Development of a Bait System for the Pharaoh's Ant, *Monomorium Pharaonis* L. (Hymenoptera: Formicidae)

M. Y. Osae[1*], M. A. Cobblah[2], F. T. Djankpa[3], E. Lodoh[2] and P. K. Botwe[2]
[1]*Department of Animal Science, Biotechnology and Nuclear Agriculture Research Institute, Ghana Atomic Energy Commission, Box LG 80, Legon, Accra*
[2]*Department of Animal Biology and Conservation Science, University of Ghana*
[3]*College of Health Sciences, University of Ghana Medical School*
*Corresponding author; Email: *mosae5@yahoo.com*

Abstract

The infestation of the Pharaoh's ant, *Monomorium pharaonis* L. is widespread and, sometimes, very serious in homes, hospitals, restaurants, factories, etc. People are helpless because effective baited traps are not available locally, and little has been done locally to develop effective control strategies for these ants. The study aimed at developing an appropriate bait system from local materials for the control of the Pharaoh's ant. Nine baits and three insecticides were evaluated in the laboratory and field situations. Groundnut cake, dry fish and granulated sugar were the most attractive baits. Rimon (a Benzoylphenyl urea), an insect growth regulator, was the most promising insecticide for incorporation into the bait system. It is, therefore, recommended that a bait system, containing groundnut cake, sugar and dry fish, mixed with 1% Rimon, be evaluated for Pharaoh's ant control.

Introduction

The Pharaoh's ant, *Monomorium phara-onis* L. (Hymenoptera: Formicidae), is believed to have originated from North Africa, spread along international trade routes, and now distributed worldwide (Wheeler, 1910). They form large colonies with multiple queens and easily split into smaller colonies at the slightest sign of stress (Sudd, 1960). They often nest in dark cracks and crevices in close proximity to their food sources (Pedersen, 2004). Pharaoh's ants are highly prevalent in the tropics and do not infest a structure unless it is heated up to a minimum temperature of 18 °C, and thrive well in temperatures ranging between 18-30 °C (Peringuey, 1924).

Pharaoh's ants are major pests worldwide. More than just the food they consume or spoil, they are considered serious pests simply due to their ability to "get into things". They have even been reported to have penetrated well secured recombinant DNA laboratories (Haack & Granovsky, 1990). As pests, Pharaoh's ants infest homes, hotels, hospitals, supermarkets, restaurants and offices. They feed on a wide variety of foods (Pedersen, 2004) and are capable of gnawing holes in natural and man-made materials such as silk, rayon, rubber and even electrical cables (Holldobler & Wilson, 1990).

Infestation in hospitals is a chronic problem in Africa (Cook, 1953). Hospital infestations pose health risks to patients because Pharaoh's ants are capable of spreading over a dozen pathogenic microorganisms including *Salmonella* spp., *Staphylococcus* spp., and *Streptococcus* spp. (Beatson, 1977; Haack & Granovsky, 1990; Smith & Whitman, 1992). Apart from being potential vectors, Pharaoh's ants can cause skin irritation and lesions (Eichler, 1990). They have also been found feeding directly on open wounds of burn-unit patients (Anon., 1986), under bandages covering wounds (Cartwright & Clifford, 1973), on bedridden elderly or post-operative patients (especially patients who leak body fluid) (Anon., 1974), on premature newborns in incubators (Edwards & Short, 1990) and in intravenous tubes that supply fluids to patients (Beatson, 1973; Edwards & Baker, 1974). As a result, they spread diseases among patients by contaminating their foods and sterile materials with pathogens.

In homes, Pharaoh's ants live in close association with humans and cause a lot of inconvenience by invading, polluting, and destroying a wide range of food stuff, clothes, books and other domestic materials (Dumpert, 1981). Their presence in homes cause a lot of inconvenience and public health concerns (Peacock *et al.,* 1954). In extreme cases of skin sensitivity, Pharaoh's ants may cause painful and irritating stings to individuals in homes (Cook, 1953).

