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PENIOPHORA GIGANTEA (Fr.) MASSEE AND WOUNDED SPRUCE (PICEA ABIES (L.) KARST.) PART II

PENIOPHORA GIGANTEA JA KUUSEN VAURIOT OSA II

Tauno Kallio

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PENIOPHORA GIGANTEA JA KUUSEN VAURIOT OSA II

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I FOREWORD

The present work was a continuation of the author's study published previously under the title »*Peniophora gigantea* (Fr.) Massee and wounded spruce *(Picea abies* (L.) Karst.)», Acta Forestalia Fennica 133, 1973.

The wounding of the spruce trees covered by the entire study took place, simultaneously for the trees of the two reports, during 1971 and 1972, but the investigation of these trees has been carried out in two parts. In the first part (covered by the earlier paper) the characteristics of the discoloration originating from the wounds in the spruce were studied one year after the wounding. The second part, the findings of which are presented in this report, was concerned with the situation in the wounded spruce trees three years after the wounding. The method of study was much the same on both occacions. The principal difference was that the first phase investigated the microbial flora much more throughly than the second, which only studied the rate at which discoloration advanced upward from the defects that started from wounds made at breast height in the stem.

II INTRODUCTION AND PURPOSE

Summer-time harvesting is causing increasing damage to the growing stock left in the stand. The most dangerous decay fungus of the Finnish spruce stands, *Fomes annosus* (Fr.) Cooke (Isomäki and Kallio 1974) is among those spreading through the wounds inflicted in this way. No effective means of controlling and reducing the damage caused by *F. annosus* is as yet available. Airborne distribution of the fungus has been cut down e.g. by inoculating the cut surfaces on tree stumps with competiting fungi, such as *P. gigantea*, immediately after felling (Rishbeth 1948, 1959, 1963, Kallio 1971). *P. gigantea* is currently used e.g. in Britain and the USA to protect the cut surfaces of pine stumps. Although *P. gigantea*, like *F. annosus*, is a decay fungus, it plays only a minor role in the decay of growing spruce (Nilsson and Hyppel 1968, Lundeberg 1972, Kallio 1973). Before inoculation of the cut surfaces of spruce stumps with a suspension of *P. gigantea* spores can be started on a large scale, it is necessary to make sure that the *P. gigantea* will produce no risk of decay for the growing spruce e.g. by infecting wounds that have arisen in connection with timber harvesting.

The purpose of the present work was to study:

1. the reliability of specimens taken with an increment borer at stump height as indications of decay
2. the extent to which *F. annosus* had infected the spruce wounds inflicted three years previously
3. the rate at which discoloration, macroscopically visible and starting from sapwood and heartwood wounds at breast height, advanced upward, comparing this rate with the corresponding rates of one-year old discolorations.
4. the causative factor in the discoloration that had advanced over the longest distance from the wounds.

III MATERIAL AND METHOD

The study was carried out in Helsinki in an approximately 100-year old spruce stand on *Myrtillus* type soil. Wounding of the growing spruce trees was carried out once monthly during the year 14 April 1971 to 16 March 1972, a fresth lot of eight trees being wounded each month. Half of these trees were dealt with in the earlier report, while the remaining were investigated in the present part of the study. In order to detect any possible existing decay, the spruce trees intended for inclusion in the study were first bored to the pith at stump height with an increment borer. Only trees found to be sound were included. Since the boring to the pith at stump height was not aseptic, the hole made by the borer was counted among the wounds to be studied (Fig. 1, wound S). In addition, the

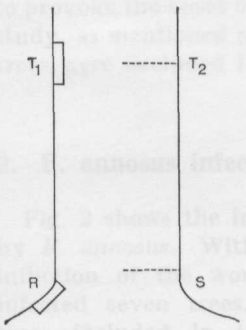

Fig. 1. Location of the wounds.
Kuva 1. Vaurioiden sijainti puussa.

trees included in the study were wounded at breast height and just above the soil level.

