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Some treatments which render Monterey pine (*Pinus radiata*) attractive to the wood wasp *Sirex noctilio* F.

J. L. MADDEN
CSIRO, Tasmanian Regional Laboratory, Stowell, Stowell Avenue, Hobart, Tasmania 7000

Introduction

The attractiveness of trees for Siricids (Hym., Siricidae) is known to be generally associated with tree suppression (Rawlings, 1956) and debilitation (Wickman, 1964), but the factors which predispose a tree to attack are not yet fully understood. *Sirex noctilio* F. females show immediate but short-lived attraction to healthy *Pinus radiata* trees from which small pieces of bark have been removed (Author's unpubl. data). This suggests the presence of an attractant in the cambium-phloem region of healthy trees. In an attempt to locate the attractant, field and insectary tests were carried out in Tasmania during the summers of 1964–65, 1965–66 and 1966–67 to assess the responses of *S. noctilio* to trees which were debilitated by a number of different methods.

Materials and methods

All field experiments were performed in a *Pinus radiata* forest at Pittwater, Tasmania, which contained a small natural population of *S. noctilio*. The insects used in laboratory trials were reared from both field- and laboratory-infested logs and were given access to host material of *P. radiata* in laboratory cubicles for two to three days before use, because freshly emerged females respond to light rather than to host material.

The following treatments were used:

(i) Felling;
(ii) Girdling, in which a complete ring of bark was removed from the trunk, and also all limbs and foliage below the ring;
(iii) Lopping, in which trees were denuded of all limbs and foliage;
(iv) Conditioning, in which caged mature female insects were permitted to oviposit on sections of the trunk of healthy test trees.

Attack was assessed either (i) by counting oviposition punctures and expressing the results on a per square foot basis, or (ii) by recording daily the number of females present on the test material at noon.

The investigations were carried out in fine, clear weather except where otherwise stated. In most cases the work was conducted in areas of 12–14-year-old natural regeneration.

Results

Felling

Several experiments were carried out. In the first, designed to measure the insects' response to stem material at various times after felling, a large regrowth tree, felled in October 1963, was trimmed and cut into twenty 18-in. sections in January 1964. The cut ends were coated with mastic (Shell L Grafting Mastic) to reduce drying and fungal contamination. These sections were then placed in random positions inside

a 6×6×6-ft flywire mesh cage outdoors. Thirty *S. noctilio* females added to the cage demonstrated no particular preference for any one of the 20 sections.

Two regrowth trees were then felled and trimmed every two days for 10 days. From one of the first pair an 18-in. section was cut from the butt, and from the other a similar section was cut from the top; all cut surfaces were coated with mastic. These sections replaced two of those already in the cage. The same procedure was followed when each pair of trees was cut, and at the same time the sections from all the preceding pairs of trees were replaced by fresh sections cut from the same trees. Thus material of a wide age range was provided for the *S. noctilio* females.

The levels of attack, assessed as oviposition punctures or drills per square foot of bark surface per day for the first three pairs, are shown in Fig. 1. Inclement weather limited oviposition activity on tree pairs 4 and 5, but it is evident that sections exhibited different levels of attractiveness at times after felling and that maximum oviposition activity occurred 5–8 days after felling. The sections that had been replaced were examined for oviposition drills and then discarded.

