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Peniophora gigantea (Fr.) Massee and wounded spruce (*Picea abies* (L.) Karst.)

Peniophora gigantea ja kuusen vauriot

Tauno Kallio

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PENIOPHORA GIGANTEA (FR.) MASSEE AND WOUNDED SPRUCE (PICEA ABIES (L.) KARST.)

TAUNO KALLIO

SELOSTE:

PENIOPHORA GIGANTEA JA
KUUSEN VAURIOT

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I INTRODUCTION, AND PURPOSE OF THE STUDY

Fomes annosus (Fr.) *Cooke* has in many countries been found to be a cause of disease difficult to control. Timber harvesting during the summer, and its mechanization, are likely to increase the airborne infection of this fungus (KALLIO 1970, ISOMÄKI 1972, ISOMÄKI and KÄRKKÄINEN 1972). Attempts to counteract, or even reduce, the increased risk of *F. annosus* infection have so far failed. Based on findings reported by RISHBETH (1948, 1959, 1963), the possibilities of restricting the aerial distribution of this fungus by means of fungi competing with or antagonistic to *F. annosus* have been studied. *P. gigantea* is one of the most studied antagonits to *F. annosus*. According to a study in Finland, *P. gigantea* protected spruce stumps against airborne infection by *F. annosus* (KALLIO 1971 a). However, *P. gigantea*, like *F. annosus*, is a decay fungus. To date no study results from Finland are available concerning the infection by *P. gigantea* of wounds made on spruce, although in Norway (ROLL-HANSEN 1970), Sweden (NILSSON and HYPPEL 1968, HYPPEL 1973) and Germany (PECHMANN and AUFSESS 1971) this fungus is known to infect damaged spruce.

Before starting to treat the stump surfaces with mycelial suspension of *P. gigantea* after summer-time thinning of spruce stands, it is important to find out whether *P. gigantea* infects damaged spruce.

The purpose of the present work was to study:

1. whether *P. gigantea* infects the wounds in spruce on inoculation or spontaneously,
2. which other microbes spontaneously infect spruce wounds (microbes in the present study were understood to comprise fungi, bacteria and nematodes),
3. the distance over which discoloration, starting from the wound and visible to the naked eye, spreads in the spruce within a year from the date of injury and the frequency of microbes in the part of the discoloration furthest from the damaged site,
4. whether the speed at which the discoloration advances depends on the time of year, the crown class or the type or site of the wound.

II MATERIAL AND METHOD

The study was carried out in Helsinki in an approximately 100-year old spruce stand on *Myrtillus type* soil. Growing spruce trees were damaged once monthly for a year. To start with, the spruce trees intended for inclusion in the study were bored, at stump height, with an increment borer to obtain cores from which any decay visible to the naked eye could be ascertained. Only trees found to be sound were included. The boring at stump height extending to the pith of the tree was not aseptic and this hole in the spruce was counted as one of the wounds to be studied (Fig. 1, wound S).

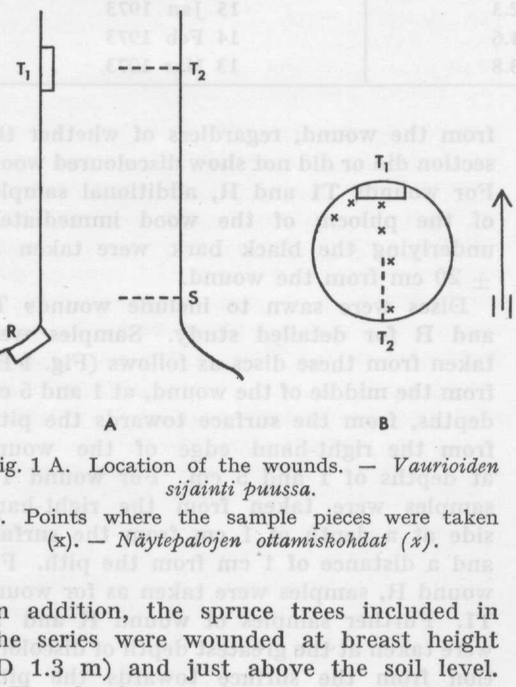

Fig. 1 A. Location of the wounds. — *Vaurioiden sijainti puussa.*

B. Points where the sample pieces were taken (x). — *Näytepalojen ottamiskohdat (x).*

In addition, the spruce trees included in the series were wounded at breast height (D 1.3 m) and just above the soil level.

Two dominant and two suppressed spruce trees were taken into the study every month. The total of the dominant trees in the final study material was 20, and their mean height was 21.9 m. The corresponding figures for the suppressed trees were 22 and 13.0 m, respectively. Diameters at breast height were 28.2 and 14.1 cm.

Damage inflicted. The spruce trees which were sound, according to the boring cores taken at the stump height, were further wounded by punching a circle 1 cm deep in the wood material with an iron cylinder of a diameter of 70 mm. The wood within the circle was removed to a depth of 1 cm with a chisel. This wound was made on the north side of the stem at a height of 1.3 m from the felling cut (wound T1). A root on the north side of the tree was similarly damaged at soil surface level, however so that the root wound was entirely above the soil (wound R). An additional, aseptic increment borer hole extending to the pith was made on the south side at 1.3 m height (wound T2).

Inoculation. Wounds R, T1 and T2 in one of the two trees in each crown class were inoculated with a mycelial suspension of *P. gigantea* while the other tree served as a control. The *P. gigantea* strain was the same as had been used previously in the studies of the biological control of *F. annosus* (Kallio 1971 a). The suspension for inoculation was prepared as follows. Fifteen ml malt agar was measured into a Petri dish 9 cm in diameter (Nobles 1948). *P. gigantea* was inoculated onto the dish and allowed to grow for 3 weeks. After this the cultures were collected from five dishes and homogenized in 50 ml sterile water per dish. The contents of the five dishes were combined

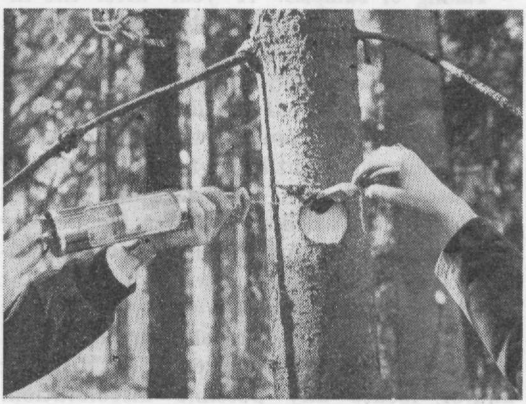

Fig. 2. Inoculation of *Peniophora gigantea* into wound T1. — Peniophora gigantea*-infektion suorittaminen T1-vaurioon.*

Table 1. Date of inoculation (= date of wounding), number of living diaspores of *P. gigantea* per 10ml of the suspension used for inoculation, and the date when samples were taken.

Saastutuspäivä (= vaurioittamispäivä), 10 ml:ssa saastutussuspensiota olleiden itämiskykyisten P. gigantean diasporien lukumäärä ja näytteen ottamispäivä.

Date of inoculation — *Saastutuspäivä*	Number of diaspores, million — *Diasporien lukumäärä, milj. kpl*	Date of taking the sample — *Näytteen ottamispäivä*
14 Apr 1971	4.2	12 Apr 1972
14 May 1971	3.1	9 May 1972
14 Jun 1971	4.8	13 Jun 1972
13 Jul 1971	6.7	17 Jul 1972
9 Aug 1971	7.1	14 Aug 1972
13 Sep 1971	4.5	11 Sep 1972
11 Oct 1971	4.8	10 Oct 1972
10 Nov 1971	4.6	9 Nov 1972
15 Dec 1971	4.1	11 Dec 1972
13 Jan 1972	2.3	15 Jan 1973
14 Feb 1972	4.6	14 Feb 1973
16 Mar 1972	3.8	13 Mar 1973

and mixed be careful shaking. The method used to make the suspension was, as far as possible, identical every time. Ten ml suspension was injected into each wound with a syringe (Fig. 2), except for wound S which was not inoculated. The number of viable diaspores per 10 ml suspension, which varied from time to time as can be seen from Table 1, was studied by dilution in water and cultures on malt agar substrates. The reading for each month is the mean of five culture plates.

Taking of samples. A year after the infection the trees were felled and samples taken. The stems were sawn into 20 cm lengths over a distance of 60 cm above and below the wound. If the discoloration persisted at 60 cm, sawing was continued at 20 cm intervals until the furthest point of the discoloration was passed. Small samples of discoloured wood were taken from every sawn section for fungal and bacterial cultures. If no discoloured wood was seen at ± 60 cm distance from a wound, the samples were taken along a line following the grain of wood fibres in the attempt to discover and/or locate any possible discoloration. Samples were, thus, in every case taken at 20 cm intervals over a distance of ± 60 cm from the wound, regardless of whether the section did or did not show discoloured wood. For wounds T1 and R, additional samples of the phloem of the wood immediately underlying the black bark were taken at ± 20 cm from the wound.

