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Daily foraging pattern and proteinaceous food preferences of *Solenopsis geminata* (Fabricius) (Hymenoptera: Formicidae)

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Abstract. A field study on foraging activity and proteinacous food preference was performed on the tropical fire ant (*Solenopsis geminata)* (Fabricius) at the School of Biological Sciences and Desasiswa Bakti Permai, Universiti Sains Malaysia (USM), Penang. Foraging activity studies of 4 colonies of *S. geminata* were conducted in the field for 24 hours. Foraging activity significantly increased 4 hours before sunset and maximum foraging occurred at midnight until early morning. Three types of proteinacous food; anchovy, meat and egg yolk were tested among the five colonies of *S. geminata* in the field. The egg yolk was the most preferred food (100%) followed by meat (31%) and anchovy (15%).

INTRODUCTION

Colonies of the tropical fire ant (*S. geminata*) build large, conspicuous mounds. The unsightly mounds and the species aggressiveness make this insect a pest in home lawns, recreational areas and some agricultural situations (Byron & Hays, 1986). Fire ants are aggressive when disturbed and will defensively attack anything that disturbs their mounds or food sources. Because of this, people are often forced to alter outdoor activities when fire ants are present. Fire ant can sting repeatedly. Symptoms of a fire ant sting include burning and itching. The ant injects venom containing an oily alkaloid called Solenopsin A that is toxic to cells. It causes a white pustule to form in a day or two. Although the sting is not usually life threatening, they are easily infected and may leave permanent scars (Dress *et al.*, 1996). The fire ant has also been reported to be a significant economic pest causing damage to many crops, wildlife and domestic livestock (Eden & Arant, 1949; Wilson & Oliver, 1969). It has been viewed variously as a nuisance and health hazard, a threat to natural biodiversity, and occasionally as a positive factor in their ability to control other pest species (Folgarait *et al.*, 2002). An understanding of feeding behavior of the tropical fire ant is essential to the development of a successful bait approach to control (Petralia & Vinson, 1978). The purpose of our study was to examine daily foraging pattern and the most attractive diet for *S. geminata* and the result of it can be used in bait formulation to control the fire ant.

MATERIALS AND METHODS

Field sites

Colonies of *S. geminata* were located at the School of Biological Sciences (PPSK) and Desasiswa Bakti Permai, USM, Penang. Several *S. geminata* colonies found at these two sites were located in a lawn, in the soil in clumps of grass and under the trees. The distance between one nest to another is 50-70m. About 10 of the worker ants from all of

the colonies were collected and brought back to the laboratory for identification before the study began. They were identified under the dissecting microscope using the key from Bolton (1994), Shattuck & Barnett (2001) and Na & Lee (2001).

Foraging study

Ground anchovy was used to study daily foraging activity. The anchovy was soaked in water to soften the texture before roughly blending it. Then, it was dried in the oven under 50ºC for 48 hours before blending it again for the second time to make sure that the anchovy granule was in the small particle size (<2mm) so that the worker ants can easily carry the diet. Ground anchovy was placed in the field near 4 *S. invicta* colonies (A, B, C and D), and ants were allowed to take the food *ad libitum*. Four grams of the food were placed in a modified plastic petri dish and covered with the lid. Four centimeters from the side of the petri dish was cut to allow the ants to go in and out from the petri dish to take the food. The following methods are based on the method described by Hooper & Rust (1997). One petri dish was placed 30 cm from each nest entrance. In this study, we chose only the entrances that were actively used by the worker ants. This is because, in our observations, although the colony of *S. geminata* has many entrances, not all of the entrances were actively used by the worker ants during the foraging time. The petri dish was replaced every 2 hours with another petri dish placed 90º from the position of the petri dish from the previous in a clockwise fashion to minimize the effects of recruitment by workers to the diet during the previous hour. Petri dish was replaced continuously for 24 hours. The petri dish were returned to the laboratory and the remainder food was dried in the oven for 6 hours before being weighed to determine the amount of food removed. This experiment was performed every weekend for 4 weeks.

Proteinaceous food preferences

Test was conducted with 5 field colonies marked as colony E, F, G, H and I. Three types of food were used in this test; ground anchovy, ground meat and dried powdered egg yolk. The ground anchovy was prepared as described above. The ground meat was prepared by cutting the meat into small slice and dried in the oven at 50ºC for 48 hours. After that, the meat was ground and dried again in the oven at 50ºC until the ground meat was completely dried for 24 hours. The powdered egg yolk was prepared by firstly drying mashed up hard-boiled egg yolk in an oven at 50ºC for 24 hours. Then, the egg yolk was ground in a blender to form a powder. A modified plastic petri dish (4cm from the side of the petri dish had been cut to allow the ants to go in and out from the petri dish) provisioned with 2 grams of each food were simultaneously placed 15 cm from colony entrance (Hooper & Rust, 1997). The food was placed at one of the colony entrance that was actively used by the worker ants. The petri dishes were checked every 30 minutes until one of the food was completely removed. The remaining diets were weighed after being dried in the oven at 50ºC for 6 hours, and the amount of diet removed was calculated. This field test began at 1700 hours and was repeated for another 4 colonies using the same method.

