Tropical Biomedicine 27(3): 559–565 (2010)

Comparative performance of two commercial neonicotinoid baits against filth flies under field conditions

Nurita, A.T. and Abu Hassan, A.*
Medical Entomology Laboratory, School of Biological Sciences, Universiti Sains Malaysia, 11800, Minden Pulau Pinang, Malaysia
*Corresponding author email: aahassan@usm.my
Received 20 June 2010; revised in revised form 8 August 2010; accepted 10 August 2010

Abstract. Two performance (efficacy and attractiveness) comparisons of neonicotinoid baits QuickBayt® (imidacloprid) and Agita® (thiamethoxam) against filth flies were conducted under field conditions to determine suitability for use outdoors. The first experiment compared bait performance and the second compared effects of different applications on QuickBayt® performance. Applications compared were: (i) scattered in petri dish (SPD); (ii) wet-down in petri dish (WPD); (iii) scattered on cardboard (SCB) and (iv) painted on cardboards (PCB). Efficacy and attractiveness were assessed based on knockdown percentage (KD%) and number of flies feeding on baits, respectively. The KD% of QuickBayt® (34% ± 3.0%) was not significantly higher than Agita® (29% ± 1.3%) (t-test, $P>0.05$). Agita® (101 ± 5.7 flies) was significantly more attractive to flies than QuickBayt® (76 ± 4.8 flies) and the sugar solution (49 ± 7.2) (one-way ANOVA, $P<0.05$). The PCB and SCB applications were significantly more attractive to filth flies than WPD and SPD (One-way ANOVA, $P<0.05$), however differences in KD% were not significantly different (One-way ANOVA, $P>0.05$). The two baits provided the same level of efficacy in a wide-open area against filth flies of various species. QuickBayt® was more versatile; efficacy was not significantly affected by different applications. Surface area and moisture affects attractiveness of the bait.

INTRODUCTION

Flies that breed and feed on filth-ridden substances such as decaying organic material, domestic garbage and animal dung are collectively known as filth flies (Olsen, 1998). The most common filth flies in places such as landfills, livestock facilities and poultry farms are from the family Muscidae (house flies and dog dung flies), Calliphoridae (blow flies) and Sarcophagidae (flesh flies) (Koehler & Oi, 1991). They have the potential to disperse to nearby residential areas, restaurants and other food outlets where they become a nuisance and a threat to public health (Ferriera & Lacerda, 1993). Breeding habits, feeding mechanisms and indiscriminate travel between filth and human food, make filth flies efficient mechanical vectors of disease causing organisms (Emerson *et al*., 1999; Graczyk *et al.*, 2001). Public health risks associated with large populations of filth flies can be considerable and necessary steps should be made to prevent population outbreaks.

Toxic baits are one of many formulations for insecticides and they are applied as paint-on, dry scatter and liquid sprinkle baits (WHO, 1991; Freeman & Pinniger, 1992). Neonicotinoids or chloronicotinyls, are a fairly new class of synthetic insecticide that resemble the natural compound nicotine. They are a viable alternative to organophosphates, carbamates and pyrethroids for use in bait

formulations (Ware, 2000; Cox, 2001). Neonicotinoids will selectively bind and interact with insect nicotinic acetylcholine receptor sites of insects rather than the receptor sites of vertebrates. Their selective nature thus plays a role on safety to vertebrates (Matsuda *et al.*, 2001; Kim, 2006).

Chemicals in the neonicotinoid class include the widely used imidacloprid and newer second generation chemicals such as thiamethoxam (Antunes-Kenyon & Kennedy, 2001). Imidacloprid is used against various nuisance and public hygiene insect species such as flies, cockroaches and fleas (Pospischil *et al.*, 2005). Thiamethoxam is the first commercially available second-generation neonicotinoid and belongs to the thianicotinyl sub-class. The compound has broad-spectrum insecticidal activity and offers control of a wide variety of important pests (Maienfisch *et al.*, 2001). Neonicotinoid baits are marketed for fly control under a variety of trademarks such as QuickBayt® (imidacloprid) and Agita® (thiamethoxam).