Successful control of Pharaoh's ants requires the destruction of their nests, which is very difficult to achieve because the nests are often located in inaccessible places. Four main methods have been used against these ants, the oldest being insecticides. Insecticides from all the classes have been used against them but these do not get rid of the main colony in the nest, are harmful to humans and other non-target organisms, and, in some cases, result in resistance development (Berndt, 1976). Other methods include baiting, biological control and thermal control. Of these, baiting is the most effective. It is environmentally friendly and allows pesticide laced bait to be carried to the nest, especially when slow acting insecticides are used, thereby, destroying the entire colony. Baits laced with juvenile hormones, queen sterilizing agents, as well as insecticides, have been used to successfully eradicate Pharaoh's ants (Berndt, 1976; Klunker *et al.,* 1984; Holldobler & Wilson, 1990; Stanley, 2004).

In Ghana, though Pharaoh's ant infestation is widespread and, sometimes, very serious in homes, hospitals, restaurants, factories, markets, meat shops, etc. (Djankpa, 2004), People are helpless because baited traps are not available, and little has been done locally to develop any effective control strategies for these ants. This paper reports efforts at developing baited traps from locally available food sources and insecticides. The aim was to develop a bait/insecticide formulation that can be used to control Pharaoh's ants in Ghana.

Materials and methods

Evaluation of different baits

Nine baits were selected for evaluation based on the feeding preference of Pharaoh's ants. These included powdered groundnut cake (Kulikuli), groundnut paste, powdered dry fish (Herrings), granulated sugar, tooth paste (Close-up® red gel), dead cockroach, corn dough, sugar bread and palm nut chaff. All the materials, except the tooth paste, granulated sugar and groundnut paste were shade dried for 4 days and milled into powder in a kitchen blender. Baited traps were prepared using drinking straws cut to 2 cm long and filled with the baits. A baited trap, consisting of 10 bait-filled straws, were then placed in 10-ml test tubes and wrapped in black polyethylene sheaths to create a dark environment attractive to Pharaoh's ants. A piece of cotton wool was soaked in water and placed in each trap to keep the environment moist and suitable for feeding by Pharaoh's ants. Control traps were similarly set with straws.

One of each baited trap and control trap were placed in five different buildings, which preliminary works showed were infested with Pharaoh's ants. All traps were placed in cool dark corners and at the same location in each building to allow equal access by Pharaoh's ants. Spacing between buildings used was approximately 10 m. Traps were renewed every 4 days for 24 days. Collected traps were placed separately in ethyl acetate killing jars. The number and species of ants trapped were subsequently determined.

Evaluation of different insecticides using baited traps

Based on results from the bait evaluation experiment above, groundnut cake was found to be the best bait, and, being also the cheapest, it was used for evaluation of the different insecticides. Three different types of insecticides, based on their mode of action, were used in this experiment: Neem Azal, a neem based preparation, which has repellent, antifeedant and insect growth regulation properties; K-Orthine, a deltamethrin-based product with knockdown effect on insects and Rimon, a novaluron based product with insect growth regulation property. Each insecticide was mixed with the bait at 5% (v/w) before filling the straws.

Traps were set as described for the bait evaluation experiments above. One room in a Pharaoh's ant infested building was used for each insecticide and the control. There were three replicates for each treatment. Trapping was done over 8 days, with the traps collected and replaced daily. Baited traps without insecticides were used for the first trapping day and the last two trapping days. This was done to enable comparison of the trap catches before, during and after the introduction of insecticides. Trap collection and handling was done as above. For each trap collected, the number of ants trapped, and the proportion alive and dead was recorded.

Determination of effective concentration of Rimon

Rimon was found to be the most effective insecticide in the baited groundnut trap in the above experiment. In order to determine what concentration of this insecticide was most effective for the baited traps, two experiments were carried out: first to determine the effect of different concentrations on survival of the ants, and, second, to evaluate traps baited with groundnut cake, laced with different concentrations of Rimon. In the first experiment, ants were exposed to Rimon-laced groundnut cake baits at 1, 2, 3 and 4% (v/w) concentrations. 500 ml glass jars were prepared by covering the outer with black polythene sheath, and the inside lined with filter paper. The lid was replaced with cheese cloth held in place by rubber bands.

Fifty ants were introduced into each jar and allowed to acclimatize for 2 h. For each setup 5 g of one of the four concentrations of Rimon-laced groundnut cake baits in drinking straw was introduced. The control group was provided groundnut cake without Rimon. Cotton wool, soaked in water, was placed in each jar to keep the humidity high enough. The setup was then placed in a bowl of water to prevent the ants from escaping and other animals from invading the setup. The number of dead ants was counted in each setup daily and used to compute percentage survival till the end of the experiment. The experiment was replicated five times.

