FACTORS INVOLVED IN THE SUCCESSFUL USE OF HYDRAMETHYLNON BAITS IN HOUSEHOLD AND INDUSTRIAL PEST CONTROL

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Abstract—Commercial bait products are becoming increasingly important for household and industrial pest control. The advantages of baits are widely acknowledged and include convenience and ease of use, discrete placement of the insecticide, reduced environmental contamination and minimal disruption to the customer during application.

When ingested by an insect hydramethylnon inhibits mitochondrial electron transport and thus the formation of ATP, an essential energy supply for most biological processes. This unique mode of action makes hydramethylnon the ideal complement for modern pest control practices.

Laboratory and field testing of hydramethylnon baits against ants and cockroaches has provided a wealth of information relating to the many factors that can affect performance. This has led to improvements in the design and dispensing of baits.

It is recognised that there are some situations where insecticidal baits are used in conjunction with other pest control products. The successful integration of baiting and conventional treatments is discussed.

INTRODUCTION

Commercial bait products are becoming increasingly important in the control of cockroaches and ants. The advantages of baits compared with other methods of control are widely acknowledged. For example their discrete placement minimises environmental contamination and poses less hazard to operators, consumers and non-target organisms. There is limited interaction with surfaces making them suitable for use in more sensitive areas where the use of conventional surface sprays may be restricted. Their convenience and ease of use allowing applications to be made with the minimum mess and disruption makes a bait treatment highly acceptable from the user's standpoint.

There are however some disadvantages associated with baits. As a bait relies on the target pest visiting and feeding on the toxicant, activity, as judged by the user, tends to be slower than conventional control methods. This is particularly a problem in insect sensitive areas such as restaurants where rapid elimination of the pest in question is usually required. In these situations the integration of a non-residual, rapid acting space or surface spray in combination with a bait application may be an option. Baits must also compete with other food sources so correct placement can often be critical.

Since commercial hydramethylnon cockroach baits were first introduced in 1985 in the USA and in 1991 in the UK, laboratory and field performance against ants and cockroaches has been well documented (eg Milio *et al* 1986, Lucas *et al* 1992) and also supported by comprehensive product literature.

The purpose of this paper is to consider specific factors involved in the-successful use of the amidinohydrazone, hydramethylnon, in commercial cockroach and ant bait formulations.

The amidinohydrazones, a new class of insecticides, were first described by Lovell in 1979. The structure and activity of technical hydramethylnon was described by Hollingshaus and Little (1987), who demonstrated that amidinohydrazones had a unique mode of action, inhibiting energy production at the cellular level, hydramethylnon itself acting as a site II inhibitor of the mitochondrial electron transport chain.

This unique mode of action should avoid any cross resistance to organophosphate, carbamate, organo-chlorine and pyrethroid insecticides. The activity of hydramethylnon against resistant cockroaches will be considered below.

Laboratory trials with hydramethylnon baits presented to *Blattella germanica* demonstrated that this insecticide has a relatively slow mode of action, with symptoms of intoxication not evident within 24 hours of ingestion. (Hollingshaus and Little, 1987).

