of the needles increases (Fagerström and Lohm 1977).

Nitrogen fertilization has been observed to increase the resistance of trees against some Scolytids. On the basis of these observations, fertilization has been proposed as a protection method (Merker 1967, 1969). Young

Scots pine stands have been fertilized in south-eastern Finland with the aim of controlling the pine bark bug without any precise knowledge about the effect of the fertilization on the bug population.

The damage caused by *Aradus cinnamomeus* is visible in the crown of the tree in particular. Since fertilization is known to affect this part of the tree (Saramäki and Silander 1982), fertilization can be considered as one easy solution to improving the growth of the tree. In general, rather little is known about the effect of fertilization on pest populations, although interaction between forest fertilization and pests have been investigated by several authors (Büttner 1961, Stark 1965, Hoffmann 1966, Merker 1967, 1969, Löyttyniemi and Hiltunen 1976a, 1976b, Löyttyniemi 1978).

The aim of the present study was to investigate the effect of nitrogen fertilization on young pines heavily infested by *Aradus cinnamomeus* and the effect of fertilization and some insecticides on the population density of the bug. Attention was also paid to the height growth of pines after insecticide treatment.

## 2. STUDY AREA, MATERIAL AND METHODS

The study was carried out in a 20-year-old Scots pine (*Pinus sylvestris* L.) stand growing on a site of the *Calluna* type in southern Finland (59° 50' N, 23° 13' E). The stand was restocked by natural regeneration in the early 1960s. Most of the trees were suffering from *Aradus* infestation, showed poor growth and had yellowish, short needles.

The trees to be included in the study were selected from along five lines laid out at a distance of 10 paces from each other. 50 sample trees were taken along each line at intervals of 10 paces. The sample trees were treated in May 1980 as follows:

- Line no. 1. Nitrogen fertilization with ammonium nitrate with lime, containing 27,5 % nitrogen. The fertilizer was spread over a circular area around the tree, the radius of the treated area being equivalent to the height of the tree. Before spreading, the amount of fertilizer to be applied was weighed out separately for every tree. The fertilizer doses were equal to 150 kg nitrogen/ha, this being the amount used in practical forest fertilization (Viro 1972).
- Line no. 2. NPK fertilization (Puutarhan Y-lannos 2), containing 6 % nitrogen, 7 % phosphorus, and 17,4 % potassium. The treatment was carried out in the same way as on line no. 1, the fertilizer dose being equal to 150 kg nitrogen/ha.
- Line no. 3. Treatment with "Silvanol", containing 200 g lindane per litre. A 2 % aqueous solution of the insecticide, as recommended in the directions for use, was spread with a hand sprayer over the lower part of the trunk up to the mid point of the trunk. According to previous studies the bugs feed on this part of the trunk (Heliövaara 1982a).
- Line no. 4. Treatment with "Roxion", containing 400 g dimethoate per litre. A 2 % aqueous solu-

tion was applied in the same way as on the line no. 3. The trees were retreated after one month.

Line no. 5. Untreated trees (control).

The effect of the different treatments was assessed in June, 1983. Only the first 30 trees along each line were included in the study because several of the trees had died or been destroyed by moose during the last three years. A quantitative method presented by Heliövaara (1982a) was used to estimate the population density of the bugs. The height growth of the trees during the last five years was measured. The distribution of the sample trees into different height classes in 1983 is presented in Fig. 1.