The present study compared the performance of two commercial neonicotinoid baits, QuickBayt® (Bayer Environmental Science Malaysia) and Agita® 10WG (Distributed by Syngenta) in terms of efficacy and attractiveness under field conditions. The manufacturer of QuickBayt® recommends (on product label) that the bait granules can be scattered on the ground, placed in bait stations or mixed with water for a paint-on application. Therefore, in addition, we also assessed the affects of various application methods on the efficacy and attractiveness of QuickBayt®.

MATERIALS AND METHODS

Baits

The two commercial neonicotinoid baits compared were Agita® and QuickBayt®. Agita® 10 WG containing 10.0% w/w of thiamethoxam is marketed as a water-soluble granular bait for a paint-on application. When dissolved in water, Agita® becomes a milky beige suspension broth. QuickBayt® is a granular fly bait containing 0.5% w/w of imidacloprid. Both Agita® and QuickBayt® contain the house fly sex pheromone Z-(9)-Tricosene at a 0.5 g kg^{-1} and 1.0 g kg^{-1} concentration respectively.

Bait application methods

Two studies were conducted to compare the performance of neonicotinoid baits against filth flies under field conditions. The first study, which compared the efficacy and attractiveness of the two neonicotinoids baits, was conducted once a week for 7 weeks at an outdoor food court. In this study, plain white paper plates (20 cm in diameter) and transparent plastic sheets measuring (30 x 21 cm) were used as bait receptacles. QuickBayt® granules were distributed evenly into two paper plates according to the manufacturer's recommended application rate of 2g m^{-2}. Agita® 10WG was prepared according to the manufacturer's recommendation (1.3 kg per litre water) and painted onto two transparent plastic sheets. The attractiveness of the two baits was also compared to 10% sugar solution (control) which was applied onto cotton pads placed on paper plates. There were three replicate treatments per week for each of the baits and the replicates were randomly placed at the study site each week.

The second study investigated the affects of four different application methods on the efficacy and attractiveness of QuickBayt®. The study was conducted once a week for 3 weeks at a small outdoor village market. The four application methods compared were, i) scattered in Petri dish (SPD); ii) wet-down in Petri dish (WPD); iii) scattered on cardboard (SCB); and iv) painted onto cardboards (PCB). The cardboards and plastic Petri dishes each measured 30 x 31 cm and 9 cm in diameter, respectively. In the WPD method, the bait granules were scattered evenly on cotton squares in the Petri dishes and wetted down (sprayed) with distilled water in the field until the granules were thoroughly wet. In

the PCB method, QuickBayt® granules were diluted in distilled water (200g per 80mL per 100m^2) and subsequently painted onto the cardboards.

In both studies, bait receptacles were placed onto white expanded polystyrene boards (fly-count targets). The white background provided by the polystyrene boards facilitated the counting of the flies that were knocked down by the baits. Once baits were applied, flies were allowed to feed on the baits at a time of peak fly activity from 1200–1600 hours and fresh bait was used each week.

In each study, the feeding and knocked down fly count methods were similar. Counts of flies were made using manual counters. The number of flies feeding on the baits was recorded and those that were knocked down within bait receptacles and fly-count targets were placed in plastic containers and brought back to the laboratory for identification using keys given by Gregor *et al*. (1971) and Kurahashi (2002). Flies were considered knocked down if they were unable to co-ordinate their locomotory movements.

The efficacy and attractiveness of the baits were evaluated based on knockdown percentage and number of feeding flies. Knockdown percentage was calculated as the percentage of flies that were knocked down out of the total number of flies that fed on baits.

Data analysis

Knockdown percentage data in both evaluations were transformed by Arcsine. Data were tested for normality using the Kolmogorov-Smirnov statistic. Two statistical analyses were used in this study, a t-test and a one-way ANOVA. After the analyses were completed, a post-hoc analysis, Tukey's Multiple Comparison test was conducted. All analyses were conducted by a PC version of Statistical Packages for the Social Sciences (SPSS).

