TRIFLUMURON AND IMIDACLOPRID BAITS EVALUATED AGAINST FIELD COLONIES OF COASTAL BROWN ANTS (*PHEIDOLE MEGACEPHALA*)

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Abstract—The Coastal Brown Ant (*Pheidole megacephala*) is a major introduced nuisance pest species in the most populated regions of Australia. The aim of this trial was to examine the potential of imidacloprid and triflumuron as active ingredients for ant baits.

Baits based on peanut butter and the nitromethylene insecticide Imidacloprid and the chitin synthesis inhibitor Triflumuron were fed to nests of *Pheidole megacephala* for about 12 months. Commercially available Hydramethylnon ant bait stations were used for comparison.

A method is described in which the active ingredients are mixed into peanut butter and placed in weather-proof bait stations. Assessment of nest activity used visual assessment of ant activity along with the daily consumption rates of untreated peanut butter monitoring baits. The method proved effective but it is essential that more than one parameter is measured in order to establish whether nests are eradicated or merely foraging elsewhere.

Imidacloprid formulated in peanut butter was not found to be efficacious against *Pheidole megacephala* due to its rapid action and associated a "bait shyness" for doses above 0.002%. Any initial effect on the colony at 0.0005% disappeared over the following months.

Triflumuron was effective at 3% but baiting must continue for many months, even a year. This is possibly due to the longevity of the worker ants. Eradication from areas may require a wide area baiting campaign because other colonies invade the areas made vacant by the elimination of the primary nest.

Commercially available Hydramethylnon baits were not readily eaten by ants. Visible ant activity declined within 2–3 months of starting baiting however placement of untreated peanut butter baits at the site of the previously active entrance site, resulted in large numbers of ants appearing and the consumption of bait quantities similar to consumption at untreated controls. Hydramethylnon bait stations are therefore considered to be insufficiently efficacious against *Pheidole megacephala*.

INTRODUCTION

Pheidole megacephala (common names include the Coastal Brown Ant in Australia and the Big-headed Ant in Hawaii), is prominent in domestic situations in many coastal and inland settlements around Australia. Originally from Africa, it is considered the major ant pest in many tropical areas of the world. Its spreading, densely packed nests can overrun large areas, eliminating native ants, other insects and small reptiles and mammals. Distinctive large-headed soldiers are present along with ordinary workers. The ants are attracted to protein based foods and commonly swarm over kitchen benches, pet food bowls and even in bathrooms during the warmer months. Their nest building activity undermines paving stones, small structures and even the root systems of some plants. This species infests houses, stores and gardens, with food preferences ranging from sugar to cheese, meat and bread. These ants also tend sap-sucking insects including aphids facilitating the transmission of plant pathogens, and interfere with gardening, cultivation and harvesting operations. Plastic irrigation equipment and the sheathing on telephone cables may also be destroyed (Brimblecombe, 1958; Chang & Ota, 1976; Chapman 1981).

Pheidole megacephala is a polygynous species i.e. with nests containing multiple inseminated queens. Such species can have short-lived nest sites which take advantage of localised sites that are unsuitable to support large colonies but more commonly are specialised on entire habitats that are long-lived, patchily distributed but extensive enough to support large populations. They form unicolonial populations which spread largely or entirely by budding off of groups of workers accompanied on foot by inseminated queens. In addition, workers can readily be exchanged between "nests". They seem pre-adapted for patchy but persistent habitats which are species poor such as those created in man-made environments (Hölldobler and Wilson, 1990).

There is little published data on the longevity of *Pheidole megacephala*, but species with similar behaviour have been shown to have queens which live for several years and workers which survive from 10 weeks to over a year. Chang (1985) reported that 6 out of 10 *Pheidole megacephala* workers

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eclosing from pupae in laboratory trials had died within 7 weeks. Chang (1985) also reports that in laboratory tests at 26–27° C, queens deposited eggs in groups of 2–82 on random days, averaging 6 eggs per queen per day. Eggs took 6–11 days to hatch and the larvae required 9–21 days to mature, and the pupae required 7–11 days to become minor workers. A generation of minor workers took 34 to 38 days to complete its life cycle. Phillips (1934) however reported an average life cycle of 59 days at 24.5–26.7°C. Fluker (1969) reported a life cycle of 66–78 days at 20–22°C.

