

Effects of Colony Compositions and Food Type on Foraging Behavior of *Monomorium orientale* (Hymenoptera: Formicidae)

by

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ABSTRACT

Monomorium orientale is a common household pest ant species in the Asian region. There is little information on the foraging behavior of this species. A laboratory study was conducted on its foraging activity and foraging group size. It focused on how different colony compositions and different food sources influence daily foraging rhythm and the number of foragers. The light/ dark cycle was adjusted over a 72-hour period to observe foraging trends. Results showed that colonies with a balanced caste composition (normal) had a circadian rhythm, with peak activity recorded between 0000-0400 h. Queenless and broodless colonies had no evident trends of foraging activity. Different food sources did not have any effects on the normal colonies. Queenless and broodless colonies showed larger foraging groups for carbohydrate and lipid foods, respectively ($p < 0.05$).

Keywords: *Monomorium orientale*, foraging activity, foraging group size, colony composition, food type.

INTRODUCTION

Monomorium orientale is a common structure-invading and food-infesting pest species in the Asian region. It is closely related to the Pharaoh's ant, *Monomorium pharaonis* and the Singapore ant, *Monomorium destructor* which are also common household pest ants (Yap & Foo 1984, Yap & Lee 1994, Na & Lee 2001, Lee *et al.* 2002). To date, there is limited information on its colony foraging habits. Many studies have been conducted on the foraging behavior of other ant species (Sudd 1967, Hölldobler & Wilson 1990). Different species adopt different foraging patterns or strategies (Ayre 1962) with a particular proportion of foragers feeding on liquid food and demonstrating high trophallaxis rates (Stradling 1978). Previous work reported that foraging workers of *Monomorium* spp. are passive-movers unlike the erratic foragers from the *Tapinoma* or *Paratrechina* genera (Edwards 1986).

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Sudd (1960) and Fourcassié & Deneubourg (1994) reported that *M. pharaonis* prefer to forage in the day. Foraging activity in the ant colony is promoted by hunger, temperature and condition of the brood (Wallis 1962; Hölldobler & Wilson 1990) and recruitment activity was found to increase with hunger as well as being dependent on the nature of food and the presence of brood in the colony (Sudd 1960; Portha *et al.* 2004; Mallieux *et al.* 2000). With the examples mentioned, there are certainly many aspects that need exploring before we could completely understand the foraging behavior of one particular species. It is only with that knowledge that we could effectively manage household ant infestation problems. The objective of this study was to determine the foraging activity of *M. orientale* in terms of circadian rhythm and the foraging group size of a colony. The authors hypothesize that food type and colony composition influence foraging activity. Therefore, these factors were taken into account to determine if they affect how foraging decisions are made. We believe that this information would aid in the execution of an effective and efficient management program to control this pest species especially in areas of bait placements and bait palatability according to changes that take place in the colony.

MATERIALS AND METHODS

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. Each colony consisted of approximately 100-150 queens, 10,000 to 15,000 workers with at least 2.0 g of brood of mixed stages. Food provided *ad libitum* comprised a mixture of carbohydrate, protein and lipid sources. Colonies were maintained in laboratory conditions (27 °C, 66 % RH) with a 12:12 photoperiod.

Daily foraging activity under various colony compositions

Experimental colonies with three different colony compositions were separated from the main colony into new aluminium trays; normal (10 queens: 2000 workers: 50 mg brood), queen (20 queens: 2000 workers) and immature (2000 workers: 100 mg brood). Every condition was replicated 10 times. Three food types were used; 40% sucrose solution (w:w) (carbohydrate), freshly-mashed canned tuna (protein) and olive oil (lipid). Colonies were subjected to a 12:12 daily photoperiod. Ant activity was recorded using a video camera (Geovision™ - 600 Multicam System, GV-Series System Software) for a total of 72 hours for each replicate. The numbers of ants that foraged and fed on the foods were counted every half hour. Data were processed using the program, Curve Expert 1.3.