In the second experiment, Rimon-baited traps were prepared as described above. The concentrations of Rimon were 1, 2, 3 and 4% (v/w). The traps were placed in ant infested rooms and monitored daily, and the number of ants (dead and alive) was recorded. The setup for each concentration was replicated three times.

Data analysis

The completely randomized design was used for all experiments. All count data were transformed using natural log ($\log_n$) and all percentage data transformed using Arcsine transformation before analyzing. Means were compared using analysis of variance (ANOVA) and, where there was significant difference, means were separated using Tukey's Honestly Significant Difference Test. All analysis was done at the 0.05 alpha level using SPSS v16 for Windows software (SPSS, 2007).

Results

Evaluation of different baits

Results for bait evaluation are presented in Fig 1, 2 and 3. All the nine baits used attracted significantly higher numbers of Pharaoh's ants than the control ($P < 0.05$). Groundnut cake, dry fish and sugar attracted significantly higher numbers of ants than all the other baits while corn dough attracted the least number of ants ($P < 0.05$). Groundnut cake maintained higher trap catches throughout the trapping period, whereas dry fish started with low catches, increased to a peak by the 16th day and dropped to a low by the 24th day.

Evaluation of different insecticides using baited traps

The control traps consistently recorded higher numbers of ants over the trapping period (Fig. 3). When the neem treatment was introduced on day three, no ant was trapped till day seven, when the neem treatment was removed and bait only traps reintroduced. On the first day of introduction of K-Orthine, no ant was trapped. The K-Orthine baited traps subsequently trapped ants till they were replaced with bait only traps. Similar to the control traps, Rimon-baited traps consistently trapped ants throughout the trapping period, except that the numbers trapped reduced gradually and increased slightly when the Rimon-baited traps were replaced with bait only traps.

All the ants trapped by the control traps were collected alive and all those trapped by the K-Orthine baited traps were collected dead (Fig. 4). In the Rimon-baited traps, both dead and live ants were collected, with more of the dead (82%) than alive (18%).

Determination of effective concentration of Rimon

From the exposure experiment, the survival rate of the ants decreasded as the Rimon concentration increased (Fig. 5). In the 4% concentration, ants survived up to 72 h whereas in the 1% concentration, they survived up to 144 h just as the control group. From the trap experiments at different concentrations, the results (Fig. 6) show that there were significantly more ants alive in the 1% concentration than in all the others. The 1% concentration also had some dead ants at the time of trap collection.

