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Developing and Testing a Lure-trap for the Woodwasp Sirex noctilio F.

SUMMARY

Lure-traps consisting of girdled or topped radiata pine trees (*Pinus radiata* D.Don) implanted with organophosphate insecticide (Bidrin), were successful in forests where the population density of *Sirex noctilio* was low.

The lures did not predispose adjacent undamaged trees to attack. The attack was invariably restricted to a single lure in each plot. Attack patterns and density of attack on lures were similar to those found on infested trees in other parts of the forest.

It is estimated that each lure-trap costs $1.75 to establish and operate.

INTRODUCTION

The principle of the lure-trap is well known, and entomologists have tested many lures for various pests over a considerable period. The use of host-material as a means of attracting insects to a poison has indicated that complex relationships are involved in pest behaviour. For instance, Martin (1936) found that girdled trees were not attractive to *Scolytus;* but he concluded from a series of seasonal fellings that *Scolytus* was most attracted to Autumn-felled logs partially exposed to the sun, while *Hylurgopinus* preferred Spring-felled, shaded logs. Graham (1959), Anderson (1948) and Gara (1963) have shown that certain such factors may be critical at some time during the exposure of the lure. Thus combinations of lures may often be more successful than one sort used alone.

Adult insects pass through a series of physiological ages in which they may react differently to particular stimuli. Some of these reactions have been studied closely on forest insects (Chapman 1962, Gara 1963, Wood 1962). Termites for example are strongly photopositive on emergence and disperse in the direction of high light intensity. When they have utilised a proportion of their food reserves and body moisture, they enter a mate-attracting phase during the latter part of which they become photonegative. There are strong indications that phagostimuli and tactile stimuli modify subsequent behaviour and contribute to successful attack on host plants (Morgan 1959, Nutting 1969). It is therefore vital to the establishment of a successful lure-trap for any pest that the behaviour of the adult be well known.

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Development of a successful lure requires either the provision of composite attractants or an appropriate sequence of, attractants to match the variation in behaviour of the pest, or the use of a single attractant at appropriate concentration over the entire period of adult life.

The use of a host-plant for Sirex, an ovipositing insect, poses some problems.

The proposed lure should compete with nearby susceptible trees, and the chemical trap should remain effective over the flight period of the woodwasp, so that it is not necessary to replace the lures.

The lures should not predispose adjacent trees to attack and they should be economical to establish. There was adequate evidence that gravid females attacked damaged logs and trees (Madden 1968, Morgan et al 1971); but the most efficient lure for the woodwasp was not known and the time of effectiveness of any lure was not adequately established. We used three different types of lure in each plot with slight variation in their time of establishment.

We considered that the lure would be subjected to a better test of its efficiency in forests where the woodwasp population was low. It would then be free of the intense competition for oviposition sites that we had observed where the population was high.

The experiments were conducted in three Gippsland Forests of A.P.M. Forests Pty. Ltd. at Longford, Flynn Creek and Maryvale. These are young forests of radiata pine in which the woodwasp has become established. Consistent culling of infested trees is practised in these stands, and a vigorous thinning programme involving all stands from nine years of age has kept the number of attacked trees found in some 25,000 acres to less than 2,000 in most years.

The forest records provided valuable information on the compartments where infested trees had been found, and the plots were located so that there was a good chance that some would be visited by woodwasps; but it was not expected that all lures or plots would be attacked. The aim was to provide a range of sites and lures in an attempt to obtain oviposition by 'wild' insects. We hoped to obtain data on the comparative effectiveness of the lures provided in at least some of the plots. We also wanted information on the effect of tree volume on the lethality of a certain dose of Bidrin as well as an indication of the longevity of its insecticidal effect under natural forest conditions. We therefore established five plots in each of the Flynn Creek, Longford and Maryvale forests in such a way that distances between plots within each forest varied from about 20 yards to 400 yards and lures within plots varied from 3 feet to 50 feet apart. In this way we hoped to obtain some preliminary information on the density of lures required to detect woodwasps as they colonised new areas of forest.

The presence of living foliage on lures could conceivably affect the concentration and translocation of implanted chemical within the xylem of the trunk. Continued transpiration and respiration would be higher, for at least an initial period, in lures with living branches than in those without them. We wished to examine the effectiveness of Bidrin under both conditions as they were important to the establishment of a successful lure and to the cost of establishment, particularly if branches had to be removed.