RESULTS

Comparison of efficacy and attractiveness

Table 1 shows the mean number of flies feeding on the bait targets and the mean percentage of knocked down flies over the period of 7-weeks. The mean number of flies (per replicate) feeding on Agita® (101 ± 5.7) was higher compared to QuickBayt® (76 ± 4.8) and the sugar solution (control group) (49 ± 7.2). A one-way ANOVA and Tukey multiple comparison test determined that the mean number of flies feeding on the baits was significantly different ($F_{2,60}$= 33.75, P<0.05).

The total number of flies knocked down by Agita® was 606 compared to only 571 flies knocked down by QuickBayt®. When the knockdown percentages (KD%) were calculated, QuickBayt® showed a slightly higher mean KD% than Agita® (Table 1). A t-test analysis however, showed that the difference in knockdown percentage between the two baits was not significant (t = -1.680, df =40, P>0.05).

Figure 1 shows the percentages of the different species of flies knocked down by Agita® and QuickBayt®. The predominant

Table 1. Mean number of flies feeding on baits and mean percentage of knocked down flies per replicate over a period of 7 weeks (mean ± SD)

Baits	n	Mean no. feeding flies ± SD	Mean KD% ± SD
Agita	21	101 ± 5.7[a]	29 ± 1.3[a]
Quick Bayt	21	76 ± 4.8[b]	34 ± 3.0[a]
Sugar (control)	21	49 ± 7.2[c]	0

Means in each column followed by the same letter are not significantly different (p>0.05; Tukey's multiple comparison test); n = number of replicates

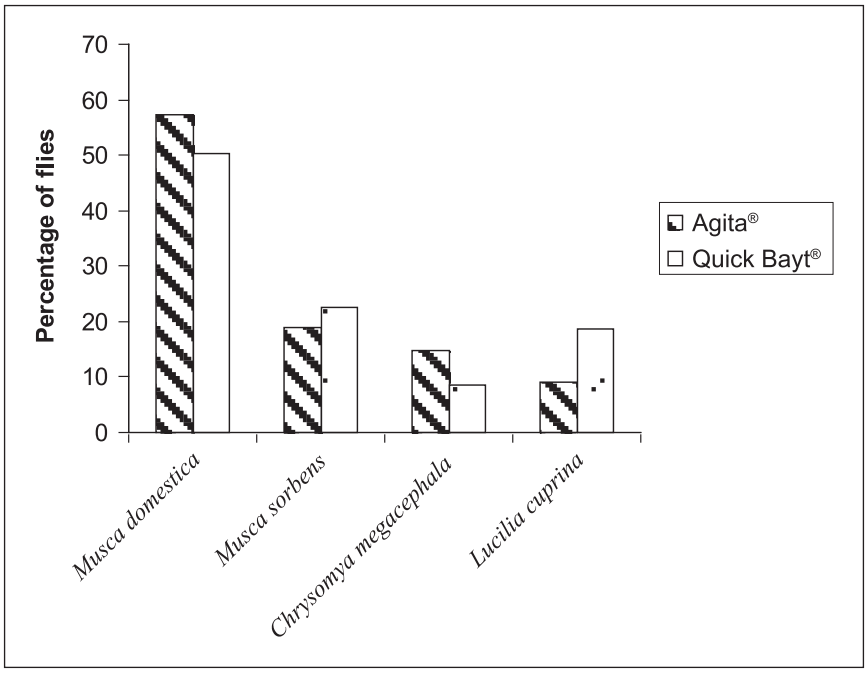

Figure 1. Overall percentages of different species of flies knocked down by Agita® and QuickBayt®