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FIGURE 1

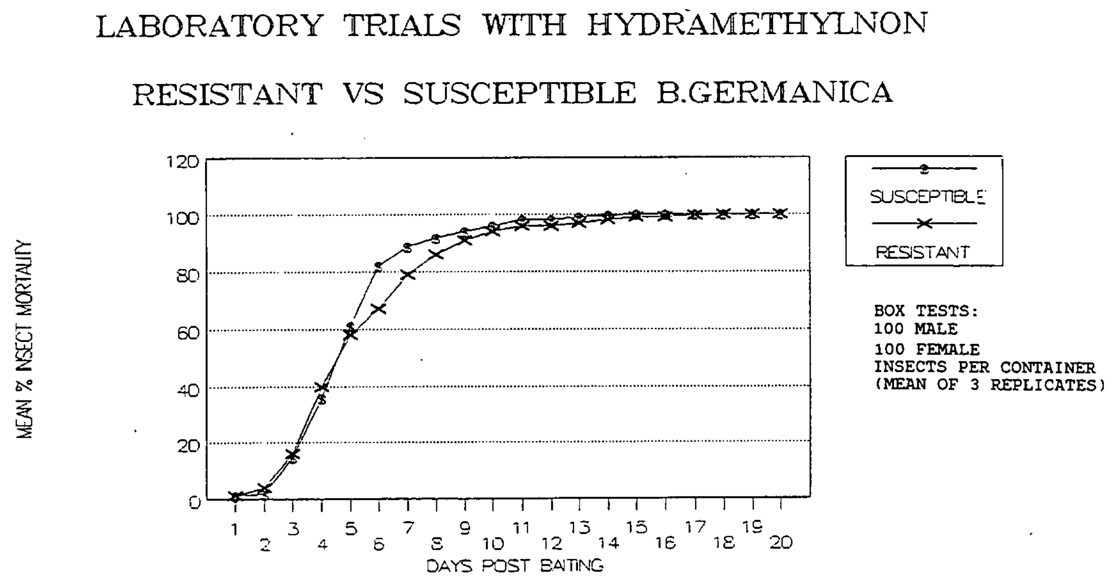
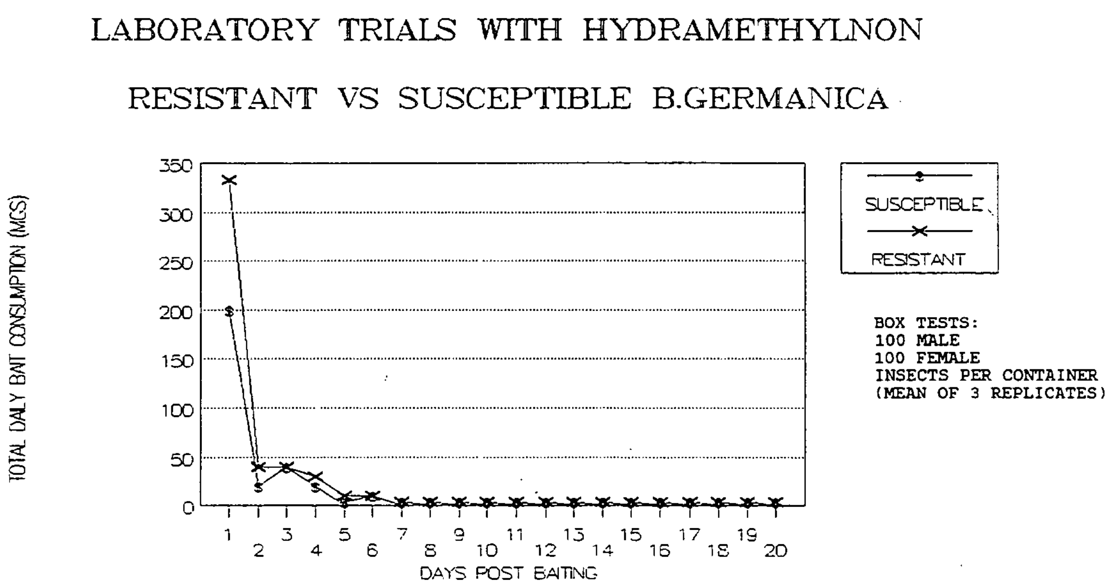


FIGURE 2



More recent studies by Appel (1990) demonstrated that when compared alongside boric acid and chlorpyriphos baits hydramethylnon had the greatest potential for field effectiveness against cockroaches.

MATERIALS

Hydramethylon baits are currently available in a variety of commercial presentations for use against ants and cockroaches. Three formulations will be considered:

Maxforce® black plastic cockroach bait stations measuring 83 x 83 x 17 mm, holding 7.5 g of bait, containing 1.90% w/w pure hydramethylnon.

Maxforce gel, supplied in a 300 g cartridge containing 2.04% w/w pure hydramethylnon.

Maxforce Pharaoh's Ant Killer grey plastic bait stations measuring 52 x 52 x 10 mm holding 1.5 g of bait, containing 0.95% w/w pure hydramethylnon.

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METHODS

Resistance studies

Trials were conducted in the laboratory to determine the efficacy of Maxforce bait stations against a field strain of *B.germanica* with a factor of resistance to permethrin of > 20, compared alongside a laboratory susceptible strain. One hundred male and female insects of each strain were placed in test boxes and provided with a food and water source, along with a 1.90% w/w hydramethylnon Maxforce bait station. Bait stations were weighed daily and weight loss adjusted using unexposed stations held under similar conditions. Results (Figure 1) indicate that there was no difference in mortality, however there was a difference in the amount of bait ingested, the resistant strain eating 1.7 times as much, with the majority taken on the first day (Figure 2). This appears to be due to greater appetite—as resistant insects also ate approximately twice as much of the alternative dog chow food during the test period as the susceptible strain. This pattern of increased bait take has also been observed for other field collected strains.