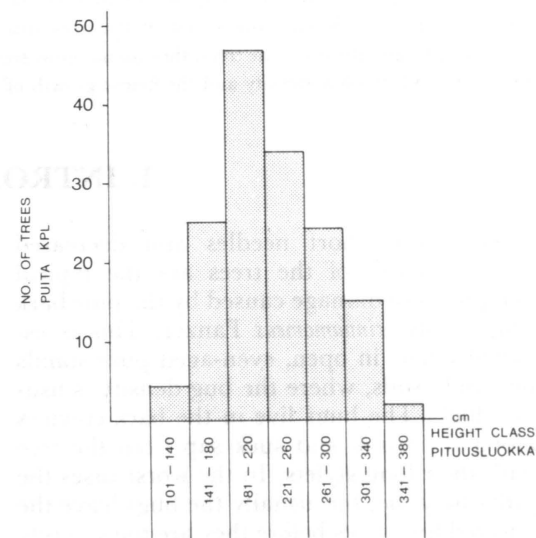


Fig. 1. Frequency distribution of the sample trees into height classes in the sampling year, 1983.

Kuva 1. Näytepuiden jakautuminen pituusluokkiin näytteenotovuonna 1983.

## 3. RESULTS

### 3.1. Height growth of the sample trees

The annual height growth of the sample trees had increased in all five groups during the last five years (Fig. 2). The growth of the fertilized trees was the highest (Table 1). The differences between the groups (total height growth in 1981 and 1982) are statistically significant ( $F = 2.62$ ,  $P < 0.05$ ,  $df_1 = 4$ ,  $df_2 = 145$ ) after the treatment, but not ( $F = 0.93$ ) before treatment. The increasing height growth in each group is mainly due to the aging of the stand – which results in a natural decrease of the bug population – and perhaps the exceptional amount of precipitation in 1981 (Kuukausikatsaus Suomen ilmastoon 1981).

### 3.2. Density of the bug population

The number of bugs was counted only once (in 1983), because the trees must be debarked when samples are taken. The lowest density was found in the trees treated with insecticides, as expected, while the densities in the fertilized trees were higher than those in the control trees (Table 1). The differences in the bug densities between the groups were statistically highly significant ( $F = 21.03$ ,  $P < 0.001$ ,  $df_1 = 4$ ,  $df_2 = 145$ ).

Table 1. The total height growth of the sample trees in 1981–1982 and the densities of the bug population in 1983 in the different treatments. For the treatments see Fig. 2.

Taulukko 1. Koepuiden pituuskasvu vuosina 1981–1982 ja latikoiden esiintymistiheys vuonna 1983 eri käsittelyissä. Lisäselitykset käsittelyistä kuvassa 2.

Treatment Käsittely	No. of trees Puita kpl	Total height growth in 1981–1982, cm Puiden pituuskasvu vv. 1981–1982, cm			Density of the bug population, No./dm <sup>2</sup> Latikoiden esiintymistiheys, kpl/dm <sup>2</sup>		
		$\bar{x}$	SD	F	$\bar{x}$	SD	F <sup>1)</sup>
1	30	49.6	18.7	5.50*	15.1	7.9	4.98*
2	30	48.5	23.4	3.37	17.8	13.2	5.10*
3	30	37.4	18.5	0.10	5.0	4.2	23.37***
4	30	39.7	19.8	0.03	7.3	7.2	9.31**
5	30	38.6	17.0		11.5	7.0	