Effects of colony caste composition and food type on the foraging group size

Experimental colonies and settings were established similar to the first part of the study. Every condition was replicated 10 times and was separately tested with the different food types similar to the previous test. Ant activity was recorded using a video camera (Geovision™ – 600 Multicam System, GV-Series System Software) for a total of 72 hours for each replicate. The number of ants that foraged for food within an area of 25.0 cm x 21.0 cm was counted every half hour. Data were analyzed using Univariate General Linear Model and means were separated using Tukey's HSD ($p < 0.05$).

RESULTS AND DISCUSSION

Daily foraging activity under various colony compositions

Normal colonies displayed foraging activity which fits a sinusoidal curve ($y = 6.376 + 2.952 \cos(0.003x - 1.733)$), with peak activities recorded early in the morning, between 0000 and 0400 h daily (Fig. 1). Queens and immature colonies did not reveal any specific peak activity period. Sudd (1960) reported that *M. pharaonis* colonies became inactive at night but began foraging again between 0700 and 0900 h while Lee (2002) reported that field colonies recorded peak foraging activity from two to four hours after sunset till late afternoon the next day. This is in contrast with our findings, indicating that different species from the same genus may employ different foraging hours. Lee (2002)

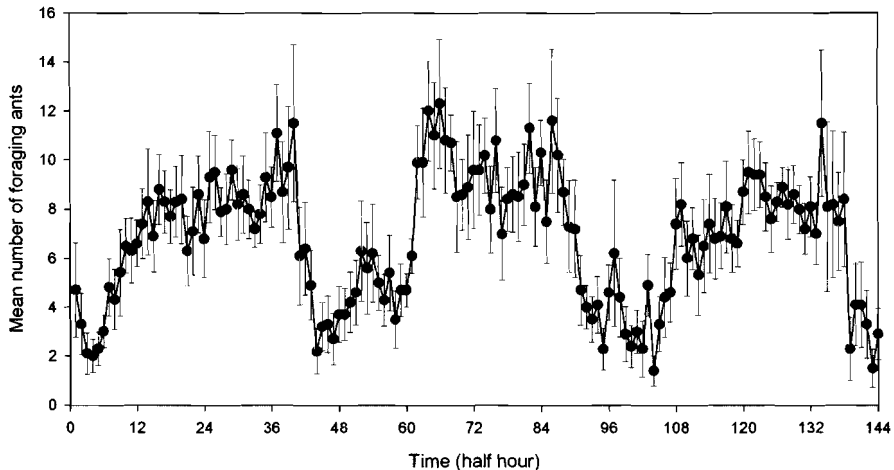


Fig. 1. Foraging activity of *Monomorium orientale* under the normal colony condition (10 queens, 2000 workers, 50 mg brood). Error bars represent SEM.

reported that the foraging activity patterns of *M. pharaonis*, *Paratrechina longicornis* and *Solenopsis geminata* were negatively correlated with ambient temperature.

Foraging activity is constrained by low humidity in the day and low temperature at night. In field situations, activity diminishes once ground temperature exceeds 30 °C. This suggests that substrate temperature is a significant factor in the natural environment but not in laboratory conditions where foraging activity increases as humidity decreases (Haines & Haines 1978). In this study, we did not take into account how temperature could induce different foraging activity because it was conducted in the laboratory and quantitative fluctuations in laboratory temperature were negligible. Foraging temperature ranges of ants are the shortest and have the least amount of overlapping among different species (Bernstein 1979) explaining the discrepancies between *M. orientale* and other species. Daily and seasonal schedules of foraging activity may also be consequences of morphological, physiological or behavioral characteristics of the foragers. Bernstein (1974) had described the relationship between seasonal foraging time and food abundance and how it is perpetuated by the requirement for increased colony food intake during development of reproductives. Diaz (1992) reported that maximum foraging was observed when a colony is increasing its workforce and allocating resources to reproductives even when it is out of phase with food availability.

Our studies provided constant food supplies so the different results recorded were primarily influenced by the simulated colony compositions. Queens and immature colonies failed to display obvious trends in foraging activity most probably because of the lack of brood signal or queen control respectively, as opposed to the balanced caste composition in the normal colonies.

