Effects of Colony Composition and Food Type on Nutrient Distribution in Colonies of *Monomorium orientale* (Hymenoptera: Formicidae)

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ABSTRACT *Monomorium orientale* Mayr (Hymenoptera: Formicidae) is a common structure- and food-infesting ant in Asia. There is only limited information on the biology and habits of this species, especially on the preferred foods and distribution of nutrients in colonies. We conducted a laboratory study on the distribution of carbohydrates, proteins, and lipids, which were represented by respective food sources, in *M. orientale* colonies. Three colony conditions were applied: normal, with a balanced ratio of castes, queenless (only workers and brood), and broodless (only queens and workers). Food sources were stained to track the flow of the respective food in the colonies. Results revealed that carbohydrates had rapid distribution, with >60% of the colony indicated in 24 h, in all colony conditions. Queens in all colonies did not feed on protein. Protein showed a more delayed distribution in the brood in all colony conditions; <10% of the colony fed on protein by 24 h. Only queens in broodless colonies showed signs of feeding on lipid, with <10% indicated in 24 h. Workers in all colonies fed on lipid as soon as it was delivered, whereas the brood only began to reveal feeding response after 24 h.

KEY WORDS *Monomorium orientale*, food distribution, colony composition, food type

Monomorium orientale Mayr is closely related to the Pharaoh ant, *Monomorium pharaonis* (L.), and *Monomorium destructor* (Jerdon). The pest status of *M. pharaonis* and *M. destructor* in Asia has been reported previously (Yap and Foo 1984, Yap and Lee 1994, Na and Lee 2001, Lee et al. 2002). However, there is little biological information on *M. orientale,* except that it is omnivorous and feeds on a variety of foodstuffs (Hedges 1998). Trophallaxis in ants occurs in response to carbohydrate, protein, and lipid foods (Howard and Tschinkel 1980; Sorensen and Vinson 1981; Sorensen et al. 1981, 1985). In *M. pharaonis,* trophallactic activity associated with liquid carbohydrate directly affects duration of foraging. The foragers collect and distribute liquid carbohydrates quickly, possibly because of the rapid replenishment of the high energy requirements of workers.

The objective of the research presented here was to examine how different food types are distributed in the colony of *M. orientale* under different colony compositions in the laboratory. By integrating other aspects of its feeding behavior such as food preference and foraging activity with the findings from this study, we would be able to obtain a more in-depth understanding of how the social organization of the colony governs its feeding preferences and subsequently manipulate these behaviors to come up with effective, attractive, and palatable bait materials.

Materials and Methods

Insects. Ants used in this study were from stock cultures at the Urban Entomology Laboratory, Vector Control Research Unit, School of Biological Sciences, Universiti Sains Malaysia, Penang, Malaysia. These subcultures were kept in petri dish nests (9.0 cm in diameter) with corrugated paper as harborage, placed in aluminum trays (40.0 by 24.5 by 8.0 cm). The upper-inner sides of the trays were coated with a thin layer of Fluon (polytetrafluoroethylene suspension) to prevent ants from escaping. Moisture and water were provided via an inverted plastic cup on a petri dish lid sealed with damp cotton around its rims. Foods provided ad libitum comprised a mixture of carbohydrate, protein, and lipid sources. Colonies were maintained under laboratory conditions (27°C, 66% RH, and a photoperiod of 12:12 [L:D] h). Each colony consisted of ≈100–150 queens and 10,000–15,000 workers with at least 2.0 g of brood of mixed stages.

