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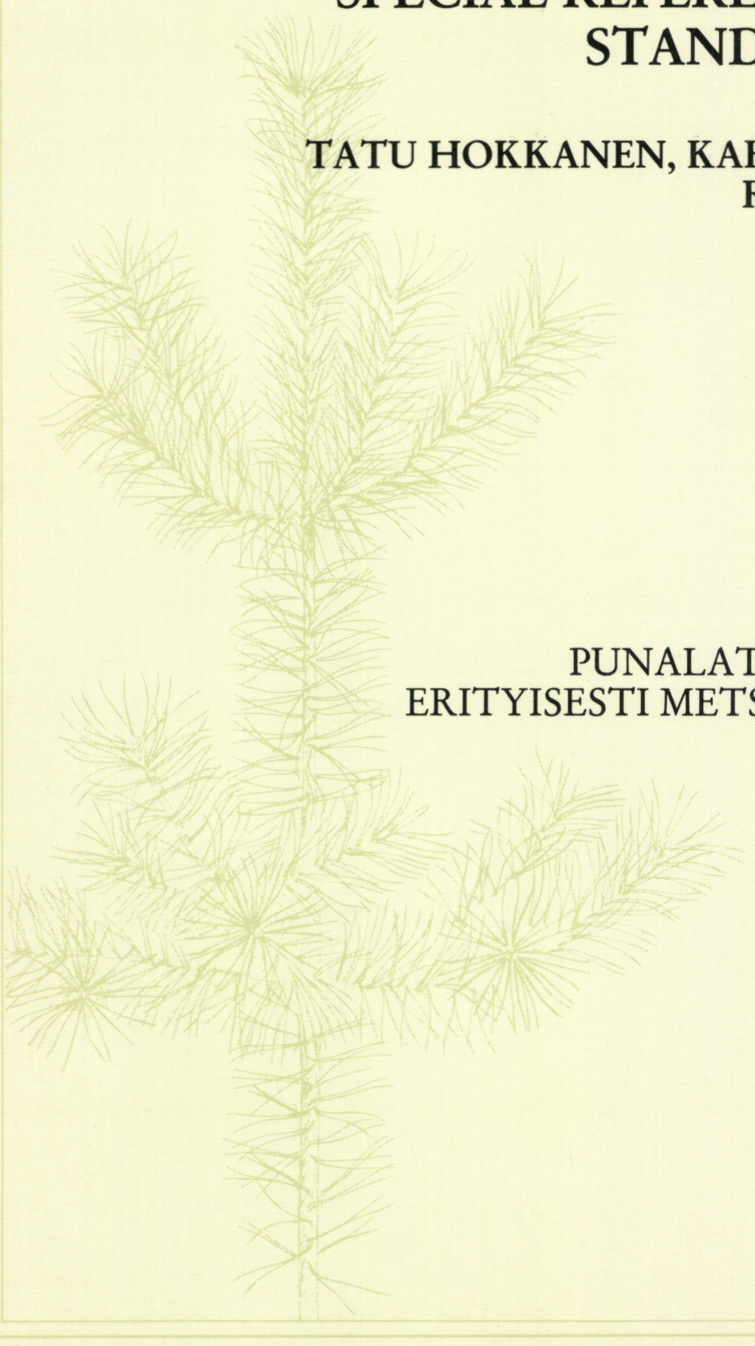
CONTROL OF ARADUS CINNAMOMEUS (HETEROPTERA, ARADIDAE) WITH SPECIAL REFERENCE TO PINE STAND CONDITION

TATU HOKKANEN, KARI HELIÖVAARA & RAUNO VÄISÄNEN



SELOSTE

PUNALATIKAN TORJUNTA ERITYISESTI METSÄNHOIDOLLISIN MENETELMIN

HELSINKI 1987

COMMUNICATIONES INSTITUTI FORESTALIS FENNIAE

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Unioninkatu 40 A
SF-00170 Helsinki 17
FINLAND

Director:
Professor Aarne Nyyssönen

telex: 125181 hyfor sf
attn: metla/

phone: 90-661 401

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Cover (front & back): Scots pine (*Pinus sylvestris* L.) is the most important tree species in Finland. Pine dominated forest covers about 60 per cent of forest land and its total volume is nearly 700 mil. cu.m. The front cover shows a young Scots pine and the back cover a 30-metre-high, 140-year-old tree.

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Hokkanen, T., Heliövaara, K. & Väisänen, R. 1987. Control of *Aradus cinnamomeus* (Heteroptera, Aradidae) with special reference to pine stand condition. Seloste: Punalatikan torjunta erityisesti metsänhoidollisin menetelmin. Communicationes Instituti Forestalis Fenniae 142. 27 p.

Prophylactic silvicultural, chemical and biological control methods against the pine bark bug *Aradus cinnamomeus* were investigated. In the silvicultural part of the study attention was paid to the effect of stem number and mixed tree stands on the bug density, the height growth rate of the stand, and damage caused by the bug. The investigation was carried out in southeastern Finland in 1980 in seven pine stands with different stem number (1600...5700 trees per hectare), in three stands with birches *(Betula pendula)* present as admixtures, and in two stands with a low number of bugs.

Pines with typical *Aradus* symptoms usually grew farther apart from each other than healthy-looking trees. The proportion of badly damaged trees exceeded 28 % in stands with about 2000 trees per hectare. A small admixture of deciduous trees (10—20 %) was not able to prevent damage caused by the bug.

Several chemical and biological methods including systemic insecticides and fungal diseases have been used with variable results in the control of *A. cinnamomeus.* However, prophylactic silvicultural practices would probably give the most favourable result in the control of the bug. The structure of the pine stand should be even and dense without gaps, and heavy early thinnings should be avoided in susceptible areas.

Tutkimus käsittelee metsänhoidollisten, kemiallisten ja biologisten menetelmien käyttömahdollisuuksia punalatikan torjunnassa. Tutkimukset tehtiin Kaakkois-Suomessa 12 kanervatyypin mäntytaimikossa, joissa selvitettiin taimikoiden tiheyden (1600...5700 tainta/ha) ja koivujen määrän (10...20 %) vaikutusta punalatikkatuhoihin.

Tyypilliset latikoiden vioittamat männyt kasvoivat taimikoissa keskimäärin kauempana toisistaan kuin hyväkuntoiset puut. Taimikossa, jonka tiheys oli n. 2000 tainta/ha, latikoiden pahoin vioittamien mäntyjen osuudeksi todettiin neljännes kokonaisrunkoluvusta. Vähäinen lehtipuusekoitus ei kyennyt estämään punalatikoiden imentävioituksia.

Punalatikan torjunnassa on käytetty useita kemiallisia ja biologisia menetelmiä (mm. systeemisiä hyönteismyrkkyjä ja sienitauteja) vaihtelevin tuloksin. Ennaltaehkäisevillä metsänhoidollisilla menetelmillä voidaan saavuttaa parhaat tulokset. Mäntytaimikon tulisi olla rakenteeltaan tiheä, aukoton ja tasainen. Lisäksi voimakkaita, aikaisin suoritettavia taimikon harvennuksia ja perkauksia tuhoalueilla on syytä välttää.

Key words: *Pinus sylvestris,* pest control, stem number, monoculture
ODC 453+41+145.7x14.06 *Aradus cinnamomeus*+174.7 *Pinus sylvestris*

Authors' addresses: *Hokkanen & Heliövaara:* The Finnish Forest Research Institute, PL 18, SF-01301 Vantaa, Finland. *Väisänen:* Department of Entomology, Zoological Museum and Department of Zoology, University of Helsinki, SF-00100 Helsinki, Finland.

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CONTENTS

PREFACE

The present investigation has been carried out at the Department of Silviculture and Department of Forest Protection, Finnish Forest Research Institute, and at the Department of Entomology, University of Helsinki. It represents an attempt to apply integrated silvicultural, forest zoological and entomological knowledge in practice.

Our sincere thanks are due to several persons for their valuable contribution. The positive attitude of Mr. Tauno Turunen (Enso-Gutzeit OY) made this investigation possible. Mr. Toivo Vähämäki (Enso-Gutzeit OY) helped in the location of sample stands, and in other practical problems in the field work. Measurements and sampling in the field were effectively carried out in collaboration with Mr. Jukka Kettinen and Mr. Pentti Sairanen. Mr. Veli-Pekka Salmi and Miss Marja Ruhkanen helped with the calculations. The figures have been drawn by Mr. Ilkka Taponen. Prof. Erkki Annila, Prof. Timo Kurkela, Dr. Lalli Laine, Prof. Matti Nuorteva and Mr. Heikki Veijalainen have read various versions of the manuscript and proposed constructive suggestions.

1. INTRODUCTION

The pine bark bug, *Aradus cinnamomeus* Panzer, lives on the pine trunk in crevices in the bark, and both the adults and the nymphs suck sap from young tissues surrounding the cambium, thus disturbing the conduction of fluids in the tree. It is an example of an insect pest that has derived considerable advantage both from modern silvicultural practices (Heliövaara & Väisänen 1984, 1985) and air pollution (Heliövaara & Väisänen 1986 a). The pine bark bug was long almost unknown as a pest insect and the earlier literature on Finnish forest entomology contains only short, general descriptions on this species (e.g. Kangas 1937, 1958, Saalas 1949). It was not until the mid 1960s that the bug was reported to cause considerable damage especially in the forested area along the esker ridge of Salpausselkä (Laine 1968, 1971).

The area of young, even-aged pine stands has greatly increased during the last few decades. This has brought about a corresponding increase in pests. Since the early 1950s the area covered by young tree stands in Finland has increased by 2.4 million hectares. Scots pine has been favoured, especially when establishing new stands after clear cutting or in the afforestation of drained peatland (Kuusela 1978). Large-scale, pure-stand forestry has been favoured over practices where trees grow in mixed stands, in rotations that alternate species, or in uneven age and size classes. Since the wide-scale establishment of new pine stands primarily commenced in the 1960s, there are now a great many plantations between 10 and 30 years old (Kuusela 1972). This process has benefitted several insect species which exploit young pines in a variety of ways, and has been very beneficial for the pine bark bug (Heliövaara & Väisänen 1983).