Although the queen and major workers are unable to tend the larvae, colonies could survive chemical treatment if the queen and as few as 10 minor workers or even 10 pupae survived treatment (Chang *op. cit.*). Ideally, treatments should target the queens rather than the workers because a reduction of the workers alone (as achieved with spray applications) does not seem to be sufficient to prevent the colony from recovering. Baiting strategies offer the most logical approach to control of these ants because the active ingredient may be transmitted to the queen by the worker ants. However, because these ants are not readily attracted to baits currently commercially available in Australia, control measures have relied on chemical sprays applied to nest entrances, foraging areas and as barriers.

Triflumuron is an insect growth regulator belonging to the chitin synthesis inhibitors which acts to inhibit the production of the insect cuticle (Hammann & Sirrenberg, 1980). Effects against insects in general include the death of larvae at moulting and temporary sterilisation of females. The possibility for chitin synthesis inhibitors as the active component of ant baits does not seem to have been adequately investigated even though insect growth regulators of the juvenile hormone analogue group have been commercially developed in Europe and the USA. Edwards *et al.*, (1981) investigated the efficacy of the juvenile hormone analogue methoprene against *Pheidole megacephala* in the field and found that colonies could be eradicated within 24 weeks with a marked increase in the ratio of major workers during this period. Similar results were reported in Australia by Horwood (1988) where complete control was obtained within 20 weeks using methoprene formulated in peanut butter.

Imidacloprid, a nitromethylene insecticide, is an agonist at nicotinic acetylcholine receptors in the post-synaptic regions of neuromuscular junctions resulting in behavioural effects and moribund state in affected insects (Elbert *et al*, 1991). Several workers have investigated the potential of this new insecticide group for ant control.

Zeck & Price (1988) examined the efficacy of Imidacloprid baits against the Red Imported Fire Ants (*Solenopsis invicta*) and found that repellency occurred at higher doses (2%) and at lower doses (0.001–0.01%) the colony was affected but eradication was not achieved. Klotz & Reid (1993) examined the efficacy of Imidacloprid against Carpenter Ants (*Camponotus pennsylvanicus*) at doses of 0.001–0.05% and concluded that its action was too fast for consideration as a bait toxicant. Davis and van Schagen (pers. comm.) examined Imidacloprid in the laboratory and found no repellency at dose up to 0.0032% against Argentine ants (*Linepithema humile*) but it proved repellent to *Pheidole megacephala* at 0.0016%.

Nentwig (1994a,b) examined the efficacy of Triflumuron (at doses of 1–5%) and Imidacloprid (at doses of 0.001–0.05%) in honey-based baits against laboratory colonies of Pharaoh's ant (*Monomorium pharaonis*) and Garden Ants (*Lasius niger*). He found that Triflumuron at doses up to 5% was not repellent to ants and that brood numbers could be reduced significantly over 12 weeks but the colony was not eradicated within this period. Higher doses of Imidacloprid proved somewhat repellent (or rather, induced "bait shyness") but lower doses were similarly effective to Triflumuron in reducing brood numbers but again not eradicating the colony within 12 weeks. A combination of the two compounds (5% Triflumuron + 0.001–0.1% Imidacloprid) however resulted in complete eradication of the colonies in some bait matrices. Acceptance of Imidacloprid baits varied between species.

In view of these mixed results the following trial was established to examine the efficacy of Imidacloprid and Triflumuron against the economically important ant species *Pheidole megacephala* when applied on a continuous baiting regime over extended periods.

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METHODS AND MATERIALS

Site selection

Because of their unicolonial habits, it is difficult to be certain where one "nest" finishes and the next starts. In order to minimise the chance of cross-contamination from treatments nest entrances were selected for baiting which were at least 20 metres apart and preferably separated from each other by some feature such as a building, cliff or other barrier. Each treatment was replicated over 5–7 nests. Most nest entrances were clearly defined against the side of buildings or at the base of tree stumps but a few "nests" were diffuse areas of infestation in gardens.