Effects of Caste Composition. Experimental colonies were separated from the main colony into aluminum trays (40.0 by 24.5 by 8.0 cm). Three colony compositions comprising queens, workers, and brood of mixed stages were used. These colonies were named

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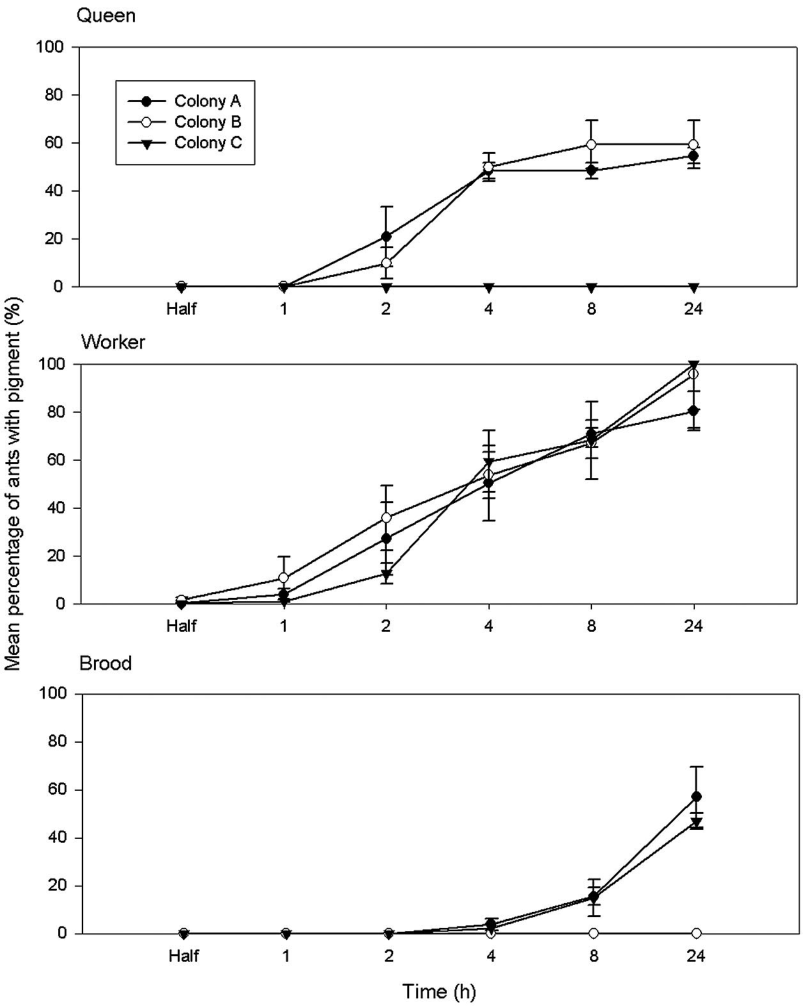

Fig. 1. Distribution of carbohydrate in *M. orientale* under different colony compositions: 10 queens, 2,000 workers, and 50 mg of brood (A); 20 queens and 2,000 workers (B); and 2,000 workers and 100 mg of brood (C). Error bars represent SEM.

colony A (all castes present) (10 queens, 2,000 workers, and 50 mg of brood), colony B (broodless) (20 queens and 2,000 workers), and colony C (queenless) (2,000 workers and 100 mg of brood). Every condition was replicated four times. Still digital images of the colonies were captured with a camera (Nikon Coolpix 880), and the number of stained ants (queens, workers, and active brood) as well as the total number of ants were counted and recorded at intervals 0.5, 1, 2, 4, 8, and 24 h or at 72, 120, and 144 h when necessary.

Effects of Food Type. Three food types used were 40% sucrose solution (carbohydrate), freshly mashed canned tuna (protein), and olive oil (lipid), all chosen based on preliminary food preference tests and nutrient content. The foods were stained: sucrose and tuna blue [True Blue Color 10% (vol:vol) and (wt:wt), respectively], and oil, red [Sudan IV 10% (wt:wt)]. Foods were given separately to colonies with the respective caste compositions mentioned above with each replicated four times. Still digital images of the colonies were captured with a camera (Nikon Coolpix 880). The number of stained queens, workers, active brood and the total number of ants were recorded at intervals 0.5, 1, 2, 4, 8, and 24 h or at 72, 120, and 144 h when necessary.

Data Analysis. Results that were recorded in percentage were arcsine transformed before being analyzed with univariate General Linear Model. Means were separated with Tukey's honestly significant difference (HSD) ($P = 0.05$) by using SPSS 11.0 for Windows (SPSS Inc., Chicago, IL).