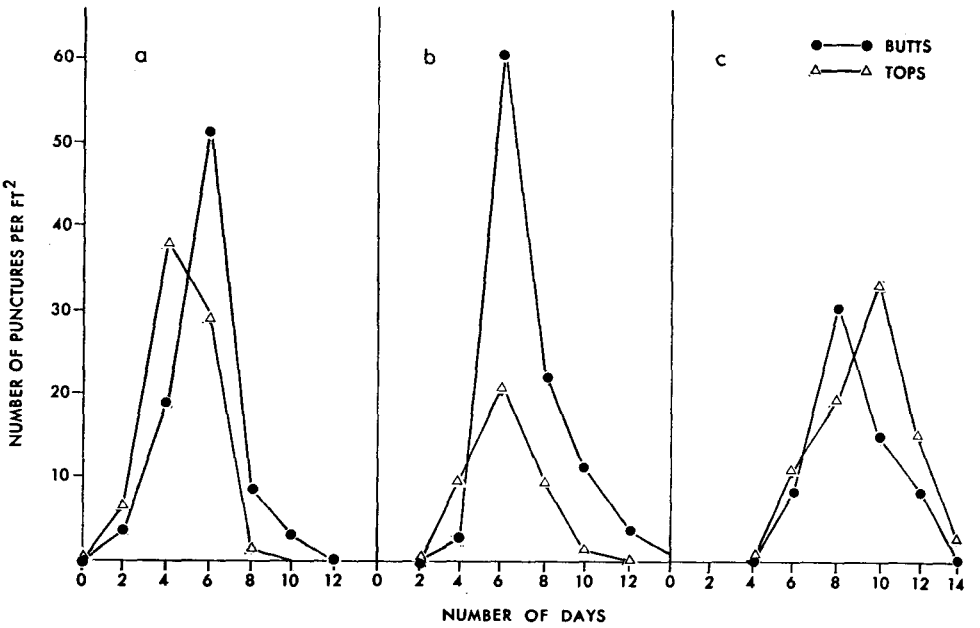

Fig. 1.—*S. noctilio* attack on 18-in. *P. radiata* logs cut from two trees felled on days 0, 2 and 4 (*a*, *b* and *c*, respectively) and exposed for 48 h to 30 females in an outdoor cage.

In the second experiment, five pairs of regrowth trees of 5 in. diameter were felled and each tree was divided into two 10-ft sections. In each pair the upper section of one and the lower section of the other were trimmed. The sections were then supported horizontally three feet above the ground by wooden cradles located at different sites in the forest.

The average time that elapsed after felling before females located the 20 sections was 1·0 days (range 0–5 days—day 0 being the day of felling). The number of females found on the sections increased to a maximum on the fifth to seventh days and then declined. Females were observed on sections over an average period of 10 days (range 6–14 days) after felling, although they were observed to make short-term visits to some sections up to three weeks after felling (Fig. 2).

Trimming delayed the attainment of maximum attractiveness by 48 h but had no significant effect on the general level of attractiveness reached, the average number of female-days being 8·2 for the trimmed and 8·6 for the untrimmed sections. Females were generally first recorded on the upper sections, and there were more females on these sections on the fourth to sixth days (mean 5·6 female-days) than on the thicker-barked butt sections (mean 3·3 female-days). Sections located in shaded and protected situations were attacked one or two days later than those in exposed sites.

In general, *S. noctilio* activity was depressed during cool and wet conditions, and some trees felled during such periods were not located until the resumption of fine, warm weather, in some instances, two to three weeks later.

Girdling

During 1965–66, fifty trees were trimmed up to 18 ft above ground level and allotted to ten groups of five trees. Four trees in each group were girdled, one each at 1, 4, 8 and 16 ft above the ground, while the fifth tree provided the control. Trees in five of the groups were girdled by removing a one-inch band of bark tissue only, and in the other five by removing a one-inch band of bark tissue plus a quarter-inch of wood. The girdles at 16 ft in two groups of trees were covered with grafting mastic to examine the possibility of any attractant being released at the site of operation. Five additional controls were provided by girdling trees and leaving them untrimmed below the level of the girdle.

Location of the test material by *S. noctilio* females did not occur until 9–12 days after girdling. For the first six or seven weeks the attack was confined almost exclusively to the region below the girdle. Females were observed to alight on the upper regions of the tree, but after a period of testing and assessment these regions