Table 2. Performance of four different application methods of Quick Bayt®

Baits	n	Mean no. feeding flies ± SE	Mean KD% ± SE
Painted on cardboard (PCB)	21	185 ± 1.7[a]	28 ± 1.7 [a]
Scattered on cardboard (SCB)	21	164 ± 3.8[b]	29 ± 1.0 [a]
Wet-down in petri dish (WPD)	21	50 ± 3.1[c]	27 ± 2.2 [a]
Scattered in petri dish (SPD)	21	38 ± 3.5[c]	24 ± 1.8 [a]

Means in each column followed by the same letter are not significantly different ($p>0.05$; Tukey's multiple comparison test); n = number of replicates

species knocked down by both baits was *Musca domestica*. Overall, 57% (Agita®) and 50% (QuickBayt®) of the total flies knocked down by each of the baits were *Musca domestica*.

Effects of various application method on efficacy of QuickBayt®

Table 2 shows the performance of four different application methods of QuickBayt® in terms of mean number of fly feedings and mean knockdown percentage per replicate over a period of 3 weeks. The mean number of feeding flies (per replicate) for the four different methods was significantly different ($F_{3,32}$= 586.06, $P<0.05$). The Tukey Multiple Comparison test showed that compared to the wet down in Petri dish (WPD) and the scattered in Petri dish (SPD) methods, both the painted on cardboard (PCB) and scattered on cardboard (SCB) methods resulted in significantly higher number of flies feeding; 185 ± 1.7 and 164 ± 3.8, respectively.

Whereas, the mean number of flies feeding on both WPD (50 ± 3.1) and SPD (38 ± 3.5) were significantly smaller.

The highest mean knockdown percentage was achieved using the SCB method (29 ± 1.0%), followed by the PCB (28 ± 1.7%), WPD (27 ± 2.2%) and SPD methods (24 ± 1.8%). However, a one-way ANOVA determined that the difference in knockdown percentage of the four different application methods was not significant ($F_{3,32}$= 2.011, P>0.05), even though the mean percentage of flies knocked down by the scatter on cardboards (SCB) method was higher compared to the others.

DISCUSSIONS

Comparison of efficacy and attractiveness

The result shows that the efficacy of the two commercial neonicotinoid baits, Agita® and QuickBayt® was almost similar. Cross-resistance of house flies to thiamethoxam and imidacloprid baits indicates that there are similarities in the mechanism of toxicity of the baits (Kristensen & Jesperson, 2008). This could explain the similarity in efficacy of Agita® and QuickBayt®.

A study conducted by Novartis Animal Health Inc. (2002) produced contradictory results. In the study, Agita® demonstrated significant superiority over the imidacloprid bait. The study however was carried out around enclosed animal pens and not in a wide-open area. Ayyapath *et al.* (2000) showed that imidacloprid was significantly more effective against fruit flies (Tephritidae) than thiamethoxam. In the present study, the two neonicotinoid baits were tested against a broad range of fly species, which could indicate that when used against fly populations of various species, the two baits provide the same level of efficacy.

In the present study, the mean number of flies feeding on Agita® was significantly higher than QuickBayt®. This indicates that Agita® is more attractive to filth flies compared to QuickBayt®. However, the reason for the difference in attractiveness of the two baits is unclear because both baits are formulated with sugar and the fly pheromone Z-(9)-Tricosene. The difference in attractiveness could be due to the difference in the application method of the baits and further investigation is warranted.

Effects of Various Application Method on Efficacy of QuickBayt®

According to the product label, QuickBayt® can be scattered on the ground or placed into a bait station and can also be mixed with water and painted onto surfaces to kill resting flies. The suggested application methods were compared to see whether they affected the attractiveness and efficacy of the bait. When mutually compared, the overall knockdown effect of the 4 QuickBayt® application methods did not vary significantly.