Pollution caused both by industry and traffic has increased the abundance of *A. cinnamomeus*. Already Schnaider (1968) and Brammanis (1975) noticed that the bugs thrived well near industrial areas. In a recent study (Heliövaara & Väisänen 1986 a) the highest bug densities, which was also evident from the poor growth of the pines, were usually recorded at a distance of 1—2 kilometres from a distinctive source of emissions. The densities were high over a wide area around polluting factories. There is also much anecdotal evidence that the bugs are concentrated along highways. Pollution is supposed to decrease the density of small parasitic wasps, but it more likely affects the crown structure and physiology of the pines and reduces their resistance against pests (Heliövaara et al. 1982, Heliövaara & Väisänen 1986 a).

The damage caused by the pine bark bug in northern Europe has so far been mainly a local phenomenon. The damage typically continues for several years in a certain area without the appearance of any striking symptoms. The yield of the stand is gradually reduced or, in the worse case, the whole stand has to be renewed. The chronical damage may cause considerable, localised, economic loss. At Vehkalahti, southeastern Finland, for instance, several hectares of young pine stands attacked by the pine bark bug had to be felled for firewood because of this pest (Laine 1971). Corresponding clear cut areas in Sweden have amounted up to several hundred hectares (Brammanis 1975). In Central and Eastern Europe the pine bark bug has been regarded as a harmful pest for a long time (Sajo 1895, Eckstein 1915, Krausse 1919, Gajl 1922, Strawinski 1925, Vasarhelyi 1983). The bug has caused serious damage especially in pine stands planted in sandy soils with nitrogen deficiency in the Ukraine, White Russia, Latvia and Poland (Stark 1933, Tropin 1949, Ozols 1960, Padij 1962, Voroncov 1962, Erskaya & Novoselov 1977). In Lithuania the area of forest chronically damaged by this pest has been estimated to be at least 1000—1300 hectares (Valenta et al 1980). *A. cinnamomeus* has also caused problems in the Netherlands (Doom 1976) and Sweden (Ringselle 1962, Brammanis 1975).

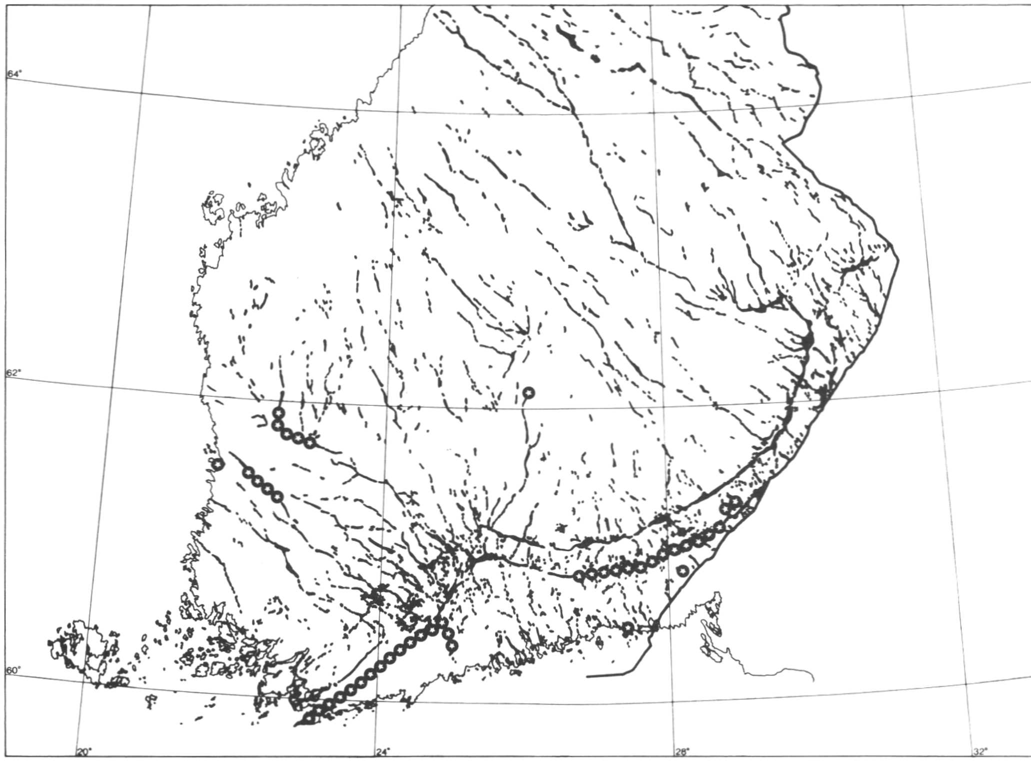


Fig. 1. The main esker areas in southern and Central Finland (black lines). Most of the pine stands known to be seriously infested by the pine bark bug (combined with stars) are concentrated along these eskers where Scots pine abounds.
Kuva 1. Etelä- ja Keski-Suomen harjualueet on merkitty karttaan mustalla. Useimmat tunnetuista punalatikan tuhoalueista (merkitty tähdillä) ovat keskittyneet näille mäntyä kasvaville harjualueille.

In Finland the damage has been concentrated in areas of extreme nitrogen deficiency (Fig. 1). The most susceptible areas include stands growing on dry mineral soils and on pine bogs. The proportion of *Calluna* and *Cladonia* type (CT, ClT) forest sites in the total area of forest land is about 3.3 % (Ilvessalo 1956). Consequently, the potential economic value of such damage is not usually considered to be very significant, especially when the low productivity of this type of forest is taken into account.

Although the damage caused by sucking is not externally striking in areas of higher fertility, it is evident that it does also occur on forest sites of the *Vaccinium* type (VT). However, the damage on such sites does not manifest itself as dry crowns, yellowish needles etc. because of the better resistance of the pines.

It should be noted that symptoms resembling *Aradus* damage (i.e. decreased height growth, short, yellowish needles etc.) may also be due to other factors. For instance, nutrient analyses made on both the soil and needles have suggested that a low level of calcium and magnesium in relation to aluminium results in damage of this sort (Raitio & Tikkanen 1986). Owing to disturbances in the nutrient balance, the weakened saplings become susceptible to frost, fungal pathogens and insect pests. However, the obscure causalities between air pollutants, nutrient in balances and insect damage (*Aradus* injury) deserve more detailed investigations.

The aim of the present investigation is to review recent advances in the study of the pine bark bug. In the silvicultural part of the study special attention is paid to the effect of stem number and the presence of other tree species on the population density of the bug, as well as to the height growth rate of the stand and damage caused by sucking.

The need and possibilities of controlling this pest by prophylactic silvicultural, biological or integrated methods are discussed. Since recent studies have brought a lot of new information on the bark fauna of Scots pine saplings, it is interesting to discuss whether there could be potential agents for biological control.

2. MATERIAL AND METHODS

21. Stem number and mixed pine-birch stands

The field work for this part of the study was carried out in southeastern Finland in the vicinity of Ruokolahti, Taipalsaari and Valkeala during summer 1980. The location of the study stands are shown in Fig. 2, and photographs of the stands in Fig. 3. Twelve study stands, all of which had been restocked by natural generation, were selected in pine forest of the CT site type. The effect of stem number on the incidence of bug damage was studied in seven sample stands of varying stem number, and the effect of an admixture of other tree species in three sample stands where birches *(Betula pendula)* grew among the pines. Two sample stands with a rather low number of bugs were used as 'control' stands for both substudies (Table 1). Three to five circular sample plots (100 m^2) were marked out in each stand. One of these plots was selected to be the most representative of the site as regards vegetation and stem number in each stand. The other plots were sited at a distance of 40 metres from the central plot to the main points of the compass.

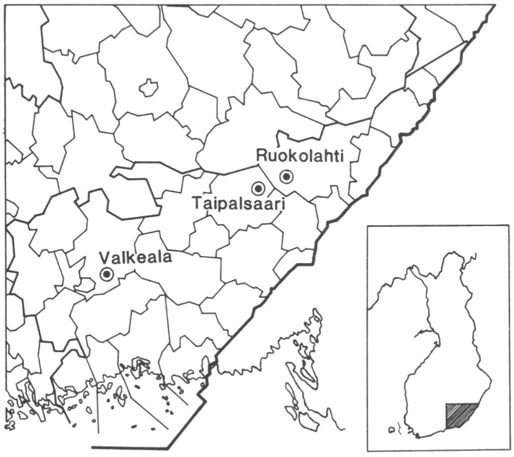


Fig. 2. Study sites in southeastern Finland. Stand 8 is situated in Taipalsaari, stands 2, 3 and 6 in Ruokolahti, and 1, 4, 5, 7, 9, 10, 11 and 12 in Valkeala.

Kuva 2. Tutkimusalueiden sijainti Kaakkois-Suomessa. Taimikko n:o 8 sijaitsee Taipalsaarella, taimikot 2, 3 ja 6 Ruokolahdella ja 1, 4, 5, 7, 9, 10, 11 ja 12 Valkealassa.

Every pine taller than 1.5 metres and thicker than 30 mm in the lower part of the trunk was studied. Trees that did not meet these selection criteria or has twin trunks or by moose damage were not investigated as such, but were included when determining the stem number.

The height increment of the last ten year period (1970—1979) was then measured. The real age of the trees was determined by adding three to four years to the number of branch whorls. The mean of the distances to the three nearest trees was used as the density index for each pine. The stem number of a sample stand was not considered to be a reliable measure of the stand density. The number of studied pines is given in Table 1.

In order to determine the loss in growth the pines were divided into three classes according to their condition as follows:

Class 1. Healthy-looking, well-growing pine,
Class 2. Moderately growing pine with slight damage caused by *Aradus cinnamomeus,* or other pests or pathogens,
Class 3. Slowly growing pine with typical *Aradus* symptoms.

The bug density in one pine in every condition class per sample plot was estimated using the maximum density method. The bark was removed over a 100 × 200 mm area at a point on the trunk where continuous tests suggested that the bug density would be highest (see Heliövaara 1982 a). The number of trees examined totalled 147, and the number of pine bark bugs recorded 8856.

When the pine bark bug sucks sap from the tree it damages the underlying tissue. This can be clearly seen as dark areas in cross sections of the trunk of an affected tree. Thin cross-section disks sawn from different parts of the trunk may give details about the history of the bugs on the pine. The annual variation in the sap-sucking activities, as well as the location of damage at different heights along the trunk can be observed. It is possible to make direct comparisons between the area of the trunk affected by sucking damage and the height growth rate. Dark-coloured tissue in the annual rings can also be caused by frost (see Aronsson 1980). However, most of the stands were situated at the top of Salpausselkä ridge in a microclimatically stable area which is not very susceptible to frost damage.