Effects of colony caste composition and food type on the foraging group size

Normal colonies showed peak foraging at 1200 h while inactivity was recorded at midnight. This was consistent for all three food types. The different food types did not cause significant changes in forager numbers (Fig. 2). Queen colonies showed that carbohydrate induces a relatively higher number of foragers ($p < 0.05$) while immature colonies revealed that lipid attracts more foragers ($p < 0.05$) with peak foraging hours demonstrated at night (Fig. 2). Bernstein (1975) reported that food density and foraging area are inversely related but this relationship could not be observed in our study since we only manipulated the food type.

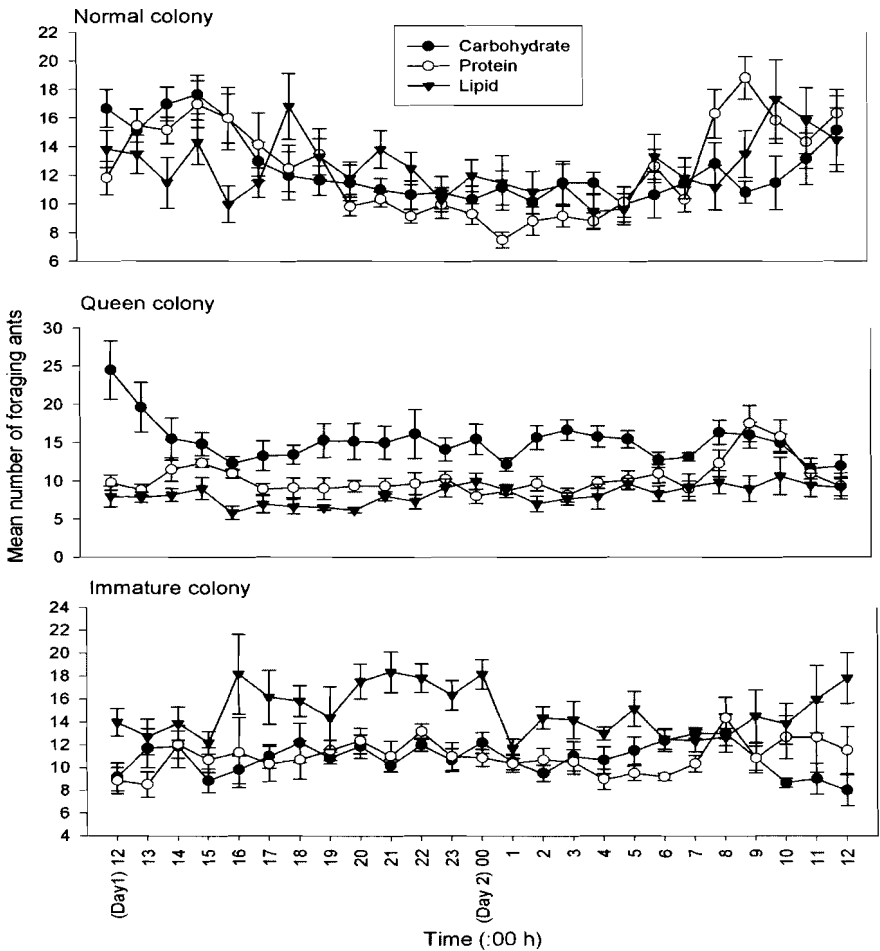


Fig. 2. Foraging group size of *Monomorium orientale* to various food sources under different colony compositions; Normal (10 queens, 2000 workers, 50 mg brood). Queen (20 queens, 2000 workers) and Immature (2000 workers, 100 mg brood). Error bars represent SEM.