Results of these tests confirm the findings of other workers. Schal (1992) for example, demonstrated that hydramethylnon bait stations were as effective against field strains of *B.germanica* which were resistant to organophosphate, carbamate and pyrethroid insecticides as to laboratory susceptible strains. However, up to a 22 fold resistance ratio was observed for field strains in these tests using a commercial sulfluramid based bait, suggesting a level of cross resistance with existing insecticides. Unlike sulfluramid based baits, which have been shown to be insecticidally active to *B.germanica* by vapour action (Schal 1992) hydramethylnon has no detectable vapour action, as a result of very low vapour pressure. In addition laboratory tests by Appel (1990) demonstrate little or no repellency of hydramethylnon baits to cockroaches in choice boxes. If resistance were to occur to hydramethylnon baits, this could be as a result of behavioural avoidance of a particular formulation component. Reformulation by the switching of one bait component or even total reformulation is a much simpler option than identification, synthesis, toxicological screening and registration of a new (and unresisted) molecule. Reformulation of hydramethylnon baits has been discussed by Silverman (1992).

Integration

To be truly valuable as a tool in the pest control armoury, baits should be able to be used in conjunction with other treatment regimes.

As mentioned above, there may be instances where the relatively slow performance of a bait treatment may necessitate the additional use of a more rapidly acting non-residual space or surface spray treatment.

In addition, there may be cases where combination of a bait with a residual treatment is desirable, for example in situations where the long term activity of a deposit is compromised by cleaning or by adverse chemically reactive or absorbant surfaces.

