Proceedings of the Sixth International Conference on Urban Pests
William H Robinson and Dániel Bajomi (editors), 2008
Printed by OOK-Press Kft., H-8200 Veszprém, Pápai út 37/a, Hungary

SUCROSE BAIT BASE PREFERENCE OF SELECTED URBAN PEST ANTS (HYMENOPTERA: FORMICIDAE)

CHOW-YANG LEE
Urban Entomology Laboratory, Vector Control Research Unit, School of Biological Sciences,
Universiti Sains Malaysia, 11800 Penang, Malaysia.

Abstract Choice experiments determined sucrose bait base preference by using laboratory colonies of 10 species of urban pest ants, namely *Monomorium pharaonis* (L.), *Monomorium floricola* (Jerdon), *Monomorium destructor* (Jerdon), *Monomorium orientale* Mayr, *Tapinoma indicum* (Forel), *Tapinoma melanocephalum* (Fabricius), *Anoplolepis gracilipes* (Fr. Smith), *Paratrechina longicornis* (Latrielle), *Pheidole* sp. and *Solenopsis geminata* (Fabricius). Four bait bases (liquid, gel, paste and granule) without toxicants were prepared in 30% sucrose w/w. They were presented simultaneously to the foraging ants. The number of ants foraging to each bait base was recorded after 60 minutes. Results indicated that liquid bait base was the most attractive base to all species tested (with exception to *Pheidole* sp. and *S. geminata*), followed by gel bait base. Granular bait base was only attractive to *Pheidole* sp. and *S. geminata* while response to paste bait was limited. *T. indicum*, *T. melanocephalum*, *P. longicornis* and *A. gracilipes* foraged very quickly to both liquid and gel bait bases (mean = 5.4 - 9.4 min after introduction), when compared to the paste and granular bait bases (mean = 8.4 and 20.3 min). On the other hand, *S. geminata* and *Pheidole* sp. took ≥ 29 min for the first forager to arrive at a bait base.
Key Words: bait matrix, liquid, gel bait, paste bait, bait granule

INTRODUCTION

Baiting is a reliable method to manage many urban pest ant species (Knight and Rust, 1991; Forschler and Evans, 1994; Vail et al, 1996; Lee, 2000; Lee et al., 2003; Lee, 2007). A food bait base is usually formulated with a slow-acting insecticide. Via trophallaxis, baits with toxicant that were consumed by foraging workers are transferred to other colony members, and this will suppress the population, or even cause elimination of the population. A good toxic bait generally consists of four major components (Cherrett and Lewis, 1974), namely a food attractant, or pheromone that will increase its palatability and acceptance (Peregrine, 1973), a carrier which provides the physical structure or matrix to the bait, a non-repellent toxicant with a delayed action (Stringer et al., 1964), and other materials such as emulsifiers and antimicrobial agents. Bait acceptance and the amount of bait that are taken back to the colony are crucial to the success of baiting (Forschler and Evans, 1994).

Certain bait bases are more attractive to some pest ant species, while others are less attractive. In general, liquid and gel baits were more acceptable than granular and paste baits to the crazy ant (*Paratrechina longicornis*) (Lee, 2002; Lee and Tan, 2004). An acceptable bait base is extremely important to ensure enough intake of toxicant by foraging individuals to achieve effective management. This study was initiated to determine the preference of some species of urban pest ants in Malaysia to sucrose-based bait base formulations.

MATERIALS AND METHODS

Ants

Laboratory colonies of *Monomorium pharaonis*, *Monomorium floricola*, *Monomorium destructor*, *Monomorium orientale*, *Tapinoma indicum*, *Tapinoma melanocephalum*, *Anoplolepis gracilipes*, *Paratrechina longicornis*, *Pheidole* sp. and *Solenopsis geminata* were used in the evaluation. They were collected earlier from the field and have been reared in the laboratory for more than 6 months prior to the evaluation. The insects were cultured under environmental conditions of 26 ± 2°C and 60 ± 5% RH and provided with 20% sucrose solution, freshly killed lobster cockroach (*Nauphoeta cinerea*) and boiled egg

yolk *ad libitum*. For the experiments, small colonies that were separated from the culture stocks were used. Each small colony consisted of 2- 4 queens, 0.1 g brood and 400 — 600 worker ants.