Sites were categorised as :-

building	nest entrance at the side of a building with nest site inaccessible
pavers	nest entrances between pavers
tree base	nest in soil at base of tree or tree stump
garden	no clear or fixed nest entrance but a lot of activity in soil

(2) Assessment of population

Pre-treatment ant numbers were assessed at each baiting site by placing a piece of salami on the nest entrance for 5 minutes and then picking up the ant covered salami and dropping it into 70% ethanol for later counting. Later assessments used untreated peanut butter monitoring baits placed for about 1 week. The quantities of bait consumed and the numbers of ants at the peanut butter monitoring baits were estimated to try and overcome the variability observed with salami counts. Where no bait was consumed by the ants, the baits showed a slight increase in weight (probably due to uptake of moisture and the growth of mould). Slight increases are shown as negative values.

The number of ants active at treated baits was estimated at each visit. Observations on general ant activity were also recorded.

(3) Baiting

Imidacloprid (Bayer AG, Germany) was used in field trials at 0.0005%, Triflumuron (Bayer AG, Germany) at 3.0% and the commercially available 0.9% Hydramethylnon (Maxforce Ant Control System Insecticide Baits; The Clorox Company, Oakland, CA, USA).

Baits were prepared by adding the required quantity of active ingredient to 100g of smooth peanut butter. This was then hand blended for several minutes until evenly mixed. The mixing procedure was tested using a dye as a visual marker. The very low Imidacloprid concentration was

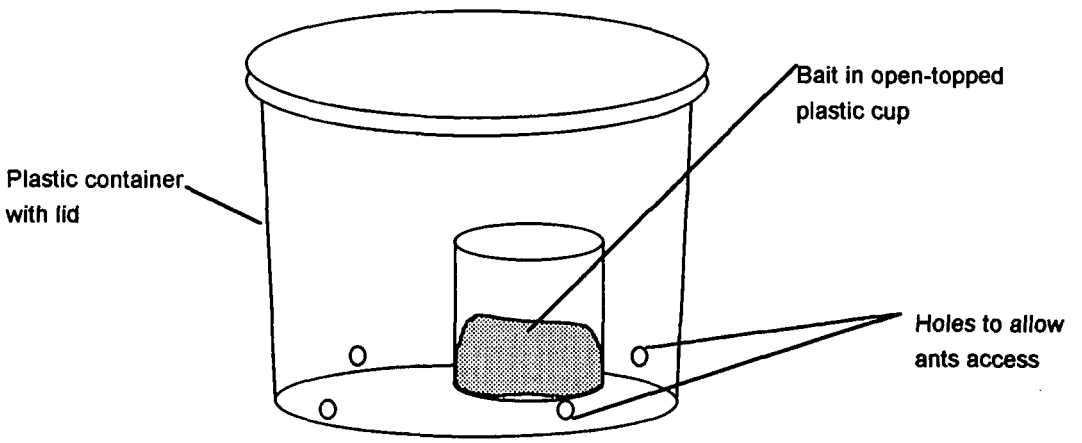

Figure 1. Weather-proof bait station

prepared by serial dilution in peanut butter. Baits were prepared on several occasions during the trial and stored in a refrigerator (+4°) until used.

In order to protect the baits from the weather, a bait station was prepared where the bait was sheltered in a plastic container as shown in figure 1. Ants readily entered the container and climbed up into the bait. Hydramethylnon bait stations were placed within the outer plastic containers without the inner plastic cup. Baits were weighed prior to placement and again after collection. The daily consumption rate was then calculated.

RESULTS

(i) Bait consumption

The mean daily consumption of treated baits each month is shown in Table 1 below. Consumption of control baits was less in the cooler winter months but always greater than that of treated baits. Consumption of Triflumuron baits declined over the year in line with ant activity whereas that of Imidacloprid baits remained relatively constant throughout the trial. Consumption of Hydramethylnon baits was low throughout the trial.