Discs were sawn to include wounds T1 and R for detailed study. Samples were taken from these discs as follows (Fig. 1 B): from the middle of the wound, at 1 and 5 cm depths, from the surface towards the pith; from the right-hand edge of the wound at depths of 1 and 5 cm. For wound T2, samples were taken from the right-hand side at a depth of 1 cm from the surface and a distance of 1 cm from the pith. For wound R, samples were taken as for wound T1. Further samples of wound R and T1 were taken at the greatest depth of discoloration from the surface towards the pith. The furthest point to which discoloration extended both above and below wound S was determined by sawing the stem into lengths. Samples were taken from the highest and lowest points of discoloured wood.

Growth substrates. A minute portion of every sample, taken as close to its centre as possible, was cultured on three different substrates, which were:

Bacterial substrate (Taylor 1951): 15 g agar-agar, 0.4 g K_2HPO_4, 0.05 g $MgSO_4 \times 7\ H_2O$, 0.1 g NaCl, 0.01 g $FeCl_3$, 0.5 g Bacto-Trypton, 0.5 g Difco yeast extract. All these were added to one litre water prepared as follows: 30 g spruce chips dried at room temperature were autocloved under a 0.7 atm. pressure for 1 hour in 1.25 l water. The mixture was filtered and a litre of the extract was used in the growth substrate. The chips used during the whole year were always taken from the same spruce tree. The pH of the substrate was adjusted to seven with 0.1 N NaOH.

Corn agar substrate: 17 g corn flour, 5 g glucose, 1 000 ml water autoclaved with spruce chips as described above.

Malt agar substrate (Nobles 1948): 20 g agar-agar, 12.5 g malt extract, 1 000 mk distilled water.

III RESULTS

1. Reliability of boring at stump height for appraisal of decay

When the trees were being wounted, it was hoped that the precaution of boring to the pith at stump height would ensure that the trees included in the study were sound and not decayed. Six trees (about 12 % of the total number) that at this stage were believed to be sound were in fact decayed. The finding supports the view that increment borer cores are not a sufficient basis for reliable estimation by the naked eye as to whether a tree is decayed or not (cf. DIMITRI 1968, 1970, PECHMANN and AUFSESS 1971, KALLIO and NOROKORPI 1972, LUNDEBERG 1972). Trees that on felling were found to be decayed were not included in the study.

2. Success of the Peniophora gigantea infection

The *P. gigantea* infection was most frequently successful in the T2 wound made with the increment borer at breast height in suppressed trees (Fig. 3). The success percentage was 75. The time of year did not affect the successful infection of the T2 wounds. The infection percentage of the dominant trees was 50. According to the result obtained, the damaged areas extending to the heartwood of the suppressed trees were the most easily infected. In sapwood wounds, the *P. gigantea* infection was successful much less frequently than in heartwood wounds. Successful infection of the sapwood wounds usually showed no difference between the dominant and suppressed trees. Comparison of sapwood wounds T1 and R showed that infection was more often successful in stem damage T1 than in root damage R above the soil surface. Infection of trees through sapwood wounds was successful only from June to November.

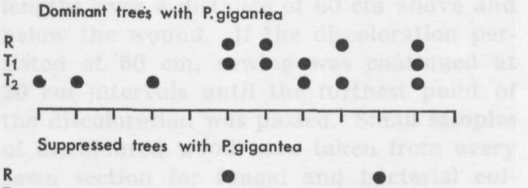

Fig. 3. Success of the *Peniophora gigantea* infection (symbols of damage explained on p. 5). — Peniophora gigantea-*infektion onnistuminen (vaurioiden selitykset s. 5).*

R wounds in two control trees, one dominant and one suppressed, were infected by *P. gigantea* in July and October, respectively.

3. Fomes annosus infection

F. annosus infected two dominant and two suppressed control trees. All these infections occurred in June—September (Fig. 4), that is, when the aerial distribution of *F. annosus* is at its maximum (KALLIO 1970).

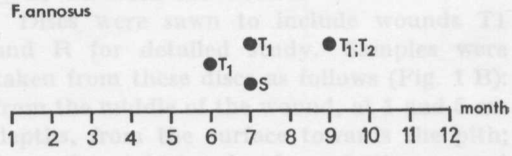

Fig. 4. *Fomes annosus* infection of the control trees. — *Kontrollipuiden* Fomes annosus-*infektio.*

In three cases the infection was in a stem wound (T1), in one case a non-aseptic increment borer wound (S) at stump height, and in one a wound (T2) at breast height, made by increment borer under aseptic conditions. In this last-mentioned tree, *F. annosus* also infected the sapwood wound (T1) at breast height.

4. Microbial occurence in spruce wounds

Stains in wood material visible to the naked eye are called discoloration in the present study. The study tried to ascertain how often a discoloration starting from a wound contained microbes at its furthest point. Regardless of discoloration, the possible occurrence of microbes was studied at 20 cm intervals to a distance of ± 60 cm from the wound. The results are presented in Table 2. For root wounds (R) the difference between the dominant and suppressed trees was not very great. Above the wounds made with an increment borer at stump height (S), stained wood material without microbes was 19 % more common in suppressed than in dominant trees. Below the wounds the corresponding difference was only 10 %. Microbes, on the other hand, were almost twice as common above the wound in dominant than in suppressed trees, and even below the wound 10 % more frequent.

Stem wounds (T1) in sapwood at breast height produced an upward discoloration without microbes 25 % more often in the dominant than in the suppressed trees. Below the wound the difference was 10 % in favour of the suppressed trees. The upward advancing discoloration containing microbes was approximately eight times as common in the suppressed than the dominant trees. The presence of microbes without discoloration, both above and below the wound, was roughly twice as common in the dominant than in the suppressed trees. A downward course in both crown classes was about twice as common than an upward course.

With the wounds made by breast high increment borings extending to the heartwood (T2), in discoloration starting from the wound upward, staining of the wood material alone was 33 % more common in the dominant than the suppressed trees. In discoloration downward from the wound, the proportion of stained wood was similar but the difference between the crown classes was 23 %.

Microbes causing discoloration advanced both up- and downward more than twice as frequently in the suppressed than in the dominant trees. Microbes unconnected with discoloration of the wood were almost twice as frequent, both above and below the wound, in the dominant than the suppressed trees. Classification of the damage, disregarding the crown class, showed that discoloration without microbes, above and below the wound, was more common after wound T1 than the other wounds. A discoloration with microbes was most common above and below wound S. Microbes without discoloration were found most often after wound R, while wound T2 came a good second.

Summarizing from Table 2, it may be concluded that the wound has usually produced either discoloration or microbial infection. Only one per cent of the damaged areas remained uninfected. The result is on the same lines as that obtained for axe marks on spruce (HAKKILA and LAIHO 1967). In Germany, 88 % of increment borer damge on spruce has been found to become infected (SCHÖPFER 1961). In Sweden (HYPPEL 1973) 59–92 % of haulage damage on roots and 1–36 % on stems was infected. The age of the scars caused by timber transportation ranged from 3 to 9 years. Discoloration without microbes was in the present study 13 % more common above than below the wound, discoloration with microbes 5 % more common below than above the wound, and microbes not causing discoloration were 8 % more common below than above the wound. Above the wound, discoloration without microbes was almost 2.5 times as common as the presence of microbes without discoloration. Discoloration with microbes above the wound occurred in approximately one–third of the cases. Below the wound, discoloration without microbes, discoloration with microbes, or microbes without discoloration were almost equally frequent.