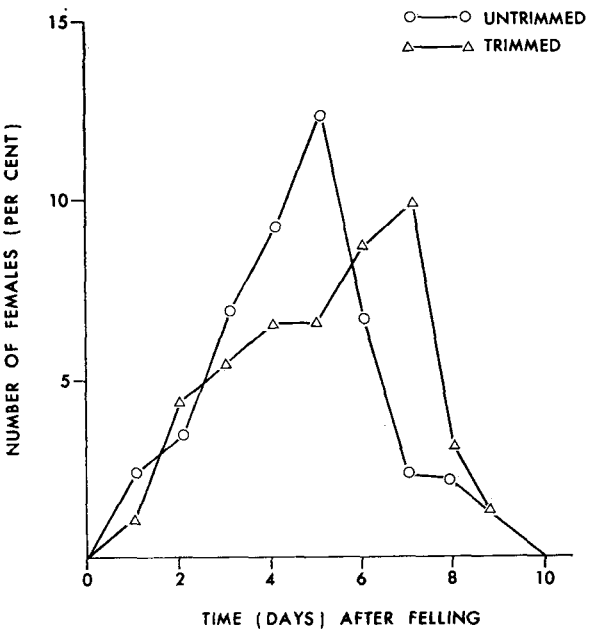

Fig. 2.—The numbers of females of *S. noctilio*, at midday, on untrimmed and trimmed sections of felled trees expressed as a percentage of the total numbers of females recorded on all the sections over a 10-day period.

were rejected, and after one or more short flights the female located the lower region which, at this stage, was acceptable for oviposition. Neither deep nor shallow girdling affected the response. However, the intensity of oviposition increased with the height of the girdle (Table I) as more females were attracted to the larger areas of isolated tissue. For example, there were totals of 11, 5 and 4 females on the trees girdled at 16, 8 and 4 ft, respectively, 21 days after the treatments were established. Trees which had girdles coated with mastic were attacked at the same time as those with open girdles. No oviposition was recorded on either the pruned but ungirdled or the girdled and unpruned controls.

TABLE I. *The effect of girdling* P. radiata *regrowth at various heights on the attack by* S. noctilio

Height of girdle (ft)	Shallow girdling		Deep girdling	
	No. trees attacked	No. punctures/ft² (Mean & S.E.)	No. trees attacked	No. puncture/ft² (Mean & S.E.)
Control (both types)	0	—	0	—
1	0	—	0	—
4	2	14·00 ±2·00	3	15·47 ±0·52
8	5	24·82 ±3·18	3	25·10 ±5·71
16	5	89·50 ±6·96	5	81·50 ±5·70

Oviposition was confined to the region below the girdle for a period of six to seven weeks, after which there was also some attack on the upper region. In the latter instance, foliage colour changes indicated that all regions were in a stress condition. Trees girdled in December, and attacked in mid-January, were still attracting *S. noctilio* to both regions in late March.

The duration of the attractive condition was further examined by girdling groups of trees in different months during 1965 and 1966. A total of 104 trees was girdled and the subsequent attack indicated that trees girdled at any time in the six months prior to the emergence season of *S. noctilio* (late December–March) were equally attractive at the beginning of the season. Girdled trees, which were not attacked or had survived any attack received in the season in which they were girdled, were found to be attractive in the following season some 10 months later.

Lopping

Trees were completely trimmed and lopped at a height of 16 ft and the pattern of attack by *S. noctilio* was found to be similar to that on trimmed and girdled trees throughout the season. A distinctive time lag of 10–12 days occurred before attack commenced; however, the duration of the attack was more variable than that recorded in girdled trees. Trees trimmed and lopped prior to November–December were not always attacked and the actual period for which the trees remained attractive ranged from two to ten weeks. Unlike girdled trees, lopped trees were not attractive to wasps in the following season.

Conditioning

Conditioning has been used extensively in forest pest research to invoke wild attack. The technique was applied to assess whether wild *S. noctilio* females were attracted by the drills of other females. One 1-foot-long wire-mesh cage containing five medium-sized *S. noctilio* females was affixed at a height of four feet to each of five healthy regrowth trees on 9 January 1964. All females began to drill into the trees immediately. The females were permitted to drill to repletion and death which, under the prevailing conditions, occurred in approximately three days. All five trees were found to have been attacked by wild females above and below cages when examined 15 days later.

In another experiment, different numbers of cages containing different numbers of *S. noctilio* were positioned at three-foot intervals up the stem to assess if (i) insects were attracted to the sites where females were drilling or to the tree stem as a whole, and (ii) the response of wild females was affected by the density of females per cage (Table II). Conditioning females were again permitted to drill to repletion within the cages which remained on the trees throughout the duration of the test.