Twelve pines in every stand were selected for this study. Six of them were severely suffering from bug infestation and the other six healthy-looking, well-

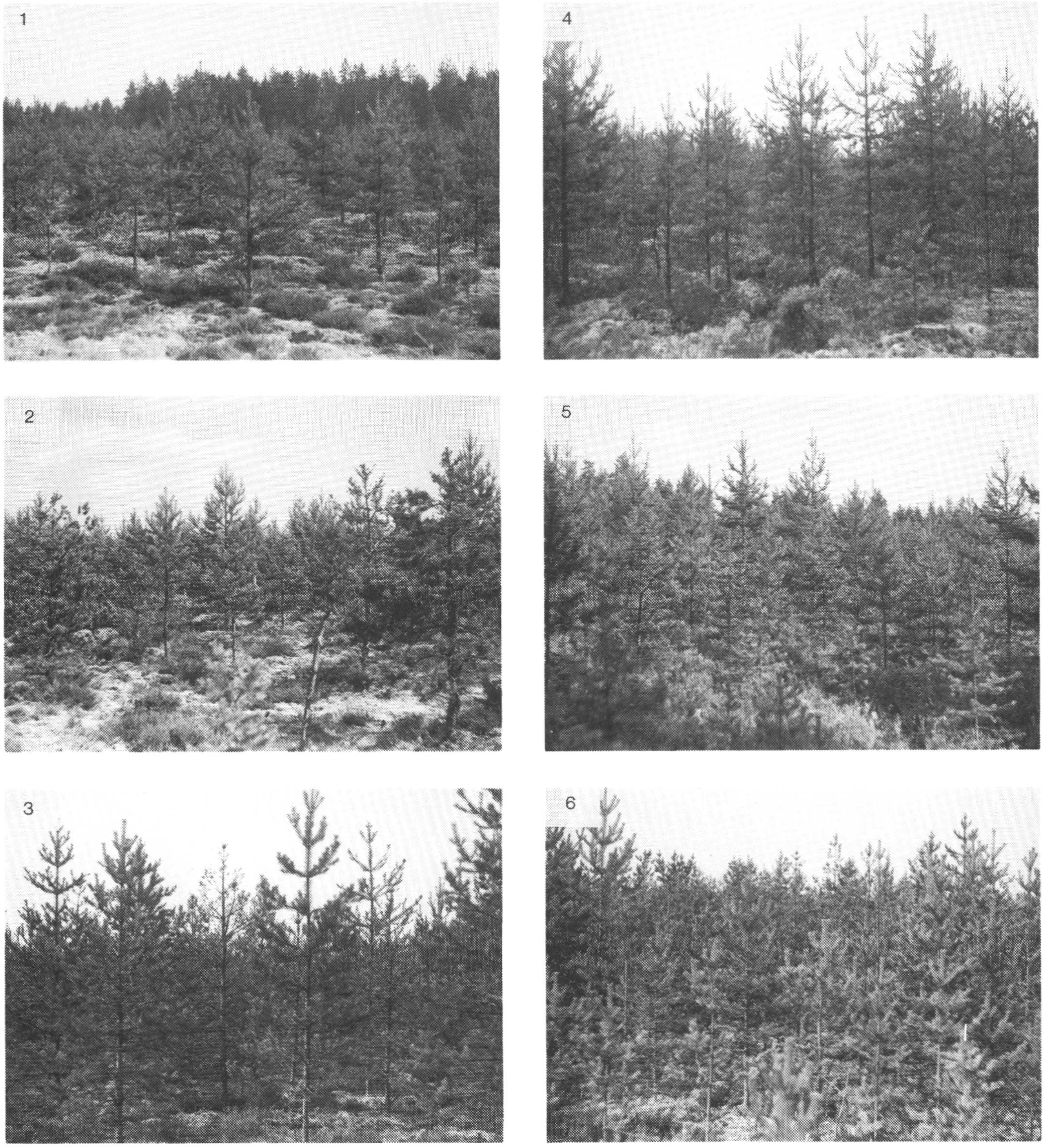


Fig. 3. General views of the study stands. The numbers on the photographs refer to Table 1 and Fig. 2.
Kuva 3. Yleisnäkymät tutkimusmetsiköistä. Kuvien numerot viittaavat taulukkoon 1 ja kuvaan 2.


7


8


9


10


11


12

Table 1. Number of pines and birches in the sample stands. C = control stand.
Taulukko 1. Mäntyjen ja koivujen lukumäärät eri taimikoissa. C = kontrolli.

Stand no. *Taimikko*	Number of sample plots *Koealojen lkm*	Pines *Mäntyjä*	Pines/ha *Mäntyjä/ha*	Birches *Koivuja*	Birches/ha *Koivuja/ha*	Percentage of birch *Koivu-%*
1	5	79	1580	2	40	2.5
2	5	95	1900	1	20	1.0
3	5	104	2080	0	0	0
4	4	118	2950	0	0	0
5	4	137	3425	4	100	3.5
6	3	149	4970	2	70	1.3
7	3	155	5170	15	500	9.7
8 C	5	113	2260	0	0	0
9	5	97	1940	13	260	11.8
10	4	99	2475	22	550	18.2
11	3	90	3000	22	730	19.6
12 C	3	111	3700	14	470	11.3

growing pines. 120 trees were felled in total, and 1093 cross-section disks were analysed. The disks were sawn from the mid point between every two branch whorls along the trunk. The disk was then viewed against the light, and the coverage of damaged tissue estimated visually (Fig. 4).

22. Natural enemies and chemicals

The literature on the natural enemies of the pine bark bug and the possibilities of its biological control are reviewed. In this respect special attention is paid to a recent study where the relationships between the abundances of bark invertebrates in pine saplings were analysed in Finland (Heliövaara & Väisänen 1986 b). Ten sample sites, twenty-five pines in each, had been studied from various biogeographical zones and from areas of different life cycle rhythms of the pine bark bug. Some unpublished information on certain co-existing invertebrates has also been included in the present discussion. The review of chemical control is entirely based on the literature.

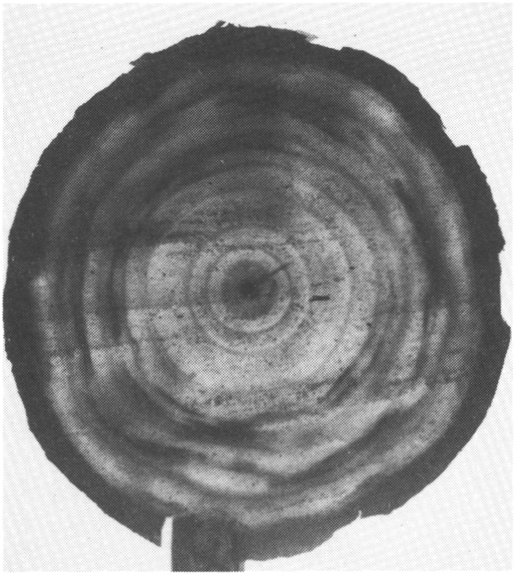


Fig. 4. Tissue damage caused by the pine bark bug in a cross section disk of an infested pine.
Kuva 4. Punalatikan imentävioituksia männyn poikkileikkauskiekossa.

3. ARADUS DAMAGE IN RELATION TO PINE STEM NUMBER AND MIXED PINE-BIRCH STANDS

31. Condition of the trees

The intensity of the damage caused by the pine bark bug in different sample stands is reflected in the proportion of the three tree condition classes. The proportion of the most severely damaged pines (class 3) was more than 20 % in five stands, with a stem number of 1900, 2100, 2200, 3000 and 5000 pines per hectare (Fig. 5). Two of these stands are mixed ones. This at first sight would seem to indicate that the bug may be abundant in stands with a very different stem number. However, the abundance of the bugs in the stand with 5000 trees per hectare is explained by the uneven distribution of the trees, the bugs being concentrated around gaps in the stand. In the combined material, the proportion of trees severely damaged by *A. cinnamomeus* was 11—12 % in both pure and mixed stands.

32. Variation in the height growth rate

The high variation in the height growth rate between stands during the first half of the ten-year study period is due to the different age structure of the stands and also to the use of different silvicultural practices. The estimation of growth loss is thus based on the latter part of the ten-year period. It should be noted that in some cases the height growth curves bisect each other. One reason for this may be that the bugs have attacked well-growing trees with the result that their height growth has subsequently started to decrease (Fig. 6).

The differences in the height growth rate between the healthy-looking (class 1) and *Aradus* damaged (class 3) pines were statistically highly significant (Table 2). Differences between the healthy-looking (class 1) and slightly damaged (class 2) were also clear.

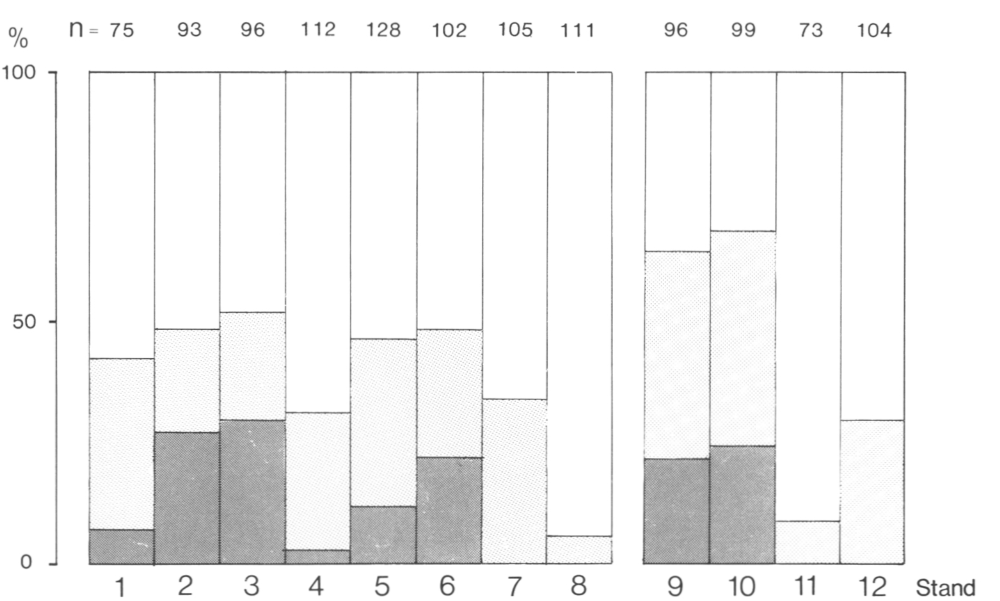


Fig. 5. Proportions of pines in different tree condition classes in the study stands. White — class 1, grey — class 2, black — class 3. See the text for class definitions.
Kuva 5. Tutkittujen mäntyjen jakaantuminen kuntoluokkiin. Valkea — luokka 1, harmaa — luokka 2, musta — luokka 3. Kuntoluokkien määrityksestä tarkemmin tekstissä.

