Laboratory Tests with Candidate Insecticides for Control of the Big-Headed Ant, *Pheidole megacephala* (Fabricius)[1]

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The big-headed ant, *Pheidole megacephala* (Fabr.) is the dominant ant species in pineapple fields in Hawaii (Phillips, 1934). Its main importance is the role it plays in nursing mealybugs; in particular the gray mealybug, *Dysmicoccus neobrevipes* Beardsley, the principal vector of mealybug wilt to pineapple. According to Carter (1967) the ant is essential to the well-being of the mealybug in that it "fights off predators and parasites, cleans up the masses of honeydew secreted by the mealybugs and eats dead and dying members of the colony." Carter (1967) pointed out further that the ants move mealybugs from one plant to another and that in the absence of ants, "mealybug infestations either die out or are very small in numbers."

Prior to 1945, ant control in pineapple plantations was difficult to achieve, the only methods available being the use of ant fences and long intercycles between plantings. Mealybugs were abundant and pineapple wilt a serious factor in production. When DDT became available it was found that this insecticide provided control of the big-headed ant and the practice was adopted of using a broadcast spray of 4 lbs. active per acre as soon as possible after the pineapples were planted followed by three more applications of 2 lbs. active per acre at monthly intervals. In fields where excessive trash was present, the ants were more difficult to control and DDT at 10 lbs. per acre was sometimes applied to the standing ratoon field prior to knockdown.

When the cyclodine insecticides became available these proved to be better formicides than DDT, and heptachlor was used at 3 lbs. active per acre as a preplanting treatment followed by 1 or 2 lbs. active per acre, annually, to the growing crop (Carter, 1967).

Efforts toward developing inexpensive and effective methods to control the imported fire ants, *Solenopsis richteri* Forel and *S. invicta* Buren, concentrated on baits and chlordecone (Kepone®) was found effective when incorporated in a variety of baits (Hays and Arant, 1960; Bartlett and Lofgren, 1961). A closely related compound Mirex® was found more effective (Lofgren *et al.*, 1962) and experiments showed that among others, soybean oil was highly attractive to the ants and that corn cob grits were a most practical carrier (Lofgren *et al.*, 1963). Later studies confirmed the superiority of Mirex® (Stringer *et al.*, 1964) and a Mirex® bait using soybean oil as the attractant and corn cob grits as the carrier came into general use for control of the imported fire ants. This represented a major development in efficient use of pesticides.

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The Mirex® bait (3,000 ppm Mirex®) was found effective in controlling ants in pineapple plantings when used at about 2.5 lb. bait per acre (Sakimura, 1970) and aerial applications of this bait was adopted by some plantations as the method of control for the big-headed ant. Some plantations, however, continued to use the broadcast treatments with heptachlor. As a result of the availability of these materials, plantations have achieved excellent control of ants; mealybugs are seldom found in large numbers and mealybug wilt has virtually disappeared.

DDT, heptachlor and Mirex® are each persistent insecticides, only slowly degraded in nature. As a result, residues of these compounds or their breakdown products have appeared in many non-target organisms, sometimes with deleterious effects (Edwards, 1973). Thus, in the United States, DDT has been banned for use on agricultural crops and heptachlor and Mirex® currently are under review. Mirex® bait may not be applied by air after December 31, 1977 (O'Neil, 1976).

Since the pineapple industry must have effective methods of ant control to ensure that the devastating wilt disease does not reappear, a number of insecticides were evaluated for their potential as formicides against the big-headed ant. Emphasis was placed on bait preparations since baits offer the most efficient use of insecticides and have the added advantage of providing a degree of selectivity since only those animals attracted to the baits will be exposed in a major way to effects of the pesticide.

Materials and Methods

Baits were prepared using corn grits with 15% soybean oil as used in the commercial Mirex® baits (Fancher, personal communication). In most cases the insecticide formulation tested would dissolve in the soybean oil. Where the formulation did not disperse well in the oil, the corn grits were treated with the appropriate amount of oil and the insecticide added in a water suspension. Baits were prepared of 1000, 100, 10, 1 and 0.1 ppm with each insecticide.

After the baits were prepared they were tested in two ways.

1. *Toxicity to the big-headed ant.* For this test, about 1 gram of bait was placed in the bottom of a 10 dram plastic vial. Four vials were utilized for each dosage rate of each chemical tested. A small piece (4 mm^3) of a honey agar (100 ml H_2O; 13 ml honey; 1 gm agar) was added to each vial to provide water and nourishment for the ants. Worker ants were collected by placing bait (the honey agar described above) in a Petri dish near the base of a kiawe tree where ants were abundant and after collection these weie placed, 10 per vial, in the vials containing experimental baits. The vials were capped (snap-on plastic tops) and retained in an upright position for 48 hours. Mortality was determined after 24 and 48 hours.

