SOME ASPECTS OF THE DEVELOPMENT OF TOXIC BAITS FOR THE CONTROL OF LEAF-CUTTING ANTS

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INTRODUCTION

The genera Atta and Acromyrmex constitute the leaf-cutting, fungus-growing ants which in the Neotropics are a pest of prime importance in agriculture, horticulture, forestry and range management (Cramer, 1967; Cherrett & Sims, 1968; Weber, 1972; Lewis & Norton, in press). In the past, a wide range of control methods has been used against these ants (Mariconi, 1970), but since "Mirex 450" pelleted bait was successfully introduced about 10 years ago the greatest interest has been centred around the use of toxic baits (Cherrett & Lewis, in press). The advantages in using baits are that ants collect widely scattered particles, then concentrate and redistribute them within nests which are often difficult to locate.

It has been stressed that large-scale control by aerial application of baits is desirable, particularly where agricultural holdings are small and interspersed with uncultivated land, and that such methods are practicable, economic, and spread less total insecticide in the environment than the current 'on farm' methods (Lewis & Norton, in press; Lewis & Phillips, in press; Lewis, 1972).

For general aerial application in the humid tropics, a bait should possess the following characteristics:

1. be attractive to ants (preferably from sone distance);
2. be carried to the nest whenever encountered;
3. be sufficiently slow acting so that it can be carried for long distances and have its toxicant widely distributed throughout the colony before poisoning symptoms appear;
4. be specific as far as possible to the target ant species;
5. have low mammalian toxicity;
6. have as small a proportion of inert carrier as is consistent
   (a) with good coverage of the area with bait, and
   (b) with obtaining a high bait effectiveness/weight ratio in the aircraft;
7. remain on the ground as an effective bait (particularly resisting mould attack) for about 10 days under conditions of high temperature, humidity and rainfall;
8. contain a biodegradable toxicant which does not accumulate in the environment.

Pelleted "Mirex 450", currently the most widely used commercial bait, fulfils some of these requirements reasonably well, but not numbers 4, 6, 7 and 8.

A CITRUS PULP BAIT FOR AERIAL APPLICATION

An improved bait for aerial application was devised, consisting of 91% coarse citrus pulp (a dried by-product of citrus canning, sold as stock feed), 8.5% sunflower oil, and 0.5% aldrin or mirex, and the bait waterproofed by the addition of 2% methyltrichlorosilane (Cherret & Sims, 1968; Cherrett, 1969; Cherrett & Merrett, 1969). The dried citrus pulp was readily taken by Acromyrmex octospinosus and Atta cephalotes, and the oil enabled the toxicant to be added easily. The role of oil in enhancing the acceptability of bait is still under investigation; previous work (Cherrett, 1969) provided no evidence for this, but its importance in stimulating pick-up by Atta texana has been stressed (Echolls, 1968). Dried citrus pulp bait has the advantage of consisting of whole particles instead of pelleted grains, thus having less tendency to disintegrate when wet; waterproofing the pulp with methyltrichlorosilane produced a bait which A. octospinosus strongly preferred to fresh leaves after weathering for 2 weeks (Lewis & Phillips, in press). Citrus pulp, particularly non-waterproofed, is susceptible to fungal attack, but recent work (Phillips, in press) has shown that this can be completely suppressed by the incorporation of 0.5% propionic acid to the bait. One of the commercial baits uses 2% sodium benzoate as a preservative.

Aerial application trials (Lewis, in press) using a bait consisting of 91.1% dried citrus pulp, 8.5% soya bean oil, and 0.4% technical aldrin (as these materials were readily available) were carried out against A. octospinosus. One trial, in the dry season on a Trinidad offshore island, gave 91% nest mortality with bait coverage of 2.2 kg/ha (2lb/acre), and another, in the wet season in Trinidad on mixed farming land, gave 85% nest mortality. In the first trial, there was no evidence of a decline in either the lizard or the crab populations, even at bait application rates two or three times those required for satisfactory ant control. These encouraging results were obtained with a bait which fulfilled requirements 2 and 7. The replacement of aldrin by mirex should additionally fulfil requirements 3 and 5, but not the others.

A SYNTHETIC BAIT FOR AERIAL APPLICATION

To obtain all the desirable characteristics, a new bait would have to be formulated, consisting of attractants, arrestants and phagostimulants, toxicant, and carrier (together with any other material necessary for formulation). Current studies on these components are outlined below.

(i) Attractants. The use of a synthetic scent-trail pheromone to attract ants to bait particles from a short distance is described by Robinson and Cherrett elsewhere in these Proceedings. The attractant increases the physiological size of the bait particles (requirement 1), perhaps allowing the bait to be applied at a lower rate. It may also increase bait specificity (requirement 4), because few non-target species are likely to be attracted by this specific pheromone.