Table 2. Height growth of the study trees in pure stands (1—8) and in mixed stand (9—12) in 1975—1979. n = number of trees. Values of t-test have been calculated for growth losses between healthy-looking pines (Class 1) and typical *Aradus*-infested pines (Class 3). Significances: * = P < 0.5, ** = P < 0.01, *** = P < 0.001. SEM = standard error of mean.

Taulukko 2. Vuosien 1975—1979 yhteenlasketut pituuskasvut kuntoluokittain puhtaissa mäntytaimikoissa (1—8) ja sekataimikoissa (9—12). n = puiden lukumäärä. Normaalikuntoisten mäntyjen (Luokka 1) ja Aradus-*mäntyjen (Luokka 3) välistä kasvutappiota on vertailtu t-testillä. Merkitsevyydet: * = P < 0.5, ** = P < 0.01, *** = P < 0.001. SEM = keskiarvon keskivirhe.*

Stand no. *Taimikko*	Class *Luokka*	Height growth in 1975—1979, cm *Pituuskasvu vuosina 1975—1979, cm*					Annual loss of height growth, cm *Vuotuinen pituuskasvutappio, cm*	
		x̄	SEM	n	t: Class 1 *Luokka 1*	t: Class 2 *Luokka 2*	x̄	%
1	1	135.5	4.52	45	—	—		
	2	107.1	4.08	25	4.263***	—		
	3	81.6	6.24	5	4.285***	1.953	10.8	39.8
	1—3	122.4	3.63	75	—	—		
2	1	126.7	4.11	48	—	—		
	2	97.0	6.27	22	4.077***			
	3	96.9	5.40	25	4.273***	0.015	6.0	23.5
	1—3	112.0	3.26	95	—	—		
3	1	157.0	4.06	46	—	—		
	2	141.0	5.53	23	2.114*	—		
	3	124.7	6.71	27	4.502***	1.944	6.5	20.6
	1—3	144.1	3.30	96	—	—		
4	1	138.1	3.46	79	—	—		
	2	90.7	4.18	30	7.718***	—		
	3	52.7	6.57	3	5.077***	2.198*	17.1	61.8
	1—3	123.1	3.51	112	—	—		
5	1	133.5	2.52	70	—	—		
	2	99.0	2.27	45	8.503***	—		
	3	74.6	3.31	13	9.430***	3.884***	11.8	44.1
	1—3	115.2	2.57	128	—	—		
6	1	117.2	3.57	53	—	—		
	2	97.4	5.00	28	3.144***	—		
	3	103.5	6.51	21	1.961	0.792	2.7	11.6
	1—3	108.9	2.78	102	—	—		
7	1	139.8	3.68	71	—	—		
	2	96.2	3.80	34	7.337***	—		
	3	—	—	—	—	—	—	—
	1—3	125.7	3.41	105	—	—		
8	1	161.3	3.21	105	—	—		
	2	115.7	9.58	6		—		
	3	—	—	—	—	—	—	—
	1—3	158.9	3.23	111	—	—		
1—8	1	140.7	—	517	—	—		
	2	103.1	—	213	14.802***	—		
	3	101.1	—	94	11.338***	0.535	7.9	28.1
	1—3	126.5	—	824	—	—		
9	1	116.2	4.14	34	—	—		
	2	89.6	2.18	42	6.179***	—		
	3	74.5	3.62	20	7.924***	2.972	8.3	35.9
	1—3	95.9	2.50	96	—	—		
10	1	147.9	5.37	33	—	—		
	2	123.8	3.99	42	3.571***	—		
	3	93.5	6.50	24	6.987***	4.078***	10.9	36.8
	1—3	124.5	3.55	99	—	—		
11	1	123.8	3.83	66	—	—		
	2	105.7	7.00	7	1.508	—		
	3	—	—	—	—	—	—	—
	1—3	122.1	3.57	73	—	—		
12	1	129.7	2.43	104	—	—		
	2	96.1	2.67	31	8.052***	—		
	3	—	—	—	—	—	—	—
	1—3	119.78	2.43	104	—	—		
9—12	1	128.5	—	206	—	—		
	2	103.9	—	122	7.994***	—		
	3	84.9	—	44	9.764***	4.028***	8.7	33.9
	1—3	115.3	—	372	—	—		

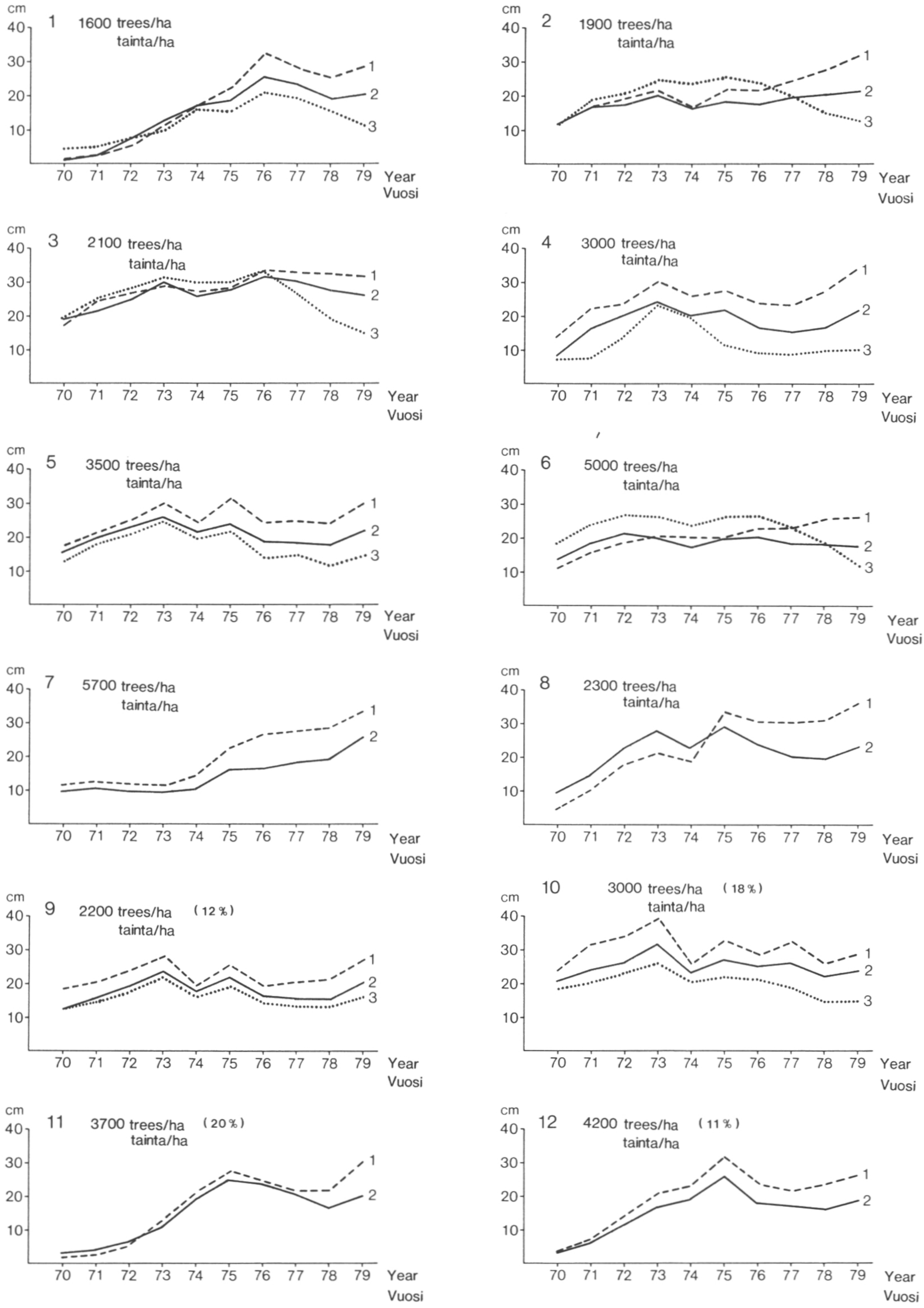


Fig. 6. The height growth rates of the study pines in the three tree condition classes in different stands (1—12) in 1970—1979.

Kuva 6. Eri kuntoluokkiin kuuluvien mäntyjen pituuskasvun kehitys tutkimusmetsiköissä (1—12) vuosina 1970—1979.

Table 3. Density indices (mean SE) for the study pines in pure stands (1—8) and in mixed stands (9—12). Significances for the t-test values as in Table 2.
Taulukko 3. Taimikohtaiset tiheystunnukset (keskiarvon keskivirhe) puhtaissa mäntytaimikoissa (1-8) ja sekataimikoissa (9-12). Merkitsevyydet t-testissä kuten taulukossa 2.