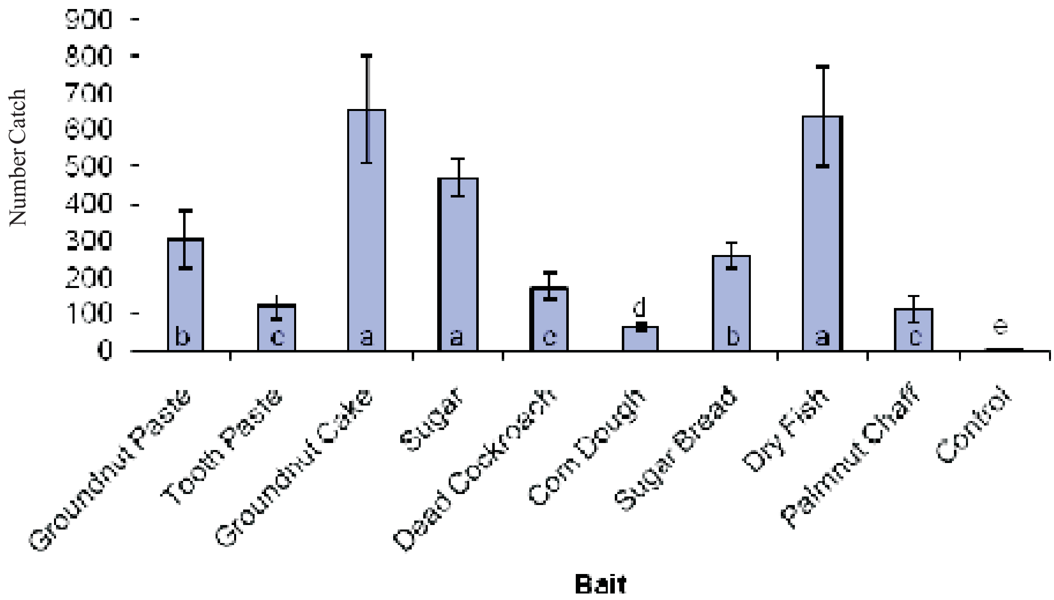

Fig. 1. Total number of *M. pharaonis* trapped using different baits

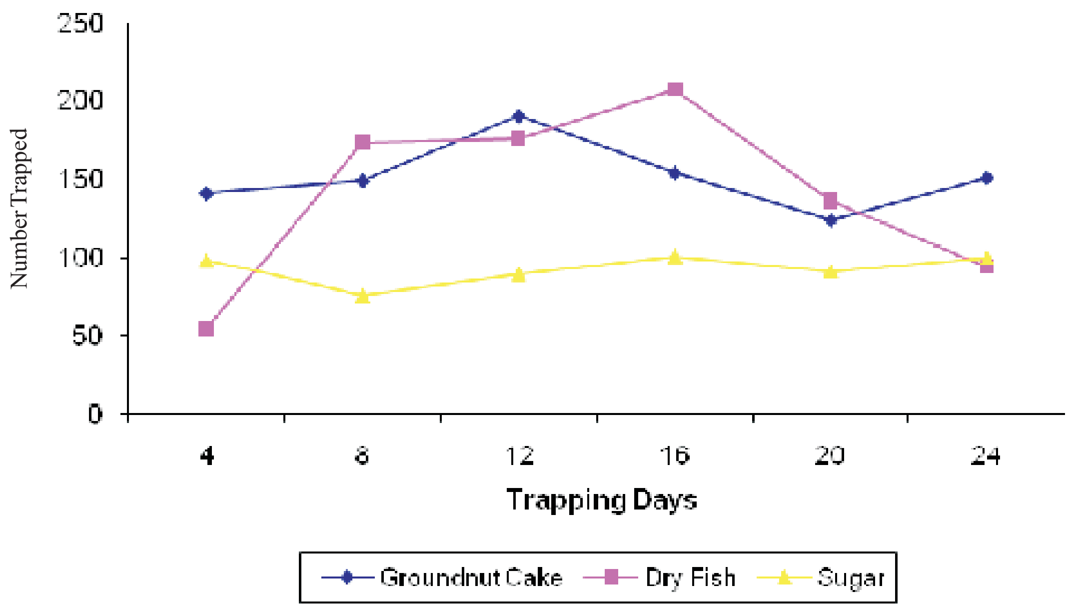

Fig. 2. Mean trap catch for groundnut cake, dry fish and sugar over a 24-day period