For the present investigation, two dominant and two suppressed spruce trees were wounded every month in the way described. The mean height of the dominant trees was 22.7 m and mean diameter at breast height 29 cm. The corresponding figures for the suppressed trees were 12.7 m and 14 cm. The total number of dominant trees included in the final study material was 23, that of the suppressed trees 19.

The trees that had been verified as sound by the increment borer specimen were wounded by making an incision one cm deep with a steel cylinder of a diameter of 70 mm. The wood within the circle incised by the cylinder was removed with a chisel. One wound of this kind was made on the north side of the stem at a height of 1.3 m from the felling cut (wound T 1), and another similar wound was made at soil surface level (wound R). A third wound extending to the pith was made with an increment borer at 1.3 m height from the felling cut on the south side of the stem (wound T 2).

The wounds R, T 1 and T 2 of two trees, one per crown class, were inoculated with a mycelial suspension of *P. gigantea*. Two trees, one per crown class, served as monthly control trees. The *P. gigantea* strain was that previously used in *F. annosus* studies (KALLIO 1971, 1973). The amount of viable diaspores in the *P. gigantea* suspension on different occasions of inoculation in the course of a year ranged from 2.5 to 7.1 million per wound (KALLIO 1973).

Three years after the wounding, the trees were felled month by month, according to the month in which they had been wounded. C. 10 cm thick discs containing the wounded sites were taken from every tree for identification of any *F. annosus* in the damaged wood. The stems were cut into lengths and the distance over which discoloration visible to the naked eye had advanced from the wounds was assessed. A small piece of wood, taken from the furthest point of the discoloration, was placed on malt agar in the laboratory in order to obtain a pure culture of the microbial growth in the wood. Another piece of wood, immediately adjacently to this sample, and towards the wound, was taken and stored in plastic wrapping in the laboratory, to be used in identifying the fungus on the basis of the conidiophores. In some trees the discolorations starting from wounds T 1 and R, and T 2 and S, had converged and united in the

course of the three years, so that it was impossible to tell with any certainty how far discoloration had advanced from each individual wound. In these cases another specimen was taken from the tree stem at a point where it was still definitely possible to ascertain the wound from which the discoloration had started. The microbes were cultured and the *F. annosus* was accordingly identified from this specimen. As pointed out before, the rates at which the discoloration advenced could be calculated only from the discolorations that had advanced upward from wounds T 1 and T 2.

IV RESULTS

1. Reliability of borer cores, taken at stump height from the pith of growing spruce, as indicators of decay

The results of research into the reliability of increment borer cores as indicators of decay are contradictory. Many findings suggest, however, that the colour of the increment borer core does not provide reliable evidence as to whether or not the wood is decayed (DIMITRI 1968, 1970, LUNDEBERG 1972, KALLIO and TAMMINEN 1974). Six decayed trees (c. 12 %) had been erroneously included in the present study on the basis of the colour of the increment borer core. The same precentage of decayed trees was also contained in the first part of the sudy (KALLIO 1973). Boring, therefore, does not seem to be a particularly reliable method of determining spruce decay, added to which is the fact that every hole left by increment borer is a wound liable to provoke the onset of decay . In the present study, as mentioned previously, the decayed trees were excluded from the final material.

2. F. annosus infection

Fig. 2 shows the infection of the wounds by *F. annosus*. Within three years of the infliction of the wounds, *F. annosus* had infected seven trees, i.e. c. 17 % of the trees included in the study. One year after the wound had been inflicted the percentage of infection had been 9.5 % of the number of stems (KALLIO 1973). The incidence of *F. annosus* in Germany (PECHMANN and AUFSESS 1971) was 15 % of spruce stem wounds, in Norway 17—29 % (ROLL-HANSEN 1970), and also in Sweden the fungus had been found to spread by this route (HAGNER et al. 1964, NILSSON and HYPPEL 1968). The percentage of *F. annosus* infection in spruce wounds therefore seems to increase slightly in the year following the infliction of the wound (cf. ISOMÄKI and KALLIO 1974). Norway, however, has reported an opposite finding (ROLL-HANSEN 1970). The proportion of spruce stumps infected by aerially disseminated *F. annosus* in two years also seems to have been 11.5 % after the first and 17.0 % after the second year (KALLIO 1965). *F. annosus* had infected (the ringed dot in Fig. 2) the T 2 and R wounds of one dominant tree inoculated with *P. gigantea* in September. This is the first time in Finland that *F. annosus* has been found to infect a wound previously inoculated with *P. gigantea*.