Stand no. *Taimikko*	Class *Luokka*	Density index *Tiheystunnus*				
		$\bar{x}$	SEM	n	t	
					Class 1 *Luokka 1*	Class 2 *Luokka 2*
1	1	190.4	8.17	45	—	—
	2	170.9	10.21	25	1.428	—
	3	237.0	31.20	5	1.814	2.473*
	1—3	187.0	6.49	75	—	—
2	1	184.3	4.14	48	—	—
	2	178.2	6.30	22	0.805	—
	3	200.0	6.26	25	2.145*	2.518*
	1—3	187.0	3.12	95	—	—
3	1	178.5	3.74	46	—	—
	2	195.3	6.56	23	2.383*	—
	3	196.4	5.36	27	2.687**	0.151
	1—3	187.5	2.93	96	—	—
4	1	155.4	3.26	79	—	—
	2	154.8	3.34	70	0.102	—
	3	150.0	15.28	3	0.345	0.299
	1—3	155.1	2.48	112	—	—
5	1	129.2	3.36	70	—	—
	2	140.3	4.25	45	1.980*	—
	3	153.8	10.41	13	2.771**	1.456
	1—3	135.6	2.67	128	—	—
6	1	90.9	4.27	53	—	—
	2	119.7	7.12	28	3.617***	—
	3	120.0	7.97	21	3.319**	0.038
	1—3	104.8	3.64	102	—	—
7	1	99.7	4.44	72	—	—
	2	102.3	6.20	34	0.327	—
	3	—	—	—	—	—
	1—3	100.5	3.60	106	—	—
8	1	163.0	3.05	105	—	—
	2	165.7	13.45	6	0.203	—
	3	—	—	—	—	—
	1—3	163.1	2.96	111	—	—
1—8	1	146.8	—	518	—	—
	2	147.7	—	213	0.236	—
	3	175.1	—	94	5.391***	4.726***
	1—3	150.2	—	825	—	—
9	1	180.8	4.34	34	—	—
	2	179.0	5.15	42	0.255	—
	3	200.3	7.61	20	2.234*	2.534*
	1—3	184.1	3.24	96	—	—
10	1	150.2	6.50	33	—	—
	2	146.4	5.33	42	0.437	—
	3	161.0	8.44	24	1.077	1.526
	1—3	151.2	3.75	99	—	—
11	1	102.0	5.28	66	—	—
	2	116.9	14.66	7	0.880	—
	3	—	—	—	—	—
	1—3	103.4	4.97	73	—	—
12	1	136.1	3.45	73	—	—
	2	133.8	4.86	31	0.368	—
	3	—	—	—	—	—
	1—3	135.4	2.81	104	—	—
9—12	1	152.7	—	122	3.731***	—
	3	178.8	—	44	6.298***	3.525***
	1—3	145.9	—	372	—	—

The annual loss in growth was calculated as the difference between the height growth rates of healthy-looking pines and pines infested with *Aradus*. The annual loss in height growth varied from 30 to 170 mm (12—63 %). The annual mean loss in height growth was 79 mm (28 %) in pure stands, and 87 mm (34 %) in mixed stands.

33. Effect of stem number

The pines with typical *Aradus* symptoms (class 3) were growing further apart from each other than the healthy-looking pines (class 1) in seven stands out of eight. The density indices calculated for each pine in class 3 were 16 % higher than those in pure stands, and 25 % higher in mixed stands compared with the indices of normally growing pines (Table 3). The results show that the pine bark bugs preferably attack pines growing in relatively isolated positions.

34. Height growth rate in relation to damaged tissue

Damaged tissue in cross section disks was recorded in all the sample stands. In several cases it was concluded that at least eight years had elapsed since the first attack by the bug. Despite this, no tendency of decreasing growth was observed. The two-year periodicity and alternate-year reproduction of the bugs (even years in the study area) can be observed in the amount of damaged tissue (Fig. 7). 1976 and 1978, especially, seem to have been favourable for the bugs. In 1978, the mean coverage percentage of damaged tissue in the five most severely damaged annual rings exceeded 50 % in six of the stands.

Moderate sucking of *A. cinnamomeus* does not necessarily decrease the height growth rate of pines (Fig. 7). Slightly damaged tissue was observed even in healthy-looking control trees. In several cases the height growth rate had not decreased, even though the proportion of the damaged area of the annual ring was about 20 %. It was also observed that even severe sucking in one year does not immediately decrease the growth of pines. If the sucking continues for several years in succession, a lower level of sucking is enough to cause a cessation of growth. However, it should be pointed out here that other factors also regulate the growth of pines. In poor soil, where *Aradus* damage often occurs, the nutrient balance is easily disturbed (see Raitio & Tikkanen 1986).

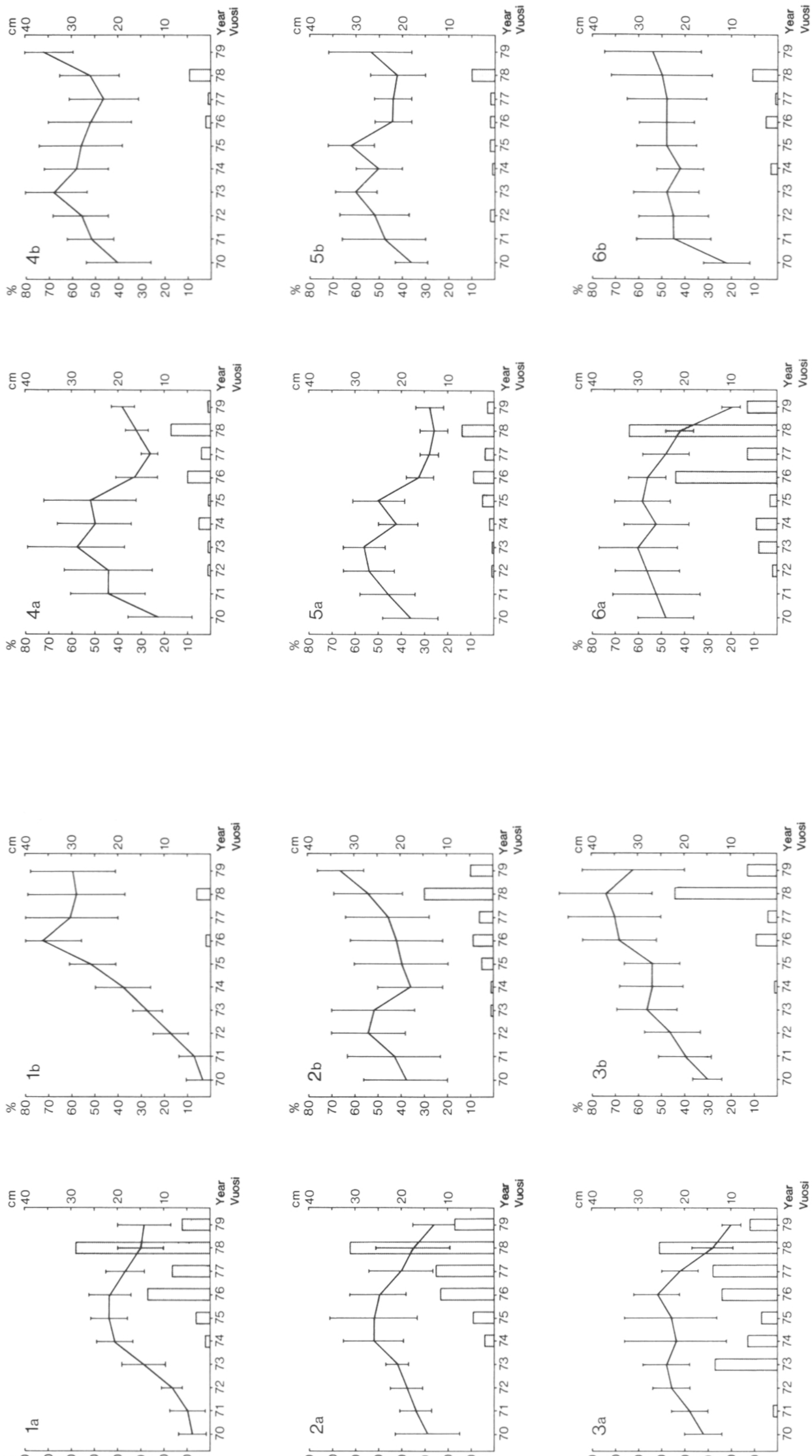
35. Population density of *A. cinnamomeus*

The mean density of the pine bark bugs was higher than 20 exx/dm^2 in six stands (Table 4). In all the five stands where the proportion of pines in class 3 exceeded 20 %, the mean bug density also exceeded 20 exx/dm^2 (cf. Fig. 5). The densities in stands 4 and 5 are remarkably low. This supports the results obtained from the cross-section disks that some other ecological factors may be responsible for the decrease in growth in these stands. It is also noteworthy that in stand 7, with a stem number of 5700, the mean bug density was as high as 18 exx/dm^2. The highest mean bug density, 49.2 bugs/dm^2, was recorded in a mixed stand. The highest bug density in a single tree, 115 bugs/dm^2 (392 bugs in a 200 mm^2 sample of bark) was also observed in this stand.

Table 4. Numbers and densities of the pine bark bugs in samples taken in different study stands. C = control stand. SD = standard deviation.

Taulukko 4. Näytteiden sisältämät punalatikoiden määrät ja tiheydet eri taimikoissa. C = kontrolli. SD = keskihajonta.

Stand no. *Taimikko*	Bugs *Latikoita*	Bugs/sample *Latikoita/näyte*	Mean density exx/dm^2 *Latikkatiheys yks./dm^2* $\bar{x}$	SD
1	840	56.0	22.0	20.7
2	1556	103.7	34.3	24.0
3	945	63.0	20.9	20.5
4	205	17.1	5.6	4.2
5	189	15.8	5.9	4.9
6	720	80.0	25.2	15.2
7	470	52.2	18.1	8.0
8 C	589	39.3	12.9	9.7
9	2148	145.6	49.2	32.7
10	818	68.2	20.8	11.5
11	262	29.1	11.0	9.7
12 C	78	8.7	3.5	2.9