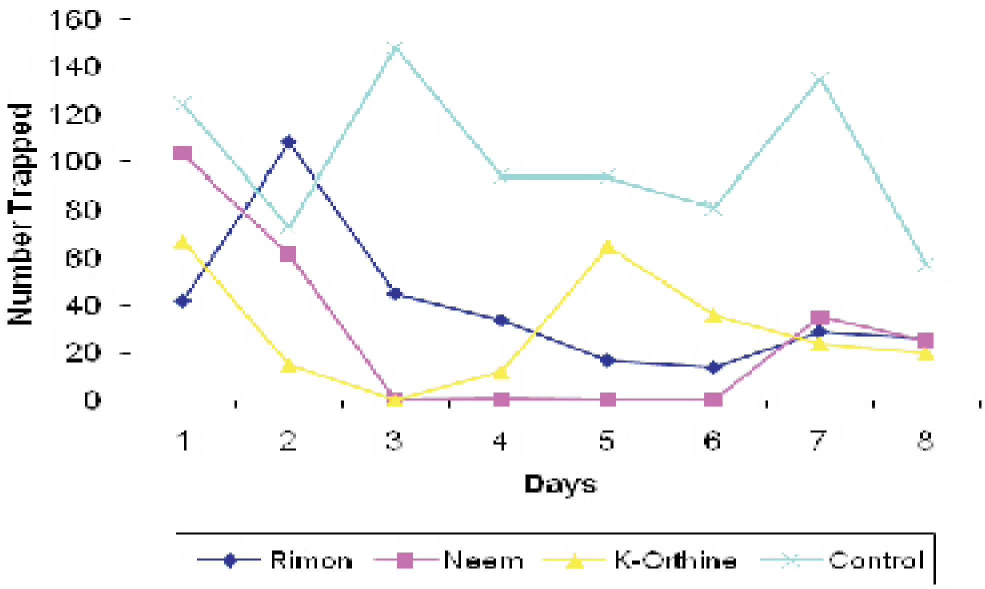

Fig. 3. Mean daily catch for traps containing insecticide laced groundnut cake over an 8-day period

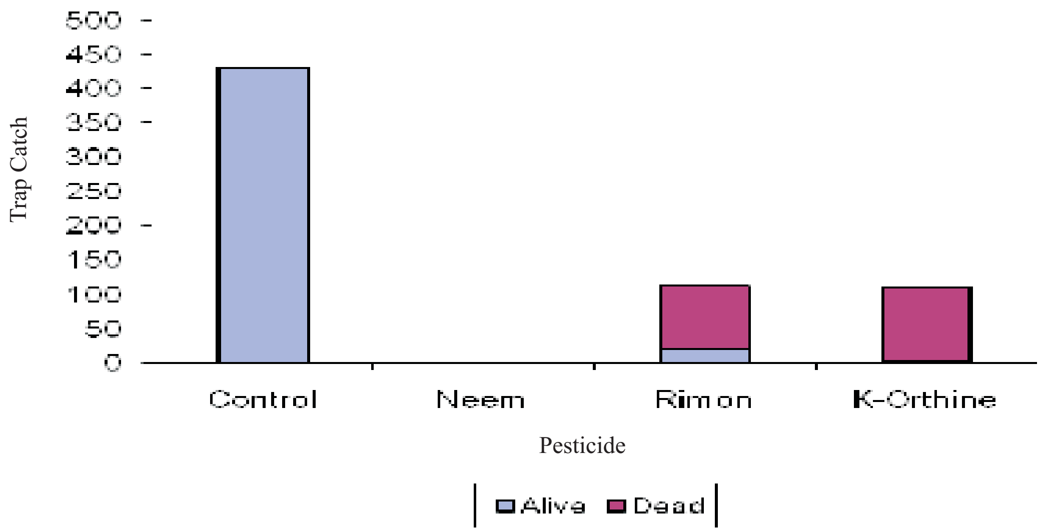

Fig. 4. Total catch for traps containing groundnut cake laced with different insecticides showing proportions dead and alive

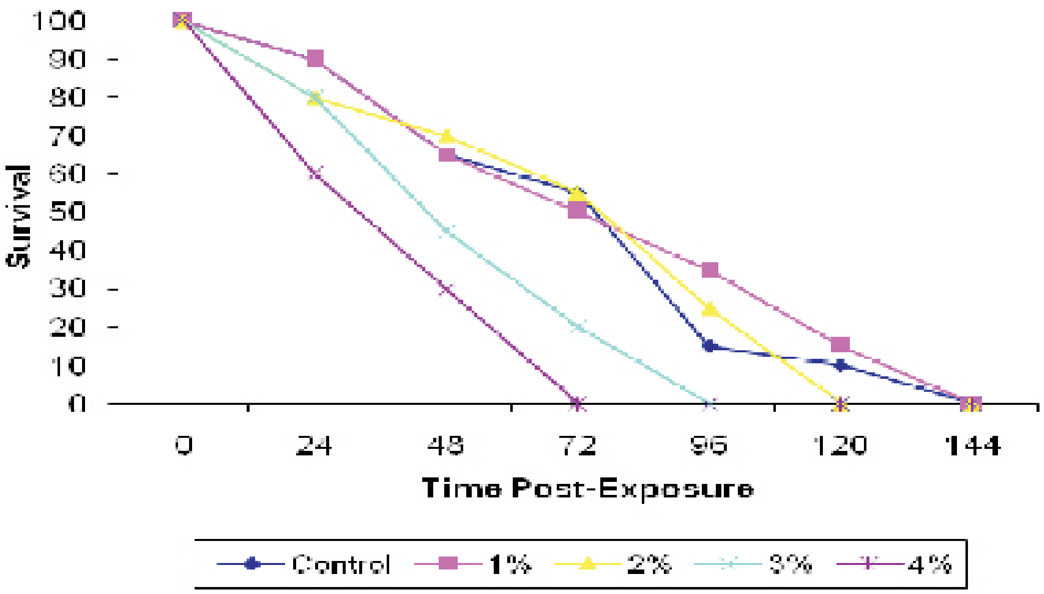

Fig. 5. Survival of *M. pharaonis* exposed to diferent concentrations of Rimon in groundnut cake baits