The mean daily consumption of untreated peanut butter monitoring baits approximately 2, 5, 9 and 12 months after the start of baiting is shown in table 2 below. Nests treated with Triflumuron

Table 1. Mean daily consumption of treated baits each month.

	Mean daily bait consumption (grams) each month												
	Jan '95	Feb '95	Mar '95	Apr '95	May '95	Jun '95	Jul '95	Aug '95	Sep '95	Oct '95	Nov '95	Dec '95	Jan '96
Imidacloprid	0.28	0.24	0.34	0.22	0.25	0.13	0.11	0.08	0.11	0.15	0.12	0.12	0.12
Triflumuron	0.15	0.12	0.28	0.13	0.11	0.04	0.03	0.04	0.02	0.03	0.03	0.03	0.03
Hydramethylnon	0.04	0.03	0.03	0.02	0.02	0.03	0.01	0.01	0.02	0.02	0.02	0.03	0.02
Control	1.10	1.45	1.55	0.88	0.75	0.35	0.22	0.30	0.35	0.25	0.32	0.49	0.67

Table 2. Consumption of untreated peanut butter monitoring baits.

	Consumption of untreated peanut butter baits (g/day)			
	End March	Mid June	Early October	Early January
Imidacloprid	0.63	0.28	0.21	0.52
Triflumuron	0.18	0.05	0.13	0.08
Hydramethylnon	0.89	0.63	0.28	1.22
Control	1.38	0.39	0.26	0.70

Table 3. Average numbers of ants active on treated baits each month.

	Average number of ants at baits each month												
	Jan '95	Feb '95	Mar '95	Apr '95	May '95	Jun '95	Jul '95	Aug '95	Sep '95	Oct '95	Nov '95	Dec '95	Jan '96
Imidacloprid	99	69	52	95	47	92	28	15	28	12	15	24	57
Triflumuron	78	66	64	150	64	48	14	2	13	47	4	5	130
Hydramethylnon	–	3	3	0	1	0	0	0	0	0	0	0	0
Control	83	121	120	103	135	151	138	39	19	50	11	101	101

consumed the lowest levels of peanut butter monitoring baits. Consumption levels of monitoring baits for Hydramethylnon and Imidacloprid were similar to or even higher than the controls.

(ii) Ant numbers

The mean number of ants visible within each bait station each month is shown in the table 3 below. Ant numbers were always low at Hydramethylnon baits. Ant numbers declined over several months at Triflumuron baits but unexpectedly increased to large numbers at some locations following months of negligible activity. Ant numbers at Imidacloprid baits remained moderate and constant throughout the trial. Ant numbers were highest on control baits and there was a distinct seasonal influence on numbers.

(iii) Nest activity

Nest activity as determined by the consumption of untreated peanut butter monitoring baits at the end of the trial in conjunction with observations of ant activity in the immediate vicinity is shown graphically in figure 2 below. Only Triflumuron reduced the number of active nests below that of the control.

DISCUSSION

Imidacloprid was found to be unacceptably repellent to *Pheidole megacephala* at doses above 0.002% when formulated in peanut butter. Initially some ants will feed on the baits but they are quickly affected by the active ingredient and no further ants come to the bait ("bait-shyness"?). Often several dead ants were found on higher dose baits indicating that Imidacloprid is too rapid in its action to be carried back to the nest.

Imidacloprid at 0.0005% was accepted by ants but in lower quantities than would be expected for untreated peanut butter. In the first 3 months of baiting there was a drop in ant activity with the quantity of untreated monitoring peanut butter consumed being 55% less than at control sites. Subsequent assessments consistently resulted in peanut butter monitoring bait consumption levels only 25% less than at control sites indicating that although Imidacloprid seems to have an initial effect on ant nests, the effect is short lived and the ant nests recover even though they continue to feed on the baits.