1a
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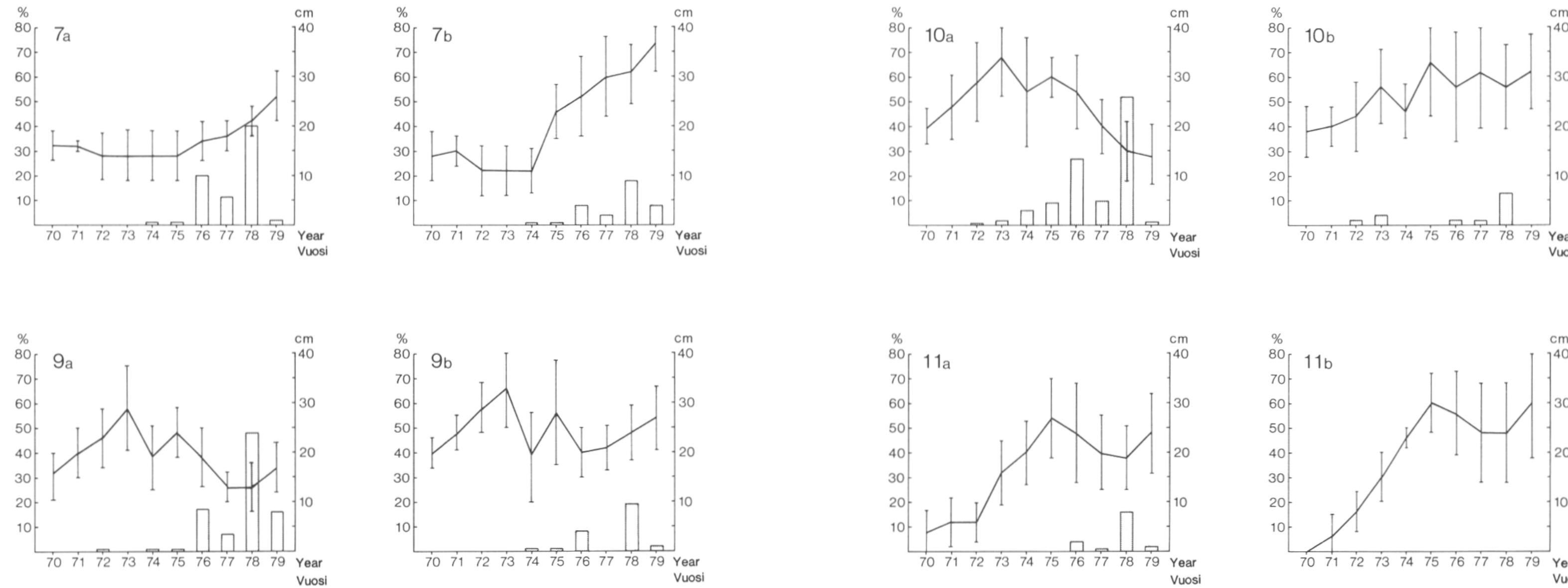

Fig. 7. Height growth rates of the felled study pines in relation to the amount of sucking damage in 1970—1979. Figures on the left (indicated by a) show results for *Aradus*-infested trees (n = 6), those on the right (b) in healthy-looking trees (n = 6). The line indicates the annual height growth rate of a pine (mean ± SD). The columns indicate the mean coverage of damaged tissue in the five most severely damaged cross section disks.

Kuva 7. Kaadettujen analyysipuiden pituuskasvu suhteessa imentävioituksen määrään vuosina 1970—1979. Vasemmalla (a) Aradus*-männyt (n = 6), oikealla (b) hyväkasvuiset männyt (n = 6). Murtoviiva kuvaa puiden vuotuista pituuskasvua (keskiarvo ± keskihajonta). Pylväät ilmaisevat vioittuneiden solukkojen keskimääräisen vuotuisen peittävyysprosentin viidessä pahimmin imetyssä poikkileikkauskiekossa.*

36. Vertical distribution of the damaged tissue

The cross-section disks provided the possibility to compare the vertical distribution of the damaged tissue, and also the occurrence of bugs, in pure and mixed stands. The location of the damage depended slightly on the age of the pine. The mean age of healthy-looking trees in pure stands was 15.2 years (range 10—21), and for *Aradus* pines 15.4 (10—23). In mixed stands the age was 15.1 (10—18) and 16.1 years (10—21), respectively. The results show that the damage caused by sucking was concentrated in 4th to 7th annual shoot in 15-year-old pines (Fig. 8). It can also be seen that damage caused by sucking at the base of trees is less severe in mixed stands than in pure stands.

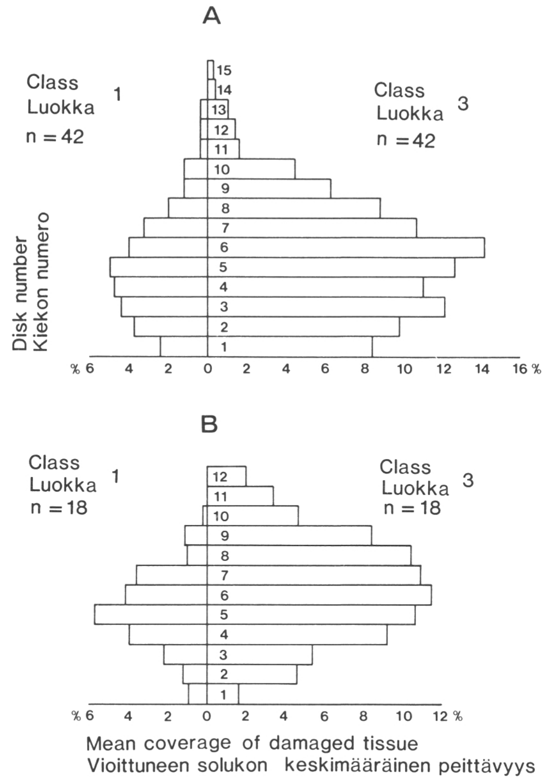

Fig. 8. Mean coverage of damaged tissue in 1975—1979 in the cross section disks of different annual shoots in pure pine stands (A) and in mixed stands (B). On the vertical axis the disks taken between branch whorls are numbered from the ground to the top of the tree (1. . . 15).

Kuva 8. Vuosina 1975—1979 vioittuneiden solukkojen keskimääräinen peittävyysprosentti puhtaissa mäntytaimikoissa (A) ja sekataimikoissa (B). Oksakiehkuroiden väliset poikkileikkauskiekot on numeroitu pystyakselilla maanpinnasta ylöspäin (1 . . . 15).

4. NATURAL ENEMIES OF ARADUS CINNAMOMEUS

41. *Telenomus aradi*, egg parasitoid of *A. cinnamomeus*

Telenomus aradi causes heavy mortality in the egg stage of the pine bark bug. Tropin (1949) has shown in the USSR that up to 63 % of the eggs can be parasitized. In Finland, parasitization of the eggs of *Aradus* by *Telenomus* varies from 6.5 % to 72 % in different areas (Heliövaara & Väisänen 1984). The biology of this scelionid wasp is very poorly known. In a previous study, the only sample containing a marked number of *Telenomus* wasps had been collected in the transition zone where the life cycle of the bug changes from two to three years (Heliövaara & Väisänen 1986b). This coincidence is not necessarily mere chance. Bugs of different age-classes occur sympatrically in the transition zone and eggs are available for the parasitoid every year, unlike the situation in the two-year area.

42. Other arthropod predators

There are only a few potential predators of the bug that occur in reasonable quantities on pine trunks, viz. Neuroptera (especially *Raphidia* larvae), *Telenomus aradi* Kozlov, a bdellid mite *Bdella longicornis* (L.), and spiders (Heliövaara & Väisänen 1986b, see also Doom 1976). The most prominent species of spiders are *Philodromus fuscomarginatus* Degeer, *Clubiona subsultans* Thorell, *Drapetisca socialis* (Sundevall), *Micaria subopaca* Westring, *Salticus cingulatus* (Panzer) and *Moebilia penicillata* (Westring). It has been observed that spiders very seldom eat *Aradus*. The less numerous *Raphidia* larvae have sometimes been seen carrying single bugs, but they cannot be of any major importance. However, one larva of *Raphidia* has been reported to have killed 55 adults of the bug during a four-day period (Brammanis 1975, and his references. These reports were not found in the references mentioned by Brammanis). In addition, ants have sometimes been seen to remove bugs or their eggs. The predacious mite, *Bdella longicornis*, has never been observed to attack the bug, but it could be a predator of eggs and small larvae of the pine bark bug.

43. Birds

As a whole, the pine bark bug seems to be very rarely a target of vertebrate predators, especially when its extreme abundance is taken into account. However, it is so well camouflaged that it is very difficult to detect even when exposed on the bark. Insectivorous birds such as the tree creeper *(Certhia familiaris)* and the great spotted woodpecker *(Dendrocopos major)* may have some significance as predators, although they usually locate their prey on the basis of visual sighting. In fact, according to Brammanis (1975) a great spotted woodpecker has on one occasion been reported as eating 272 pine bark bugs. In autumn, 1986, we daily observed willow tits *(Parus montanus)*, crested tits *(P. cristatus)* and great tits *(P. major)* looking for food on pine trunks in an *Aradus*-infested stand.The willow tits were able to remove bark scales and pick up insects they found underneath.

44. Diseases

Several pathogenic fungi attack the pine bark bug particularly during hibernation. Larvae hibernating in large numbers in small areas are more susceptible to infection than adults (Tropin 1949, Brammanis 1969). The most abundant fungal disease is that caused by *Beauveria bassiana*, which has also been used in the biological control of this bug. *Paecilomyces farinosus* and *Spicaria farinosa* have also been identified in the material collected by Brammanis (1975).

5. OUTLINES AND PROSPECTS OF CONTROL

51. Silvicultural measures

511. Stem number

In several previous papers it has been concluded that a low stem number favours the pine bark bug (Voroncov 1956, Obozov 1964, Valenta 1970, Brammanis 1975). Brammanis (1965, 1973) reported that the greatest bug densities in even-aged stands usually occur on pines growing around gaps or at the edges of the stand. The results of the present study agree well with these observations in that the bugs had aggregated on pines with ample growing space in almost every sample stand. The reason for this may be either the microclimate, or the architecture of the stand. Evidently the bug prefers warm, dry and sun-exposed trees. On the other hand, macropterous females colonising new sites on the other hand may first attack the trees at the edges of the stand.

According to the silvicultural directions issued by the Central Forest Association Tapio the conifer-dominated stands should be thinned to 2000 trees per hectare (Yksityismetsien käsittelyohjeet 1981, Taimikonperkaus ja harvennus 1986). The stem number for pine and birch is allowed to be 1000 trees/ha higher in areas damaged by moose, or when branchiness is specifically prevented. The directions of the National Board of Forestry allow a minimum stem number of 1600 trees per hectare in dry-heath forests (Ohjekirje metsien... 1985). A suitable admixture of deciduous trees permits the stem number to be increased 10—20 % in coniferous stands. The directions include a small margin for potential damage.

