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THE PINE BARK BUG, *ARADUS CINNAMOMEUS* (HETEROPTERA, ARADIDAE) AND THE HEIGHT GROWTH RATE OF YOUNG SCOTS PINES

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Seloste

PUNALATIKKA, ARADUS CINNAMOMEUS (HETEROPTERA, ARADIDAE) JA MÄNNYNTAIMIEN PITUUSKASVU

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Relationships between densities of the pine bark bug, *Aradus cinnamomeus* Panzer and the height growth of young Scots pines, *Pinus sylvestris* L. were studied in several habitats, including a highly infested area in South Finland. The slower the growth of the pines was, the greater was the height up to which bugs were found. On the average maximum bug density was noted at a height corresponding to a fifth of the height of the tree. In stand restocked by natural generation, the greatest bug densities were noted in pines about three metres high and over twenty years old. Bug densities in trees whose height growth had been decelerating for five years were twice those in trees whose growth was accelerating. A significant negative correlation was found between the bug density and the last-year height increment.

1. INTRODUCTION

The pine bark bug, *Aradus cinnamomeus* Panzer, has come in for increasing attention during the past twenty years because the height growth of young pines has been found to correspond with the density of the bug (Ringselle 1962, Brammanis 1964, 1965, Laine 1968, 1971). In continental Europe, especially Eastern Europe, the pine bark bug has long been regarded as an expensive pest (Krausse 1919, Strawinski 1924–1925, Tropin 1949).

Imagos and larvae of the pine bark bug live under bark crevices and slow down the growth of the tree by sucking fluids from the phloem, cambium and xylem layers. When present in large numbers, the bugs detract from the generation of medullary rays and the cells in the cambium layer. This disturbs the formation of annual rings. The interference with the conduction of fluids causes yellowing needles, slows down the growth and, in the worst cases, kills the tree (e.g. Tropin 1949, Brammanis 1975). Further the bugs are known to secrete a substance, apparently from their salivary glands, which also disturbs the growth of the tree (Danilov and Krasnov 1970).

The effect of most pests on tree growth is poorly known. The number of pests is often difficult to estimate, trees grow under different conditions, and there is no information on the way the trees would grow without any pests. (e.g. Kulman 1971, Långstöm 1980). The purpose of this paper is to present some simple connections between the densities of *Aradus cinnamomeus* and the height growth of young pines.

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2. MATERIAL AND METHODS

The study was made on the Hanko Peninsula, at the southernmost point of the Finnish mainland (Grid 27° E 664:28) during the summers of 1979 and 1981. The study area proper is part of a twenty-year-old heath forest restocked with Scots pine (*Pinus sylvestris* L.) by natural generation and infested by pine bark bug (*Aradus cinnamoeus*). As is typical on an area injured by pine bark bug, the pines are yellowish and rather slow-growing though differences in height growth are considerable. To test how soon the host tree begins to suffer, one pine was deliberately infested with about three hundred fourth-instar larvae in May. The pines for investigation were selected unsystematically from the edges of roads and glades and further inside the forest. The average height of the trees studied was 3.2 m (range 1.4...6.5 m), and their diameter at breast height was 4.4 cm (range 1.1...9.2 cm). Their density was approximately 3,200 trees per hectare.

The height of maximum bug density on the trunk depends partly on the undergrowth and climate (Aničkova 1972, Heliövaara and Terho 1981) and quality of bark and the age of the tree (Tropin 1949, Smeljanec and Matovyh 1974, Brammanis 1975). This means it is not always possible to determine the bug densities at the same height of the tree. To test the location of the bugs, material collected in 1979 from different habitats in the same area (pine barren, sand pit, rock, fresh heath, bog, old field and grass herb-woodland) was used. In summer 1979 three pines from 18 sample plots were felled and cut into 20 cm fragments, and the bug densities of every fragment were calculated. (For further information on the sample plots and the selection of trees for felling, see Heliövaara and Terho 1981, Terho and Heliövaara 1981).

The trees felled in 1979 were also used to calculate a coefficient indicating the average density of pine bark bugs in one tree. The coefficient (0.50±0.02) was obtained by dividing the average bug density of the tree by maximum bug density in a 10 cm fragment. This fragment (sample) was taken from a point where the bug density was known to be the greatest, basing on earlier experience and the location test described above. With this coefficient the pine bark bug density in the part of the tree where bugs occur can be estimated by halving the bug density of the 10 cm sample. In poor habitats, however, the sample tends to be too small and the coefficient too big, and in productive habitats vice versa. Trees with no bark bugs were disregarded in determinating the coefficient. The average bug density of the samples in the heath forest was 16.4 bugs/dm^2 (range 0.9...48.1 bugs/dm^2).