MATERIALS AND METHODS

A total of 45 lure-traps was established in 15 plots. Three types of traps were used, viz. topped, severed, and girdled pines, and other undamaged trees were selected for use as controls.

Radiata pine 10 to 12 years' old and 20 to 50 ft high were used. Irrespective of the volume of their trunks (1.5 to 6.7 cu ft from ground to 3 in. diameter) 20 ml of technical grade Bidrin was implanted in each lure tree as previously described (Morgan et al ibid).

The lure-traps within each plot were established in two stages. One girdled lure and one topped lure were established early in February, and a severed lure was added about a month later, still within peak flight season, to provide a new source of attractive material for oviposition. All lure trees were mechanically damaged four days after implanting the insecticide.

The first lures were implanted about three weeks after consistent emergence of woodwasps had begun in nearby insectaries at Traralgon. One tree was girdled deeply into the wood at 15 to 20 ft above the ground, and the other had its top removed at a similar height.

The third lure was almost completely severed near ground level. Its crown was hung up in the crowns of adjacent trees. Most of the trees treated thus fell to the ground during a period of strong winds shortly after establishment. Thus they typically represented felled trees, and as previous observations indicated, these are often attacked within hours of being cut.

Five of the lures were exposed to oviposition by caged woodwasps in mid-April, when emergence for the season was almost completed, to provide data on the effectiveness of the Bidrin near the end of the flight season and about 10 weeks after implantation. A cage containing two females was attached after the surface of the bark had been examined to ensure that no oviposition by wild woodwasps had occurred at that site.

The locations of the plots and lures were recorded on a map, and the data recorded for each lure included height and diameter at breast height. Also recorded were the numbers of whorls of living branches below the site of mechanical damage, and the numbers along the whole trunks of the trees which were severed at ground level.

The following spring, during September and October, the lure trees were felled and barked, and the number of attacks were counted. Control trees were examined in the field. Logs from attacked lures were kiln-dried and despatched to the Waite Agricultural Research Institute for assessment.

Eggs, eclosions, and larval survivals to the third instar were recorded. More than 1,250 attacks were found and over 800 drills were opened.

A survey was made of the trees standing in about half an acre of the forest around each plot in the flight-season following removal of the lures, to determine whether undetected attack on the control trees had been successful. This precaution was necessary because partial death of attacked trees and emergence of part of the woodwasp population over two consecutive years are often recorded (Morgan and Stewart 1966, Morgan 1968).

A separate test of the effectiveness of the insecticide was made by exposing logs to wood wasps in cages. One cage contained logs taken from trees implanted with 20 ml of Bidrin and the other contained logs from trees implanted with water.

An assessment of the comparative effectiveness of lures was made by estimating the density of attack on naturally attacked trees removed from near two lures in the Maryvale forest, later referred to as M1 and M5.

Since the lure-trap system has possible practical applications in woodwasp detection and control, the average cost of establishing a lure was estimated.

RESULTS

Occurrence of Attack

Wild female Sirex drilled for oviposition in one severed lure at Flynn Creek (the tree to which the cage was attached) and three girdled trees at Maryvale (Table 1).

TABLE 1
Attack on lure-traps by *Sirex noctilio*.

Forest	Longford 1966	Longford 1968	Flynn Creek	Maryvale
Year	1966	1968	1968	1968
Number of plots	6	5	5	5
Lures per plot	3	3	3	3
Damage category	topped	various*	various	various
Plots attacked	4	0	1	3
Lures attacked per plot	1	0	1	1
Undamaged controls attacked	0	0	0	0

* One lure topped, one girdled, and one severed.

No trees were attacked at Longford and no topped trees at all were attacked. Thus no comparison between damage treatments could be made. There was no apparent effect of the various spacings between trees and plots.

The restriction of attack to a single tree on the plot in each case confirms an observation made in a previous experiment (Horwood et al 1970).

The initial attacks on treated trees could possibly have been due to their chance locations rather than to their superior attractiveness, and they may have become predisposed to subsequent attack by the resulting resin flows (Rawlings 1948).

The insects did not oviposit in any adjacent untreated trees. Apparently the treated trees were more attractive than untreated, and the attacks on the treated trees did not predispose nearby trees to attack. A number of damaged trees on the plots and dying trees near them were expected to attract the woodwasps but they were not attacked at all. Most of these effects could have been due to a low cost density of woodwasps in the study areas.

Effectiveness of the Insecticide

The insecticide (Bidrin) was effective when used under field conditions. The effect of 20 ml of insecticide per tree on eggs and larvae did not vary with volume of the treated tree over the range 1.6 to 4.6 cu ft nor with the number of whorls of living branches on the trees. (Table 2).