The time of year at which the tree was wounded has been found to affect the frequency of discoloration (HAKKILA and LAIHO 1967). According to Table 3, upward discoloration without microbes in suppressed trees in January–March was nearly twice as common as in the corresponding figures for the dominant trees. In April–June, the discoloration (with and without microbes) was 13 % more common above than below the wound in dominant trees, whereas in suppressed trees a downward course of discoloration was 4 % more common than an upward course. In July–September discoloration without microbes was considerably more common above than below the wound in both crown classes. In October–

Table 2. Incidence rate of microbes or discoloration, per cent of the total number of wounds. — *Mikrobien tai värivian esiintymisen tavallisuus, prosenttia vaurioiden lukumäärästä.*

Wound — *Vaurio*	Crown class — *Latuvsluokka*	No stain & no microbe — *Ei väriä eikä mikrobia*		Stain but no microbe — *Väri ilman mikrobia*		Stain & microbe — *Väri mikrobin kera*		Microbe & no stain — *Mikrobi ilman väriä*	
		Up — *Ylös*	Down — *Alas*	Up — *Ylös*	Down — *Alas*	Up — *Ylös*	Down — *Alas*	Up — *Ylös*	Down — *Alas*
R	Dominant — *Vallitsevat*	0	0	30	15	35	30	35	55
	Suppressed — *Vallitut*	0	0	37	9	27	32	36	59
	Total — *Yhteensä*	0	0	33	12	31	31	36	57
S	Dominant — *Vallitsevat*	0	0	45	35	50	60	5	5
	Suppressed — *Vallitut*	9	5	64	45	27	50	0	0
	Total — *Yhteensä*	5	2	55	41	38	55	2	2
T 1	Dominant *Vallitsevat*	0	0	75	45	5	15	20	40
	Suppressed — *Vallitut*	0	0	50	55	41	23	9	22
	Total — *Yhteensä*	0	0	62	50	24	19	14	31
T2	Dominant — *Vallitsevat*	0	0	60	50	15	20	25	30
	Suppressed — *Vallitut*	0	0	27	27	41	55	14	18
	Total — *Yhteensä*	0	0	43	38	29	38	28	24
R		0	0	33	12	31	31	36	57
S		5	2	55	41	38	55	2	2
T1		0	0	62	50	24	19	14	31
T2		0	0	43	38	29	38	29	24
Total *Yht.*		1	1	48	35	31	36	20	28

Table 3. Incidence rate of microbes or discoloration in different seasons, per cent of the total number of wounds. —
Mikrobien tai värivian esiintymisen tavallisuus eri vuodenaikoina, prosenttia vaurioiden lukumäärästä.

Month — *Kuukausi*	Crown class — *Latvusluokka*	No stain & no microbe — *Ei väriä eikä mikrobia* Up — *Ylös*	Down — *Alas*	Stain but no microbe — *Väri ilman mikrobia* Up — *Ylös*	Down — *Alas*	Stain & microbe — *Väri mikrobin kera* Up — *Ylös*	Down — *Alas*	Microbe & no stain — *Mikrobi ilman väriä* Up — *Ylös*	Down — *Alas*
Jan— Mar	Dominant — *Vallitsevat*	0	0	38	55	50	30	12	15
Tammi— maalis	Suppressed— *Vallitut*	0	0	75	50	10	39	15	11
Apr— Jun	Dominant — *Vallitsevat*	0	0	63	29	4	25	33	46
Huhti— kesä	Suppressed — *Vallitut*	0	0	52	33	23	46	25	21
Jul— Sep	Dominant — *Vallitsevat*	0	0	50	33	21	25	29	42
Heinä— syys	Suppressed — *Vallitut*	0	4	21	12	54	42	25	42
Oct— Dec	Dominant — *Vallitsevat*	0	0	56	44	44	31	0	25
Loka— joulu	Suppressed — *Vallitut*	10	0	45	40	25	40	20	20

December all injuries of the dominant trees showed some discoloration above, and 75 % below the wound. Wounds in the suppressed trees showed 70 % upward and 80 % downward discoloration.

The presence of microbes without discoloration of the wood was most frequent in April—September. In both crown classes, approximately one—third of all wounds made during this period had been followed by microbial infection, both above and below the wound, although no discoloration visible to the naked eye was present. Infection of wounds, therefore, was most common when the settling of diaspores was at its maximum (Kallio 1970, 1971 a, 1971 b).

A downward course of microbes without discoloration of the wood was most frequent in R wounds. 84 % of the R wounds of July—September showed microbes below the injury although no discoloration was noticeable. From wounds made by increment boring at breast height (T2) in July—September, microbes began to grow almost as often upward (42 %) as downward (41 %), without producing discoloration.

Apparently the discoloration in the wood above the wounds, especially in the sapwood of dominant trees, is caused by a host response at the furthest point of the discoloration (Shain 1971). According to the result obtained, it is evident that discoloration visible to the naked eye produced by wounds in growing spruce trees does not reliably reveal the presence of wood-decomposing microbes (Shigo 1965, Lundeberg 1972). On the basis of the material studied, the chances that a discoloration does or does not contain wood—decomposing microbes are almost equal, regardless of whether the trees involved are dominant or suppressed and whether the discoloration is above or below the wound. In the heartwood the host response cannot cause discoloration. This probably explains the rich microbial flora without discoloration found in T2 wounds. The even greater incidence found in connection with root wounds, from the site of damage towards the root apex, may be due to microbes, especially bacteria, infecting the injured root from the soil (cf. Kallio 1971 a, Lundeberg 1972).

5. Advance of discoloration from the wounds

51. Rate of advance

Table 4 gives the mean values of the rate at which the discoloration advanced in all types of the wounds.

The furthest point of discoloration without microbes advanced upward in trees damaged in January—March more than twice as fast as in trees damaged in April—June. In October—December the advance was distinctly slower than in January—March. In the winter (November—April) advance was about 20 cm faster than during the summer (May—October). The downward advance was much slower than the upward. According to the mean for the whole year, upward discoloration (39 cm) advanced almost twice as fast as downward (23 cm). This difference was highly significant with a risk of less than 0.1 %.

Above the wounds, the advance of the furthest point of discoloration with microbes was usually slower than that of discoloration withough microbes. An exception was made by the trees wounded in July—September, in which discoloration with microbes showed a slightly faster upward advance than that without microbes. The downward advance of microbes in trees wounded in April—September was faster than the upward. In January—June microbes travelled slightly faster upward than downward. Taken as a mean for the whole year, the advance of the farthest point of discoloration caused by microbes was equally fast upward as downward.

On the average, the rates of advance of the discoloration were very similar to the values recorded by Swedish authors (Nilsson and Hyppel 1967, Lundeberg 1972).

52. Correlations between rate of advance and the type of wound, and between rate of advance and crown class

The only statistically highly significant positive correlation, with a risk of less than 0.1 %, was between the various types of wounds (R, S, T1 and T2) and the rate of upward advance of discoloration without microbes. This coefficient of correlation was highly significant for wounds made in January—March and October—December, and during the whole year. For wounds made in April—September the correlation coefficient was significant (with a risk of less than 1 %). In October—December there was a significant negative correlation (with a risk of less than 1 %) between the crown class and the advance of discoloration without microbes. The same correlation, with a risk of less than 5 %, was also valid for all wounds made throughout the year.

The correlations reveal that the type and location of the wound are of greater importance to the rate of advance of discoloration than e.g. the date of infection. Crown class was seen to play a part in the advance of the discoloration but its effect on the rate of advance was less than that of the location and type of wound.

53. Dependence of the advance on various factors

531. Discoloration advancing without microbes

In the dominant trees the discoloration advanced upward from all wounds at an average rate of about 50 cm/year. The figure for suppressed trees was about 30 cm/ year. The difference is significant, with a risk of less than 1 %. The mean downward advance of discoloration in the dominant trees was 27 cm/year and in the suppressed trees about 20 cm/year. Even

Table 4. The mean rate of advance of the discoloration, cm/year. — *Värivian etenemisnopeuden keskiarvot cm/v.*

Month — *Kuukausi*	Discoloration without microbes — *Värivika ilman mikrobeja*		Discoloration with microbes — *Värivika mikrobien kera*	
	Up *Ylös*	Down — *Alas*	Up *Ylös*	Down — *Alas*
Jan—Mar *Tammi—maalis*	62	26	24	16
Apr—Jun *Huhti—kesä*	30	20	20	24
Jul—Sep *Heinä—syys*	25	17	26	31
Oct—Dec *Loka—joulu*	48	34	29	28
Nov—Apr *Marras—huhti*	51	27	23	22
May—Oct *Touko—loka*	30	20	26	28
Jan—Dec *Tammi—joulu*	39	23	25	25

this difference is significant, with a risk of less than 1 %.

The advance of discoloration during the different seasons of the year is shown in Table 4. From wounds infected in January—March the discoloration advanced upward, with a risk of less than 2 %, faster than from those of April—June and, with a risk of less than 1 %, faster than from those of July—September. The advance from wounds made in October—December was, with a risk of less than 0.2 %, faster than from those made in July—September.

Downward advance from wounds made in October—December, with a risk of less than 0.1 %, was faster than from those of July-September and, with a risk of less than 1 %, faster than from those of April—June. In November—April the advance above the wound, with a risk of less than 1 %, was faster than below. In May—October, with a risk of less than 5 %, the discoloration advanced faster upward than downward.

Discoloration, with a risk of less than 0.1 %, advanced faster from stem wounds T1 than from root wounds R (cf. Nilsson 1967, Nilsson and Hyppel 1968, Kärkkäinen 1971, Isomäki 1972) and from increment borer wounds at breast height, T2. From root wounds (R), with a risk of less than 1 %, from increment borer wounds at stump height (S), with a risk of less than 0.1 %, and from stem wounds (T1), with a risk of less than 5 %, the discoloration advanced faster upward than downward. From T2 wounds the discoloration, with a risk of less than 1 %, spread faster upward than downward. For all wounds taken together, the upward course was, with a risk of less than 0.1 %, faster than the downward (cf. Isomäki 1972). Discoloration that started from T1 wounds of the dominant trees advanced, with a risk of less than 1 %, faster than the discoloration that started from the R wounds.