The material of this investigation consisted of 129 living pines and 5,607 bugs.

3. RESULTS AND DISCUSSION

3.1. Tree growth rate and location of bugs

Under favourable circumstances pine bark bugs attack the pine as soon as enough bark has developed in the lower part of the trunk to provide the shelter they need. The bugs move upwards on the trunk as the tree grows and rough bark grows higher up the trunk, but they generally avoid the upper thin-barked part of the trunk (Tropin 1949, Brammanis 1975).

Several studies have shown that the greatest bug densities are found in the middle part of the tree (Tropin 1949, Turček 1964, Brammanis 1975), or above it (Doom 1976). Smeljanec and Matovyh (1974) report that chemical composition of the pine bark is most attractive in the middle part. Turček (1964) discovered no bugs at heights under 1.5 m in pines over 20 years old.

On the Hanko Peninsula the pine bark bugs were clearly found to live in the lower half of the trunk. In the felled trees the maximum density was usually observed at a height corresponding to $\frac{1}{5}$ (range $\frac{1}{13} \dots \frac{1}{2}$) of the height of the tree. No significant correlation existed between the location of maximum density of the bugs and the growth rate of the trees (r = –0.28, d.f. = 34, NS). According to Aničkova (1972), pine bark bugs often vary their location on the trunk to a remarkable extent according to the weather: during hot summers they move downwards.

3.2. Height of the pines and bug densities

The pine stand was heterogeneous in height and age. The sample pines were divided into seven height classes (Fig. 1). The pine bark bug densities differed very significantly from class to class (F = 7.27, d.f. = 6, 86, P < 0.001). The greatest bug densities (max. 48.1 bugs/dm^2) were found in the three-metre class in pines over twenty years old (Fig. 1). According to Tropin (1949), Voroncov (1962) and Turček (1964), the highest bug densities are generally found in 8 to 25-year-old pines; bugs seldom occur in trees over 35 years old.

In my study I found hardly any tendency for bug densities to decrease with as the height or age of the trees increased. However, the pines studied were quite small: all of them were less than 6.5 m high, even those over 50 years old, whereas in Tropin's (1949) material trees aged 17 to 18 reached heights of 10 m.

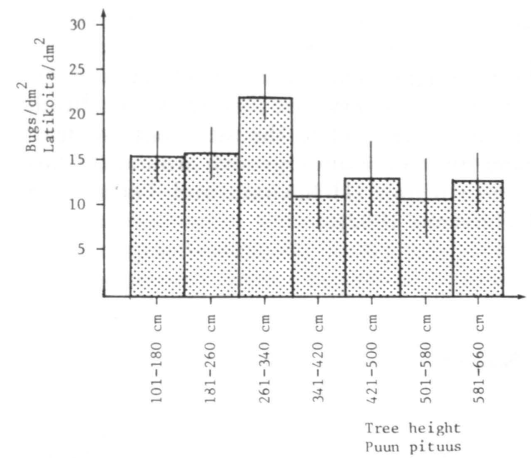

Fig. 1. Bug densities in different tree-height classes (mean ± *SE*).

Kuva 1. Latikkatiheydet puiden eri pituusryhmissä (keskiarvo ± keskivirhe).

3.3. Height growth rate of the pines and the bug densities

Pine bark bugs utilize their host tree as long as sufficient nutrition is available. When the tree stops growing the bugs usually die off or desert the tree for a nearby pine (Brammanis 1975, Doom 1976). If they migrate from a slow-growing to a fast-growing pine the latter harbours more bugs than the slow-growing tree. After such a migration the former host tree usually recovers and its growth accelerates, while the new host begins to suffer. So one feature by which an area infested by *Aradus cinnamomeus* can be recognized is acceleration and deceleration of height growth at fairly regular intervals.

In the present study a deliberate infestation of about three hundred fourth-instar larvae in May resulted in the tree becoming yellowish within four weeks, a typical symptom of *Aradus* injury. Brammanis (1975) has demonstrated that raising the population density decreases the growth of the pines in the following years. Earlier Brammanis (1964) estimated that about 100 pine bark bugs per tree were enough to cause the growth to decelerate. This is equivalent to about 8 bugs/dm^2 in a 10 cm sample used in the present study. The growth rates of pines also vary remarkably due to differences of genetic background or growth habitats.

It is assumed that long-winged females are born when the nutrition is inadequate (Tropin 1949, Turček 1964, Heliövaara and Terho 1981). It may be that poor nutrition also slows down the reproduction rate of the bugs.