Results and Discussion

For all three colony compositions, carbohydrate had a relatively rapid distribution, with >60% of the various castes (queens, workers, and brood taken into account) showing the pigment in 24 h (Fig. 1). Visual observation indicated that ants continued feeding on sucrose for >30 min, and it was dispersed to almost the

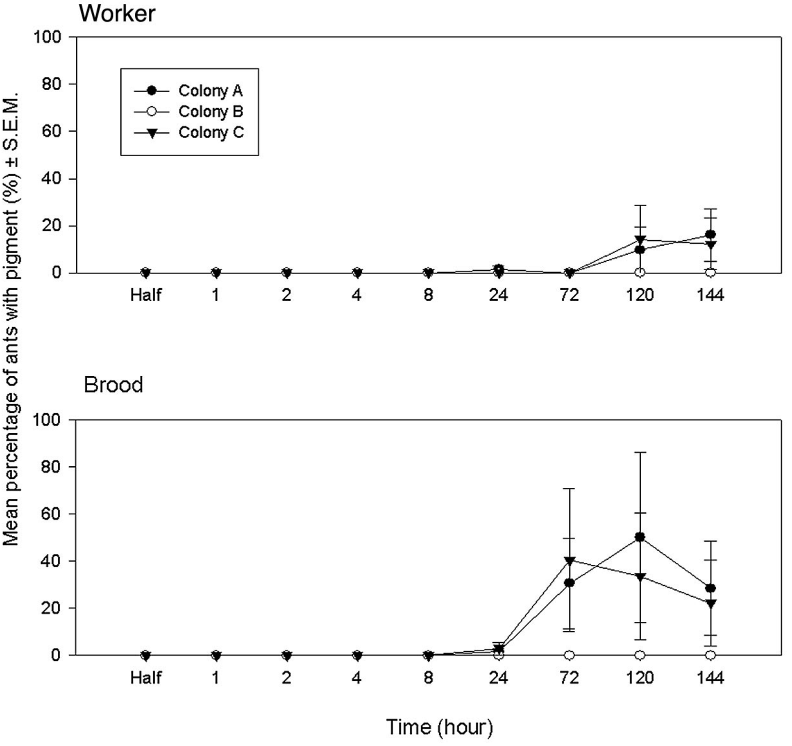

Fig. 2. Distribution of protein in *M. orientale* under different colony compositions: 10 queens, 2,000 workers, and 50 mg of brood (A); 20 queens and 2,000 workers (B); and 2,000 workers and 100 mg of brood (C). Error bars represent SEM.

entire colony after that, judging from the pigment observed in most of the colony members. Although there was a delayed flow of carbohydrate in larvae and was less accumulated than in the workers, it has been reported that larvae can contain twice the amount of sugar water per unit weight compared with foragers in colonies that are well-supplied with sugar water (Petralia and Vinson 1978, Sorensen and Vinson 1981).

Queens in all colonies were not fed protein at all, even after 144 h. Because the queens used were fertile queens, this unusual finding suggested that *M. orientale* queens might need a longer time than the one allocated for the predigestion of protein by larvae before they finally get a share of it. After 120-h exposure, workers showed signs of protein feeding in colonies A and C (Fig. 2). Protein showed a delayed response in the brood in all colonies (<10% of the colony by 24 h). Sorensen et al. (1983) reported a significant difference in protein consumption between the temporal subcastes of *Solenopsis invicta* Buren in terms of the rate of protein transfer and its internal distribution. As protein supply increases, the reserves respond by transferring food more slowly, so it was deduced that there is only a short-term reserve for proteins in the colony. Because our study provided a constant supply of protein, the delayed response toward protein could have been signaled by the reserves.

Proteolytic activity in the workers' midguts increases with the presence of larvae, suggesting the possible exchange of proteinases from larvae to workers during feeding. Proteinase activity was still found in the midguts of workers in the absence of larvae but was thought to be correlated with food type (Sorensen et al. 1983). Proteolytic activity in the queen is higher in the presence of workers. This may be because the predigestion of food by workers feeding the queen. Starvation was not a considered parameter in our study because the food source was given and replaced continuously. Yet, the queen ants in the colonies A and B did not reveal signs of feeding even after some of the workers have fed. In colony B, where no immature caste was present, the workers did not show ingestion of protein.