Evaluations

Experiments were set up by acclimatizing one small ant colony in a plastic Petri dish at the center of a test arena (measuring 40.0 x 24.5 x 8 cm) for 72 hours in the presence of food and water. After that period, the ants were starved overnight and the experiment was initiated the next morning. Four bait bases (without toxicant), namely liquid, gel, paste and granule (particle size: 0.72 — 1.22 mm) bait formulations, were prepared in 30% sucrose w/w. Two grams each of the bait base was randomly placed at a corner of the test arena. Delivery of the liquid bait was made via a cotton bung (to prevent ants from drowning), while the rests were placed on a small petri dish. Food and water were removed from the test arena during the test. Observation was made as soon as the bait bases were placed. The time taken for the first foraging ant to arrive at each bait base ant was recorded. After 60 minutes, the number of foraging ants within the 2 cm radius of each bait base was recorded by taking a digital picture and later counted on a computer. The number of foraging ants on the four bait bases were combined, and the percentage ants on each base of the total foraging ants was determined. Each experiment was replicated 5 times by using a colony each time.

Data Analysis

Data on the time taken by foraging ants to arrive to each bait base were subjected to one-way ANOVA and means were separated with Tukey HSD. Data on bait base preference were analyzed with Kruskal-Wallis (KW) one-way analysis of variance, and means were separated by using KW multiple range test. All statistical analyses were performed by using Statistix™ Version 7.0 (Statistix, 2004).

RESULTS AND DISCUSSION

The time taken for foraging ants to first arrive to each bait base varied with species of the ants evaluated. *T. indicum*, *T. melanocephalum*, *A. gracilipes* and *P. longicornis* were the quickest in foraging to all bait bases when compared to other species (Table 1). On average, they took between 5.4 and 20.3 min to first arrive to a bait base, when compared to other species such as *Pheidole* sp. and *S. geminata* that required a minimum of 29 min. This could likely be due to the active foraging behavior of the former species (Lee and Tan, 2004). Most foraging ants evaluated (with exception to *M. orientale*, *A. gracilipes*, *Pheidole* sp. and *S. geminata*) showed significantly ($P < 0.05$) quicker time to arrive to liquid and gel baits, when compared to the other two bait base candidates.

Ants normally demonstrate 3 foraging strategies: (1) an individual exploring and collecting food, (2) an individual exploring for food and then recruiting other colony members to collect (mass recruitment), or (3) numerous ants exploring for food, but only an individual does the collection (Bernstein, 1975). For most pest ant species, the second strategy is normally used, as it is efficient and less time and energy-consuming. The ability to move fast and explore the environment quickly is also an additional advantage to fast foragers like *P. longicornis*, *T. melanocephalum*, *T. indicum* and *A. gracilipes*.

Table 1. Mean time taken by foraging ants to first arrive to each bait base evaluated.

Species	Mean time ± SEM (min)[1]			
	Liquid	Gel	Paste	Granule
M. pharaonis	21.8 ± 1.8 a	22.2 ± 1.9 a	31.5 ± 1.0 b	34.0 ± 1.0 b
M. floricola	20.8 ± 1.6 a	21.4 ± 1.4 a	29.0 ± 0.4 b	36.6 ± 2.0 c
M. destructor	24.6 ± 1.8 ab	23.0 ± 0.9 a	34.3 ± 2.3 b	32.5 ± 4.4 ab
M. orientale	29.6 ± 5.0 a	32.0 ± 1.7 a	35.7 ± 2.4 a	43.5 ± 8.5 a
T. indicum	7.8 ± 1.4 a	9.4 ± 1.6 a	20.3 ± 1.8 b	18.0 ± 2.6 b