Fig. 2- Efficacy of Imidacloprid, Triflumuron and Hydramethylnon baits against nests of Coastal Brown Ants

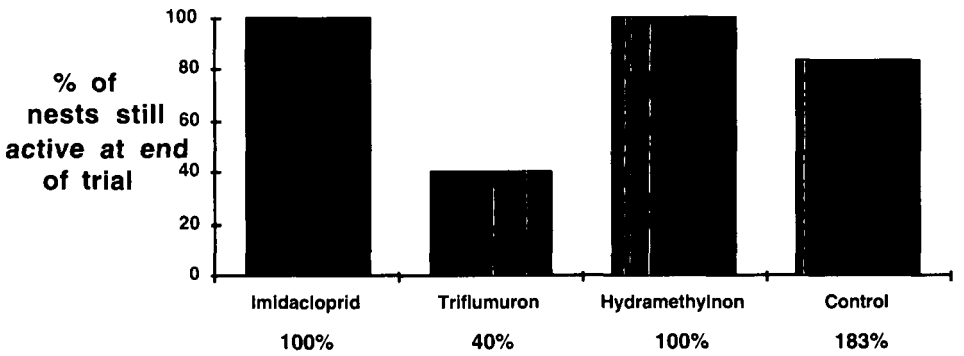

Figure 2. Efficacy of Imidacloprid, Triflumuron and Hydramethylnon baits against nests of Coastal Brown Ants

Triflumuron was not repellent to the ants at 3% with quite high bait consumption levels initially (up to 0.813g/nest/day). Consumption declined over the following months but ants were observed for many months feeding on the baits and it is assumed that the workers in the nest may be quite long-lived, surviving for many months.

It was observed, at 3 of the five nest sites, that the nest had appeared to be completely or nearly eliminated. Very little ant activity had been observed for about three months, including at peanut butter monitoring bait assessments. Then large numbers of ants were found on the bait for one or two assessments. It is likely that the initial nest had been eliminated by the treatment but the bait was then discovered by workers of a nearby colony who recruited other workers to collect the bait.

Triflumuron is capable of eradicating nests of *Pheidole megacephala* when baiting is carried out over sufficient lengths of time. This does not prevent other nests in the vicinity from feeding at the bait station once the initial colony vacates the area. More rapid results may in fact be possible if baiting was to commence in June-August when the nests are in their winter phase. No larvae or eggs can be found in the nest over winter in Sydney and only reduced numbers of workers. It is assumed that these workers are already relatively old and that they will die early in the following season after the new brood hatches.

Hydramethylnon was initially visited by ants in reasonable numbers but consumption of the bait was quite low (<0.1g/nest/day). Ant activity, as indicated by visible ants and excavation of sand diminished within 2–3 months so that the nests appeared to be eradicated. However, in every case whenever peanut butter monitoring baits were placed in the bait containers, large numbers of ants appeared within a short period of time indicating that the nests were still quite active but that the ants had been foraging elsewhere. This contrasts to the Triflumuron sites where the disappearance of activity was accompanied by a lack of feeding on the untreated peanut butter monitoring baits.

The *methodology* which evolved during the trial seems to be acceptable for future work. The bait containers protected the baits from the environment and were readily entered by the ants. Five to six replicates allows for variation between nests and the occasional loss of a site. Clearly defined, isolated nest entrances gave less ambiguous results than baits placed in gardens where the infestation can be quite widespread. However, reinvasion by other colonies in the area can be hard to avoid. A peanut butter monitoring assessment should be carried out for a week prior to the start of the trial and at appropriate intervals throughout the trial. Control sites should not be continually baited but only baited at the peanut butter monitoring assessments.

CONCLUSION

Imidacloprid formulated in peanut butter is not suitably efficacious against *Pheidole megacephala* due to its rapid action and associated a "bait shyness" for doses above 0.002%. Any initial effect on the colony at 0.0005% disappears over the following months.

Triflumuron can be effective at 3% but baiting must continue for many months, even a year. This is possibly due to the longevity of the worker ants. Eradication from areas may require a wide area baiting campaign because other nests invade the areas made vacant by the elimination of the primary nest.

Hydramethylnon baits were only superficially efficacious against *Pheidole megacephala*. Visible ant activity declines at the site but the nest itself remains active.

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