Laboratory Performance of Gel Baits Against German Cockroach (Dictyoptera: Blattellidae)

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ABSTRACT An experiment was executed to measure the attractiveness and mortality of four commercial gel baits namely Mangicap (Boric acid 68% w/w), Family roach killer (Imidacloprid 3.0% w/w), Roach away (Fipronil 0.05% w/w), Cockroach ou le (Chlorpyrifo 1.0% w/w) against German cockroach (*Blatella germanica* L). Cockroaches consumed more Roach away bait, which is significantly different than other 3 baits and control (dog chow). The same bait gave complete mortality earlier than other 3 baits. However, Cockroaches were quickly attracted toward the Family roach killer which is significantly higher than Roach away, the same bait gave significantly quicker average mortality than other baits within 3 hours of exposure. On visual observation, the bait seems desiccated very fast within 48 hours so the average mortality of others baits was higher after 48 hours exposures than the baits. Within 24 hours Cockroach ou le gave significantly higher mortality than other Roach away, Family roach killer, and Mangicap.

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Cockroaches (*Blatella germanica* L) are among the most important urban pests and causing nuisance in and around the home (Lee 2000, Lee and Khalid 2000, Shahraki 2013). Their distribution and abundance in residential areas, hotels and food preparation area lead to contaminate food preparation areas and food with their saliva, faces, body parts and vector to a number of disease causing parasite and micro-organism like bacteria and fungus (Fotedar et al. 1991, Kopanic Jr et al. 1994, Fathpour et al. 2003, Menasria et al. 2014). Moreover, cockroaches and their secretions may be allergenic to sensitive people (Sarinho et al. 2004, Gore and Schal 2005, Sohn and Kim 2012)

A survey finding stated that 50% of low income residences in Gary, IN, USA were infested by *B. germanica* during 2002–2004 (Wang and Bennett 2006). It was found that, in USA, Boston (21.5%), St Louis (16.3%), and Baltimore (13.4%) had the highest percentages of homes with detectable levels of cockroach allergen (Huss et al. 2001).

Cockroaches and their secretions may be allergenic to sensitive people (Sarinho et al. 2004, Gore and Schal 2005, Sohn and Kim 2012). Furthermore, it was found that from 9.9% - 21.5% of homes have detectable levels of the cockroach allergen Bla g 1 in 4 cities of USA (Huss et al. 2001).

In a survey of public hospitals in Hamadan, in western Iran, (Salehzadeh et al. 2007) also

collected *B. germanica* that were found to be harboring 10 species of bacteria. Similarly, (Zarchi and Vatani 2009) recently found 19 species of bacteria in cockroaches *(P. americana, B. germanica and B. orientalis)* collected in three army hospitals in northern Tehran, and implicated the insects in the spread of pathogenic bacteria to humans. At least 25 different species of medically important bacteria were isolated and identified from the *P. americana, B. germanica* species and at least 22 were Gram negative (Fakoorziba et al. 2010). *Salmonella spp.* was isolated from the mid gut of the *B. germanica* which were found in the hospital. (Fathpour et al. 2003).

Bait formulations are the most common and effective methods for the control of German cockroaches, *Blatella. germanica* (L.) populations (Appel and Tanley 2000)These are toxic diets that contain an active ingredient (AI) incorporated within a food matrix, which generally contains a sugar as a phagostimulant (Appel 1990, Schal and Hamilton 1990, Rust et al. 1991, Ko et al. 2016). In contrast to other methods of control, such as broadcast sprays, baits over a more targeted approach resulting in less AI required for control and less AI exposure to non-target organisms such as children and pets (Schal and Hamilton 1990). A number of effective, non-repellent active ingredients have been incorporated within baits (Appel 1990, Silverman et al. 1991, Appel 1992, Buczkowski et al. 2001, Buczkowski et al. 2008).

German cockroach has developed resistance to nearly every class of insecticides which were used for the control (Roslavtseva 2002). The resistance of German cockroach against to avert to gel bait was reported (Wang et al. 2004, Liang 2005a, Miller and McCoy 2005). German cockroaches shown some gel bait highly resistant to a variety of current gel baits in the market (except the new baits and modified bait formulations). Previous studies revealed that German cockroach showed resistance in Avert (0.05% abamectin), Maxforce FC (0.01% Firpronil), and Pre-Empt (2.15% imidacloprid) gel (Wang et al. 2006). Rotation of gel baits may not overcome the resistant cockroaches because they exhibited adverse behavior to gel baits from different manufacturers with various active ingredients.

Boric acid and hydramethylnon baits were failing to provide consistent control of *P. americana* to sewer shafts due to the problems of mold on the baits and large population of cockroaches depleted the baits (Rust et al. 1991). Imidacloprid gel bait significantly reduced German cockroach, the population was reduced by 50% after 1 wk and 80% after 4 wk treatment (Appel and Tanley 2000).