<sup>1)</sup> Statistical analyses with log (x+1) transformed values

\*\*\* =  $P < 0.001$

\*\* =  $P < 0.01$

\* =  $P < 0.05$

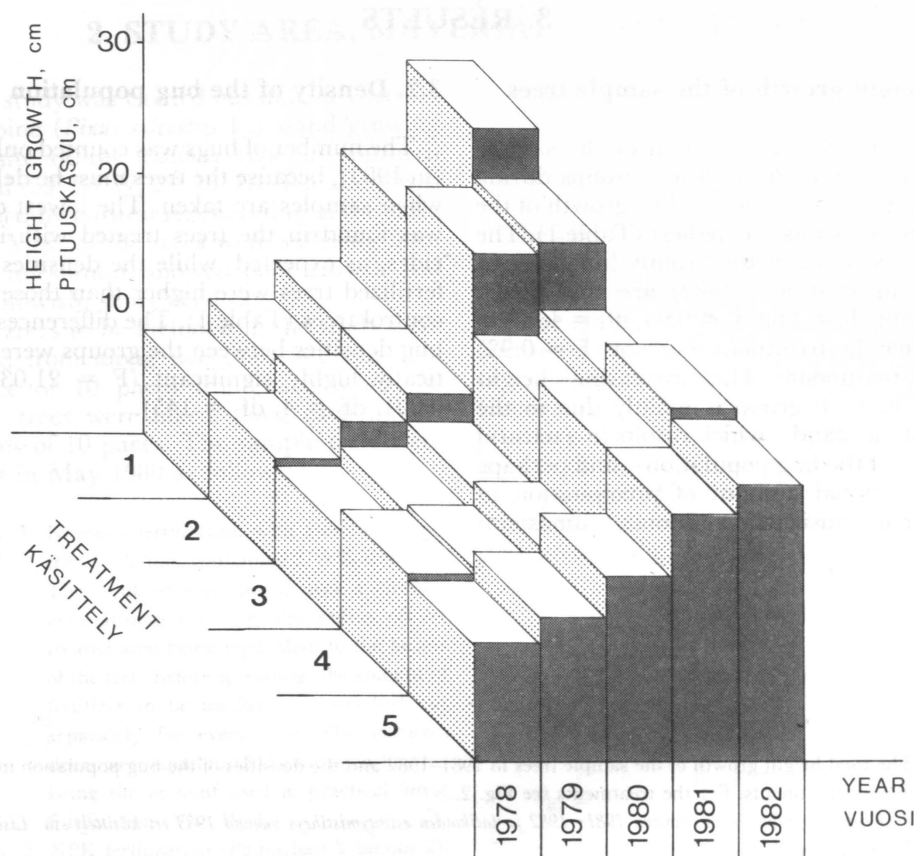


Fig. 2. The annual height growth of the sample trees in 1978–1982. Treatments: 1 = nitrogen fertilization, 2 = NPK fertilization, 3 = lindane treatment, 4 = dimethoate treatment, 5 = untreated.

Kuva 2. Näytepuiden vuotuinen pituuskasvu vuosina 1978–1982. Käsitteilyt: 1 = typpilannoitus, 2 = NPK lannoitus, 3 = lindaanikäsitteily, 4 = dimetoaattikäsitteily, 5 = ei käsitteilyä.

## 4. DISCUSSION

### 4.1. Fertilization

Fertilizers may change the physiological state of the host tree as well as the nutrition of insects. The impact of these changes has been discussed by several authors (Büttner 1961, Merker 1967). Forest fertilization has been found to affect the occurrence and harmfulness of many insects (Oldiges 1960, Schwenke 1960, Stark 1965). On the other hand, Löyttyniemi (1978) reported that ni-

trogen fertilization with the standard dosage has little effect on pine shoot beetles (*Tomicus* spp., Scolytidae) and causes no essential changes in the level of damage.

*Aradus cinnamomeus* can be regarded as a phytophagous primary pest which infests healthy young pines while avoiding poorly growing or sick trees in the stand (Razumova 1960, Voroncov 1962, Hoberlandt 1972). It

has been concluded that fertilization usually increases the number of sucking insects, but decreases the number of insects feeding on needles or phloem (Schwenke 1960, 1961, 1962). The rate of mortality of the larvae feeding on needles has been observed to depend on the sugar content in the needles. On the other hand, it is probably easier for sucking insects to take up sap from host trees which have a high turgor pressure owing to fertilization (Schwenke 1962). Saikku (1973) observed that nitrogen fertilization decreased the amount of bark in large pines. In theory, this could make it easier for the bugs to penetrate the bark with their stylets.

On the other hand, fertilization can increase the amount of resin and change its chemical composition (Oldiges 1960, Valenta et al. 1980). Hiltunen et al. (1975) suggested that the total oil concentration and the level of some terpenes in Scots pine could be affected by nitrogen fertilization. The distribution of the bugs along the trunk has been observed to depend on the chemical characteristics of the bark, but the distribution within a stand has not been found to be correlated with the oil concentration of the trees (Smeljanez 1973).