TABLE 2

Census of wild and induced attack on field lures by *Sirex noctilio* F.

Forest	Tree	Volume cu ft**	Damage category	Number of living whorls of branches on lure	Total number of drills found	Number of drills dissected	Number of eggs found	Number of eggs hatched	Number of larvae survived to instar III‡
Flynn Creek	2*	4.6	R†	1	98	88	41	1	0
	14	4.1	S	9	128	37	14	4	0
	14*	4.1	S	9	12	12	6	1	0
Longford	4*	4.1	T	0	214	188	85	7	0
Maryvale	1	1.6	R	6	373	143	57	4	0
	5	1.7	R	2	151	90	20	0	0
	8*	2.3	R	0	11	11	12	0	0
	9*	2.0	T	1	202	185	81	47	0
	10	2.2	R	3	65	52	11	0	0
Totals	8	22.6			1254	806	327	64	0

** To 3 inch diameter top.
* Attack in cages.
† R = girdled S = severed T = topped.
‡ No larvae reached second instar.

The insecticide affects the adults and their oviposition. The mean percentage of drills containing eggs in the wild attack on the lures was 30.25, which is similar to that obtained in our experiment with caged logs (Morgan et al 1971, and Bidrin Control, Table 3). Because the mean percentage of drills with eggs in the caged attacks on lures in April 1968 was 59 and as the difference between the pertinent means is highly significant we may conclude that after 10 weeks from implantation the insecticidal effect of Bidrin on ovipositing adults is insignificant (see also the Water Control in Table 3). These results also indicate that the 'wild' attack on lures occurred much earlier than that in the cages.

This assessment of the insecticidal effect of the lures is based on the assumptions that all eggs in lures would have hatched by the Spring following their deposition and that most larvae would have entered at least the third stage before the logs were kiln dried for shipment to the laboratory. Examination of the larvae in natural infestations indicated that such assumptions were justified.

Comparison of Density Attacks on Lures and Trees

Density of attack varied in the natural infestations from less than 5 to more than 200 per cubic foot.

A naturally infested tree with a dead top near lure M5 had a volume of 1.4 cu ft and contained 137 drills. The lure had a volume of 1.7 cu ft and contained 151 drills. Another tree in the same compartment as lure M1 had a volume of 2.4 cu ft and 213 drills, whereas M1 with a volume of 1.6 cu ft, contained 373 drills. Thus the density of attack on the lures was similar to that on other trees in the same locality.

The degree of attack on any tree or lure appears to be governed by conditions within the trunk which are 'assessed' by the woodwasp using sensillae on the tip of the ovipositor. This may explain the wide variation sometimes found in attacks on test logs and in natural infestations.

DISTRIBUTION AND TYPE OF ATTACK

The drills in the topped lures were distributed over the upper 6 to 12 feet. The highest density of drills was usually in the lower portion of this range. Thus where attack was distributed over the upper nine feet of the lure, most of the attacks were in the second and third 3-foot sections from the top. The single severed lure had all its wild attack in the butt log.

The two trees assessed for comparison with lures M1 and M5 mentioned above, had attacks distributed in a similar way to that on the ringbarked lures.

Generally, in trees or logs with a high moisture content or in those which successfully resist woodwasp attack, there is a high proportion of single drills (each site is a single drill hole into the wood). In logs that have been pre-conditioned to an optimum moisture content, an increasing proportion of the drills are found in groups emanating from a single drill through the bark. In the latter instance a higher proportion of drills contain eggs.

In the several thousand of drills examined in several experiments during the last four years, about one-third of the single drills contained eggs, and about 45 per cent of all drills contained eggs. (See also Horwood et al 1970 and the Water Control in Table 3.)

TABLE 3

Survival of woodwasps in lures compared with that in caged logs from trees implanted with water or Bidrin.

Treatment	Drills containing eggs %	Eggs hatched %	Larvae survived to instar III %
Lures (Trees with Bidrin)	41	20	0
Bidrin control (Logs caged with Sirex)	28	0	0
Water control (Logs caged with Sirex)	44	84	86

TABLE 4

The ratio of drills present at single sites to drills present at multiple sites.