It has been found in Germany (Schöpfer 1961) that the discoloration starting from increment borer wounds in spruce was more extensive in suppressed than in dominant trees. The resin accumulation has been less on bark wounds and suppressed standing trees than on wood wounds and dominating trees (Schnurbein 1972).

There were no statistical differences between the suppressed trees. Discoloration starting from S wounds of the dominant trees, with a risk of less than 1 %, advanced faster upward than downward, and so did discoloration starting from T1 wounds, but with a risk of less than 2 %. In all wounds of the dominant trees, with a risk of less than 1 %, the upward advance was faster than the downward.

The two-way variance analysis concerning the role of crown class and wound class in the upward advance of discoloration showed crown class to be the more important. In the downward advance of discoloration, on the other hand, the wound class was of greater importance than the crown class.

532. Discoloration with microbes

The discoloration in the dominant trees, for all wounds, advanced upward at the mean rate of approx. 27 cm/year, and in the suppressed trees at one of approx. 22 cm/year. The corresponding figures for downward advance were approx. 28 and 23 cm/year. The differences are not statistically significant. For *Juniperus virginiana* L. it has been found in the USA that the proximal movement of *F. annosus* was greater in roots of dominant trees than in roots of suppressed trees (Howell and Stambaugh 1972). Nor did the present study reveal any statistically significant differences between crown classes, seasons of the year, or rates at which discoloration advanced above and below the wound. But differences between the different kinds of wounds were statistically significant. Discoloration starting from root injury (R), with a risk of less than 1 %, moved upward at a faster rate than one that started from wound S. When discoloration started from wounds T1 it advanced upward, with a risk of less than 0.1 %, faster than that starting from wounds R and S. Discoloration that started from wounds R advanzed downward, with a risk of 0.1 %, faster than that starting from wounds S, discoloration that started from wounds T1 advanced downward, with the same risk, faster than from wounds S, and from wounds T2 faster than from wounds S.

According to the two-way variance analysis, discoloration with microbes advancing above the wound was definitely more markedly affected by the wound than by the crown class. Also in the downward advance of discoloration the wound was of greater importance than the crown class.

6. Microbes isolated from the wounds

61. Microbial flora

Microbes listed in Table 5 were isolated from the wounds, and above and below the wounds. The total of species or families of *Phycomycetes*, *Ascomycetes* and *Fungi imperfecti* identified was 28, whereas only nine species of *Basidiomycetes* were identified. Bacteria were very frequent. Nematodes were observed only once. The microbial flora was very similar to that reported by many other authors (Nilsson and Hyppel 1968, Roll-Hansen 1970, Pechmann and Aufsess 1971, Lundeberg 1972, Hyppel 1973).

Of all fungi, the *Penicillium* species were the most common. The second commonest was *Stereum sanguinolentum* (Alb. & Schw. ex Fr.) Fr. In the present study, *P. gigantea* is not comparable with the other fungi since it was inoculated into a total of 63 wounds. However, it was isolated from only 36 wounds, including two into which it had not been inoculated. The *Cephalosporium* species and *Coryne cylichnium* (Tul.) Boud. were also relatively common.

62. The microbes found farthest above and below the wounds

The microbes that had advanced at the fastest rate upward and downward from the wounds are given in Table 5. The species

Table 5. Microbes isolated from wounded spruce, and those that advanced farthest above and below the various types of wounds inflicted. —
Vaurioista eristetyt ja eri vaurioissa pisimmälle ylös- ja alaspäin edenneet mikrobit.

All microbes isolated from the wounds. — *Vaurioista kaikkiaan eristetyt mikrobit*		Microbes travelling farthest upward and downward from the various types of wounds — *Eri vaurioista pisimmälle ylös- ja alaspäin edenneet mikrobit*									
Index no. and name of the microbe — *Mikrobin numero ja nimi*	Number of wounds — *vaurioiden luku,kpl*	R		S		T1		T2		Total — *yht.*	
		Up — *Ylös*	Down — *Alas*	Up — *Ylös*	Down — *Alas*	Up — *Ylös*	Down — *Alas*	Up — *Ylös*	Down — *Alas*	Amount — *kpl*	% [1])
Fungi — *Sienet*											
1. *Rhizopus nigricans* Ehrenb.	2								1	1	<1
2. *Ceratocystis spp.*	5	1			1	1	1		1	5	2
3. *Chaetomium dolihotrichum* Ames	1										
4. *Chaetomium spp.*	4				1					1	<1
5. *Coryne cylichnium* (Tul.) Boud. ...	23		1	2	1			1	1	6	3
6. *Coryne sarcoides* (Jacquin ex Fr.) Tul.	15		1	1		1	1	1		5	2
7. *Coryne spp.*	2										
8. *Myxotrichum sp.*	1	1								1	<1
9. *Armillaria mellea* (Vahl ex Fr.) Quel.	1		1							1	<1
10. *Fomes annosus* (Fr.) Cooke	5				1	1	1			3	1
11. *Grandinia farinaceae* (Pers.) Bourd. & Galz.	1										
12. *Peniophora gigantea* (Fr.) Massee ..	36	1				3	2	6	10	22	10
13. *Polyporus resinosus* Fr.	2					1	1			2	1
14. *Polyporus zonatus* Nees ex Fr. group	2			1						1	<1
15. *Stereum purpureum* (Pers. ex Fr.) Fr.	2										
16. *Stereum sanguinolentum* (Alb. & Schw. ex Fr.) Fr.	36	5	3	1	4	10	10	1	1	35	16
17. *Trametes serialis* Fr.	1										
18. *Acremonium butyri* Beuma	1			1						1	<1
19. *Alternaria spp.*	3										
20. *Aspergillus niger* van Tieghem ...	2						1			1	<1
21. *Aspergillus spp.*	9		1					1		2	1
22. *Aureobasidion pullulans* (de Bary) Arnaud	2										
23. *Cephalosporium spp.*	23	1	2	1	4			1		9	4
24. *Cladosporium cladosporioides* (Fres.) de Vries	1										
25. *Cladosporium sp.*	1										
26. *Cytospora sp.*	1					1				1	<1
27. *Dendrodochium spp.*	2										
28. *Fusarium spp.*	5										
29. *Graphium spp.*	9	1			2				1	4	2
30. *Hyalodendron sp.*	1				1					1	<1
31. *Penicillium spp.*	68	8	9	4	3	9	6	11	7	57	26
32. *Phialophora spp.*	9		2	1						3	1
33. *Rhinocladiella atrovirens* Nannf. ..	1	1								1	<1
34. *Sclerophoma pithyophila* (Corda) Höhnel	1										
35. *Sphaeropsidales*	9	2	1	2	2				1	8	4
36. *Trichoderma viride* Pers. ex Fr.	1										
37. *Tubercularia sp.*	1			1						1	<1
38. Unidentified fungi — *Tunnistamattomat sienet*	55	1	1	1	3	2			1	9	4
39. Bacteria — *Bakteerit*	47	5	10	1	2	2	5	5	7	37	17
40. Nematodes — *Nematodit*	1							1		1	<1
										220	

[1]) per cent of the total number of the microbes — *prosenttia mikrobien lukumäärästä*

composition contained mostly bacteria, *Ascomycetes* and *Fungi imperfecti*. There were only six *Basidiomycetes* species. The *Penicillium* species were usually seen farthest from the wounded site. In wounds S these fungi were definitely fewer than in the other wounds. Bacteria were unexpectedly numerous. Their incidence was highest in wounds R and lowest in wounds S. In the present study, *S. sanguinolentum* particularly infected the sapwood wound at breast height (T1), and was by far the most common decay fungus in this wound. Once it had infected a wound it also advanced, upward and downward, at a faster rate than the other microbes. It infected a total of 36 wounds, and in 35 of them it had advanced farthest from the wound. Earlier information on the important role of *S. sanguinolentum* in causing decay in wounded spruce is abundant (Nilsson and Hyppel 1968, Roll-Hansen 1970). *P. gigantea*, inoculated into R, T1 and T2 wounds, was most frequent in increment borer wounds extending to heartwood (T2). In root wounds it did not seem able to hold its own. It is possible that, in these wounds, perhaps the *Penicillium* species and/or bacteria were superior competitors or antagonists to it.

The microbes showing the farthest upward or downward advance were sometimes observed in pairs. The most common observation was bacterium in combination with some fungus. Bacteria with the farthest upward or downward movement were accompanied by: *Armillaria mellea* (Vahl ex Fr.) Quel., the *Ceratocystis* species, *F. annosus*, the *Penicillium* species, and *Phialophora* species. *Cephalosporium* species were once accompanied by nematodes, once by *Penicillium* species, and once by *S. sanguinolentum.* On two occasions *P. gigantea* and *S. sanguinolentum* occurred together at the greatest distance from the wound and had decayed the wood. A few other fungi also occurred in pairs.