Fig. 6. Mean catch for traps containing different concentrations of Rimon in groundnut cake

Discussions

The attractiveness of ants to bait depends largely on the nutritional composition of the bait. Ants generally like sugary, oily and proteinaceous foods (Peringuey, 1924; O'Toole, 1986). This is evident in the results, with Pharaoh's ants having the highest preference for groundnut cake, dry fish, and sugar. Groundnut cake is primarily made up of fat, a rich source of energy, and also acts as an anti-oxidant (Blomhoff *et al*., 2006). Dry fish contains mainly proteins, which contribute immensely to growth and development, especially in the larvae and the queen. Sugar is mainly carbohydrate and supplies energy to meet the energy demands of the active workers. Corn dough was the least attractive bait to Pharaoh's ants. This may be due to the fact that corn dough contained no sugar because of the formulation. The major components of corn dough are starch and by-products of fermentation such as alcohol, which might not be attractive to the ants.

Pharaoh's ants have been shown to demonstrate satiation and alternation response to foods. Edwards & Abraham (1990), working with laboratory and field colonies of Pharaoh's ants, demonstrated that, initially, worker ants from laboratory colonies showed a distinct preference for sugary and oily foods as has been the case for sugar and groundnut cake in the present study. However, the workers subsequently showed a marked preference for proteinaceous foods, even though they were still attracted to other foods. In addition, workers showed a marked tendency to alternate between carbohydrate, protein and fatty foods. The results of the present study do not differ from the above findings. The satiation and alternation response to foods demonstrated by Pharaoh's ants ensure that the colonies receive a diet that is both varied and balanced (Edwards & Abraham, 1990). This pattern of feeding behaviour also has an important implication for the use of baiting to control Pharaoh's ants since it enables formulation and use of appropriate baits. Pharaoh's ants are, thus, most attracted to groundnut cake, sugar and dry fish. An appropriate bait system would have to include all three types of bait in a mixture.

In developing a bait system for effective control of ants, the action of the insecticide should be delayed enough to allow workers carry the bait to the nest. Edwards (1975) reported that stomach poisons work too quickly and reduce worker numbers so much that poisons are not distributed to queens and brood, as shown by K-Orthine in the present study. Of the three insecticides evaluated, K-Orthine killed the ants before they could return to the nest. K-Orthine is a deltamethrin-based insecticide, belonging to the Pyrethroids which are known to have a knockdown effect on insects. Neem-laced baits did not attract any ants when introduced. Neem contains Azadirachtin, which has repellent, antifeedant and growth regulating properties (Schmutterer, 1990).

In the present study, neem acted as a repellent, since ants were trapped on the 7 and 8 days when neem was withdrawn. Rimon showed the greatest prospect for incorporating into a bait system since it did not repel the ants and did not also kill all the ants it attracted. Rimon contains Novaluron, a Benzoylphenyl urea, which acts as an insect growth regulator (IGR). It also has some contact effect on certain insects at higher concentrations (Stanley, 2004). A good IGR is not supposed to reduce worker number so much. Evaluation of different concentration in the present study show that Rimon at 1% kills only 10% of the ants that feed on it and allows Rimon-fed workers to survive as long as control workers. Similar results were reported by Klotz *et al.* (1996) with 1% boric acid in sucrose solution and 0.9% hydramethylnon.

The use of sub-lethal doses of a slow acting insecticide that does not act as a stomach poison in a properly formulated bait system will allow workers to carry the insecticide-laced bait to the colony. The continuous application of this bait system should wipe out the colony completely. It is, therefore, recommended that a bait system containing groundnut cake, sugar and dry fish mixed with 1% Rimon be evaluated for Pharaoh's ant control in Ghana.

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