It has also been suggested that the mortality of the bugs could be increased by promoting the growth of the ground vegetation through fertilization (Heliövaara 1982b). This may raise the humidity of the air around the trees and increase the winter mortality of the bugs (see Brammanis 1975).

The results obtained in the present investigation do not agree very well with the results of previous studies concerning the effect of fertilization on the population of *Aradus cinnamomeus*. Valenta et al. (1980) reported that fertilizers increase the secretion of resin and change the level of carbohydrates, thus resulting in the death of the bugs. However, according to Smeljanez (1969) the quality, not the quantity, is important in the natural defense mechanism of trees against the pests. Brammanis (1975) found a strong decrease in the number of bugs in a fertilized forest, and recommended forest fertilization for the control of the pine bark bug in heavily infested areas.

### 4.2. Insecticides

Several chemicals have been used with variable results in the control of *Aradus cinnamomeus*, particularly in the USSR (Tropin 1949, 1968, Mačtet and Pašov 1955, Obozov 1964). The pine bark bug seems to be a tenacious species. The results obtained with many different chemicals have not been encouraging, partly because the bugs return to the treated trees after a couple of years. Systemic insecticides have recently been used (Treskin et al. 1960, Andreeva 1964, 1966, Brammanis 1975) with better results.

The timing of the insecticide application is important. The larvae from the first to fourth instars are more susceptible to insecticides than the adult insects (Voroncov 1962, Valenta et al. 1980). Owing to the two-year life cycle of the bug and the alternate-year population (Terho and Heliövaara 1981), the best results can be obtained when insecticides are applied every second year. In the present investigation the chemicals were applied during the mating time of the bugs and only eggs, but no larvae, were present. The bug population was estimated three years later when most of the bugs were in the larval stage. These larvae were the offspring of the adults which developed from the treated eggs. It is likely that chemicals were not spread at the best possible time even though the treatment with "Roxion" was renewed when the larvae had already hatched. However, the lowest population density of the bugs was observed in the trees treated with insecticides. The height growth of these trees was not, however, greater than that of the untreated trees. Voroncov (1956) and Razumova (1960) have shown that removing the bugs with tanglefoot hoop traps increases the height growth of the pines after one year.

It may be that the insecticides did not penetrate all the crevices in the bark (hiding places of the bugs) in spite of careful and individual spraying of the trees. Moreover, the migration of the bugs between trees, flying macropters or walking brachypters, rapidly levels off the population after the decomposition of the insecticides.

## 5. CONCLUSIONS

The insecticides used in the present study decreased the density of the pine bark bug population, but the recovery of the height growth of the treated trees was not clearly noticeable compared with the control trees. Nitrogen fertilization increased both the bug population and the height growth of the

pinus. Thus the value of nitrogen fertilization as a protection method against *Aradus cinnamomeus* remains obscure. If fertilization really benefits the bugs, repeated fertilization is needed to maintain the tolerance of the pines.

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## SELOSTE

### TYPPILANNOITUKSEN JA ERÄIDEN HYÖNTEISMYRKKYJEN VAIKUTUS PUNALATIKAN SEIINTYMISRUNSAUTEEN

Typpilannoituksen ja eräiden hyönteismyrkkyjen vaikutusta punalattikkaan, *Aradus cinnamomeus* Panzer, tutkittiin eräässä eteläsuomalaisessa mäntymetsässä. Kolmen vuoden kuluttua käsitellyn jälkeen latikoita esiintyi vähiten linaamalla tai dimetooatilla käsitellyissä puissa, mutta huolimatta kiihtyvällä kasvustaan puut eivät kasvaneet käsittelemättömiä puita paremmin. Typpilannoitus lisäsi sekä tuhoisten määrää että puiden kasvua.