2. *Attractancy of baits.* About 3 grams of each bait were placed in an 8 oz plastic-lined paper hot food container and covered with a plastic lid. A hole approximately 1cm^2 was made in either side, mid-way up on the container and the container was placed in an area known to be infested heavily with the big-headed ant. Four containers were used for each bait tested and counts were made of the number of ants (workers and soldiers) attracted inside each container. The containers were placed on the ground in the infested area between 3:00 and 4:00 PM and readings were made at dusk, about 7:00 PM.

Two insecticides were tested each day and a set of four check vials, each containing the bait of corn grit plus soybean oil, was included with each day's testing.

Check containers were included also in the attractancy tests and for these the containers were randomly distributed about 30 cm apart since ant activity in the area was not uniform.

Results

In most cases mortality in the check vials was low, if the soybean oil was increased beyond 15%, mortality increased, the ants seeming to become coated with the oil. In the bait attractancy tests, each of the check containers normally attracted 50 to 100 ants. Data on percentage mortality after 24 and 48 hours and attractancy (expressed as a percentage of the check) are presented in Table 1.

The candidate insecticides tested included a number known to have activity against ants and others of unknown potential. In the toxicity tests, the procedure did not differentiate among contact, ingestion or vapor toxicity and results thus indicate maximum toxicity. Under this regime many of the insecticides were highly toxic, some giving almost complete mortality in 24 hours at dosages as low as 1 ppm. With some insecticides there were differences between formulations. With diazinon for example, the technical and emulsifiable formulations were more toxic than the wettable powder or the microencapsulted and with fonofos and N 2596, the technical material appeared more toxic than the emulsifiable. With a few insecticides, notably dichlorvos, naled and bendiocarb, mortality was extremely rapid but with most materials there was an increase in mortality (where 100% mortality did not occur in 24 hrs.) between the 24 hr. and 48 hr. counts.

In the attractancy tests, only Mirex® and Vendex® baits, attracted at the 1000 ppm level. Attractancy of the baits increased as the concentration of toxicants decreased but some repellency of the toxicants was evident even at 0.1 ppm.

Discussion

In their studies on baits for the imported fire ant, Stringer *et al*. (1964) suggested that effective toxicants for inclusion in the baits should exhibit delayed toxicity over a wide range of dosages, be transferred readily from one ant to another, and not be repellent to the ants. In earlier tests only chlordecone and Mirex® met these qualifications and despite extensive screening of compounds (Lofgren *et al*., 1967) other toxicants effective against the imported fire ant have not been found. In our tests those insecticides that were highly toxic to the ants were repellent in baits at dosages needed for control.

It is accepted generally that every effort should be made to replace non-biodegradable pesticides with those that break down readily in nature (Nat. Acad. Sci., 1975). While this concept has much merit, the requirements in control may make such a concept unrealistic in some situations. Control of some social insects is one such circumstance.

The effectiveness of Mirex® ant bait derives from two characteristics of the insecticide additional to its toxicity. It is not repellent to ants (at low concentrations) and it is not broken down readily in the insect digestive tract. Thus the insecticide remains active in the communal stomach of the ant colony and the regurgitated nourishment passed from one ant to another serves as the vehicle for distribution of the insecticide within the colony. Stringer*et al*. (1964) considered this essential for an effective toxicant for ant baits, but this kind of activity is not usually characteristic of a biodegradable insecticide.

Mirex® ant bait is used in pineapple production once each year at a dosage of 2.7 grams active chemical per acre. Under somewhat similar application dossages, large-scale applications of Mirex® bait for control of the imported fire ants in the southern United States resulted in detectable residues in some non-target animal species (Wolfe and Norment, 1973; Baetche *et al.*, 1972; Markin *et al.*, 1974), more notable in aquatic areas. In all cases residues were extremely low and unlikely to have any significance to the organism. Since this is the case, it would seem that in the absence of suitable alternative insecticides for ant baits, a strong case can be made for retaining Mirex® for discretionary usage. Control of ants in pineapple plantations would appear to be the kind of discretionary use acceptable, since pineapple fields are recycled to pineapple and other cropping or grazing is not practised. Care in application should be exercised so that waterways are not treated inadvertently. Mirex® does eventually break down in the environment (Carlson *et al.*, 1976) and with the facts in hand, it seems inconceivable that 2.7 grams of Mirex® per acre represents a greater environmental hazard than would an alternative ant control program using a broadcast application of pesticide in which up to several hundred times this amount of toxicant is required.