FIGURE 3

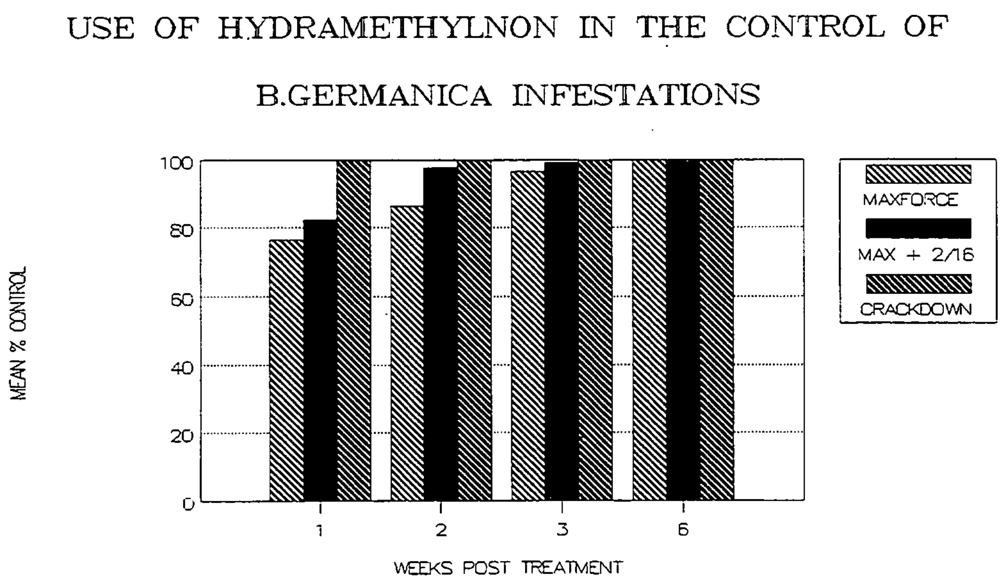


FIGURE 4

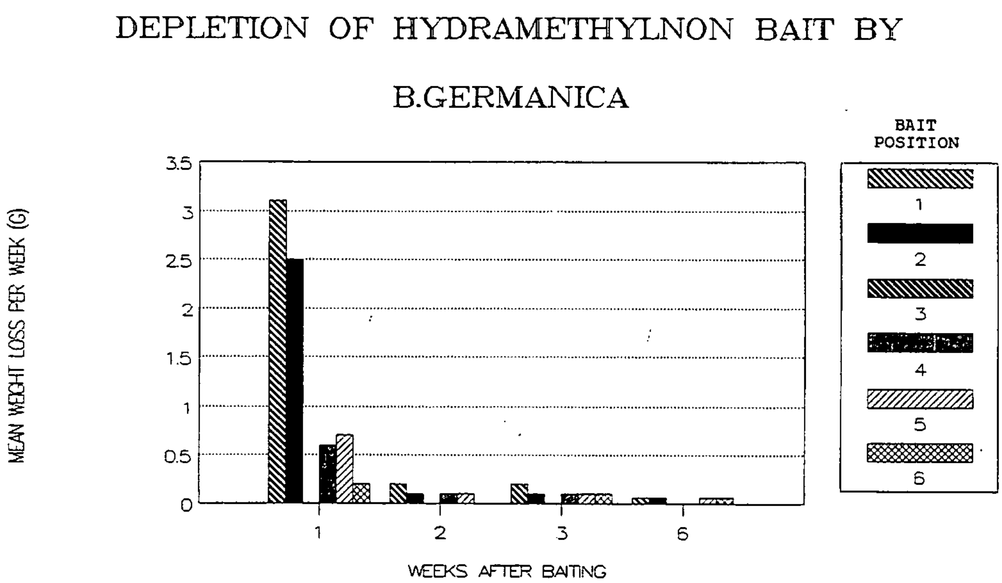


FIGURE 5

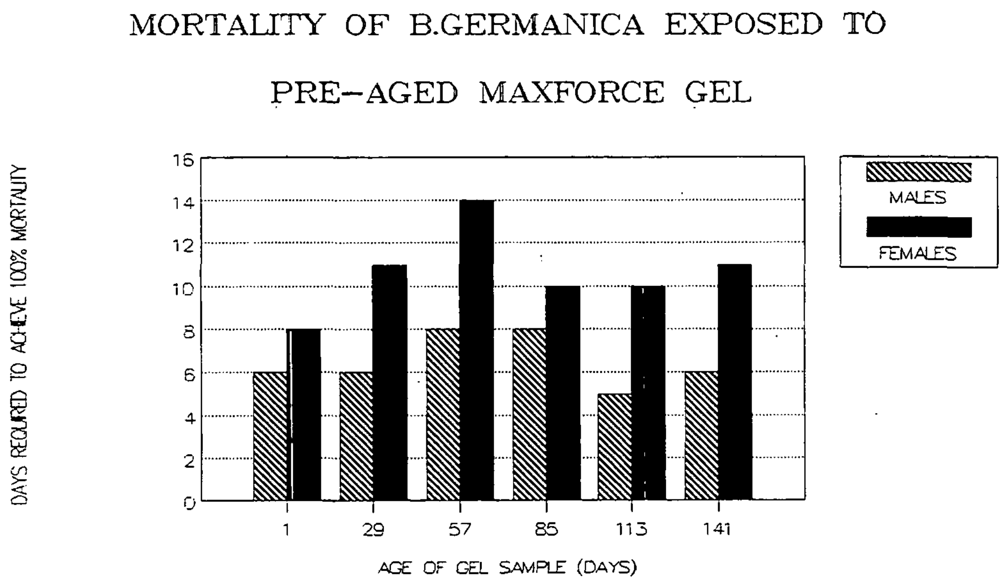
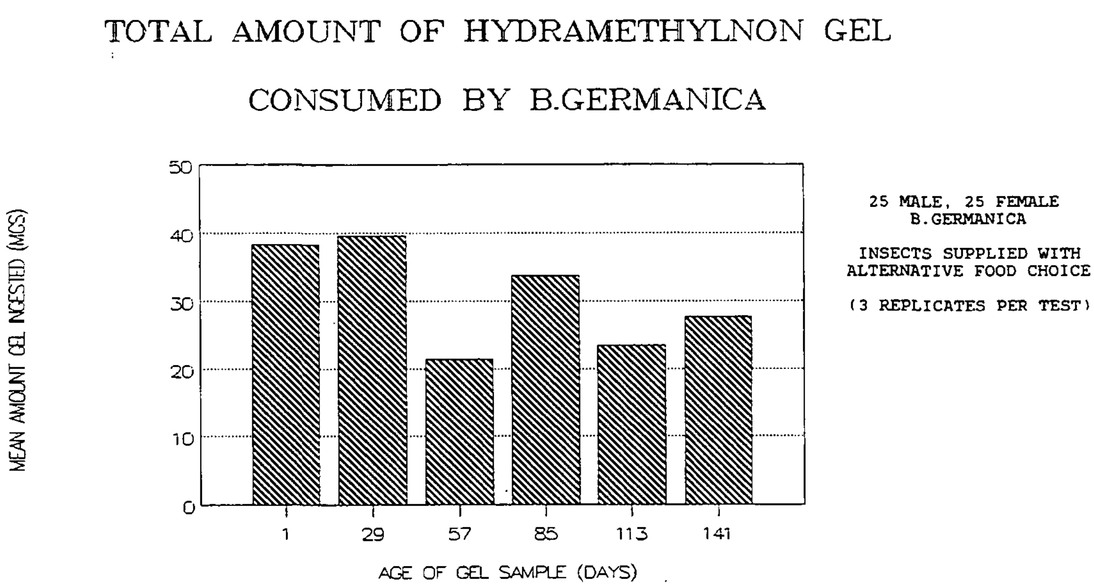