Tree-lure category	Type of attack	Site category	
		Single	Multiple
Topped lures 1966	Wild	1	11.5
Topped lures 1968	Caged	1	8.4
Girdled lures 1968	Wild	1	4.0
Girdled lures 1968	Caged	1	0.9
Severed lure 1968	Wild	1	18.0
Severed lure 1968	Caged	0	12.0
Living trees*	Wild	1	1.9

* The two trees assessed for comparison with lures M1 and M5.

The ratio of single drills to grouped drills (Table 4) therefore provides an assessment of the suitability of the trees and lures for drilling (and perhaps oviposition). Although the ringbarked lures at Maryvale were the only ones that attracted attack in 1968, the topped lures were more satisfactory for drilling at the time the caged attack occurred there. The similarity between the ratio of attack on topped lures in both 1966 and 1968 suggests that topped trees might often be more satisfactory for drilling and oviposition than ringbarked lures. The single severed lure was apparently extremely suitable, whereas the two naturally attacked trees, assessed for comparison with lures M1 and M5, were about as suitable as ringbarked lures.

If these comparisons are valid an important principle emerges from them. The initial attraction of a tree to ovipositing wood wasps does not necessarily mean that the tree is also highly satisfactory for drilling or oviposition. In other words the stimulus (or stimuli) responsible for the woodwasp selecting a host is (or are) not necessarily the same as that (or those) which govern the density of eggs deposited in that host.

COST OF ESTABLISHING THE LURE-TRAP

The cost of establishing lures and traps depends mainly on their numbers and their distribution in the forest. The following estimate of average establishment cost assumes that crews would travel from the headquarters of each forest, and not from a distant town as was the case in setting up these experiments.

Each lure-trap must be visited twice, once to implant the chemical and again to mechanically damage the tree. The variation in distance between plots and between lures within plots in this study probably resulted in a higher average cost than might be expected in operational practice. The implanting holes were bored with a hand brace and bit, and the Bidrin was introduced through a pipette. Possibly it would be quicker and cheaper to use either an electric drill or a chemical injector which does not require drilling.

Our estimate of cost includes preparation for the work, loading and maintaining equipment, selection of sites from forest maps, driving and walking times, vehicle mileage, and time spent working on the plots. Depreciation of equipment was insignificant as the value of the equipment was less than $25.00, but a nominal charge of one cent per lure was included. A cost of $3.50 per hour was adopted for a two-man team, each man earning $70.00 per week. The average weekly wage in Australia in mid-1970 was $72.50 (O'Neill, 1970); thus this labour cost could provide a skilled leader and an assistant.

Costs per lure were as follows:

	$
Preparation	0.04
Time (7 min travelling, 17 min working time per lure)	1.40
Materials	0.24
Vehicle mileage	0.06
Depreciation	0.01
TOTAL	$1.75

This average cost of establishing lures is considered to be generous, and should cover operational situations for several years to come.

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A Microclimate Research Station in a Eucalypt Forest

SUMMARY

A largely automatic microclimate research station was established in a mixed eucalypt forest at about 670 m altitude near Daylesford in Victoria in 1968. The sensing, measuring and recording instrumentation is described in detail. Air temperature and humidity, wind run and direction, precipitation and net radiation above the tree canopy (32 m); air temperature and wind run at 15 m; air temperature at 1.5 m; and air temperature and humidity and wind run at 0.3 m above the forest floor are recorded.

Measurement of soil temperature 2.5, 10, 20 and 50 cm below ground level allows temperatures at all levels to 50 cm to be calculated. Soil moisture is measured at 2.5, 10, 20, 50, 75 and 100 cm below the forest floor. Rapid corrosion of metals and plastics, moistening and deterioration of electrical contacts, effective sealing of instruments against moisture, jamming of mechanisms in chart-recorders, and insulation of electronic bridges and amplifiers against temperature changes present major problems in design and maintenance.

Double shielding of some sensing elements exposed to alternating shade and direct sunshine, and wiring of all instruments with metal sheathed cable to eliminate cross-interference have been required.

Climate inside a forest is determined in part by the macroclimate of the region in which the forest is located, and in part by influences of a more local nature — the most important of which are probably those associated with the trees themselves. Because the character of a forest may be changing continuously, due to such factors as tree growth, changes in tree or undergrowth species, exploitation, fire and others, so its microclimate will also vary with time.

Not only is the climate in a forest liable to change with time, but, because of the depth and structure of the forest, its climate changes with height from the ground upwards through the trunk and crown regions at any given time. Climatic variation with height in the forest will depend upon many factors such as the macroclimate, tree species, age of stand, canopy density, undergrowth and others.

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