Samples of the phloem of the wood underlying the black bark were taken at a distance of $\pm$ 20 cm from wounds R and T 1. The total of samples taken was 168, and the cultures were made in the usual way on three different agar substrates. *A. mellea* was isolated from samples taken 20 cm below two R wounds infected in November and December, respectively. In the November wound it was accompanied by a bacterial growth. Bacteria were also isolated three times from a sample taken 20 cm below an R wound and once from one taken below a T1 wound. *S. sanguinolentum* was isolated three times, *Penicillium* species six times, and *Trichoderma viride* (Pers. ex Fr.) once. *Graphium* species were identified twice, and an unidentified *Sphaeropsidales* fungus once. Ten of the 29 cultures remained unidentified.

Figs. 5—8 present, by types of wounds, the microbes isolated at various distances from the wounds of the trees infected with *P. gigantea* and the control trees, by crown classes, according, to the index numbering of the microbes in Table 5.

The S *wounds*, in this analysis, cannot be compared with the other wounds since samples for culture were taken only from the highest and lowest point of the discoloration starting from these wounds. However, the S wounds of the various groups can be mutually compared. In the dominant trees the microbes consisted of fungi other than *Basidiomycetes*, with the exception of *S. sanguinolentum.* The suppressed trees carried e.g. *F. annosus* and even a few other *Basidiomycetes* fungi. The number of bacteria in the S wounds was low, and they were only found on four occasions.

Nine microbial species were identified in the R *wounds* of the dominant control trees and eight in those of the dominant infected trees. The high incidence of bacteria was remarkable (cf. Lundeberg 1972). A relatively large number of the microbes isolated from an R wound in the immediate vicinity of the soil level remained unidentified. The number of microbial species isolated and identified from the R wounds of the suppressed trees was higher (16 species from control trees and 11 from the infected) than the corresponding number of species for the dominant trees. The microbial flora of the suppressed trees contained more *Basidiomycetes* than that of the dominant trees.

The number of microbial species isolated from the T1 *wounds* of the dominant trees, both the control and the infected, was 10, whereas for the two groups of the suppressed trees it was 15. The suppressed trees also

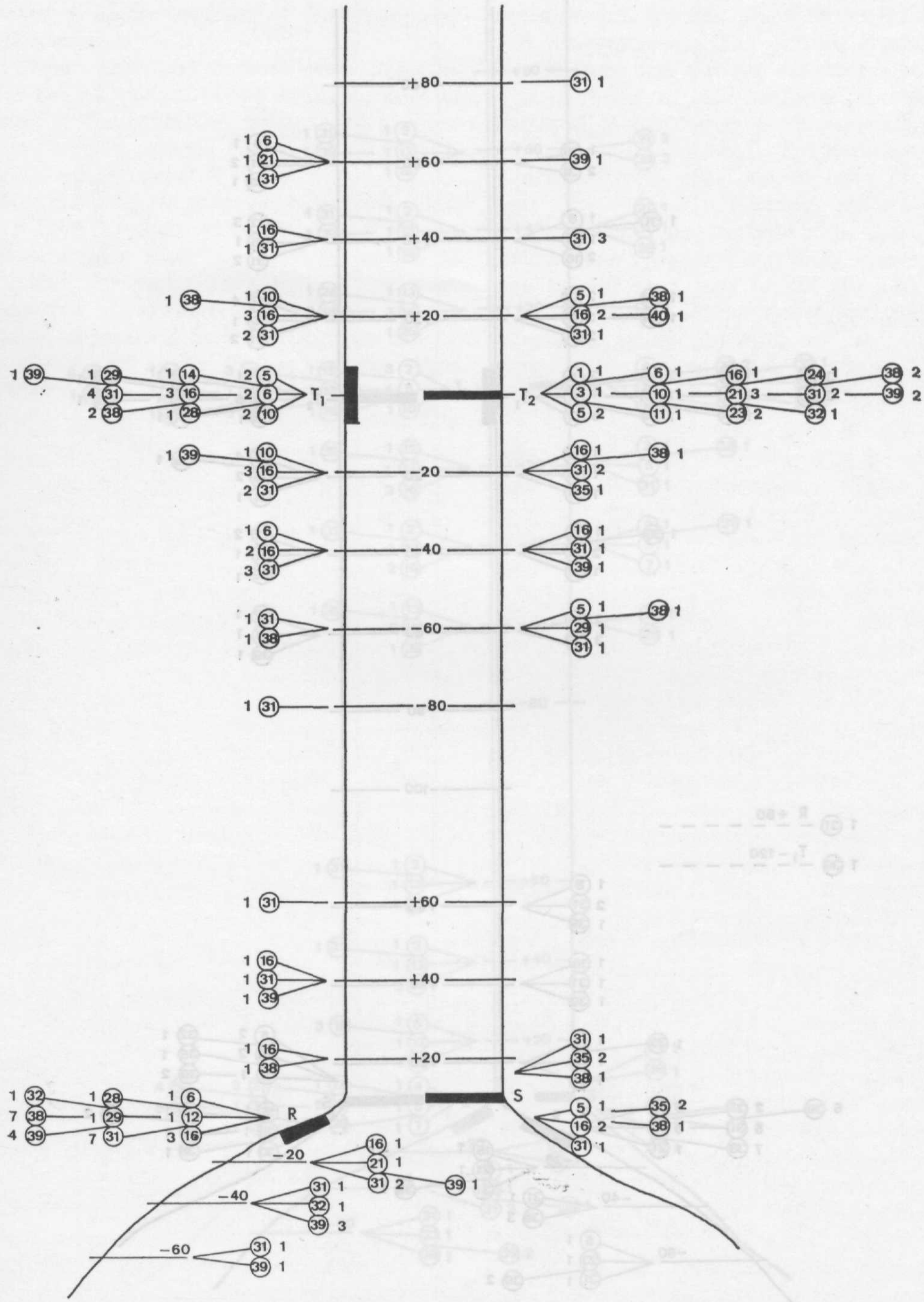

Fig. 5. The microbes that infected the wounds of the dominant control trees. In Figs. 5—8, index numbers of microbes according to Table 5 are shown in circles. Numbers outside the circles indicate the number of identified cultures. — *Vallitsevan latvuskerroksen kontrollipuihin iskeytynyt mikrobi-lajisto. Kuvissa 5—8 rengastettuna taulukon 5 mukainen mikrobin numero ja sen vieressä eristettyjen viljelmien lukumäärää osoittava numero.*

