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EVALUATING A NEW CONCEPT IN COCKROACH BAITING

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Abstract Gel bait treatments are widely used for cockroach control, in part because they are considered to be safer and more effective than other methods. However, commercially available baits are considered to have a limited range over which they can attract and, as a result, fail to lure cockroaches out of deep refuges. In addition, some strains have shown resistance to this treatment through developed bait aversion behaviour. German cockroaches are gregarious, often spending up to 75% of their lifetime at rest deep in harbourages, limiting the effect of gel treatments. The hard exoskeletons of cockroaches contain chitin and chitosan which can display paramagnetic properties, attracting ferromagnetic objects. This means that a magnetically charged powder carrying an insecticide active ingredient can be attracted to the exoskeleton and will adhere to it, overcoming disadvantages of gel baits. The active constituent can then also enter the cockroach body through the soft membranes in the exoskeleton, as well as by ingestion. A series of detailed laboratory trials were performed to confirm efficacy and produce a new concept in cockroach baits. This product is a dry flowable powder which also includes food attractants and the active constituent, fipronil. Averaged across gender and days after treatment, this new concept provided improved levels of control, and speed of control, when compared to three reference cockroach gel baits, including use of the same active.

Key words Dry flowable cockroach bait, magnetic, *Periplaneta, Blattella*, fipronil

INTRODUCTION

Ensystex Inc. (Fayetteville, North Carolina, USA) in association with Energy Investment Group Holding Co. Ltd. (Calebasses, Mauritius) have developed a Magnetic Flowable Bait, MAGNATHOR® Magnetic Cockroach Bait with Magthanite®, which is a ready-to-use, dry, flowable, granular cockroach bait that utilises a toxicant incorporated with a ferromagnetic granular compound and a food attractant for the control of cockroaches (and ants). The toxicant is 0.5 g/kg fipronil and the ferromagnetic granular carrier used is a proprietary compound, Magthanite. This is a non-hazardous proprietary oxide powder blend of strontium ferrite, iron oxide, silicon dioxide, aluminium oxide, zinc oxide, and calcium oxide; originally developed for the modern electronics industry.

Several species of social insects have been shown to use the earth's magnetic field to help them to orientate and navigate whilst foraging, migrating and building their nests. This appears to be linked to the presence of particles of magnetite in their bodies (Ferreira et al., 2005). Magnetite is a *ferromagnetic* substance, generating its own magnetic field, just like a compass needle. The magnetic remanence is reported as being low, of the order of 10^{-6} emu per individual.

Numerous experiments have shown that there is a clear attraction between ferromagnetic particles and several insect pests, and most importantly, that this effect can be utilised for their control (Entwistle, 2011). Insect exoskeletons consist of an epidermis underlying a soft endocuticle of chitin (an acetylglucosamine polysaccharide) and an exocuticle of chitin which has flexible regions containing the elastic protein resilin together with rigid plates that are strengthened through quinone cross linkages and a mixture of proteins called sclerotin. The chemical composition of the exoskeleton does not explain why it should exhibit paramagnetism, and there appears to be a gap in research in this area, though the chitin that forms the exoskeleton, and its chemically de-acetylated version, chitosan, can be processed in the laboratory into their paramagnetic forms. Enhanced pick-up by the insect cuticle has been demonstrated through use of this electrostatic powder (O'Halloran and Fryatt, 2011). Tests by Smith and Moores at the Rothamsted Experimental Station, UK were reported as showing that cockroaches passing over a residual deposit of the ferromagnetic carrier picked up an average of 56% more particulate material than those passing over a deposit of inert talc. In a further test comparing inert talc and this ferromagnetic carrier, they found that 250% more ferromagnetic carrier was transferred between cockroaches.

Cockroaches are an important group of insect pests in the urban environment. Their adaptability has made them a universal pest associated with humans. The use of insecticides remains the most common method of control, among which use of insecticide baits is the most popular method. Baits are precise, use less toxicant and carry lower risks when applied (Tee, 2014). In modern cockroach management programs, emphasis is placed on using the least amount of insecticide possible (Miller and Meek, 2004).

Cockroach baits are available in various formulation types. Gel baits are most commonly used and can be applied directly in cockroach-infested harbourages such as cracks, crevices and voids using a syringe or bait gun (Reierson, 1995). A dry flowable granular bait offers the option of reaching deep into cracks and crevices to reach deep spaces where application of gel baits is restricted (Dhang, 2011). The amount of bait consumed is considered an important criterion for bait efficacy since it determines whether a lethal dose is being ingested and it influences the amount of toxicant available for horizontal transfer. Consumption of more bait means that poisoned individuals will defecate or regurgitate more materials containing toxicant and contain more toxicant within the cadaver (Silverman and Bieman, 1996). The attractiveness and consumption of the bait is therefore considered a paramount factor in performance. However, a substance that is attractive to cockroaches may not necessarily stimulate feeding (Tsuji, 1965). An attractant functions by attracting cockroaches towards the bait, whereas a feeding stimulant induces and promotes increased consumption of the bait (Durier and Rivault, 2000).

Commercially available baits are thought to have a limited range over which they can attract and, as a result, fail to lure cockroaches out of deep refuges, (Nalyana and Schnall, 2001). In addition, some strains have shown resistance to gel bait treatments through developed bait aversion behaviour (Wang et al., 2004*)*. In addition, German cockroaches are gregarious, often spending up to 75% of their lifetime at rest deep in harbourages, (Strong et al., 2000), thus limiting the effect of traditional gel placements.