TABLE II. *Conditioning effect of* S. noctilio *on regrowth* P. radiata *as reflected in time lag and duration of attack by natural population*

No. cages/ tree	No. females/ cage	Time before wild attack commenced (days)			Duration of wild attack (days)		
		Series I	Series II	Series III	Series I	Series II	Series III
1	2	11	7	—	6	9	—
1	4	—	—	—	—	—	—
1	8	8	9	10	12	7	9
2	1	14	7	—	5	12	—
4	1	13	—	10	9	—	7
8	1	11	11	9	7	11	3

— = No attack.
Average conditioning period = 10·0 days; average attack period = 8·1 days.
Series I established 20.i.65; series II 4.ii.65; series III 16.ii.65.

Attack by wild females, if it occurred, commenced 9–14 days after exposure to the caged females. By this time, the resin flow from the punctures had ceased and the early exudate had commenced to crystallise on the bark surface. There was no indication that the wild females had been attracted to a point source, subsequent attack being distributed uniformly along the entire length of the trees in all cases. There was no consistent relationship between attack and the number of *S. noctilio* contained in the cages, but whenever a tree failed to attract wild females it was found that the intensity of drilling by the caged females had been light (< 10 punctures/ft^2). This low rate of oviposition was caused by the progressive immobilisation of females by resin.

Discussion

The general findings are summarised in Table III. The available evidence indicates that the timing and duration of the attractive period are correlated in a general way with the water content of the host tree, although no one factor could be isolated. Two treatments, girdling and lopping, produced similar results. These treatments deprive the phloem of soluble solids (including photosynthate and auxin) and the water that transports them from the crown, but still allow for a time the intake of water by the roots and its passage to the xylem and, chiefly by way of the medullary

TABLE III. *The response of female* S. noctilio *to* P. radiata *trees treated in different ways to invoke attack*

Treatment	Time between treatment and attack (days)	Duration of period of attractiveness	Comments
Felling	0–5	6–14 days	Upper regions attacked first. Maximum attraction at 5–7 days.
Girdling	9–12	3–4 months, with some carry-over to following year	Region below girdle preferred for oviposition. Region above girdle receives sustained attack only after some weeks.
Lopping	10–12	2–10 weeks	Attack on entire length.
Conditioning	9–14	3–12 days	Attack along length.

rays, to the phloem. This would result in the xylem remaining well hydrated and the phloem becoming partially desiccated and nutritionally deprived. Under these conditions the tree becomes attractive only after a considerable period but remains so for several months.

Conditioned trees were attacked by wild *S. noctilio* after a time lag similar to that in girdled and lopped trees, but the duration and intensity of attack were less. The observations suggest that oviposition produces changes in the physiology of the tree which affect its attractiveness in a manner similar to girdling or lopping. Coutts (1968) reported that, as a consequence of *S. noctilio* attack on *P. radiata*, carbohydrate accumulated in the needles as starch, indicating an interference with the translocatory mechanism of the tree.

Felling, on the other hand, has the immediate effect of cutting off the water supply from the roots to the xylem, the rate of desiccation of the tissues being more rapid in felled trees which were not deprived of their needles. Felled trees became attractive relatively rapidly but remained attractive for only a few weeks. Trimming of the felled trees delayed by about two days the onset of its attractiveness to *S. noctilio*.

The implications of the observed correlation between the water content of the tissues and attractiveness to *S. noctilio* are not as yet understood in terms of possible changes in bark permeability or in the chemical composition of the phloem. Current research is designed to elucidate the mechanism of the release of attractants, and to define their chemical nature, with a view to predicting or controlling the conditions under which their release will occur.

The results obtained from these treatments, in particular from the girdled trees, have been of considerable practical value in providing a method of indicating the presence of *S. noctilio* in the field, and a method by which seasonal activity patterns may be assessed. It is possible that girdled trees could be used as " trap " trees to reduce the *S. noctilio* population in a given area.

Summary

Characteristic temporal patterns of attack by *Sirex noctilio* F. in Tasmania were obtained when *Pinus radiata* trees were either felled, completely lopped or high trimmed and girdled. Felling resulted in immediate attack whereas lopped and girdled trees were not attacked until some 9–12 days later. Felled trees were susceptible to attack for about 14 days, but lopped and girdled trees were attacked for longer periods. In some instances girdled trees remained susceptible for more than one season. Oviposition by caged *S. noctilio* females on healthy trees was followed by attack from wild females about 9 days later. It is shown that the timing and duration of attack by *S. noctilio* are correlated with the degree of stress undergone by the host tree.

Acknowledgements

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