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TABLE 1. *24 hour and 48 hour mortality and attractancy of corn cob-soybean oil baits to* Pheidole megacephala

		24 hr. mortality % at 1/ ppm in bait						48 hr. mortality at 1/ ppm in bait						Attractancy -% of check ppm in bait2				
Insecticide	Formulation	1000	100	10	1.0	0.1	0.0	1000	100	10	1.0	0.1	0.0	1000	100	10	1.0	0.1
Bendiocarb.	76% W.P.	100	100	100	90	30	5	100	100	100	90	35	12.5	2	3	2	3	3
Carbaryl	50% W. P.	100	45	37.5	27.5	12.5	12.5	100	55	55	35	25	25	2	2	2	19	84
Carbofuran	4.8F	100	100	5	5	2.5	0.0	100	100	12.5	5	2.5	5	5	1	12	27	15
Cholobenzilate	45% W.P.	2.5	2.5	2.5	0	2.5	0	2.5	7.5	2.5	2.5	2.5	0	2	31	77	100	91
Chlordane	Tech.	100	87.5	22.5	10	0	0	100	100	100	65	2.5	2.5	0	3	12	50	36
Chlorpyrifos	41% E.C.	100	50	17.5	0	0	0	100	100	42.5	7.5	5	5	1	19	131	141	113
Chlorpyrifos	Tech.	100	80	15	2.5	2.5	5	100	100	92.5	82.5	15	5	2	6	20	85	85
Diazinon	Ag 500 E.C.	100	100	82.5	82.5	15	5	100	100	100	100	52.5	15	2	10	59	77	77
Diazinon	Mic. 23% E.C.	100	87.5	5	2.5	5	0	100	100	40	10	5	2.5	1	28	73	67	97
Diazinon	50% W.P.	100	90	22.5	0	2.5	2.5	100	100	42.5	17.5	7.5	2.5	1	21	85	90	109
Diazinon	Tech.	100	100	85	47.5	2.5	5	100	100	100	75	25	22.5	0	3	30	93	145
Dichlorvos	Tech.	100	100	100	87.5	80	47.5	100	100	100	100	100	72.5	0	1	5	34	65
Dimethoate	2 E.C.	100	95	55	16.5	5	0	100	100	92.5	60	12.5	2.5	0	3	0	12	41
Disyston	Tech.	100	100	95	62.5	7.5	10	100	100	100	100	25	17.5	1	1	10	15	11
Fonofos	4 E.C.	100	90	2.5	2.5	7.5	0	100	97.5	27.5	2.5	12.5	2.5	3	54	102	81	129
Fonofos	Tech. 93%	100	100	100	92.5	10	2.5	100	100	100	100	47.5	7.5	1	2	34	78	95
Heptachlor	Tech.	100	100	100	45	10	0	100	100	100	100	77.5	2.5	1	37	66	50	81
Methamidophos	40 E.C.	100	100	75	25	12.5	10	100	100	100	62.5	65	22.5	9	5	22	34	34
Methidathion	Tech.	100	97.5	42.5	2.5	2.5	0	100	97.5	82.5	10	5	0	1	0	1	11	26
Methidathion	79.4% E.C.	100	97.5	72.5	17.5	27.5	15	100	100	97.5	87.5	55	57.5	1	13	68	52	80
Methomyl	90% sp.	97.5	10	25	5	5	2.5	100	32.5	7.5	5	7.5	5	0	0	1	30	117
Mirex	Tech.	95	40	22.5	17.5	7.5	2.5	100	97.5	37.5	17.5	10	2.5	106	152	141	68	66
Naled	8 E.C.	100	92.5	85	75	35	1.5	100	100	100	87.5	70	57.5	0	0	4	13	71
Nemacur	Tech.	97.5	35	10	2.5	12.5	10	100	60	40	2.5	10	12.5	1	1	12	42	67
Orthene®	75% W.P.	97.5	92.5	75	27.5	7.5	0	100	100	92.5	37.5	12.5	0	0	12	48	62	56
Orthene®	15.6% E.C.	100	67.5	22.5	35	2.5	0	100	97.5	60	47.5	2.5	0	3	7	48	75	105
Phosalone	25% W. P.	52.5	15	37.5	17.5	30	12.5	55	30	40	32.5	32.5	25	26	71	51	98	70
Propoxur	Tech.	100	100	10	2.5	10	10	100	100	15	7.5	7.5	12.5	0	0	2	1	35
Trichlorfon	80% sp.	40	15	15	12.5	5	2.5	70	37.5	32.5	22.5	5	2.5	37	62	137	56	62
Vendex	50% W.P.	0	2.5	2.5	2.5	5	2.5	5	5	5	7.5	5	5	57	42	57	52	130
CGA 12223/3	13.5% E.C.	100	100	100	97.5	7.5	5	100	100	100	100	15	22.5	0	0	1	13	112
N-2596/4	4 E.C.	100	100	25	2.5	5	10	100	100	90	27.5	25	17.5	2	26	57	67	105
N-2596/4	Tech.	100	100	100	87.5	45	2.5	100	100	100	100	97.5	7.5	5	5	13	65	129

1/ 10 worker ants placed in each of 5 vials containing about 1 gm. of bait and an agar food supply.

2/ Based on number of ants attracted to 8 oz. food containers containing about 3 gr. bait. Four containers for each bait. Check bait-corn cob with 10% soybean oil.

3/ 0-(5-Chloro-1 [methylethyl]-1H-1, 2, 4-triazol-3yl) 0, 0-diethyl phosphorthioate.

4/ 0-ethyl S-(p-chlorophenyl) ethylphosphonodithioate.