For lipid distribution, queens in colony B demonstrated signs of feeding; <10% were indicated in 24 h (Fig. 3). In general, lipid had a relatively quicker response whereby workers in all colonies began to feed as soon as it was delivered. The brood began to respond after 24 h. Lofgren et al. (1964) reported acceptability of fats and oils as food for *Solenopsis saevissima richteri* Forel, and Vinson et al. (1967) reported that linoleic and linolenic acids in certain oils act as phagostimulants for this particular species. They found that the distribution of oil was very similar to that of sugar. In general, all castes contained a greater percentage of oil (amount of oil found in total ant numbers), followed by sugar and protein (Vinson 1968), which was in agreement with the observation in our studies. He also reported that the major and

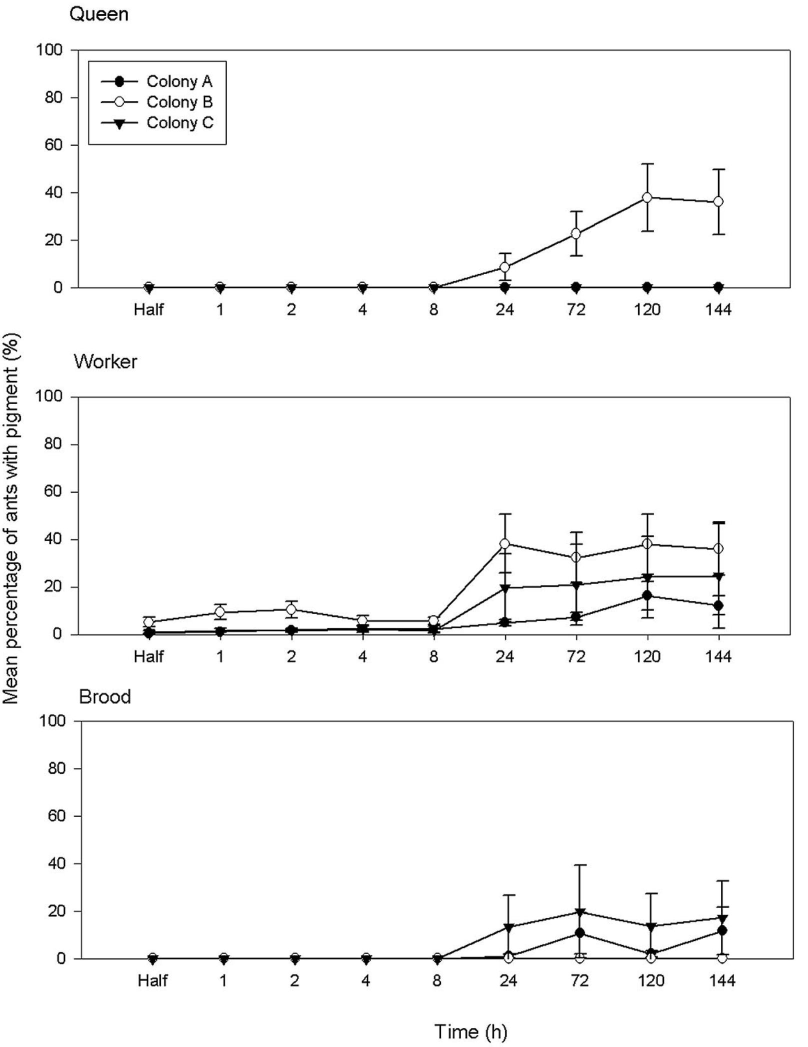

Fig. 3. Distribution of lipid in *M. orientale* under different colony compositions: 10 queens, 2,000 workers, and 50 mg of brood (A); 20 queens and 2,000 workers (B); and 2,000 workers and 100 mg of brood (C). Error bars represent SEM.

minor workers of *S. saevissima richteri* demonstrated varied behaviors when feeding. Our results also agreed that larvae had the greatest percentage of sugar, even though workers were reported to be more selfish when it comes to sharing sugar. Protein content in workers was, in contrast, negligible.