Damage caused by the pine bark bug may also be considerable in relatively dense stands with an uneven age structure. In Germany, *A. cinnamomeus* is not a serious pest in spite of the favourable edaphic and climatic conditions. This has been presumed to be due to the high stem number used in commercial forestry (see Brammanis 1975). In the USSR, a stem number of 10000—15000 trees per hectare is used on unfertile sites to prevent pest attacks prophylactically (Padij 1962). Higher stem numbers could also be applied in the worst affected areas in Finland. This would be especially easy and profitable in unfertile areas where natural reforestation is employed. In addition to a decreased risk of damage, a higher stem number would have a favourable effect on the crown structure and branchiness of pine (e.g. Uusvaara 1974, Persson 1977, Varmola 1980, 1982, Jokinen & Kellomäki 1982, Kellomäki 1984, Huuri et al. 1987). According to Huuri et al. (1984), the technical quality of pine clearly improves up to a stem number of 6000 trees/ha in stands of the CT site type in southern Finland. On the other hand, the nutrient and water status are often easily disturbed in poor soil, and raising the stem number could result in increased pine mortality. This would lead to an uneven structure of the stand which, again, would favour the bug. A rapid height growth rate in pine would be favourable since the bug damage tends to be concentrated in young saplings. The most recommendable stem number as far as the height development of pine is concerned, would be 3000—4000 trees/ha (Huuri et al. 1987).

Correct timing of thinning could decrease *Aradus* damage. Early thinning is generally recommended when the dominant height reaches five metres (e.g. Vestjordet 1959, Andersson 1968, Vuokila 1972). According to the directions of Central Forest Association Tapio (Taimikonperkaus ja harvennus 1986) pine and birch stands should be thinned when the dominant height is 3—4 m. The stands can also be thinned at a height of 4—5 m in potential moose-damage areas, and in stands where there is no need for cleaning. According to the instructions of the National Board of Forestry (Ohjekirje metsien... 1985), pine stands restocked by natural generation or seeding should be thinned in two phases. The first is carried out at a height of 1.0—1.5 m (depending on the basic stem number) to 4000 trees/ha.

The second thinning is carried out at a height of 4—6 m. To decrease the danger of damage caused by *A. cinnamomeus* two different times for thinning are proposed: The first thinning should be carried out as late as possible to allow the pines to grow in a dense position. However, the crowns of the trees may not develop sufficiently and the development of the whole tree may slow down. Tree quality, on the other hand, will be better since branchiness decreases. Furthermore, too late thinning may cause other pest problems. The pine shoot beetles (*Tomicus* spp., Coleoptera, Scolytidae) start to breed in trunks whose diameter exceed 70 mm (e.g. Butovitsch 1953, Andersson & Lekander 1966).

Another alternative is to thin the pine stand at the normal time, but to do so very lightly in order to make the stand even. This could be especially applicable in uneven stands, where high variation in the age structure and growing space of the pines occurs. As a whole, too early routine thinnings are the most dangerous and often the origin for a mass outbreak of the pine bark bug (Pravdin 1968, Brammanis 1975).

512. Mixed stands

Aradus cinnamomeus is said to avoid mixed stands where birches abound. Ozols (1960) recorded five times higher bug densities in pure pine stands compared to mixed stands. His observations were confirmed by Brammanis (1969) who noticed that birches prevent bug populations from increasing. This is based mainly on two indirect factors, the significance of habitat fragmentation itself remaining uncertain (see e.g. Kareiva 1986). First of all, birches shade the pines and thus decrease the temperature and raise the humidity on the trunks of pines. This makes living conditions for the bug more unfavourable. Voroncov (1962) has even reported that a relative humidity of 80 % prevents the eggs of *A. cinnamomeus* from developing. Secondly, the litter formed by birch leaves is very favourable for many pathogens, such as *Beauveria bassiana,* and the bugs overwintering there are easily infected and damaged. Consequently, the bugs avoid hibernating in soil covered by a thick layer of decaying birch leaves (see Hoberlandt 1972). In pure stands the bugs mainly hibernate in litter formed from coniferous trees, where the mortality is smaller than among bugs hibernating in the base of the tree (Turcek 1964, 1965, Heliövaara 1982 b). The difference in the vertical distribution of sucking damage in pines growing in pure and in mixed stands observed in the present study may be explained by these factors.

The results obtained from four mixed, birch-pine stands in the present investigation show that a small admixture of tree species is not enough to prevent damage caused by *A. cinnamomeus.* The number of *Aradus*-infested pines, the size of the growth losses, and the bug densities were at least as high in mixed stands as in pure stands. The reliability of the results is weakened by the fact that a lot of the birch saplings had been removed in some mixed stands some years earlier, and the shading effect of the new sprouts was not as great. However, the proportion of birches in the present study stands are too high from the silvicultural point of view, and are thus not representative of the normal conditions (Yksityismetsien käsittelyohjeet 1981, Taimikonperkaus ja harvennus 1986). Nevertheless, the directives themselves are well justified because raising birches as a commercial tree crop in *Calluna* type (CT) sites is not feasible. An admixture of birch decreases the diameter growth and cause mechanical injury to pine crowns, but accelerates the action of micro-organisms and nutrient cycling (see Walfridsson 1976, Folkesson & Bärring 1982). The height growth of pines is improved when birches that are shorter or the same height are cultivated among pines, but the growth is decreased when taller deciduous trees are included (Andersson 1982). Even though the results concerning the preventive effect of low numbers of birches on *Aradus* damage have not been fully valified, it would be advisable to allow a birch undergrowth to grow, whenever possible, among pines in the worst affected areas. The instructions of the National Board of Forestry (Ohjekirje metsien... 1985) to leave more birches along stand edges is highly recommendable in areas damaged by *A. cinnamomeus.*

52. Biological control

About 80 % of all the biological control successes depend on the action of parasites. Parasites have usually performed better than predators against pests of forest trees, especially Heteroptera (for a review, see Hokkanen 1985). Classical biological programmes have traditionally been based on the use of natural enemies from the native area of the pest (e.g. Sweetham 1958, Huffaker et al. 1971, Zwölfer et al. 1976). The success of introducing natural enemies as a biological control measure have been found to be about 75 % higher in the case of new parasite-host (predator-prey) associations than those based on long-evolved associations between parasitoids and hosts (Hokkanen & Pimentel 1984). New associations, however, seem to be only 0.8 times as successful for the control of hemipterous pests compared with old associations (Hokkanen 1985). Thus a search should be made for the natural enemies from both the old associations of the pine bark bug, and from other areas. Since there does not seem to be many native enemies in the bark fauna, the parasitoids of the closely related Nearctic *Aradus* species, such as *Aradus kormilevi* Heiss and *Aradus antennalis* Parshley, might be worth investigating. However, a cautious attitude should be taken when insects are transplanted.

Fungal diseases, especially *Beauveria* species, have increased the mortality of bugs on a few occasions, and have been considered as promising agents for biological control (Smirnov 1954, Turcek 1965). In the USSR, *Beauveria* species ("Boverin") have been widely used to control agricultural pests. However, no progress has yet been achieved in the control of the pine bark bug with fungal diseases, and the possibilities for biological control do not seem to be very good in this respect.

53. Chemical and integrated control

The pine bark bug appears to be a tenacious species with a high resistance to chemicals. Several chemicals have been used with variable results in the control of *Aradus cinnamomeus,* particularly in the USSR. These out-of-date methods have been reported and summarized by Eckstein (1915), Tropin (1949, 1968), Mactet & Pasov (1955), Obozov (1964), Brammanis (1975). The results obtained with a wide range of 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 with better results (Treskin et al. 1960, Andreeva 1964, 1966, Brammanis 1975). In a recent study both dimethoate and lindan treatments decreased the bug density, but the recovery of height growth of the treated trees was not clearly noticeable (Heliövaara et al. 1983). No routine chemical control methods are used in Finland at present. In the USSR much attention has been paid to the chemical control of *A. cinnamomeus,* and detailed recommendations for the application of systemic insecticides are given in recent papers (Valenta et al. 1980, Zegas 1981).

Forest fertilization has been found to affect the occurrence and harmfulness of many insects (Oldiges 1960, Schwenke 1960, Stark 1965). Fertilizers may change the physiological state of the host tree as well as the nutrition of the insects. The impact of these changes has been discussed by e.g. Büttner (1961) and Merker (1967).

Forest fertilization has been proposed as a protective method against pests because of its effect on tree resistance (see Merker 1967, 1969). Young Scots pine stands have been fertilized in southeastern Finland with the aim of controlling the pine bark bug but without any precise knowledge about the effect of fertilization on the bug population. Results concerning the effects of nitrogen fertilization on the pine bark bug are contradictory. Valenta et al.(1980) reported that fertilizers increase the secretion of resin and change the level of carbohydrates, which may result in the death of the bugs. 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. In a more detailed investigation nitrogen fertilization increased both the bug population and the height growth of pines (Heliövaara et al. 1983). It has been assumed to be easier for sap-sucking insects to take sap from host trees which have a high turgor pressure as a result of fertilization (see Schwenke 1961, 1962). It is known that plants with too high a nitrogen nutrition can be more susceptible to aphid attack (Rahier 1978, Hanisch 1980). In the case of the pine bark bug application of fertilizers may be excused at least in badly damaged stand in order to pass rapidly the susceptible sapling stage.

6. CONCLUSIONS

No single effective method of controlling *Aradus cinnamomeus* has yet become available, but the usage of several prophylactic silvicultural practices would probably give the most favourable result. The pine bark bug primarily attacks young pine stands growing in relatively isolated positions. Consequently, the structure of the stand should, right from the very beginning of stand cultivation, be even and dense without gaps and have at least 3000 (or even 5000—6000) pines per hectare. The first thinning should be conducted as late as possible (dominant height of pines 5—6 meters). Another alternative is to thin the pine stand at the normal time, but only very lightly in order to make the stand even. Early, heavy thinnings in damaged areas should be avoided. Mixed stands containing birch should be favoured whenever possible, but the results are not indisputable when the number of birches is low. The prospects of biological control do not seem to be very promising, but new associations of predators as well as old ones in the bark fauna may be worth investigating. Experiments with pathogenic fungi applied during wintertime, combined with dense, humid stands, are needed. Chemical control seems to be rather difficult but the work on this question is far from complete. Nitrogen fertilization is beneficial both to the bug and the pines, but usage of fertilization could be justificated in that the most susceptible phase of the stand is passed rapidly.