The objectives of this study were to evaluate the attractiveness and mortality of four popular gel baits representing four active ingredients (Fipronil, Imidacloprid, Chlorpyrifos and Boric acid) against *B. germanica* under laboratory condition. The information will be useful to choose the active ingredient while formulating the gel bait for German cockroache population management.

Materials and methods

Cockroach strain and rearing. The insects were from a biological laboratory of Chung Hsi Chemical Plant Ltd. Hsinchu, where the pure strains were maintained more than 10 years in Laboratory, at 25±5°C and 60±10% relative humidity. The colony were maintained and provided with nymphs and adults of both sexes. The mean temperature in the rearing room during experiment period was 25±5°C with 60±10% relative humidity under a photoperiod of 12:12 (L:D) hour as described by (Sharawi et al. 2013, Salama 2015). The colony were maintained in a plastic container (588 × 418 × 330 mm) in IPM and Urban Pest management laboratory

of National Pingtung University of Science and Technology. The inner upper 2 cm was coasted with mixture of petroleum jelly and oil (1:2) to prevent the cockroaches escaping (Snoddy and Appel 2014) and supplied with water in water vials, dry dog food pellets (Uni-president Enterprises Corp., beef flavor) and cardboard harborage as shelter (Appel 1990, Appel and Tanley 2000, Omara et al. 2013) . Adult males and females were used in the experiments.

Baits. Four commercial bait products, Mangicap (Boric acid 68% w/w, Combat company), Family roach killer (Imidacloprid 3.0% w/w), Roach away (Fipronil 0.05% w/w) and Cockroach ou le (Chlorpyrifos 1.0% w/w) were purchased from local shop and tested. Dry dog food pellets (Uni-president Enterprises Corp., beef flavor) were also included in bioassay as control.

Toxicity test. The experimental arenas were polythene container (150 cm × 60 cm × 85 cm) (Zhou and Patourel 1990, Wang and Bennett 2006) each containing water in water vial and one side cut paper cups (7 cm diameter by 8 cm high) were provided as harborage. The water vial was placed opposite to the cuts of the paper cups to reduce the bias. Thirty adult German cockroaches (15 adult male and 15 adult no gravid female) were released in each experimental arena after 24 hours of starvation. The upper inside surface of the container will be lightly greased with a mixture of petroleum jelly and oil (1:2) (Liang 2005b, Wang and Bennett 2006). Approximately 1.0 g of bait was placed in a polymer cup (6.5 cm diameter by 1.5 cm high) (Liang 2005b) put inside the arenas about 20 cm apart from the harborage. Control container included only water, dog food and harborage (Appel and Tanley 2000). Cockroaches were starved only providing water for 24 hours and released into the test arenas 24 hours before the test (Wang et al. 2004, Wang and Bennett 2006, Wang et al. 2006, Ko et al. 2016). Four replication were conducted for each treatments (Omara et al. 2013). Cockroach mortality were recorded at every 3 hours in the day and 9 hours left in the night for 10 days (Wang et al. 2006). Moribund cockroaches (defined by an inability to walk) were considered dead in this experiment. The experiment was performed at 25±5°C with 65±10%, and 12:12 h [L:D] photoperiod as described by (Wang et al. 2006).

Attractiveness test. Response of the first cockroach on each bait for each replication was recorded. The baits were weighted before allowance and re-weighted 24 h after the exposure to determine the food consumption (Bayer et al. 2012). Cockroach feces was removed from baits and dog food before reweighing (Hatim et al. 2013). Bait and dog food weight-change in the control (not insect) were reweighed after 24 h exposure to cockroaches (Bayer et al. 2012).

Data Analysis. SPSS software version 23 was used to analyze the data, which was subjected to a one-way analysis of variance (ANOVA). Cumulative mortality percentage were measured prior to ANOVA. Homogenous subsets were analyzed at α 0.05 level and results were presented as the mean ± SEM.

Results

Toxicity. Family roach killer (Imidacloprid 3.0% w/w) and Cockroach ou le (Chlorpyrifos 1.0% w/w) caused significantly higher mortality ($P < 0.05$, LSD) than other baits and control (dog chow) 3 hours after exposure which were 75.83 and 42.5% respectively (Figure 1). Within 24 hours, the mortality percentage of Cockroach ou le, Roach away and Family roach killer reached to 98.33, 92.50 and 86.67% respectively. The roach away quickly killed all the cockroaches within 48 hours, whereas the mortality by Family roach killer and

Mangicap reached to 100% on 5 and 6 days after exposure respectively.

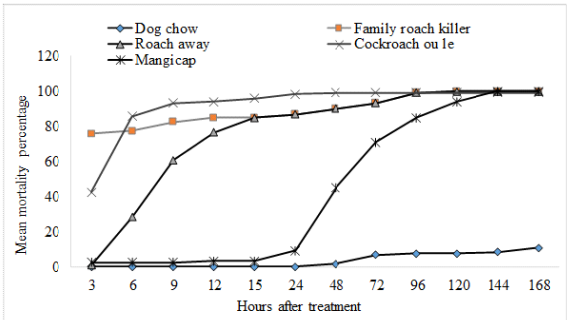

Figure 1. Effect of Family roach killer, Roach away, Cockroach ou le and Mangicap bait on German cockroaches in Laboratory.