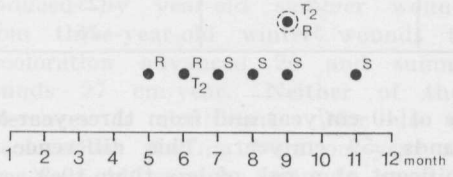

Fig. 2. Infection of the wounds by *F. annosus*.
Kuva 2. F.annosuksen iskeytyminen vaurioihin.

3. Rate of advance of the discoloration

In discolorations that had started from year-old wounds, and from the most advanced part of which no microbes had been found, the rate of advance of the discoloration showed a difference between the dominant and suppressed trees which was statistically significant with a risk of less than 2 % (50 as against 30 cm/year). For similar three-year-old wounds the difference between the rates of advance per year in dominant and suppressed trees was significant with a risk of less than 0.2 % (61 as against 36 cm/year). On the other hand, in the dominant trees, the rate of advance of the discoloration for year-old wounds (50 cm/year) did not differ statistically significantly from that for the three-year-old wounds (61 cm/year). When the discoloration contained decay microbes at the furthest point, its rate of advance in the dominant trees increased

Table 1. Upward advance of discoloration in the trees of different crown classes, cm/year (wounds T 1 and T 2.)

Taulukko 1. Värivian eteneminen ylöspäin eri latvuskerroksen puissa, cm/v (vauriot T 1 ja T 2).

Age of wound, *years* *Vaurion ikä, v*	Discoloration without microbes *Värivika ilman mikrobia*			Discoloration with microbes *Värivika mikrobien kera*		
	Crown class *Latvusluokka*			Crown class *Latvusluokka*		
	Dominant *Vallitseva*	Suppressed *Vallittu*	Mean *Keskim.*	Dominant *Vallitseva*	Suppressed *Vallittu*	Mean *Keskim.*
1	50	30	39	27	22	25
3	61	36	50	42	24	33

from 27 cm/year for the year-old wounds to 42 cm/year for the three-year-old, but even this difference is not statistically significant. Schotte (1922), Ekbom (1928) and Schönhar (1975) obtained a similar, Roll-Hansen (1970) a contrary result. Wright and Isaac (1956) reported a reduction in the rate of advance of the discoloration already within three years. With considerably older wounds, such a reduction in the rate of advance has also been observed (Parker and Johnson 1960, Nilsson and Hyppel 1968). Discolorations starting from root wounds in spruce advance considerably more slowly than those originating from root collar or stem wounds (Nilsson 1967, Nilsson and Hyppel 1968, Lundeberg 1972). Root wounds, furthermore, are less frequently infected than stem wounds (Pawsey and Gladman 1965). Isomäki and Kallio (1974) observed a reduction in the rate of advance of the discoloration from spruce wounds after 5—15 years. According to Hakkila and Laiho (1967), decay starting from an axe mark in the spruce may, in the fastest cases, advance at a mean rate of 50 cm/year for 12 years. These rapidly advancing cases, however, accounted for only 3 % of the total in their study, whereas in 10 % the decay advanced at a rate of 42 cm/year and in 40 % 33 cm/year.

Table 2. Upward advance of discolaration in trees inoculated with *P. gigantea* and in control trees, cm/year (wounds T 1 and T 2).

Taulukko 2. Värivian eteneminen ylöspäin P. gigantealla infektoiduissa ja kontrollipuissa, cm/v (vauriot T 1 ja T 2).