(ii) Arrestants and phagostimulants. Even when impregnated with scent trail pheromone, neither A. cephalotes nor A. octospinosus will pick up particles unless certain other chemicals are present which are apparently detected by contact chemoreception and may be described as arrestants (Beck, 1965). The wide range of plant material selected by the ants gives no clue to the types of chemical responsible for this behaviour, except that they are common to many plant species. When grapefruit albedo, which is readily cut by both species of ants, was investigated for arrestants, a complex picture emerged with different types of constituents having some arrestant activity but none as active as the original, whole extract (Cherrett & Seaforth, 1970). More recent work supports this conclusion, most of the activity being in the non-ionic hydrophilic constituents (mainly carbohydrates) of this extract (Mudd, Cherrett & Peregrine, unpubl.). It is evident that the chemical factors affecting the selection of plant material by these ants are complex and may be related to the nutritional requirements of their symbiotic fungus. In order to identify constituents with major arrestant activity for ultimate incorporation into a synthetic bait, the carbohydrates present in grapefruit albedo were tested for activity individually and in combination. These sugars, at various concentrations, induced pick-up by both ant species of filter-paper discs impregnated with them. The bioassay technique for estimating arrestant activity has been described previously (Cherrett & Seaforth, 1970). The results showed that some of the arrestant activity of the original extract could be obtained from synthetic mixtures of sugars and there was clear evidence of synergism between the sugars. However, at high concentrations the sugars apparently acted as phago-stimulants and pick-up of the discs was delayed as workers congregated to feed (Mustafa, 1971). In neither species was there any evidence of arrestancy or phagostimulation being restricted to a single chemical, and with A. cephalotes the most complex mixtures were the most successful. Further testing, included various combinations of citrus pulp extract, honey, commercial malt extract and sucrose were carried out, and the results showed that for A. cephalotes the most complex mixture was significantly preferred to either citrus extract or sucrose alone, and a mixture of citrus extract and malt was preferred to sucrose. For A. octospinosus, there were no statistically significant differences in activity between the complex mixtures, which were all clearly preferred to sucrose alone (Cherrett & Peregrine, unpubl.). Both species are stimulated by mixtures of arres-tants and phagostimulants that are new to them (Cherrett, 1972) and another way of obtaining these chemicals for use in baits may be to use extracts of natural vegetation, if any repellents present can be removed.

(iii) Toxicants. As a poison for social insects, mirex approaches the ideal (Cherrett & Lewis, in press), having low mammalian toxicity and being slow acting (Lofgren et al., 1967). It slow action, ready acceptability (Peregrine & Cherrett, in press A & B) and longer persistence (Phillips, in press) mean that more toxicant reaches the nest. Mirex has been des-cribed (Wagner & Reierson, 1969) as a non-repellent insecticide, whilst aldrin has been classed as repellent. This has been confirmed with the blowfly (Phormia terrae novae) which will drink a molar sugar solution containing 1% mirex but not a similar solution containing aldrin (Jones, unpubl.). Field trials against both ant species suggested that aldrin bait was marginally less acceptable than mirex bait, as measured by the degree of comminution of bait particles on the fungus gardens (Peregrine & Cherrett, in press A.). The disadvantages of mirex are the difficulties of supply for local formulation, and also its great stability and persistence in the environment (Mehendale et al., 1972). Because it is an organochlorine insecticide and does not possess requirement 8, its use against the fire ant (Solenopsis saevissima) in the U.S.A. provoked legal action (Shapley, 1971).

Currently, a search for an alternative insecticide is being carried out (Phillips & Etheridge, unpubl.) and out of 15 insecticides tested to date, five have shown delayed toxicity (requirement 3). One of these, benomyl, is of interest because it has the added attraction of being a broad spectrum fungicide and might well suppress some of the moulds found on dried citrus pulp baits. Further, it might have some effect on the ant fungus garden. Juvenile hormone mimics are another possibility being investigated; not only could they prevent moulting of larval stages but they often have ovicidal properties.

(iv) Carriers. The first aerial application trial on a Trinidadian off-shore island showed that over 90% of the costs were involved in the actual application (Lewis & Norton, in press). Here, an improved bait might help to reduce costs if: (a) particle size was more even (a non-toxic filler had to be added to enable the irregularly shaped dried citrus pulp to be delivered from the aircraft at a low enough rate); (b) less inert structural material was used; (c) the bait was denser so that the aircraft could carry a greater payload.

The bait density, the proportion of biologically active ingredients, and the performance on the ground (requirements 6 and 7) could be controlled to some extent by using a synthetic matrix as a carrier for the attractants, arrestants and toxicants. This has been achieved in fire ant baits by microencapsulating the oil (a phagostimulant) which ants can still detect through the capsule wall (Markin & Hill, 1971). These capsules contained only 13% inert material (capsule wall) compared with 85% inert material (corncob grits) in standard fire ant bait. The use of a rapidly setting foam produced by blowing air into mixtures of liquid precursors is an attractive possibility, because a light and bulky bait could then be made from dense components carried in the aircraft. The urea-formaldehyde polymer 'Ufoam' was suggested (Phillips & Etheridge, unpubl.) for this purpose, but tests of its attractiveness to pick-up by both ant species were variable and usually unsuccessful (Mustafa, 1971; Phillips & Etheridge, unpubl.) partly because of formaldehyde residues present in the polymer which made it unacceptable to the ants. Of other carriers, vermiculite with added arrestants has shown great promise (Mustafa, 1971; Phillips & Etheridge, unpubl.).

CONCLUSIONS

Until 1943, the use of toxic baits was a popular method of pest control, but with the introduction of the synthetic organic insecticides there was a marked decline in their use. They have certain clear advantages over the more usual methods of insecticide application, particularly for social insects such as termites, wasps and ants

(Cherrett & Lewis, in press). Developments in the understanding of animal behaviour, toxicology and formulation technology, coupled with an increasing awareness of the dangers involved in the general application of broad spectrum insecticides, suggest that a reappraisal of the use of toxic baits for controlling social insect pests should be made.

ACKNOWLEDGEMENTS

We thank Mr. O.T. Jones (U.C.N.W. Bangor) for permission to quote his unpublished results, and Mr. J. Greaves (I.C.I. Ltd) for preparing different samples of 'Ufoam'. These studies have been financed by the Overseas Development Administration (F.C.O.).

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