FIGURE 6



There may also be cases where a pest control operator wishes to control flying insects using a space spray and place baits for cockroach control at the same time. The concern that such integrated treatments might interfere with bait performance prompted the studies described below.

Trials were conducted in a large site, consisting of two kitchens and a bar, which were all heavily infested with *B.germanica,* with up to 87 nymphs and 26 adults caught per trap per night. Three different treatment regimes were used:

Kitchen A - 366 m^2
1.90% w/w hydramethylnon bait stations, applied at 2 stations/10 m^2. Pre-trial trapping ensured placement of baits in the more infested areas.

Kitchen B - 132 m^2
This area was treated with Pybuthrin® 2/16, a space spray containing 2% pyrethrins, 16% piperonyl butoxide. Pybuthrin 2/16 was applied to give a dose of 2 mg active ingredient (AI)/m^3 using a Curtis Cyclone Ultra Low Volume sprayer. This rate of pyrethrins application is recommended only as an aid to control of cockroaches, but is often used to control flying insects such as Warehouse moths. The area was ventilated for 1.5 hours before returning to place 1.90% w/w hydramethylnon bait stations, at the same density as in Kitchen A.

Bar - 125 m^2
This area was only treated with Crackdown®, a 1% deltamethrin suspension concentrate. This was applied, according to label instructions, to give a 15 mg AI/m^2 deposit.

Sticky traps were used to estimate the cockroach population, with traps left out overnight. Monitoring was conducted at 1 day pre- treatment and at 1, 2, 3 and 6 weeks post-treatment. Bait stations were weighed at the monitoring intervals, with weight loss determined relative to control baits which could not be accessed by cockroaches.

Results are presented on Figure 3. These indicate little difference after 1 week between hydramethylnon alone and hydramethylnon/Pybuthrin 2/16 integrated treatments, with *B.germanica* numbers falling by 80% of pre-treatment counts. The advantage of using Pybuthrin 2/16 is the much more immediate effect this treatment has when compared with hydramethylnon, with any flushed out insects knocked down and killed within 30 minutes of application. The residual surface spray caused some flush out of directly targeted insects and 100% population reduction 1 week after application.

Weight loss data indicates the importance of proper placement of the bait as, despite having access to trapping data to allow accurate placement of stations, some stations showed little or no bait depletion, while others showed up to a 3.7 g loss over the trial period, (representing 50% of the contents of the station). An example of the data is presented on Figure 4. Bait stations with a transparent red top that permits inspection of the contents with a torch have recently been introduced in the USA. This allows identification of stations that require replacing and also those that are not being visited by cockroaches. As the red top transmits light invisible to the insect eye, cockroach behaviour is unaffected.

Gel Bait Longevity

Once hydramethylnon gel is dispensed the physical nature of the gel changes as it dries and a skin forms over the surface. Tests were conducted to determine whether there was a change in activity of gel with ageing. A number of gel samples were prepared on day 1, dispensed as a 5 mm diameter, 50 mm length piece onto glass slides and stored in 12h/12h light/dark at 25°C. Laboratory bioassays were conducted at intervals in 155 x 275 x 90 mm plastic boxes against adult male and female 3-4 week old susceptible strain *B.germanica.* Tests were conducted at 26°C, 50% RH. 24 hours before introducing the gel 25 male and 25 female insects were placed into each box, which was provided with a food and water source. Gel/slide controls placed on the inside lid of boxes, out of reach of the insects, were used to adjust for any weight loss in cockroach exposed gels. Results, which are presented on Figures 5 and 6, indicate that 100% mortality of male insects was reached between 6