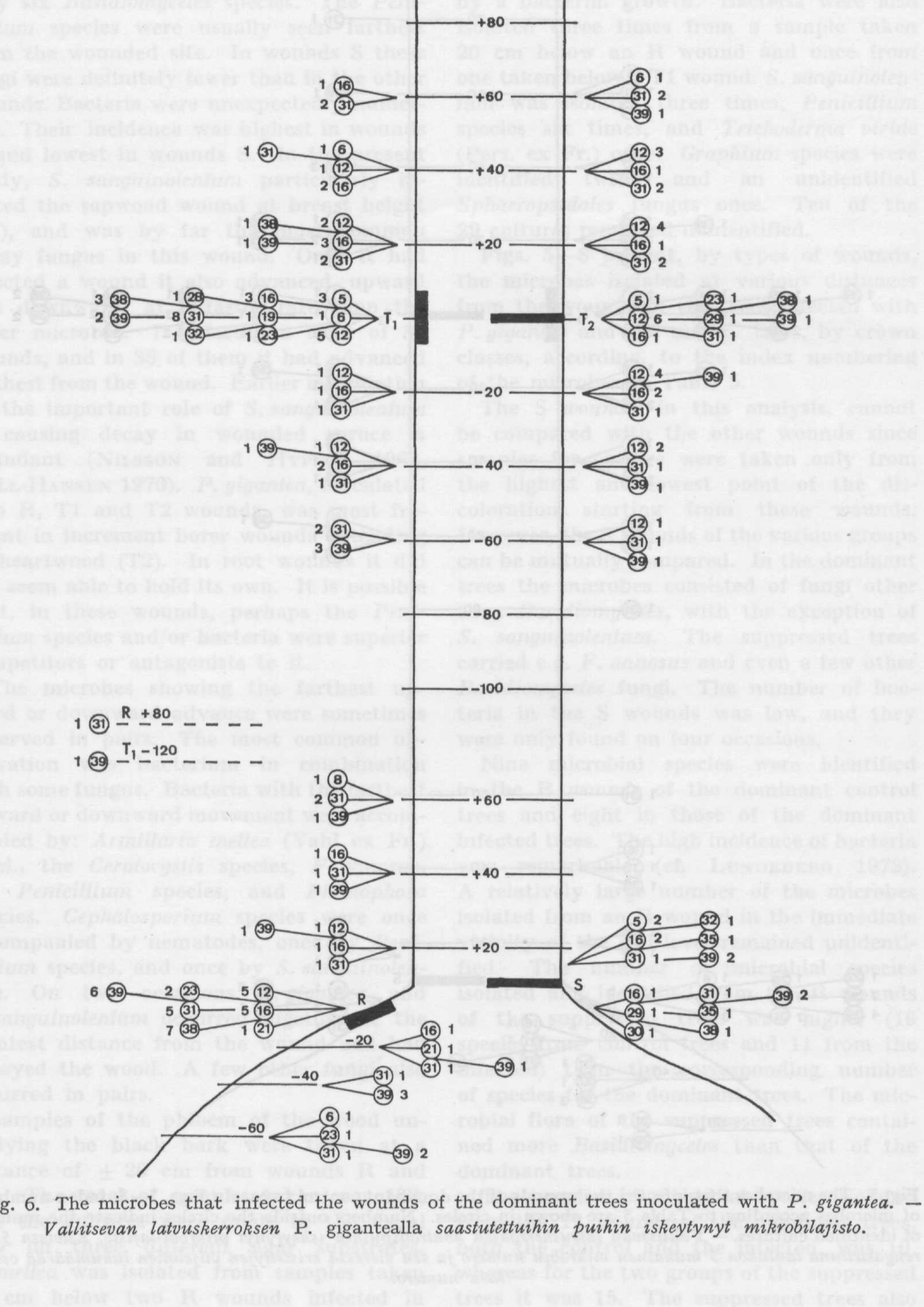

Fig. 6. The microbes that infected the wounds of the dominant trees inoculated with *P. gigantea.* — *Vallitsevan latvuskerroksen* P. giganteella *saastutettuihin puihin iskeytynyt mikrobilajisto.*

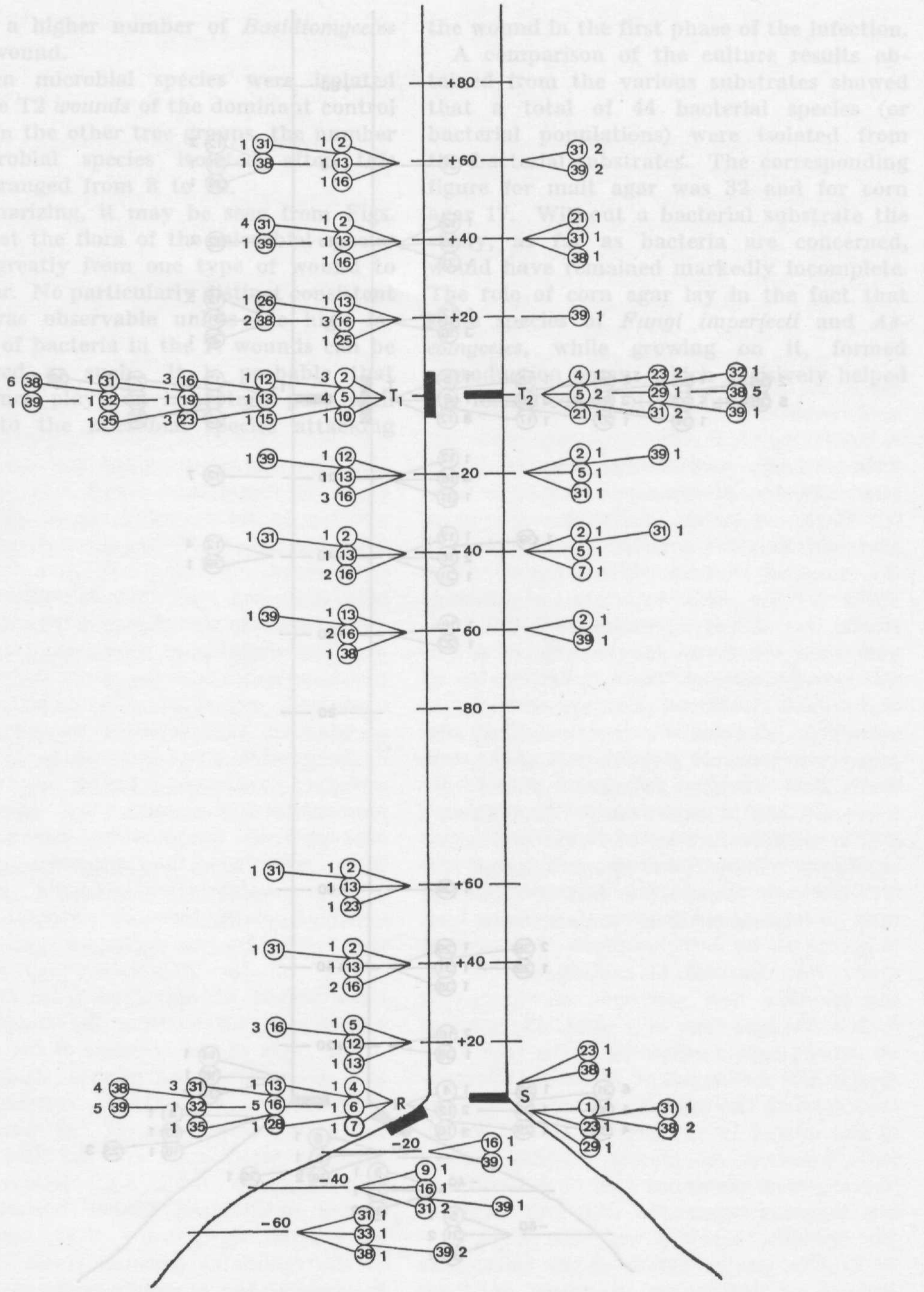

Fig. 7. The microbes that infected the wounds of the suppressed control trees. — *Vallitun latvuskerroksen kontrollipuihin iskeytynyt mikrobilajisto.*

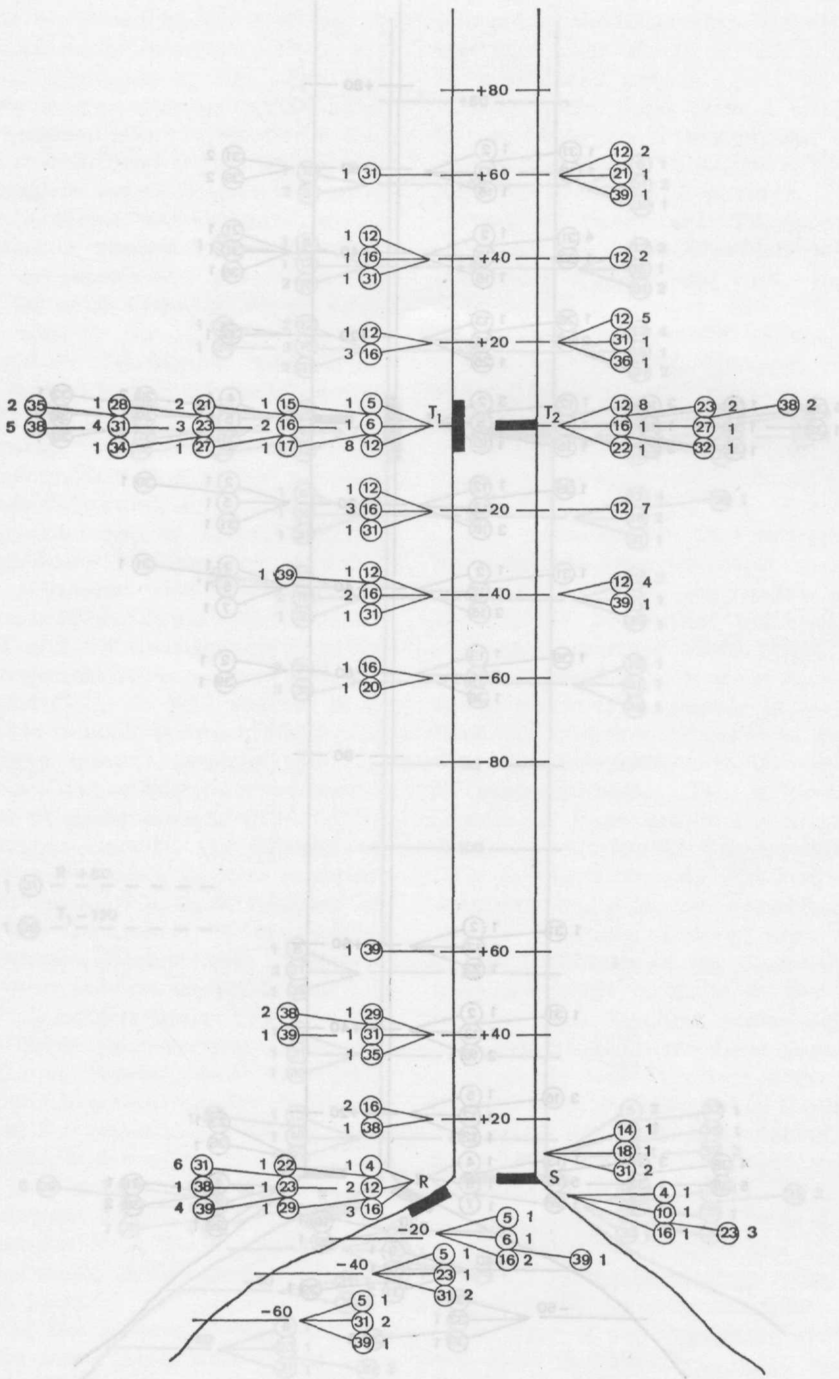

Fig. 8. The microbes that infected the wounds of the suppressed trees inoculated with *P. gigantea*. — *Vallitun latvuskerroksen* P. giganteella *saastutettuihin puihin iskeytynyt mikrobilajisto.*

showed a higher number of *Basidiomycetes* in this wound.