T. melanocephalum	6.6 ± 0.8 a	7.0 ± 0.7 a	15.6 ± 1.0 b	16.0 ± 1.3 b
P. longicornis	5.8 ± 0.7 a	6.2 ± 1.0 a	14.2 ± 1.0 b	15.2 ± 0.7 b
A. gracilipes	5.6 ± 0.6 a	5.4 ± 0.5 a	8.4 ± 1.1 a	9.8 ± 1.8 a
Pheidole sp.	29.0 ± 2.7 a	30.4 ± 2.0 a	33.2 ± 1.8 a	32.0 ± 1.2 a
S. geminata	32.7 ± 1.2 a	31.7 ± 2.3 a	31.8 ± 1.4 a	31.0 ± 1.5 a

[1]Means followed by different letters within the same row are significantly different ($P < 0.05$; Tukey HSD).

With exception to *Pheidole* sp. and *S. geminata*, most pest ant species evaluated showed a preference towards liquid and gel baits (Table 2). At 60 minutes after the introduction of the 4 bait bases to the test arena, more than 80% of total foraging ants were attracted to the those two bait bases mentioned. The preference towards bait bases with higher moisture content was expected since most ant species are constantly deprived of water and moisture (especially those nesting indoors). Some species such as *T. melanocephalum* and *T. indicum* are also highly sensitive to dessication (Appel et al., 2004). *P. longicornis* and *A. gracilipes* took very short time (5.4 — 6.2 min) to discover the liquid and gel bait bases (Table 1) and showed high preference towards these two bait bases (Table 2). The high moisture content in these bait bases could have been the principal factor in the attraction. Earlier, Lee (2002) recommended carbohydrate-based liquid or gel baits for the control of *P. longicornis*. Similar to that was found in the earlier study, this study recorded that granular base was not attractive to *P. longicornis*. Stanley and Robinson (2007) in their field studies found that *P. longicornis* were not attracted to commercial granular baits such as Maxforce, Amdro and Presto, while tuna bait, Xstinguish (paste bait), sugar water and sugar water + boric acid were preferred by this species. On studies on *T. melanocephalum* (Klotz et al., 1996) and Argentine ant, *Linepithema humile* (Mayr) (Klotz et al., 1996; Harris et al., 2002), it was found that they were also highly attracted to moist bait matrix

Paste bait base are normally sold as containerized bait station against ants inside homes. It was found to be less effective than liquid and paste baits. The results reported here should be treated with caution because unlike the 30% sucrose w/w attractant used in this study, most commercial paste baits contained one to several food attractants. In addition, O'Brien and Hooper-Bui (2005) reported that ants demonstrated different feeding behavior when fed on formulated baits than those feeding on sugar water. They indicate that the physical properties in the formulated baits may be the attributing factor. Thus, the findings obtained in this study should not be loosely extrapolated to how the evaluated species will behave under similar bait base of commercial baits.

Table 2. Bait base preference of foraging pest ants evaluated in this study.

Species	**No. replicates**	**Mean % foraging ants ± SEM[1] at 60 min post-treatment**			
		Liquid	**Gel**	**Paste**	**Granule**
M. pharaonis	5	70.0 ± 1.9 a	22.0 ± 2.9 ab	6.6 ± 2.1 b	1.4 ± 1.0 b
M. floricola	5	59.8 ± 8.1 a	27.4 ± 10.7 ab	12.0 ± 3.3 ab	0.8 ± 0.4 b
M. destructor	5	62.2 ± 3.4 a	25.8 ± 3.3 ab	1.6 ± 1.0 b	7.4 ± 3.1 b
M. orientale	5	67.6 ± 3.8 a	26.6 ± 4.6 ab	4.8 ± 2.2 b	1.0 ± 1.0 b
T. indicum	5	83.4 ± 2.4 a	13.6 ± 1.9 ab	1.0 ± 1.0 b	2.0 ± 0.9 b
T. melanocephalum	5	76.8 ± 1.9 a	19.8 ± 1.4 ab	2.6 ± 1.9 b	0.8 ± 0.8 b
P. longicornis	5	76.2 ± 4.5 a	19.0 ± 3.5 ab	3.0 ± 2.0 b	1.8 ± 1.1 b
A. gracilipes	5	58.2 ± 3.3 a	21.4 ± 2.2 ab	2.6 ± 0.9 b	17.8 ± 2.4 ab
Pheidole sp.	5	11.4 ± 4.9 ab	4.6 ± 2.7 b	16.4 ± 5.6 ab	67.6 ± 5.7 b
S. geminata	5	3.2 ± 2.1 a	3.6 ± 2.2 a	11.0 ± 3.6 ab	82.2 ± 6.6 a