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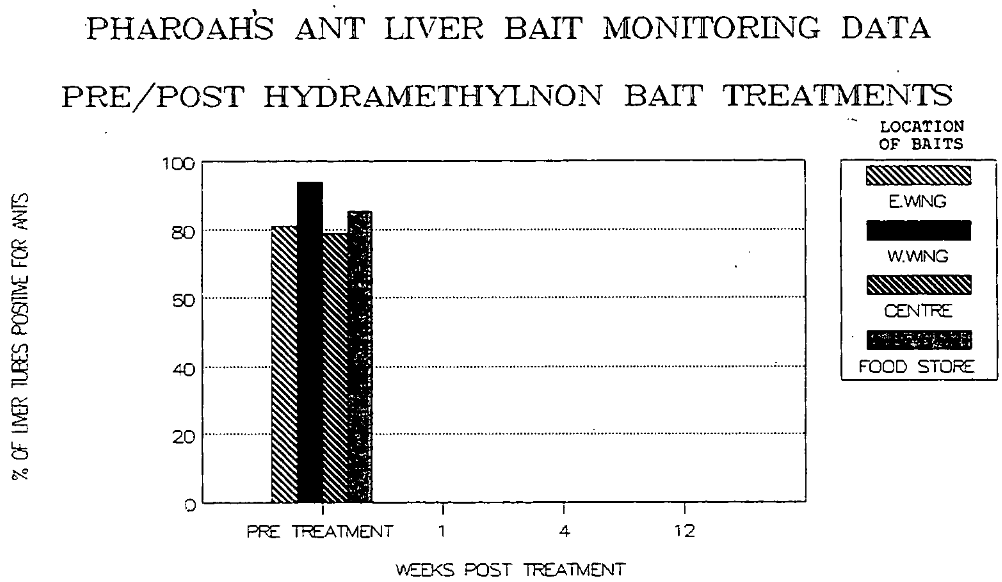
FIGURE 7



and 8 days, and for females between 8 and 14 days. These differences do not however correlate with the age of the gel samples but reflect the variation in insect susceptibility during the test period. In conclusion, the age of the gel does not appear to affect performance for at least 141 days following application. Additional tests indicate that gel stored in dispensing syringes remained active after 4 years storage, with no significant loss of hydramethylnon.

Cockroach bait longevity

Milio *et al* (1986) demonstrated that bait stations were able to retain their efficacy for at least a year after placement. Bait stations differ from gel in that the formulation is exposed to the air, even when in packaging material. Tests conducted to determine whether hydramethylnon baits remained active over extended periods of storage indicate that even after 4 years extended storage at 25 and 35°C, after which the bait pellet had hardened, hydramethylnon was still effective. Storage tests indicated that there was no significant loss of active ingredient over this period.

Ant Baits

In addition to the more established cockroach bait formulations, a bait has been specifically formulated for use against Pharaoh's ants, *Monomorium pharaonis*, containing 0.95% w/w hydramethylnon. This has been available in the UK since 1992. Trials were conducted to determine its efficiency under UK conditions in two premises with a long history of Pharaoh's ant infestation. Other commercial bait preparations had previously been used on several occasions, with only partial success.

Pre-treatment population monitoring was conducted with fresh liver baits, which were left out overnight and inspected the following day for ants. If activity was recorded by a liver bait it was usually intense, and counting was impossible without disturbing ant behaviour, so a simple 'positive' or 'negative' scoring system was used to indicate whether ants were present or not. Treatment with hydramethylnon baits was made the following day at a treatment rate of 1 station/10 m^2. Population assessments were made at 1, 4 and 12 weeks post treatment. Results, which are presented on Figure 7, indicate an extremely rapid action, with populations in both premises reduced by 100% after 1 week and no further ants found over the following 3 months. 1 year after treatment ants were still absent.

CONCLUSION

Hydramethylnon is an insecticide with a novel mode of action.

It is slow acting, non-repellant and effective at low doses making it ideally suited for both cockroach and ant control.

Commercial bait preparations containing hydramethylnon have been shown to be effective at controlling cockroach and Pharaoh's ant populations.

Bait formulations containing this amidinohydrazone insecticide have also been shown to overcome cockroach resistance to conventional insecticides.

Hydramethylnon products can be integrated where appropriate with conventional space and surface sprays. The discrete nature of bait placement ensures minimal contamination to operator, consumer, environment and non-target organisms.

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