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SELOSTE

Punalatikan torjunta erityisesti metsänhoidollisin menetelmin

Johdanto

Punalatikka on nuorissa männyissä kuoren alla elävä männyn nesteitä imevä lude. Se on selvästi yleistynyt sekä nykyaikaisten metsänkäsittelymenetelmien että ilman epäpuhtauksien lisääntymisen seurauksena. Latikkatuhot ovat Pohjois-Euroopassa olleet paikoittaisia. Tuhot jatkuvat samalla alueella usein pitkään, jolloin taimikosta tulee vajaatuottoinen ja kasvatuskelvoton. Vehkalahdella on latikoiden vaivaamaa männikköä jouduttu hakkaamaan polttopuuksi useiden hehtaarien alueelta. Ruotsissa latikoiden vioittamia taimikoita on hakattu satoja hehtaareja. Suomessa tuhojen metsätaloudellista merkitystä on pidettävä melko vähäisenä, koska latikkatuhot ovat keskittyneet vähäravinteisille karukkokankaille ja harjualueille (kuva 1), mutta paikallisesti punalatikka aiheuttaa metsänomistajalle suuria taloudellisia tappioita.

Maaperästä ja neulasista tehdyt ravinneanalyysit ovat osoittaneet, että kalsiumin ja magnesiumin niukkuus alumiinin nähden aiheuttaa männyissä punalatikkatuhoille ominaisia oireita. Ravinnetaloushäiriöiden ja hyönteistuhojen välisiä riippuvuussuhteita ei kuitenkaan ole kyetty tyydyttävästi selvittämään.

Tutkimuksen tarkoituksena on selvittää ennaltaehkäisevien metsänhoidollisten, kemiallisten ja biologisten menetelmien käytön tarvetta ja mahdollisuuksia punalatikan torjunnassa. Erityisesti pyritään selvittämään, voidaanko taimikon tiheyttä säätelemällä pienentää punalatikan aiheuttamia pituuskasvutappioita. Lisäksi pyritään selvittämään lehtipuusekoituksen vaikutusta latikkatuhoihin.

Aineisto ja menetelmät

Tutkimuksen maastotyöt tehtiin Kaakkois-Suomessa Ruokolahden, Taipalsaaren ja Valkealan kuntien alueella kesällä 1980 (kuvat 2 ja 3). Tutkimusta varten rajattiin luontaisesti uudistuneisiin nuoriin kanervatyypin mäntymetsiin 12 koealaa. Näistä seitsemällä tutkittiin runkoluvun (1600... 5700 tainta/ha) ja kolmella koivumänty -sekapuuston vaikutusta latikkatuhoihin. Lisäksi kahta latikkatiheyksiltään alhaista koealaa käytettiin kontrollitaimikkoina. Kullekin koealalle perustettiin lisäksi kolmesta viiteen 100 m^2:n ympyränmuotoista koealaa. Kaikkien pituudeltaan yli 1,5 m:n ja tyviläpimitaltaan yli 30 mm:n taimien viimeisen kymmenen vuoden pituuskasvu mitattiin, ja jokaiselle taimelle laskettiin puukohtainen tiheystunnus. Kuntonsa perusteella tutkimuspuut luokiteltiin kolmeen luokkaan. Kunkin tutkimuspuun latikkatiheys laskettiin 100×200 mm:n kuorinäytteestä. Kultakin näytealalta kaadettiin 12 mäntyä. Kaadetuista taimista sahattiin kiekkoja, joista laskettiin latikoiden aiheuttaman tummuneen solukon peittävyys (kuva 4).

Kemiallista ja biologista torjuntaa käsittelevät luvut perustuvat pääosin kirjallisuuteen. Tuloksia on täydennetty maastotöiden yhteydessä kertyneillä havainnoilla.

Tulokset

Pahimmin vaurioituneiden taimien osuus oli yli 20 % viidessä tiheydeltään erilaisessa taimikossa (kuva 5). Latikoiden runsaus tiheissä taimikoissa aiheutui taimikoiden epätasaisesta rakenteesta. Latikoiden vioittamat taimet kasvoivat keskimäärin kauempana muista taimista kuin terveeltä näyttävät taimet. Kuvassa 6 on esitetty eri kuntoluokkiin kuuluvien mäntyjen pituuskasvu kussakin tutkimusmetsikössä.

Imennän vaurioittamaa solukkoa todettiin puiden poikkileikkauskiekoissa kaikissa taimikoissa. Kuudessa taimikossa vioittuneen solukon osuus viidessä pahimmin imetyssä poikkileikkauskiekossa oli vuonna 1978 yli puolet. Kohtalainenkaan yhtenä vuonna esiintynyt imentä ei välttämättä alentanut taimien pituuskasvua (kuva 7). Useita vuosia jatkunut vähäinenkin imentä hidasti männyn pituuskasvua. Vuosittainen pituuskasvutappio puhtaissa mäntytaimikoissa oli keskimäärin 79 mm (28 %) ja sekataimikoissa 87 mm (34 %).

Kuudessa taimikossa punalatikoita oli kuorinäytteissä yli 20 yksilöä/dm^2. Tiheässäkin taimikossa (5700 tainta/ha) latikoita oli keskimäärin 18 yksilöä/dm^2. Suurin keskimääräinen latikkatiheys (49,2 yksilöä/dm^2) todettiin sekataimikossa. Sekataimikossa todettiin myös korkein puukohtainen latikkatiheys (115 yksilöä/dm^2). 15-vuotiaassa taimessa latikoiden aiheuttama imentävioitus on keskittynyt rungon alaosiin 4.—7. vuosikasvaimen alueelle. Sekataimikossa imentävioitukset puun tyvellä olivat vähäisempiä kuin puhtaassa taimikossa (kuva 8).

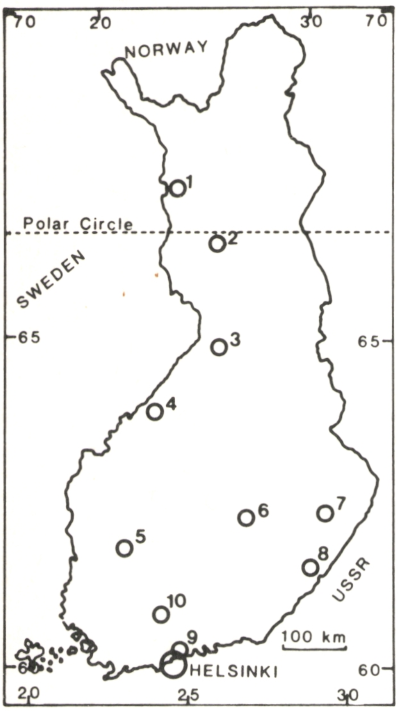
Männynrungoilla tavataan runsaina vain harvoja mahdollisia punalatikan torjuntaeliöitä. Runsain on *Telenomus aradi* -keripistiäinen, joka elää loisena punalatikan munissa. Verkkosiipisten, hämähäkkien ja muurahaisten sekä tiaisten, tikkojen ja puukiipijän on todettu saalistavan latikan eri kehitysvaiheita, mutta niiden merkitys lienee vähäinen. Useat sienitaudit tappavat latikoita erityisesti talvehtimisen aikana, mutta sienitautien käyttö torjunnassa on toistaiseksi ollut kokeilevaa. Punalatikka on osoittautunut suhteellisen kestäväksi torjunta-aineita vastaan. Parhaimmat tulokset on saavutettu kasvisolukkoon tunkeutuvilla hyönteismyrkyillä.

Päätelmiä

Punalatikan torjumiseksi ei ole käytettävissä tehokasta torjuntakeinoa, mutta taimikonhoidollisilla toimilla voidaan vähentää tuhoriskiä. Punalatikoita tavattiin eniten männyissä, jotka kasvoivat yksittäin taimikoiden reunoilla tai avoimissa osissa. Mahdollisilla tuhoalueilla, kuivilla kankailla, tulisi taimikoiden olla tasarakenteisia ja riittävän tiheitä, vähintään 3000, mieluimmin 5000. . .6000 tainta hehtaarilla. Taimikon harvennuksen tulisi tapahtua mahdollisimman myöhään eli taimikon saavutettua 5—6 metrin valtapituuden. Voimakkaita, aikaisin tapahtuvia harvennuksia on syytä välttää vähäravinteisilla hiekkamailla.

Vähäinen lehtipuiden määrä ei estäne punalatikoiden aiheuttamia imentävioituksia, sillä tutkimuksen mukaan heikkokuntoisten, latikoiden vaivaamien mäntyjen lukumäärä, pituuskasvutappioiden suuruus sekä latikkatiheydet olivat sekataimikoissa vähintään samalla tasolla kuin puhtaissa mäntytaimikoissa. Tiheitä koivu-mänty -sekataimikkoja on kuitenkin syytä suosia mahdollisuuksien mukaan, vaikka tulokset eivät olleet yksiselitteisiä niissä taimikoissa, joissa koivun osuus oli alhainen. Aiemmissa tutkimuksissa typpilannoituksen on todettu lisäävän paitsi taimikoiden kasvua myös latikoiden määrää, mutta lannoituksen avulla taimikon kehitystä voidaan nopeuttaa latikkatuhoille alttiissa vaiheessa.

Hokkanen, T., Heliövaara, K. & Väisänen, R. 1987. Control of *Aradus cinnamomeus* (Heteroptera, Aradidae) with special reference to pine stand condition. Seloste: Punalatikan torjunta erityisesti metsänhoidollisin menetelmin. Communicationes Instituti Forestalis Fenniae 142. 27 p.



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3 Muhos
4 Kannus
5 Parkano
6 Suonenjoki
7 Joensuu
8 Punkaharju
9 Ruotsinkylä
10 Ojajoki

FACTS ABOUT FINLAND

Total land area: 304 642 km^2 of which 60—70 per cent is forest land.

Mean temperature, °C:	Helsinki	Joensuu	Rovaniemi
January	-6,8	-10,2	-11,0
July	17,1	17,1	15,3
annual	4,4	2,9	0,8
Thermal winter (mean temp. < 0°C):	20.11.—4.4.	5.11.—10.4.	18.10.—21.4.

Most common tree species: Pinus sylvestris, Picea abies, Betula pendula, Betula pubescens

THE FINNISH FOREST RESEARCH INSTITUTE ● METSÄNTUTKIMUSLAITOS

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