The difference in surface area of the petri dish and cardboard when used as bait receptacles did not change the efficacy of the bait. The variation in the amount of water needed to dissolve the bait granules also did not affect the knockdown capability of the bait. This can be seen from the wet-down and paint-on application methods in this study. The wet-down application method does not follow the recommended amount of water needed to dissolve the granules; the water was only sprayed onto the granules to soak them, whereas the paint on application followed the recommended application of water to granule ratio. This indicates that the various recommended application methods, do not affect the efficacy of QuickBayt®. Bait efficacy, could be more related to dosage or positioning of baits rather than method of application. This was demonstrated by Barson (1987, 1989), when bomyl and methomyl baits were applied scattered on the ground or in suspended bait targets. In the studies, the baits that were scattered on the ground were more effective than when applied on suspended bait targets.

The attractiveness of QuickBayt® however differed significantly when applied under different methods. Surface

area and moisture appears to be important in determining the attractiveness of the bait. The attractiveness of QuickBayt® was markedly increased when applied with a high moisture method (painted on cardboard) and on a larger surface area (scattered on cardboard). A larger surface area exposes more of the bait to flies. Therefore, if QuickBayt® were applied in a paint-on application over a wide surface area, attractiveness would be significantly increased and more flies would be exposed to the bait.

Even though the attractiveness of QuickBayt® differed when applied differently, the knockdown effect of the bait remains relatively the same. Thus, this study shows that QuickBayt® is versatile and can be used in many forms without reduction in efficacy. Versatility is important in fly baits because different application methods of baits must be employed in certain conditions (Barson, 1987). In the current study location, application of QuickBayt® by scattering on the floor is not practical because municipal workers usually clean the floor. The use of the bait in this form would entail frequent and uneconomical applications. However, it has been suggested that conspicuous granules alone are sufficient stimulus to induce feeding behaviour in flies (Nicholas, 1988). In places such as animal or poultry farms for example, scatter baits cannot be applied onto the ground due to the poison risk to stock if the granules are eaten (Learmount *et al*., 1996). Therefore, in these conditions a paint-on application might be more suitable or applications of baits in granule form can be done by placing the baits in receptacles. Similarly, when paint-on applications of baits are not suitable, such as in animal pens where the walls and other surfaces are often washed, granular baits applied in bait station may be more practical. Thus, in conditions such as these, baits that offer versatility like QuickBayt® have the advantage over other baits.

In conclusion, we found that the efficacy of Agita® and QuickBayt® were similar under wide-open field conditions but that Agita® was more attractive to filth flies than QuickBayt®. QuickBayt®, however, is more versatile and can be used in a number of forms without a reduction in efficacy. This versatility gives QuickBayt® some advantages over Agita® and other strictly paint-on only based baits. The attractiveness of QuickBayt® is influenced by the surface area of exposure and moisture content.

Acknowledgements. The authors thank the Dean of the School of Biological Sciences, USM, for the facilities provided for the research. Bayer Environmental Science Malaysia and Syngenta Crop Protection Sdn Bhd. provided the chemical fly baits used in the study.

REFERENCES

Antunes-Kenyon, S.E. & Kennedy, G. (2001). Thiamethoxam: A new active ingredient review. Dept. of Food and Agriculture, Massachusettes Pesticide Bureau. 33pp.

Ayyapath, R., Polavarapu, S. & McGuire, M.R. (2000). Effectiveness of thiamethoxam-coated spheres against blueberry maggot flies (Diptera: Tephritidae). *Journal of Economic Entomology* **93**: 1473–1479.

Barson, G. (1987). Laboratory assessment of different methods of applying a commercial granular bait formulation of methomyl to control adult houseflies (*Musca domestica* L.) in intensive animal units. *Pesticide Science* **19:** 167–177.

Barson, G. (1989). Laboratory evaluation of the toxicity of 1,3-Di(methoxycarbonyl) prop-1-en-2-yl dimethyl phosphate (Bomyl) and Methomyl to susceptible and multiresistant strains of houseflies (*Musca domestica* L.). *Pesticide Science* **27:** 85–96.

Cox, C. (2001). Insecticide factsheet: Imidacloprid. *Journal of Pesticide Reform* **21:** 15–21.