Age of wound, years *Vaurion ikä, v*	Discoloration without microbes *Värivika ilman mikrobia*		Discoloration with microbes *Värivika mikrobien kera*	
	P. gigantea	Control *Kontrolli*	*P. gigantea*	Control *Kontrolli*
1	40	38	26	23
3	59	36	54	26

Discoloration starting from wounds inoculated with *P. gigantea*, but from the neighbourhood of the furthest point of which no microbe could be isolated, advanced upward from year-old wounds at the rate of 40 cm/year and from three-year-old wounds, 59 cm/year. This difference is significant at a risk of less than 10 %. In three years, the *P. gigantea* produced a discoloration advancing 59 cm/year, against

36 cm/year for the corresponding discoloration in control trees. This difference is significant at a risk of less than 1 %.

When microbes were found in discoloration that had advanced from wounds inoculated with *P. gigantea*, the first-year rate of advance of 26 cm/year increased in three years to 54 cm/year. This difference is significant at a risk of less than 5 %. While the discoloration produced by *P. gigantea* in three-year-old wounds advanced 54 cm/year, non-specific discoloration in control trees advanced only 26 cm/year. The difference is significant at a risk of less than 10 %. The *P. gigantea* infection, therefore, apparently increases the intensity of the defence reaction of the tree and this is manifested in the increase in the discoloration's rate of advance. In no case did *P. gigantea* grow at the point of discoloration furthest upward from wounds T 1 and T 2.

Table 3. Upward advance of discoloration from wounds inflicted in summer and winter (T 1 and T 2). *Taulukko 3. Värivian eteneminen ylöspäin kesällä ja talvella tehdyistä vaurioista (T 1 ja T 2).*

Age of wound, years *Vaurion ikä, v*	Discoloration without microbes *Värivika ilman mikrobia*		Discoloration with microbes *Värivika mikrobien kera*	
	Winter *Talvi*	Summer *Kesä*	Winter *Talvi*	Summer *Kesä*
1	51	30	22	26
3	55	46	26	27

When the influence of the seasons of the year was studied, November-April were considered the winter months and May-October the summer months. A discoloration from which no microbes could be isolated advanced from winter wounds at a rate of 51 cm/year and from summer wounds 30 cm/year (Table 3). The difference is significant at a risk of less than 1 %. From three-year-old wounds the figures were 55 and 46 cm/year, respectively. This difference is not significant. Discoloration where a microbe could be isolated from the furthest point, advanced at a rate of 22 cm/year when produced by year-old winter wounds and 26 cm/year when produced by year-old summer wounds. From three-year-old winter wounds the discoloration advanced 26 and summer wounds 27 cm/year. Neither of these differences is significant. Nor do the discolorations starting from one-year and three-year-old summer wounds seem to differ appreciably in their rates of advance (26 as against 27 cm/year).

4. The microbes isolated from the discolorations

41. Microbes isolated from the furthest point of discoloration

Table 4 lists the microbes, cultured on malt agar, from the furthest point of the discoloration, visible to the naked eye, which had advanced over the longest distance upward from wounds T 1 and T 2.

The microbes of Table 4 had been growing in the immediate vicinity of the furthest point of the discoloration, visible to the naked eye, that had advanced over the longest distance. It has been shown earlier that bacterial wound infection can advance very rapidly in spruce (Kallio 1973). Although in the present study no growth substrates specially intended for bacteria were used, bacteria were nevertheless isolated in a few cases from the immediate vicinity of the furthest point of discoloration. The

Table 4. The microbes that had advanced over the longest distance upward from wounds T 1 and T 2, number/species.
Taulukko 4. Vaurioista T 1 ja T 2 uloimmaksi ylöspäin edenneet mikrobit, kpl.