Foraging responses of ants have been reported to change depending on food type (Detrain & Deneubourg 1997), food size (Traniello 1987), spatio-temporal distribution of available food (Detrain *et al.* 1999), distance (Hölldobler 1976), food quality (Traniello 1983) and the intrinsic characteristics of ant colonies (Detrain *et al.* 1999). Our results agree with this explanation where normal colonies with a balanced caste composition had no particular need to increase or decrease its foraging population towards a particular food. Immature colonies which prob-

ably needed more lipids for growth and development of reproductive castes could be the reason for the larger forager group towards lipid. This concurs with Bernstein (1974) and Morrill (1977) who reported that the relationship between seasonal foraging time and food abundance is perpetuated by the requirement for increased colony food intake during development of reproductives. Besides food characteristics, there are several other factors such as physical environment (Detrain *et al.* 2001), presence of competitors (Traniello 1987), predators (Nonacs & Dill 1990), level of colony starvation (Josens & Roces 2000) and the amount of brood (Portha *et al.* 2002) that influence foraging decisions. *M. orientale* forage actively during the early hours of the morning under normal colony compositions in laboratory experiments.

Malaysia is a tropical country with an average outdoor temperature of 33°C in the day and 25°C at night. In field situations, colony compositions would not be the sole factor and ambient temperature would have an additional large influence. On the whole, we conclude that changes in the colony determine the foraging strategies of *M. orientale* where foraging groups towards protein and lipid are larger during the growth and development phase. A few elements that are worth exploring in order to substantiate the current findings include directional orientation (Klotz *et al.* 1997), net energetic gains (Traniello 1989), risk factors (Gentry & Stritz 1972, Whitford & Bryant 1979) and competition (Hölldobler 1976, Traniello 1989). In order to manipulate these in baiting strategies, further comprehensive studies would aid bait placements and number of baits needed for a specific area of infestation.

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REFERENCES

- Ayre, G.L. 1962. Problems in using the Lincoln Index for estimating the size of ant colonies (Hymenoptera: Formicidae). *Journal of New York Entomological Society* 60: 159-167.
- Bernstein, R.A. 1974. Seasonal food abundance and foraging activity in some desert ants. *American Naturalist* 108: 490-498.
- Bernstein, R.A. 1975. Foraging strategies of ants in response to variable food density. *Ecology* 56: 213-219.
- Bernstein, R.A. 1979. Schedules of foraging activity in species of ants. *Journal of Animal Ecology* 48: 921-930.

- Detrain, C. & J.-L. Deneubourg 1997. Scavenging by *Pheidole pallidula*: a key for understanding decision-making systems in ants. *Animal Behaviour* 53: 537-547.
- Detrain, C., J.L. Deneubourg, & J. Pasteels 1999. Decision-making in foraging by social insects. *In*: C. Detrain, J.L. Deneubourg and J. Pasteels (eds.) *Information processing in social insects*. Birkhauser Verlag, Basel. pp. 331-352.
- Detrain, C., C. Natan, & J.-L. Deneubourg 2001. The influence of physical environment on the self-organised foraging patterns of ants. *Naturwissenschaften* 88: 171-174
- Diaz, M. 1992. Spatial and temporal patterns of granivorous ant seed predation in patchy cereal crop areas of central Spain. *Oecologia* 91: 561-568.
- Edwards, J.P. 1986. The biology, economic importance, and control of the pharaoh's ant, *Monomorium pharaonis* (L.). *In*: S.B. Vinson (ed.) *Economic impact and control of social insects*. Praeger Publishers, New York. pp. 257-271.
- Fourcassié, V. & J.L. Deneubourg 1994. The dynamics of collective exploration and trail-formation in *Monomorium pharaonis*: experiments and model. *Physiological Entomology* 19: 291-300.
- Gentry, J.B. & K.L. Stritz 1972. The role of the Florida harvester ant, *Pogonomyrmex badius*, in old field mineral nutrient relationships. *Environmental Entomology* 1: 39-41.
- Haines, I.H. & J.B. Haines 1978. Colony structure, seasonality and food requirements of the crazy ant, *Anoplolepis longipes* (Jerd.), in the Seychelles. *Ecological Entomology* 3: 109-118.
- Hölldobler, B. 1976. Recruitment behavior, home range orientation and territoriality in harvester ants, *Pogonomyrmex*. *Behavioral Ecology and Sociobiology* 1: 3-44.
- Hölldobler, B. & E.O. Wilson 1990. *The ants*. Cambridge, Mass: Harvard University Press. Pp. xii + 732.
- Josens, R.B. & F. Roces 2000. Foraging in the ant *Camponotus mus*: nectar-intake rate and crop filling depend on colony starvation. *Journal of Insect Physiology* 46: 1103-1110.
- Klotz, J.H., L.L. Van Zandt, B.L. Reid, & G.W. Bennett 1997. Evidence lacking for magnetic compass orientation in fire ants (Hymenoptera: Formicidae). *Journal of Kansas Entomological Society* 70: 64-65.
- Lee, C.Y. 2002. Tropical household ants - pest status, species diversity, foraging behavior and baiting studies. *In*: S.C. Jones, J. Zhai and W.H. Robinson (eds.) *Proceedings of the Fourth International Conference on Urban Pests*. Pocahontas Press, Blacksburg, VA. pp. 3-18.
- Lee, C.Y., C.Y. Lim, & I. Darah 2002. Survey on structure-infesting ants (Hymenoptera: Formicidae) in food preparative outlets. *Tropical Biomedicine* 19: 21-26.
- Mallieux, A.C., J.-L. Deneubourg, & C. Detrain 2000. How do ants assess food volume? *Animal Behaviour* 59: 1061-1069.
- Morrill, W.L. 1977. Overwinter survival of the red imported fire ant in Central Georgia. *Environmental Entomology* 6: 50-52.