[1]Means followed by different letters within the same row are significantly different ($P < 0.05$, Kruskal-Wallis multiple range test).

In addition to the effect of bait base and nutritional preference, it is important to note that the limited visits by foraging ants granular baits (except *S. geminata* and *Pheidole* sp.) could be likely due to particle size of the granule used in this study (0.72 — 1.22 mm). Hooper-Bui et al. (2002) reported varying preference of food particle size of 6 species of urban ant species.

The results expressed in Table 2 are percentage of total foraging ants. In the case of *S. geminata*, the total foraging ants were 49-74 among the 5 replicates, while *T. indicum* had between 231 and 389 total foragers of all 5 replicates. *Pheidole* sp. had 86 — 132 foraging ants across the 5 replicates. The lower number of foraging for *S. geminata* and *Pheidole* could be likely due to their lower preference for carbohydrate-based food. These two species prefer to feed on proteinaceous and lipid-based food (Loke and Lee, 2004; Norasmah et al., 2006). Thus, the higher percentage of both species attracted to granule bait base did not imply comparable numbers of foragers attracted to liquid bait, for example in the case of *M. orientale*, or *T. indicum*. Silverman and Roulston (2001) cautioned against using worker numbers at baits as an indicator of bait performance, as the relative worker numbers were not consistent with actual consumption levels of the baits.

CONCLUSION

The liquid and gel bait bases were most attractive to all ant species evaluated, except against *Pheidole* sp. and *S. geminata*. Most ant species also took shorter time to discover both bait bases. *P. longicornis*, *A. gracilipes*, *T. indicum* and *T. melanocephalum* were active foragers and were able to find bait bases within a very short period when compared to other species. The current study demonstrated that there is a serious need to consider bait base preference among the different ant species, in addition to nutritional preference, when executing an ant management program. More studies will be undertaken in the field to further substantiate current findings.

ACKNOWLEDGMENTS

The author thank K.K. Peh (School of Pharmaceutical Sciences, Universiti Sains Malaysia) for formulating the bait bases used in this study; A. Lazim and T.W. Beh for technical assistance. This study was support under a short-term research grant provided by Universiti Sains Malaysia.

REFERENCES CITED

Appel, A.G., Na, J.P.S. and Lee, C.Y. 2004. Temperature and humidity tolerances of the ghost ant, *Tapinoma melanocephalum* (Hymenoptera: Formicidae). Sociobiology 44: 89 — 100.

Bernstein, R.A. 1975. Foraging strategies of ants in response to variable food density. Ecology 56: 213 — 219.

Cherrett, J.M. and Lewis, T. 1974. Control of insects by exploiting their behavior. pp. 130 — 146. In: Williams, D.F., ed. Exotic ants — Biology, impact and control of introduced species, Oxford, England: Blackwell Scientific.

Forschler, B.T. and Evans, G.M. 1994. Argentine ant (Hymenoptera: Formicidae) foraging activity response to selected containerized baits. J. Entomol. Sci. 29: 209 — 214.