The entry of food in the ant colony is governed by colony size and nutritional needs (Sudd 1967, Wilson 1971, Abbott 1978). Howard and Tschinkel (1981) reported that food-sharing behavior varied with food type, whereas the amount of food consumed was influenced by the interaction between food type and starvation. We did not induce starvation in our study so the amount of food ingested (indicated by the presence of dye contained in the abdomen) was certainly influenced only by food type.

Our findings imply that trophallaxis occur in all colonies of *M. orientale* in response to carbohydrate, protein, and lipid. Similarly to studies discussed herein, distribution rate of liquid carbohydrate was the highest, suggesting that it could be a suitable bait matrix to control infestations of *M. orientale.* Studies on the effects of different structures and formulations of carbohydrates on food distribution in the colony could be conducted to extend these findings and to verify the most effective bait material for *M. orientale.*

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References Cited

Abbott, A. 1978. Nutrient dynamics of ants, pp. 233–244. *In* M. V. Brian [ed.], Production ecology of ants and termites. Cambridge University Press, London, United Kingdom.

Hedges, S. A. 1998. Field guide for the management of structure-infesting ants. GIE Inc., Publishers, Cleveland, OH.

Howard, D. F., and W. R. Tschinkel. 1980. The effect of colony size and starvation on food flow in the fire ant, *Solenopsis invicta* (Hymenoptera: Formicidae). Behav. Ecol. Sociobiol. 7: 293–300.

Howard, D. F., and W. R. Tschinkel. 1981. The flow of food in colonies of the fire ant, *Solenopsis invicta:* a multifactorial study. Physiol. Entomol. 6: 297–306.

Lee, C. Y., C. Y. Lim, and I. Darah. 2002. Survey on structure-infesting ants (Hymenoptera: Formicidae) in food preparative outlets. Trop. Biomed. 19: 21–26.

Lofgren, C. S., F. J. Bartlett, and C. E. Stringer. 1964. The acceptability of some fats and oils as food to imported fire ants. J. Econ. Entomol. 57: 601–602.

Na, J.P.S., and C. Y. Lee. 2001. Identification key to common urban pest ants in Malaysia. Trop. Biomed. 18: 1–17.

Petralia, R. S., and S. B. Vinson. 1978. Feeding in the larvae of the imported fire ant, *Solenopsis invicta:* behavior and morphological adaptations. Ann. Entomol. Soc. Am. 71: 643–648.

Sorensen, A. A., and S. B. Vinson. 1981. Quantitative food distribution studies within laboratory colonies of the imported fire ant, *Solenopsis invicta* Buren. Insect Soc. 28: 129–160.

Sorensen, A. A., T. M. Busch, and S. B. Vinson. 1983. Behavior of worker subcastes in the fire ant, *Solenopsis invicta,* in response to proteinaceous food. Physiol. Entomol. 8: 83–92.

Sorensen, A. A., T. M. Busch, and S. B. Vinson. 1985. Control of food influx by temporal subcastes in the fire ant, *Solenopsis invicta.* Behav. Ecol. Sociobiol. 17: 191–198.

Sudd, J. H. 1967. An introduction to the behaviour of ants. E. Arnold, London, United Kingdom.

Vinson, S. B. 1968. The distribution of an oil, carbohydrate, and protein food source to members of the imported fire ant colony. J. Econ. Entomol. 61: 712–714.

Vinson, S. B., J. L. Thompson, and H. B. Green. 1967. Phagostimulants for the imported fire ant, *Solenopsis saevissima* var. *richteri.* J. Insect Physiol. 13: 1729–1736.

Wilson, E. O. 1971. The insect societies. Harvard University Press, Cambridge, MA.

Yap, H. H., and A.E.S. Foo. 1984. Household pests and household insecticide usage on Penang Island, Malaysia. A questionnaire survey. Bull. Public Health Soc. 16: 2–8.

Yap, H. H., and C. Y. Lee. 1994. A preliminary study on the species composition of household ants on Penang Island, Malaysia. J. Biosci. 5: 64–66.

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