The greatest bug densities are known to occur on pine barren, where the height growth rate is average. Bug densities are low in extremely poor habitats like in bog or rock, probably because of inadequate nutrition (Heliövaara and Terho 1981). This may be partly due to the density of the grain, which prevents the bugs from pushing their stylets into it (see Hakkila 1966). Bug densities are also small in productive habitats. It seems

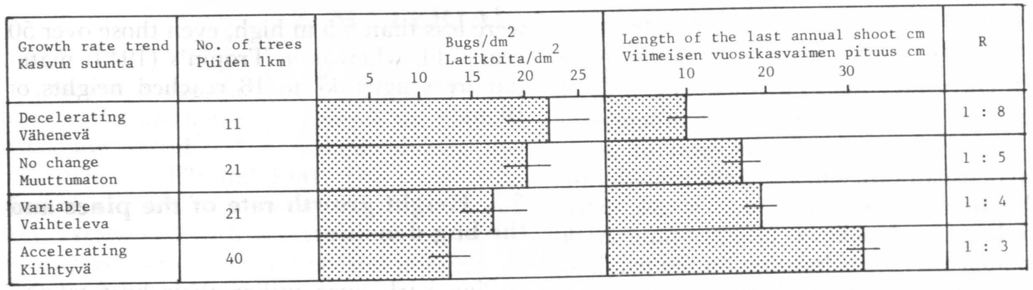

Fig. 2. Bug density and length of last annual shoot (mean ± *SE*) in four growth categories during five years. R = approximate ratio of the last annual shoot to total height growth in five years.

Kuva 2. Latikkatiheys ja viimeisen vuosikasvaimen pituus (keskiarvo ± keskivirhe) männyn eri kasvutyypeissä viiden vuoden aikana. R = viimeisen vuosikasvaimen likimääräinen osuus viiden viimeisen vuoden kasvusta.

that fast-growing pines have less rough bark to provide shelter for the bugs than slow-growing ones. The height on the trunk up to which bugs were found was divided by the full height of the tree. A significant negative correlation was noted between the quotient calculated and the latest five year height increment ($r = -0.44$, d.f. = 34, $P < 0.01$).

Pine bark bug densities on a single tree can vary widely in five years. A significant negative correlation was found between the bug density and height growth rate during the same year ($r = -0.25$, d.f. = 92, $P < 0.05$). On the other hand, no significant correlation was observed between the bug density and the latest five-year height increment ($r = -0.18$, NS).

The pines were divided into four categories according to their latest five-year height growth: 1) decelerating, 2) unchanged, 3) variable and 4) accelerating growth (Fig. 2). Bug densities differed significantly between these categories ($F = 4.14$, d.f. = 3, 89, $P < 0.01$). The pines with decelerating growth had bug densities nearly twice those of the pines with accelerating growth. In the second category it is obvious that the birth and death rates and the migration of the bugs to and from neighbouring pines were all in a certain balance with growth rate of the tree. The category comprising trees with variable height increment is the most unclear. Here, in particular, actual bug density may already have grown (or decreased) even if this is not clear from the height increment.

On the Hanko Peninsula there are two separate generations of the pine bark bug, one reproducing in even-numbered years, the other in odd years. Practically speaking, the bugs reproduce only in even years, because these represent 99.34 % of the total population (Terho and Heliövaara 1981). Thus nearly all the bugs were full-grown by late summer, 1981, when this study was made, and the numbers of bugs in trees corresponded those a year before. There may have been a slight variation due to changes of host tree, which is very rare among larvae (Brammanis 1975), and to the alteration in death rates due to the undergrowth around the host tree in winter (Heliövaara and Terho 1981, Heliövaara 1982).

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SELOSTE

PUNALATIKKA, ARADUS CINNAMOMEUS (HETEROPTERA, ARADIDAE) JA MÄNNYNTAIMIEN PITUUSKASVU

Punalatikan, *Aradus cinnamomeus* Panzer esiintymisrunsauden ja männyntaimien pituuskasvun välistä suhdetta tutkittiin erilaisilla kasvupaikoilla eräissä Hankoniemellä sijaitsevissa männyntaimistoissa. Latikoita esiintyi rungossa sitä pidemmällä matkalla mitä hitaammin puu oli kasvanut. Suurimmat latikkatiheydet tavattiin keskimäärin sillä korkeudella, joka vastaa ⅕ puun pituudesta maan pinnasta lukien. Luontaisesti syntyneessä taimikossa suurimmat latikkatiheydet todettiin noin kolmemetrisissä, runsaan kahdenkymmenen vuoden ikäisissä männyissä. Niissä männyissä, joissa pituuskasvu oli vuosittain vähentynyt viimeisen viiden vuoden aikana, latikoita esiintyi kaksi kertaa niin paljon kuin pituuskasvultaan vuosittain voimistuneissa puissa. Viimeisen vuosikasvaimen pituus oli kääntäen verrannollinen latikkatiheyteen.