Microbe *Mikrobi*	Crown class *Latvusluokka*		Season of year *Vuodenaika*		Wound *Vaurio*		Inoculation *Infektoitu*		Advance of discoloration cm/year *Värivika edennyt cm/v*
	Dominant *Vallitseva*	Suppressed *Vallittu*	Winter *Talvi*	Summer *Kesä*	T 1	T 2	*P. gigantea*	Control *Kontrolli*	
Bacteria	1	1	1	1	1	1	2	0	55
Ascocoryne cylichnium	3	1	3	1	2	2	0	4	19
Aspergillus spp. ..	0	1	1	0	1	0	0	1	6
Fomes pinicola	0	1	0	1	1	0	0	1	13
Stereum sanguinolentum	2	3	3	2	3	2	1	4	39
Total	6	7	8	5	8	5	3	10	
Yht.	(23)	(19)	(20)	(22)	(42)	(42)	(22)	(20)	

bacteria had grown at a remarkable rate, 55 cm/year. The next fastest in rate of advance was *S. sanguinolentum* (39 cm/year). The bottom line of Table 4 quotes, in brackets, the figure indicating the total number of trees, or the total number of wounds (T 1 and T 2) according to the relevant crown class, season of the year, wound, and method of infection. When these figures are compared with the total numbers of the microbes it is seen that in most wounds the furthest point of discoloration contained no microbes but was evidently occasioned by the defence reactions of the tree (cf. Isomäki and Kallio 1974).

Table 5. The microbes isolated from discoloration starting from the wounds, number/species.
Taulukko 5. Vaurioista alkaneista värivioista eristetyt mikrobit, kpl.

Microbe *Mikrobi*	Crown class *Latvusluokka*		Season of year *Vuodenaika*		Wound *Vaurio*				Inoculation *Infektoitu*	
	Dominant *Vallitseva*	Suppressed *Vallittu*	Winter *Talvi*	Summer *Kesä*	R	S	T 1	T 2	*P. gigantea*	Control *Kontrolli*
Bacteria	3	1	1	3	1	1	1	1	0	0
Ascocoryne cylichnium	4	2	3	3	1	3	2	1	1	5
Aspergillus spp. ..	0	1	1	0	0	0	1	0	0	1
Fomes pinicola	0	1	0	1	0	0	1	1	0	1
Peniophora gigantea	4	0	3	1	1	0	2	2	4	0
Stereum sanguinolentum	6	13	11	8	6	1	16	4	8	11
Total — *Yht.*	17	18	19	16	9	5	23	9	13	18

42. Microbes isolated from discolorations

As mentioned before, specimens were taken from all discolorations starting from the wounds. For wounds other than T 1 and T 2, the specimens were taken as far as possible from the wound, at a point where the discoloration could still with certainty be referred back to the wound from which it started. In these cases, therefore, the specimens were not taken from the vicinity of the furthest point of the discoloration. Table 5 combines all the microbes isolated and, after pure culture, identified from the discolorations that had started from the various wounds.

According to Table 5, *S. sanguinolentum* was the most common fungus isolated from the wounds. As its rate of growth, furthermore, was remarkably high (39 cm/year) and as, according to Table 4, it can infect e.g. wounds already infected with *P. gigantea*, it seems evident that *S. sanguinolentum* in South Finland is the most dangerous and most common fungus infecting spruce wounds (Hakkila and Laiho 1967). In other countries, too, this fungus has been found to be a common and dangerous species infecting spruce wounds (Pawsey and Gladman 1965. Roll-Hansen 1970, Pawsey 1971, Pawsey and Stankovicova 1974 a, 1974 b, Schönhar 1975). It can be noted that *S. sanguinolentum* mostly infects sapwood injuries of the stem (T 1). The second most frequent site is the wound inflicted in the sapwood of the root at soil level (R). This fungus does not seem to infect the increment borer holes as readily as the sapwood wounds, which were of a larger surface area.

V DISCUSSION

The material for the present study was collected from a forest within the boundaries of the city of Helsinki. It is therefore possible that the results of the study are exceptional e.g. owing to air pollution. The polluted air may affect the defence reactions of the tree (cf. HALBWACHS 1975) on the one hand, and the type and amount of microbial species infecting it from the air, on the other. In the present sudy, however, the microbial flora was not analysed in detail (cf. KALLIO 1973), nor were values markedly different from the earlier study results obtained in the present work for the rate at which discoloration advanced.