By developing a bait matrix in which consumption is not a primary factor for uptake, it was expected that improved control of cockroaches could be achieved, with the paramagnetic effects of the proposed carrier allowing more toxicant to be picked up.

MATERIALS AND METHODS

This trial was established to determine if the proposed formulation would attract the cockroaches so they actively picked up the particles, resulting in cockroach mortality; and to compare it with three industry standard products. The Magnetic Flowable Bait, was produced by Ensystex Inc., North Carolina, USA. This consisted of 0.5 g/kg fipronil as the active constituent, 5 g/kg of a plant-based food as the attractant, and 994.5 g/kg of the flowable magnetic carrier.

Positive controls consisted of three leading, commercially available gel cockroach baits as developed by the original registrants of the products with their respective active constituents. The active

constituents of these were 0.5 g/kg fipronil, 0.5 g/kg abamectin, and 21.5 g/kg imidacloprid. These were purchased from a distribution company in NSW, Australia. The trials were performed at the laboratories of the South African Bureau of Standards, Pretoria, Republic of South Africa.

Test conditions were maintained with the temperature set at 23-28° Celsius, relative humidity of 45-65% and a normal day/night cycle. The test insect species were the German cockroach (*Blattella germanica*) and the American cockroach (*Periplaneta americana*).

Plastic trays measuring 350 mm x 350 mm x 220 mm were used to house the cockroaches. These were fitted out with two cockroach shelters using commercially available cardboard egg cartons. These were positioned at one side of the test arena. A food source (dried dog food) and water were placed on the opposite side of the container, in the corner. The shelter closest to the food and water sources was maintained as an untreated shelter in all tests. Cockroaches were released into this untreated shelter.

For the Magnetic Flowable Bait, the internal surfaces of the second shelter were lightly dusted with 1 g of the Magnetic Flowable Bait. This was the shelter that was furthest away from the provided water and food sources. For the Positive Controls, 2 g of each gel bait, was applied to a plastic lid and placed in the centre of the container, closest to the shelter in which the cockroaches were released. The cockroaches would need to pass the gel baits in order to access the provided food or water source.

One series of trials was established using American cockroaches and a second series using German cockroaches for each Material. Three (3) replicates for each cockroach species were conducted using fourteen (14) females, fourteen (14) males, and fourteen (14) nymphs (approx. two weeks old). The cockroaches were released in each separate test container and left for one hour to settle before the Materials were introduced. Mortality counts were made daily for fourteen days. The dead cockroaches were removed after each count. A standard control was also used for each species with no Material present.

RESULTS AND DISCUSSION

The Magnetic Flowable Bait was the only material that produced 100% cockroach mortality in the trials. This was achieved within 6 days against the American cockroach, though all adults were dead within 48 hours. Against the German cockroach, total mortality of all life-stages was achieved within 48 hours.

The Fipronil Gel Bait was the next best performing material, providing 98% mortality of American cockroaches after 12 days; and 99% mortality of German cockroaches after 9 days.
Detailed statistical analysis confirmed that the Magnetic Flowable Bait demonstrated significantly faster control and more effective control than any of the gel baits tested against both species.

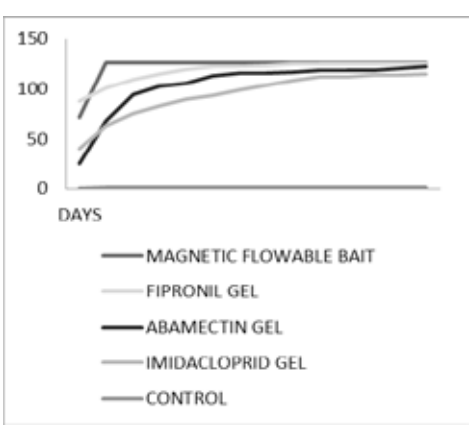

Figure 1. Graphical representation of German cockroach results.

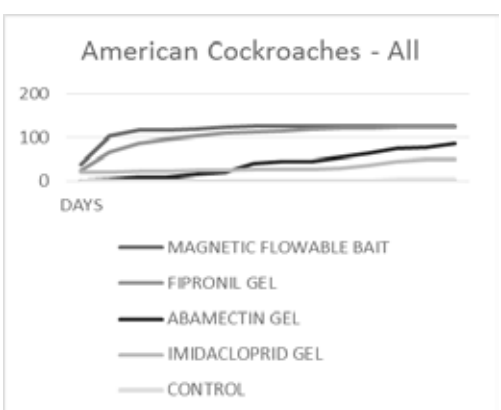

Figure 2. Graphical representation of American cockroach results.

CONCLUSIONS

The above results support the contention that a Magnetic Flowable Bait could offer improved levels of control compared to a traditional gel bait. The Magnetic Flowable Bait does not need to be consumed by the cockroaches. This means the food component is only required to lure the cockroach to the target zone. It is suggested that, once the cockroach approaches the target zone, the magnetic attraction between the cockroach exoskeleton and the Magnetic Flowable Bait draws the particles containing the active constituent to the cockroach exoskeleton. The power of paramagnetism, also causes the particles to adhere to the exoskeleton and to be transferred more readily during grooming to provide improved secondary transfer. The particles likely enter the cockroaches' bodies through the soft membranes in the exoskeleton. Ingestion of the Magnetic Flowable Bait is not necessary for toxicity. When compared with conventional gel baits it is considered that the Magnetic Flowable Bait delivered superior results due to the improved adhesion and transferability of the particles. Since it is a dry flowable bait, it will travel deep into cracks, crevices and other cockroach harbourages, allowing treatment of places that cannot be reached with other baits.

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