Fifteen microbial species were isolated from the T2 *wounds* of the dominant control trees. In the other tree groups, the number of microbial species isolated after this wound ranged from 8 to 10.

Summarizing, it may be seen from Figs. 5—8 that the flora of the microbial species varied greatly from one type of wound to the other. No particularly distinct consistent trend was observable unless the high incidence of bacteria in the R wounds can be considered as such. It is probable that coincidence plays an important part with regard to the microbial species attacking the wound in the first phase of the infection.

A comparison of the culture results obtained from the various substrates showed that a total of 44 bacterial species (or bacterial populations) were isolated from the bacterial substrates. The corresponding figure for malt agar was 32 and for corn agar 17. Without a bacterial substrate the study, as far as bacteria are concerned, would have remained markedly incomplete. The role of corn agar lay in the fact that some species of *Fungi imperfecti* and *Ascomycetes*, while growing on it, formed reproduction organs which decisively helped the identification of the fungi.

IV DISCUSSION

A wound damaging the growing tree affects it in several ways. Wounds weaken the tree physically and psysiologically, they produce discoloration and open up routes of fungal (and other microbial) infection (JAEGER 1970). Both deciduous trees (HART 1964) and conifers (ALCUBILLA 1970, ALCUBILLA et al. 1971, 1973) have been shown to have fungistatic substances in their living cells. Fungal infection may also create such substances (SHAIN 1970, 1971). On the other hand, in forests nearing maturity, it is probably almost impossible to find a tree with e.g. absolutely undamaged roots (cf. HINTIKKA 1972). Timber transportation of thinnings increases the damage to trees in managed forests (KÄRKKÄINEN 1969, 1971, 1973). The infliction of damage starts the defense reactions of the tree, but when we study the wounds of a tree we usually do not know whether it already had sustained damage earlier or, therefore, whether defense reactions are possibly in progress in some part of the tree. Resin flow plays an important part in defense reaction (SCHNURBEIN 1972). Although a tree, on felling, may be found undecayed at stump height this is no proof that the tree is sound throughout. Defense reactions may be in progress in some part of the tree, triggered off by earlier wounds. The present study was confined to examination of the discoloration and microbes accompanying each individual type of wound, disregarding all other possible reactions of the tree, such as e.g. the development of fungistatic substances, and the amount of resin. The size of the wound in the present study was always constant, no matter whether a large and vigorous dominant tree or a small and less vigorous suppressed tree was involved. The wounds, therefore, were not proportional to the size or vigour of the trees. The amount of the living diaspores of *P. gigantea* used to infect the wound varied also, although an attempt was made to keep this as constant as possible. These factors have affected the success of the *P. gigantea* and the differences observed e.g. between the infection of the dominant and suppressed trees.

According to earlier studies (KALLIO 1970, 1971 a), *P. gigantea* could be expected to infect the wounds of the control trees. The *F. annosus* infection of the control trees was also approximately what could be expected on the basis of earlier studies (KALLIO 1965, 1970, 1971 a).

In most studies dealing with wood defects, discoloured wood has been considered decayed. However, it has long been known that the defence reactions of a tree finally result in discoloured wood, irrespective of whether or not microbes are growing in the wood material. In the present study, the discoloured wood material, one year after being damaged, sometimes did and sometimes did not contain microbes. On the other hand, in a large number of cases no colour change was observable but the wood material still contained microbes. These latter trees, in practice, are classified as sound trees. Their number may increase in the future owing to mechanized timber harvesting in improvement cuttings. The shorter the interval from the previous harvesting, the more numerous the microbial infections without discoloration. Living microbes, within a short time, considerably reduce the value of a tree both for use as sawn timber or for pulpwood. All damaged trees should be extracted from the forest immediately after felling (BAZZIGHER 1973).

The rates of the advance of discoloration and microbes in the present study almost always were more closely correlated with the location and type of the wound than with the crown class and the time of year. This suggests that, e.g., lesions arising during mechanized timber harvesting are of greater significance than the vigour of the remaining growing stock. In order to improve the economic result of the final cutting, forest soil is often fertilized after the last thinning of the stand by mechanized timber harvesting. Fertilization may prove to serve no real purpose since mechanical damage to the growing stock, if it starts a decaying process and contributes to its advancement, may be of greater importance than the vigour of the remaining growing stock. Furthermore, it is known that fertilization increases the rate of advance of decay (discoloration) that has started from wounds (Isomäki 1972).

The upward course of discoloration was faster than the downward course. This was true particularly of the discoloration without microbes. It is a fact that the defense reactions of the tree produce the colour changes, especially with sapwood wounds in the stems of vigorous trees. Microbes, on the other hand, grow equally fast upward as downward. The microbial species isolated and identified in the present study, from the wound sites and at given distances above and below these sites, were largely the same as had been reported in various earlier studies (Pawsey and Gladman 1965, Maloy and Robinson 1968, Nilsson and Hyppel 1968, Roll-Hansen 1970, Pechmann and Aufsess 1971). The result obtained shows once again that decay starting from spruce wounds is produced by a microbial population and not by a single microbe. A succession of different species has been observed in the development of this microbial population (Shigo 1963, Shigo and Larson 1969, Maloy and Robinson 1968). One year after the original wound, microbes other than *Basidiomycetes* fungi were predominant in the present study. The result corroborates several earlier findings reported. But the present study brought to light a larger number of bacteria than many earlier studies. A high number of bacteria has also been isolated from spruce root wounds e.g. in Sweden (Lundeberg 1972). Some of the bacteria isolated in the present study were growing singly on the site of the wound. Plans are being made to test the possible antagonistic properties of these bacterial strains in relation to a few of the most important decay fungi, such as *S. sanguinolentum* and *F. annosus*. At the moment the total bacterial flora isolated is being subjected to a detailed study.

Shain (1971) has shown that the pH of the reaction zone of the spruce is remarkably high. The present finding also corroborates this view, for bacteria were often isolated from the utmost point of the discoloration, which of course falls inside the reaction zone. They failed to grow on a bacterial substrate unless its pH was regulated at 7.

In the present study, the main problem was *P. gigantea* and any adverse effects that might perhaps be produced by spreading it in the forest. After Rishbeth (1948, 1959, 1963), studies of the living habits and possible adverse effects of this fungus have been carried out in many countries (Boyce, Jr. 1966, Twarowska 1972, Blakeslee and Stambaugh 1973). To date, no adverse effects following the dissemination of *P. gigantea* in forests, in order to control *F. annosus*, have been reported, nor were any discovered in the present study.

V SUMMARY

The purpose of the present study was to investigate the success of infecting spruce wounds with a mycelial suspension of *P. gigantea*, to analyse the microbial species infecting the wounds of the control trees, and to observe the advance of the discoloration and the microbes above and below the wounds. In an approximately 100-year old spruce stand on Myrtillus type soil near Helsinki, two dominant and two suppressed spruce trees were wounded each month during one year, 48 trees in all. Both sapwood and heartwood wounds were infected with *P. gigantea.* One year after wounding and infection the trees were felled and sawn into lengths of 20 cm up to a distance of 60 cm above and below the wound. Small samples were taken from these discs and cultured on three different substrates in order to grow and indentify the microbes.

In the suppressed trees, the *P. gigantea* infection had been successful in 75 % of the increment borer wounds extending into heartwood at a height of 1.3 m above the cut surface of the stump. For dominant trees, the corresponding infection percentage was 50. In sapwood wounds the infection was considerably less often successful, and then only from June to November. Airborne *P. gigantea* infection of control trees was noted only in two root wounds. *F. annosus* infected four control trees in June—November.

Discoloration starting from the wounds was not a reliable proof that microbes were present. According to the present study, the chances that wounding would be followed by discoloration without microbes, discoloration with microbes, or microbial growth without discoloration of the wood material were almost equal.