Before starting a study of decay and discoloration, it would be as well to define these terms more precisely. A discoloration that is visible to the naked eye and of the type whose rate of advance was investigated in the present work, can in no case be considered reliable evidence of decay. In the living wood tissue of spruce, colour changes take place as a final result of defence reactions. A great deal is already known about the defence reactions produced by *F. annosus* in spruce (SHAIN 1967, 1971, SHAIN and HILLS 1971), whereas it is unclear whether other decay microbes induce a similar defence reaction (cf. NELSON 1973). Information concerning the effect of discoloration produced by the defence reactions of a tree on the quality and quantity of the cellulose obtained from its wood is relatively incomplete (BJÖRKMAN et al. 1949).

In the present study the microbes were cultured on malt agar only. This obviously gave an incomplete analysis, both quantitatively and qualitatively, of the microbial flora, since e.g. bacteria, in order to grow well, require another growth substrate (cf. KALLIO 1973). The microflora spreading from spruce wounds should be investigated thoroughly in the future, with special attention given to bacteria. Bacteria synthetising atmospheric nitrogen, whose presence in the wounded wood material of certain tree species is known (SHIGO et al. 1971, SEIDLER et al. 1972, AHO et al. 1974), may also belong to the microflora of spruce wounds. This may modify the opinions on the importance of wounds to the growing stand.

On malt agar, a microbe was obtained from the furthest point of the discoloration in only 13 out of 42 possible cases. The most common fungus was *S. sanguinolentum*. It advanced in three years over a mean distance of 39 cm per year. The result agrees well with the findings of both the study of decay starting from axe marks (HAKKILA and LAIHO 1967) and the study of decay starting from haulage injuries (ISOMÄKI and KALLIO 1974). In the present work the wounds were inflicted without otherwise injuring the tree, and for this reason the rate of advance of the discoloration and the amount and type of the microbes isolated are not necessarily identical with those arising from extraction wounds (BJÖRKHEM et al. 1974, 1975). On the other hand, the amount and type of the microbes agrees well with the microbial flora isolated in Sweden from three-year-old haulage wounds (BJÖRKHEM et al. 1974). The relative share of bacteria, also in Sweden, has been found to be large (LUNDEBERG 1972, BJÖRKHEM et al. 1974). The role of bacteria in the decay processes of wood, starting from wounds in growing spruce, may therefore be greater, also in Scandinavia, than has been assumed to date.

VI SUMMARY

The study investigated the rate at which discoloration advanced from wounds in the growing trees of a spruce stand in Helsinki, and the microbes growing in the discoloured wood. The role of *P. gigantea* inoculation of the wounds was considered. The wounds covered by the entire study were expressly made three years ago. In the present part of the investigation, the results obtained after three years were compared with the corresponding earlier findings from year-old wounds.

F. annosus had infected 17 % of the total number of the wounded trees. One year after the wounding the infection percentage was 9.5.

Discoloration with no microbes detectable in the part furthest advanced from year-old wounds advanced upward at a rate of 50 cm/year in the dominant and 30 cm/year in the suppressed trees. This difference is significant with a risk of less than 2 %. In corresponding discolorations from three-year-old wounds, the figures were 61 and 36 cm/year, respectively. This difference is significant with a risk of less than 0.2 %. In dominant trees, the rate of advance of the discoloration from year-old wounds (50 cm/year) does not differ significantly from the corresponding rate in three-year-old wounds (61 cm/year). In those discolorations where microbes occurred in the vicinity of the point furthest from the rate of advance increased from 27 cm/year for year-old wounds to 42 cm/year for three-yer-old wounds. The difference is not significant.

P. gigantea produced an increase in the rate at which discoloration advanced compared with the controls, both in year-old and three-year-old wounds. *P. gigantea* was never found to be the decay fungus that advanced farthest from the wounded site. Two wounds of a tree inoculated with *P. gigatea* in September had been infected by *F. annosus*.