Attractiveness. All cockroach baits showed the significantly higher ($P < 0.05$, LSD) attractiveness than control and Mangicap bait (Figure 2). Roach away amount removed was the highest by the German cockroaches within 24 hours observation the mean amount of bait removed was 0.22 gm by 30 cockroaches that was significantly higher ($P < 0.05$, LSD) then all other tested baits. When they preferred more the bait they attracted more toward the baits and they eat more.

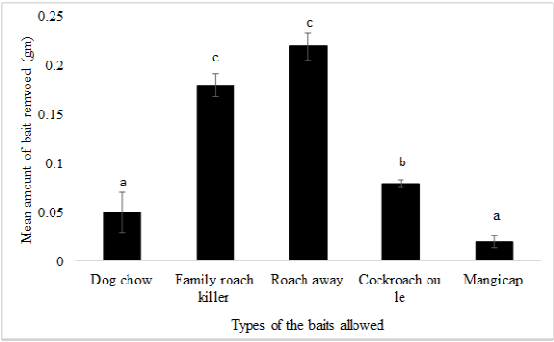

Figure 2. Mean ± SE amount of baits removed by German cockroaches in 24 hours. Bars with different letters are significantly different (n = 4, $P < 0.05$).

Family roach killer bait was detected quickly than other baits and amount removed within 24 hours was significantly higher than other baits (except Roach away bait).

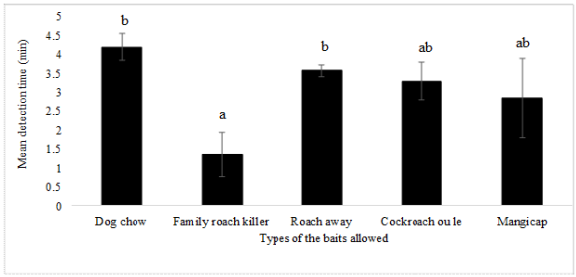

Figure 3. Mean ± SE time required to detect the bait by German cockroaches. Bars with different letters are significantly different (n = 4, $P < 0.05$)

Discussion

Roach away (Firponil 0.05% w/w) containing gel bait performed complete mortality (100%) 48 hours after exposure which was significantly higher than other baits (except Cockroach Ou le) and control. The result is in consistent with Wang and Bennett (2006), who determined that treatment with 0.1 mg g^{-1} fipronil gel bait cause 100% mortality at 2 weeks post exposure in laboratory condition where as in field condition it took 4 weeks.

Family roach killer (Imidacloprid 3% w/w) performed the significantly ($P < 0.05$) higher mortality (75.83%) than all others baits 3 hours after exposure and the mortality reached to 100%, 5 days after exposure the similar result were obtained by Appel and Tanley (2000), 2.15% Imidacloprid gel bait containing 44% water was significantly more repellent (38%) in Ebeling choice boxes against the German cockroach in Laboratory and in the field/kitchen the bait significantly reduced German cockroach trap catch in infested homes which was 50% reduction after 1 wk and 80% reduction 4 wk after treatment (Appel 1992, Appel and Benson 1995). Cockroach ou le (Chlorpyrifos1% w/w) showed significantly ($P < 0.05$) higher percentage (98.33%) of mortality till 24 hours of exposure.

Boric acid gives complete (100%) mortality 6 days after exposure which is significantly different ($P < 0.05$) than control. The similar result of boric acid from Rust et al. (1991), who found that Bendiocar, boric acid powder and provided excellent control for at least 1 month. The boric acid result was similar with previous result, boric acid containing 0.5-2.0% aqueous solation with sugar was more effective than sodium tetraborate or disodium octaborate tetrahydrate to kill German cockroach (Gore and Schal 2004, Gore et al. 2004). There was similar output from Appel (1992) who mentioned that Blue diamond (boric acid 33.3%) significantly reduced the German cockroach populations in the field.

The German cockroaches attracted more toward the Roach away (fipronil 0.05% w/w) and they consumed significantly higher amount than boric acid bait which is similar with previous result Durier and Rivault (1999) revealed that Fipronil gel was more attractive than boric acid. Feeding stimulation potential of fipronil gel was higher than boric acid. Family roach killer (Imidacloprid 3.0% w/w) detected first than Roach away (Fipronil 0.05%) which is matched with the finding that non-gravid females showed no first-choice preference but fed on fipronil gel for longer than on bread Durier and Rivault (1999). The similar result from Liang (2005b) towards the efficacy of fipronil gel, he determined that Maxforce FC select gel with fipronil performed excellent efficacy against Miami cockroaches.

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