Discoloration without microbes advanced upward from all wounds at a mean rate of 39 cm/year and downward at one of 23 cm/year. The difference is highly significant with a risk of less than 0.1 %. Discoloration with microbes advanced both upward and downward at a rate of 25 cm/year. In the dominant trees, discoloration without microbes advance upward at a rate of 50 cm/year and in the suppressed trees at one of 30 cm/year. The difference is significant with a risk of less than 1 %. The rates for the downward course were 27 cm/year in the dominant and 20 cm/year in the suppressed trees. This difference also is significant with a risk of less than 1 %. The rates of advance of a discoloration with microbes showed significant differences only between the various wounds: discoloration advancing at the fastest rate started from the sapwood wounds of the stem.

According to the variance analysis, the upward advance of discoloration without microbes showed a greater correlation with the crown class than with the type and site of the wounds. The downward advance, again, depended more on the type of the wounds than the crown class. When the discoloration contained microbes, both its upward and downward course showed a closer correlation with the type and site of the wounds than with the crown class.

A total of 37 fungi were identified by species or family, from the damaged trees. A large number of bacteria were also found, and on one occasion nematodes. Nine species of *Basidiomycetes* were identified. The most common fungi were the *Penicillium* species, and they had most often advanced farthest above and below the wound. Of the actual decay fungi, *S. sanguinolentum* showed the highest incidence and fastest growth. *Coryne cylichnium* and the *Cephalosporium* species were also relatively common.

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Seloste

PENIOPHORA GIGANTEA JA KUUSEN VAURIOT

Maannousemasienen eli juurikäävän *(Fomes annosus)* aiheuttamat tuhot ovat useitten tutkimustulosten mukaan lisääntymässä. Sienen tuhojen torjunta on osoittautunut vaikeaksi. Englannissa on jo parin vuosikymmenen ajan käytetty biologista torjuntaa ts. sivelty kantojen kaatopinnat välittömästi kaatamisen jälkeen *P. gigantea*-nimisen sienen laboratoriossa kasvatetulla rihmastosuspensiolla. Näin on estetty maannousemasienen ilmateitse kantojen kaatopintoihin tapahtuva iskeytyminen ja sen eteneminen edelleen juuristojen kautta toisiin puihin.

P. gigantea on lahottajasieni kuten *F. annosus*kin. Ensin mainittu tunnetaan kuitenkin yleisimmin kuolleen puuaineksen lahottajana. Nyt esitellyn tutkimuksen tarkoituksena oli selvittää, missä määrin *P. gigantea* iskeytyy kasvavien kuusien vaurioihin. Tutkimus suoritettiin Helsingissä n. 100-vuotiaassa MT-kuusikossa. Tutkimukseen otettiin kannonkorkeudelta kasvukairanlastun perusteella terveiksi todettuja puita. Kerran kuukaudessa yhden vuoden ajan vaurioitettiin kaksi vallitsevan ja kaksi vallitun latvuskerroksen kuusta (Kuva 1 A, s. 5). Kummankin latvuskerroksen toisen puun vauriot saastutettiin *P. gigantean* rihmastosuspensiolla ja toisen jätettiin saastuttamatta. Vuoden kuluttua vaurioittamisesta puut kaadettiin ja katkottiin 20 cm:n välein vauriosta ylös- ja alaspäin 60 cm:n etäisyydelle saakka. Vaurioitumakohtaa vastaavista paikoista otettiin pienet puupalat, joista näytepalat viljeltiin kolmella erilaisella kasvualustalla mikrobien kasvattamiseksi ja tunnistamiseksi.

Tutkimuksen mukaan ei paljain silmin arvostellun kasvukairanlastun perusteella onnistuttu luotettavasti määrittämään, oliko puu lahovikainen vai ei.

P. gigantea-infektio onnistui tavallisimmin vallitun latvuskerroksen puihin rinnankorkeudelle kasvukairalla tehtyyn vaurioon (vaurio T2, kuva 3, s. 8). Onnistumisprosentti oli 75. Vallitsevan latvuskerroksen vastaava infektoitumisprosentti oli 50. Infektio tapahtui helpoimmin vallitun latvuskerroksen sydänpuuhun ulottuviin vaurioihin. Puiden infektoiminen mantopuuvaurioista (T1 ja R) onnistui huomattavasti harvemmin kuin sydänpuuvaurioista ja ainoastaan kesä—marraskuun välisenä aikana. *P. gigantea* iskeytyi heinäkuussa ilmateitse vallitsevan latvuskerroksen kontrollipuun juurivaurioon (R) ja lokakuussa vastaavasti vallitun latvuskerroksen kontrollipuun juurivaurioon. *F. annosus* iskeytyi ilmateitse kahteen vallitsevan ja kahteen vallitun latvuskerroksen kontrollipuuhun kesä—syyskuun välisenä aikana.

Vaurioittaminen aiheutti joko värivian tai mikrobien tai molempien iskeytymisen vauriokohtaan. Vain 1 % vaurioista jäi terveiksi. Tutkimuksen mukaan oli lähes yhtä todennäköistä, että 1) vauriosta alkoi värivika, jossa ei ollut mikrobeita, 2) vauriosta alkoi värivika, jossa oli mikrobeita tai 3) vaurioon iskeytyi mikrobeita, jotka eivät aiheuttaneet mitään paljain silmin havaittavaa muutosta.

Värivika ilman mikrobeita eteni kaikista vaurioista ylöspäin keskimäärin 39 cm/v. ja alaspäin 23 cm/v. Ero on alle 0.1 %:n riskillä merkitsevä. Värivika, jossa kasvoi mikrobeita, eteni sekä ylösettä alaspäin 25 cm/v. Vallitsevan latvuskerroksen puissa värivika ilman mikrobeina eteni ylöspäin 50 cm/v. ja vallitun latvuskerroksen puissa vastaavasti 30 cm/v. Ero on alle 1 %:n riskillä merkitsevä. Vallitsevan latvuskerroksen puissa värivika ilman mikrobeita eteni alaspäin 27 ja vallitun latvuskerroksen puissa 20 cm/v. Tämäkin ero on 1 %:n riskillä merkitsevä. Mikrobien kera edenneen värivian etenemisnopeuksissa oli merkitseviä eroja vain eri vaurioiden kesken: rungon mantopuuvaurioista alkoivat nopeimmin edenneet väriviat.

Varianssianalyysin mukaan värivian eteneminen ilman mikrobeita ylöspäin riippui enemmän puiden latvusluokasta kuin vaurioiden laadusta ja paikasta. Värivian eteneminen ilman mikrobeita alaspäin riippui enemmän vaurioiden laadusta ja paikasta kuin latvusluokasta. Mikrobeita sisältäneen värivian eteneminen sekä ylös- että alaspäin riippui enemmän vaurioiden laadusta ja paikasta kuin latvusluokasta. Tämä viittaa siihen, että kasvaviin puihin harvennusmetsiköissä koneellisen puunkorjuun yhteydessä syntyneet vauriot olisivat lahon etenemisnopeuden kannalta tärkeämpiä kuin puiden elinvoima. Yhä enemmän koneellistuvien harvennushakkuiden ja niiden jälkeen suoritetun metsän lannoituksen vaikutus kuusikon päätehakkuun taloustulokseen kaipaisi pikaisesti laajaan materiaaliin perustuvia selvityksiä.

Vaurioitumiskohdista ja niistä ylös- ja alaspäin eristettiin joukko sieniä ja bakteereita sekä kerran sukkulamatoja. Kuusen lahovikaisuus on siten jo alusta alkaen pieneliöyhdyskunnan eikä minkään yksityisen sienen aiheuttama.

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

1973. *Peniophora gigantea* (Fr.) Massee and wounded spruce (*Picea abies* (L.) Karst.). ACTA FORESTALIA FENNICA 133. 28 p. Helsinki.

For the purposes of the present study, some dominant and suppressed spruce trees in Helsinki were wounded each month for a year. Some of the wounds, immediately after infliction, were inoculated with mycelial suspension of *P. gigantea*. A year later the trees were felled. In connection with the felling, the incidence and rate of advance of the discoloration starting from the wounds was studied. The stems were sawn into 20 cm lengths for 60 cm above and below the wound sites. Small specimens taken from the discs were cultured on three different substrates in order to develop microbes for identification.

According to the present findings, the probabilities are practically equal that 1. the discoloration starting from the wound contains no microbes, 2. the discoloration contains microbes, 3. microbes are growing above and/or below the site of the wound without any change of colour being noticeable. The species flora of the microbes consisted mainly of non-*Basidiomycetes* and bacteria. The commonest *Basidiomycetes* fungus was *S. sanguinolentum*. Inoculating the cut stump surfaces with *P. gigantea* suspension in order to control an aerial infection by *F. annosus* causes hardly any distribution of *P. gigantea* onto growing spruce trees. Only if the wounds extend to the heartwood is it possible that this may take place.

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