Discoloration advanced from wounds inflicted in November- April (winter wounds) with no microbes present at the furthest point of the discoloration, at a rate of 51 cm/year in year-old wounds, and from the corresponding wounds inflicted in May-October (summer wounds) at a rate of 30 cm/year. The difference is significant with a risk of less than 1 %. For three-year-old wounds the figures were 55 and 46 cm/year, respectively. This difference is not significant. If microbes were growing at the furthest point of discoloration, the rate of advance in year-old winter wounds was 22 and summer wounds 26 cm/year. For three-year-old wounds the corresponding figures were 26 and 27 cm/ year, respectively. These differences are not significant.

A microbe was isolated from the furthest point of discoloration in only 13 out of 42 possible cases. The most common microbe was *S. sanguinolentum*. It advanced at a rate of 39 cm/year. The highest rate of advance (55 cm/year) was recorded for the bacteria found at the furthest point of discoloration.

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SELOSTE:

PENIOPHORA GIGANTEA JA KUUSEN VAURIOT OSA II

Tämä tutkimus on jatkoa aikaisemmin julkaistulle tutkimukselle: T. Kallio 1973: *Peniophora gigantea* ja kuusen vauriot (Acta Forestalia Fennica 133).

P. gigantea on lahottajasieni kuten *Fomes annosus*kin. Ensin mainittu tunnetaan yleisimmin kuolleen puuaineksen lahottajana. *F. annosus* sen sijaan tekee merkittävää tuhoa Etelä-Suomen kuusikoissa ja männiköissä. Englannissa on jo pari vuosikymmentä käytetty *P. gigantea F. annosuksen* tuhojen torjumiseen mäntymetsiköissä. Nyt esiteltävän tutkimuksen tarkoituksena oli selvittää niitä mahdollisia haittoja, joita *P. gigantea* kenties aiheuttaa puunkorjuussa vaurioituneille kasvamaan jääneille puille, jos sitä kasvatushakkuiden jälkeen levitetään kuusen kantojen kaatopintoihin.

Tutkimukseen kuuluneet kuuset vaurioitettiin vuosina 1971 ja 1972. Vaurioitetut kuuset tutkittiin kahdessa osassa. Ensimmäisessä osassa, josta julkaistiin alussa mainittu tutkimusselostus, selvitettiin kuusen vaurioista alkaneen paljain silmin havaittavan värivian ominaisuuksia vuoden kuluttua vaurioittamisesta. Toisessa osassa, jonka tulokset esitetään tässä julkaisussa, selvitettiin tilanne kuusen vaurioissa kolmen vuoden kuluttua vaurioittamisesta. Menetelmä molemmissä tutkimuksen osissa oli suurin piirtein sama. Tutkimuksen ensimmäisessä osassa selvitettiin kuitenkin paljon perusteellisemmin värivioista eristettyä mikrobilajistoa kuin nyt julkaistavassa toisessa osassa. Nyt julkaistavassa tutkimusraportissa selvitettiin värivian etenemisnopeutta ainoastaan rinnankorkeudelle runkoon tehdyistä vaurioista ylöspäin.

F. annosus iskeytyi 17 %:iin vaurioitettujen puiden lukumäärästä kolmen vuoden kuluessa vaurioittamisesta. Yhden vuoden kuluttua vaurioittamisesta vastaava infektioprosentti oli 9.5. *P. gigantea*-infektio aiheutti värivian etenemisnopeuden lisääntymisen sekä yhden että kolmen vuoden ikäisten vaurioiden värivioissa. *P. giganteaa* ei tavattu vaurioista pisimmälle edenneenä lahottajana. Yhden syyskuussa *P. gigantealla* infektoidun puun kaksi vauriota *F. annosus* oli ilmateitse infektoinut.