Emerson, P.M., Lindsay, S.W., Walraven, G.E.L., Faal, H., Bogh, C., Lowe, K. & Bailey, R.L. (1999). Effect of fly control on trachoma and diarrhoea. *Lancet* **353:** 22–25.

Freeman, Z.A. & Pinniger, D.B. (1992). The behavioural responses of three different strains of *Musca domestica* (Diptera: Muscidae) to Alfacron bait in the laboratory. *Bulletin of Entomological Research* **82**: 471–478.

Ferriera, M.J.D.M. & Lacerda, P.V.D. (1993). Synanthropic muscoids associated with the urban garbage in Goiania, Goias. *Revista Brasileira de Zoologia* **10:** 185–195.

Graczyk, T.K., Knight, R., Gilman, R.H. & Cranfield, M.R. (2001). The role of non-biting flies in the epidemiology of human infectious diseases. *Microbes and Infection* **3**: 231–235.

Gregor, F., Pont, A., Paterson, H.E. & Wheeler, M.R. (1971). Keys to Adult Flies. In: Flies and Disease, Vol. 1: Ecology Classification And Biotic Association (B. Greenberg, Editor) pp85-160. Princeton University Press, Princeton New Jersey.

Kim, U. (2006) Neonicotinoid insecticides. *MMG 445 Basic Biotechnology eJournal* **2**: 46–52.

Koehler, P.G. & Oi, F.M. (1991). Filth-breeding flies. Entomology and Nematology Departmennt, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Series ENY-222.

Kristensen, M. & Jespersen, J.B. (2008). Susceptibility to thiamethoxam of *Musca domestica* from Danish livestock farm. *Pest Management Science* **64:** 126–132.

Kurahashi, H. (2002). Key to the calliphorid adults of forensic importance in the oriental region. In: Entomology And The Law (Editors, B. Greenberg and J.C. Kunich, J.C.) pp 127-138. Cambridge University Press, Cambridge.

Learmount, J., Chapman, P.A., Morris, A.W. & Pinniger, D.B. (1996). Response of strains of house fly, *Musca domestica* (Diptera: Muscidae) to commercial bait formulations in the laboratory. *Bulletin of Entomological Research* **86:** 541–546.

Maienfisch, P., Huerlimann, H., Rindlisbacher, A., Gsell, L., Dettwiler, H., Haettenschwiler, J., Sieger, E. & Walti, M. (2001). The discovery of thiamethoxam: a second-generation neonicotinoid. *Pest Management Science* **57**: 165–176.

Matsuda, K., Buckingham, S.D., Kleier, D., Rauh, J.J., Grauso, M. & Sattelle, D.B. (2001). Neonicotinoids: insecticides acting on insect nicotinic acetylcholine receptors. *Trends in Pharmacological Sciences* **22**: 573–580.

Nicholas, J.T. (1988). Behaviour of the housefly *Musca domestica* in relation to insecticide baits. PhD thesis, Southampton University.

Novartis Animal Health Inc. (2002). Agita Technical Information. Novartis Inc., Basel, Switzerland. 9pp.

Olsen, A.R. (1998). Regulatory action criteria for filth and other extraneous materials. III. Review of flies and foodborne enteric diseases. *Regulatory Toxicology Pharmacology* **28**: 199–211.

Pospischil, R., Junkersdorf, J. & Horn, K. (2005). Control of house flies, *Musca domestica* (Diptera: Muscidae), with imidacloprid WG 10 in pig farms (Germany). *Proceedings of the Fifth International Conference on Urban Pests* (eds. Chow-Yang L. & Robinson W.H.). Perniagaan Ph'ng @ P&Y Design Network, Malaysia. Pp 309-317.

Ware, G.W. (2000). The Pesticide Book, 5th edition. Thomson Publications, Fresno, California.

WHO. (1991). Insect and rodent control through environmental management: A community action programme. WHO, Geneva.