- Na, J.P.S. & C.Y. Lee 2001. Identification key to common urban pest ants in Malaysia. *Tropical Biomedicine* 18: 1-17.
- Nonacs, P. & L.M. Dill 1990. Mortality risk vs. food quality trade-offs in a common currency: ant patch preferences. *Ecology* 71: 1886-1892.
- Portha, S., J.-L. Deneubourg, & C. Detrain 2002. Self-organized assymetries in ant foraging: a functional response to food type and colony needs. *Behavioral Ecology* 13: 776-781
- Portha, S., J.-L. Deneubourg, & C. Detrain 2004. How do food type and brood influence foraging decisions of *Lasius niger* scouts. *Animal Behaviour* 68: 115-122.
- Stradling, D.J. 1978. Food and feeding habits of ants. In: M.V. Brian (ed.) *Production ecology of ants and termites*. Cambridge University Press, Cambridge pp 81-106.
- Sudd, J.H. 1960. The foraging method of Pharaoh's ant, *Monomorium pharaonis* (L.). *Animal Behaviour* 8: 67-75.
- Sudd, J.H. 1967. An introduction to the behavior of ants. E. Arnold, London.
- Traniello, J.F.A. 1983. Social organization and foraging success in *Lasius neoniger* (Hymenoptera: Formicidae): behavioral and ecological aspects of recruitment communication. *Oecologia* 59: 94-100.
- Traniello, J.F.A. 1987. Comparative foraging ecology of north temperate ants: the role of worker size and cooperative foraging in prey selection. *Insectes Sociaux* 34: 118-130.
- Traniello, J.F.A. 1989. Foraging strategies of ants. *Annual Review of Entomology* 34: 191-210.
- Wallis, D.I. 1962. The relation between hunger, activity and worker function in an ant colony. *Proceedings of the Zoological Society of London* 139: 589-605.
- Whitford, W.G. & M. Bryant 1979. Behavior of a predator and its prey: the horned lizard (*Phrynosoma cornutum*) and harvester ants (*Pogonomyrmex* spp.). *Ecology* 60: 686-694.
- Wilson, E.O. 1962. Chemical communication among workers of the fire ant *Solenopsis saevissima* (Fr. Smith). 2. An information analysis of the odor trail. *Animal Behaviour* 10: 148-158.
- Yap, H.H. & A.E.S. Foo 1984. Household pests and household insecticide usage on Penang Island, Malaysia. A questionnaire survey. *Bulletin of PHS* 16: 2-8.
- Yap, H.H. & C.Y. Lee 1994. A preliminary study on the species composition of household ants on Penang Island, Malaysia. *Journal of Bioscience* 5: 64-66.