Harris, R.J., Rees, J.S. and Toft, R.J. 2002. Trials to eradicate infestations of the Argentine ant, *Linepithema humile* (Hymenoptera: Formicidae) in New Zealand, pp. 67 — 74. In: Jones, S.C., Zhai, J. and Robinson, W.H., eds. Proceedings of the Fourth International Conference on Urban Pests, Blacksburg, Virginia: Pocahontas Press.

Hooper-Bui, L.M., Appel, A.G. and Rust, M.K. 2002. Preference of food particle size among several urban ant species. J. Econ. Entomol. 95: 1222 — 1228.

Klotz, J.H., Oi, D.H., Vail, K.W. and Williams, D.F. 1996. Laboratory evaluation of a boric acid liquid bait on colonies of *Tapinoma melanocephalum*, Argentine ants and Pharaoh ants (Hymenoptera: Formicidae). J. Econ. Entomol. 89: 673 — 677.

Knight, R.L. and Rust, M.K.. 1991. Efficacy of formulated baits for control of Argentine ant (Hymenoptera: Formicidae). J. Econ. Entomol. 84: 510 — 514.

Lee, C.Y. 2000. Performance of hydramethylnon- and fipronil-based containerized baits against household ants in residential premises. Trop. Biomed. 17: 45 — 48.

Lee, C.Y. 2002. Tropical household ants — pest status, species diversity, foraging behaviour and baiting studies. pp. 3 — 18. In: Jones, S.C., Zhai, J. and Robinson, W.H., eds. Proceedings of the Fourth International Conference on Urban Pests, Blacksburg, Virginia: Pocahontas Press.

Lee, C.Y. 2007. Perspective in Urban Insect Pest Management in Malaysia. Penang, Malaysia: Vector Control Research Unit, Universiti Sains Malaysia. 104 pp.

Lee, C.Y. and Tan, E.K.. 2004. Guide to Urban Pest Ants of Singapore. Singapore: Singapore Pest Management Association. 40 pp.

Lee, C.Y., Lee, L.C., Na, J.P.S., Loke, P.Y., Lim, K.T. and Teo, E.H.H. 2003. Evaluation of methoprene granular baits against foraging Pharaoh ant, *Monomorium pharaonis* (Hymenoptera: Formicidae). Sociobiology 41: 717 — 723.

Loke, P.Y. and Lee, C.Y. 2004. Foraging behavior of field populations of the big-headed ant, *Pheidole megacephala* (Hymenoptera: Formicidae). Sociobiology 43: 211 — 219.

O'Brien, K.S. and Hooper-Bui, L.M. 2005. Hunger in red imported fire ants and their behavioral response to two liquid bait products. J. Econ. Entomol. 98: 2153 — 2159.

Normasmah, B., Abu Hassan, A., Che Salmah, M.R. and Nur Aida, H.. 2006. Daily foraging pattern and proteinaceous food preferences of *Solenopsis geminata* (Fabricius) (Hymenoptera: Formicidae). Trop. Biomed. 23: 134 — 139.

Peregrine, D.J. 1973. Toxic baits for the control of pest animals. PANS 19: 523 — 533.

Silverman, J. and Roulston, T.H.. 2001. Acceptance and intake of gel and liquid sucrose compositions by the Argentine ant (Hymenoptera: Formicidae). J. Econ. Entomol. 94: 511 — 515.

Stanley, M.C. and Robinson, W.A.. 2007. Relative attractiveness of baits to *Paratrechina longicornis* (Hymenoptera: Formicidae). J. Econ. Entomol. 100: 509 — 516.

Statistix. 2004. Statistix™ for Windows, Version 7. Tallahassee, Florida: Analytical Software.

Stringer, C.E., Lofgren, C.S. and Bartlett, F.J.. 1964. Imported fire ant toxic bait studies: evaluation of toxicants. J. Econ. Entomol. 57: 941 — 945.

Vail, K.M., Williams, D.F. and Oi, D.H.. 1996. Perimeter treatment with two bait formulations of pyriproxyfen for control of Pharaoh ants (Hymenoptera: Formicidae). J. Econ. Entomol. 89: 1501 — 1507.