Jos vuoden ikäisistä vaurioista alkaneen värivian uloimmassa kärjessä ei esiintynyt lahottajamikrobia, värivika eteni ylöspäin vallitsevan latvuskerroksen puissa 50 cm/v ja vallitun latvuskerroksen puissa 30 cm/v. Tämä ero on alle 2 %:n riskillä merkitsevä. Kolmen vuoden ikäisissä vastaavissa vaurioissa luvut olivat 61 contra 36 cm/v. Tämä ero on alle 0.2 %:n riskillä merkitsevä. Vallitsevan latvuskerroksen puiden värivian etenemisnopeus yhden vuoden ikäisissä vaurioissa (50 cm/v) ei eronnut merkitsevästi vastaavasta kolmen vuoden vaurioiden nopeudesta (61 cm/v). Jos värivian uloimmassa osassa esiintyi lahottajamikrobeita, värivian etenemisnopeus kasvoi yhden vuoden ikäisten vaurioiden nopeudesta 27 cm/v kolmen vuoden ikäisten vaurioiden nopeudeksi 42 cm/v. Ero ei ole merkitsevä.

Marras-huhtikuussa tehdyistä vaurioista (talvivauriot), joista värivian kärjestä ei tavattu mikrobeita, värivika eteni yhden vuoden ikäisissä vaurioissa 51 cm/v ja vastaavissa touko—lokakuussa (kesävauriot) tehdyissä vaurioissa 30 cm/v. Ero on alle 1 %:n riskillä merkitsevä. Kolmen vuoden ikäisissä vaurioissa talvivaurioiden vastaava luku 55 ja kesävaurioiden 46 cm/v. Tämä ero ei ole merkitsevä. Jos värivian kärjessä kasvoi mikrobeita, oli yhden vuoden ikäisissä talvivaurioissa etenemisnopeus 22 ja kesävaurioissa 26 cm/v. kolmen vuoden ikäisissä vastaavasti talvivaurioissa 26 ja kesävaurioissa 27 cm/v. Nämä erot eivät ole merkitseviä.

Värivian uloimmasta kärjestä eristettiin mikrobi ainoastaan 13 tapauksessa 42 mahdollisesta. Tavallisin mikrobi oli *Stereum sanguinolentum*. Se eteni 39 cm/v. Nopeimmin etenivät värivian kärjestä tavatut bakteerit (55 cm/v).

Maannousemasienen tuhojen torjunta Etelä-Suomen parhailla kivennäismailla muodostunee tulevaisuudessa lähinnä ympärivuotisten hakkuiden ja koneellisen puunkorjuun tähden entistä työläämmäksi. Pyrkimyksenä on integroitu torjunta, johon yhtenä osana liittyy maannousemasienen ilmateitse kantojen kaatopintojen kautta tapahtuvan leviämisen biologinen torjunta. Nyt julkaistu tutkimusraportti vahvistaa käsitystä, että *P. gigantea*-sientä voidaan vaaratta käyttää kuusen kantojen kaatopintojen käsittelyyn kasvatushakkuiden ja niihin liittyvän koneellisen puunkorjuun yhteydessä.

KALLIO, TAUNO O.D.C. 411.1: 172.8 *Fomes annosus*

1976. *Peniophora gigantea* (Fr.) Massee and wounded spruce (*Picea abies* (L.) Karst. Part II. ACTA FORESTALIA FENNICA 149. 18 p. Helsinki.

The paper is a continuation of an earlier report by the author on the same subject (Acta Forestalia Fennica 133, 1973). Spruce wounds were inoculated with *P. gigantea* and the discolorations starting from the wounds were investigated three years after the wounding.

F. annosus had infected 17 % of the total number of wounded trees. If no microbes were growing at the furthest point of the discoloration that had started from the wound, the discoloration advanced upward from wounds made at breast height at a rate of 61 cm/year in the dominant and 36 cm/year in the suppressed trees. In the dominant trees, a year after the wound was inflicted the discoloration had advanced at a rate of 50 cm/year and after three years the rate was 61 cm/year. This difference is not significant. Where microbes were present at the furthest point of discoloration, the discoloration had advanced 27 cm/year in one year and 42 cm/year in three years. Also this difference is not significant.
A microbe was isolated from the furthest point of discoloration in only 13 out of 42 possible cases. The most common microbe was *S. sanguinolentum*. Bacteria showed the fastest rate of advance.

Author's address: The Finnish Forest Research Institute, Unionink. 40 A SF-00170 Helsinki 17, Finland

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