Statistical analyses

All of the data were tested for normal distribution before an analysis of variance (ANOVA) (SPSS V12.0) was performed. One way ANOVA was used to determine the differences of foraging time between the four colonies. The differences of food preferences were analyzed using two way ANOVA and means were separated with Turkeys Honestly Significant Difference (HSD) post-hoc test.

RESULT

Foraging study

The result indicates that foraging pattern among the four colonies did not show any differences ($F_{3, 44} = 2.371$, $P>0.05$). However, there is a significant difference between the amounts of bait removal by the worker ants of the four colonies every two hours ($F_{3, 44} = 0.000$, $P<0.05$). Figure 1 shows the average

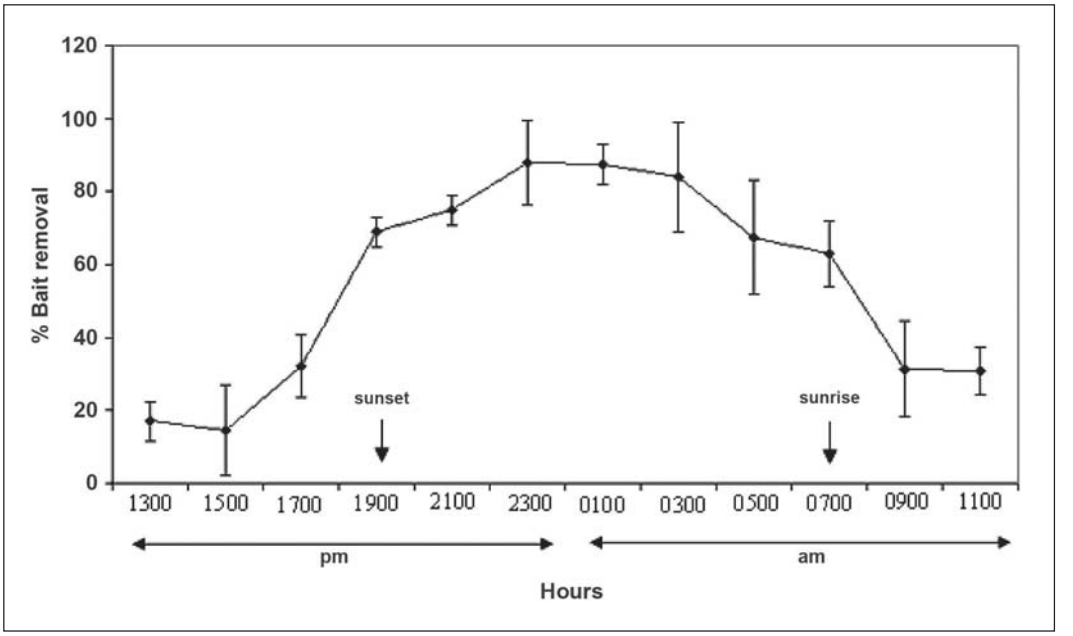

Figure 1. Foraging pattern of *Solenopsis geminata*. The vertical bars represent the standard error of means (SEM).

percentage of food removal per hour by the foraging activity of *S. geminata*. The worker ants actively forage after sunset and slowly cease after sunrise. The foraging activity started at about 1500 hours and significantly increased until 2300 hours. Average percentage of food removed increased from 14.5% to 87.8% between those times. Foraging activity peaked from 2300 hours to 0300 hours and significantly decreased after that time until sunrise. Average percentage of food removed by the worker ants at peak hours ranges from 84% to 88%.

Proteinaceous food preferences

The average amount of the proteinaceous food removed by *S. geminata* is shown in Figure 2. The result revealed that the egg yolk was the most preferred food for *S. geminata* because this diet was the first to be completely removed (100%) by the worker ants. On average, only 31.5% of meat and 15.1% of anchovy were taken by the worker ants. The percentage of baits removed by all 5 colonies was not significantly different ($p>0.05$).

However, there was a significant difference in percent of food removal across the different food types ($p<0.05$). HSD post-hoc test showed that there was a significant difference on the amount of egg yolk that was removed compared to anchovy and meat ($p<0.05$).

DISCUSSION

Each species of ants has a schedule of foraging activity, which differs from other ant species. From the study, we found that the foraging activity of *S. geminata* peaked at midnight until early morning (2300 hours-0300 hours). According to Hooper & Rust (1997), from their study on *Solenopsis xyloni* McCook, they found that the foraging activity for this fire ant species were high at night because they avoided the day when ground surface temperatures were the highest. Stradling (1978) also said that physical environmental factors such as temperature and humidity may impose rhythms of foraging activity on ant colonies. In temperate species, low night temperatures may restrict nocturnal activity and in some desert habitats, diurnal activity may cease during the heat of midday (Stradling, 1978).

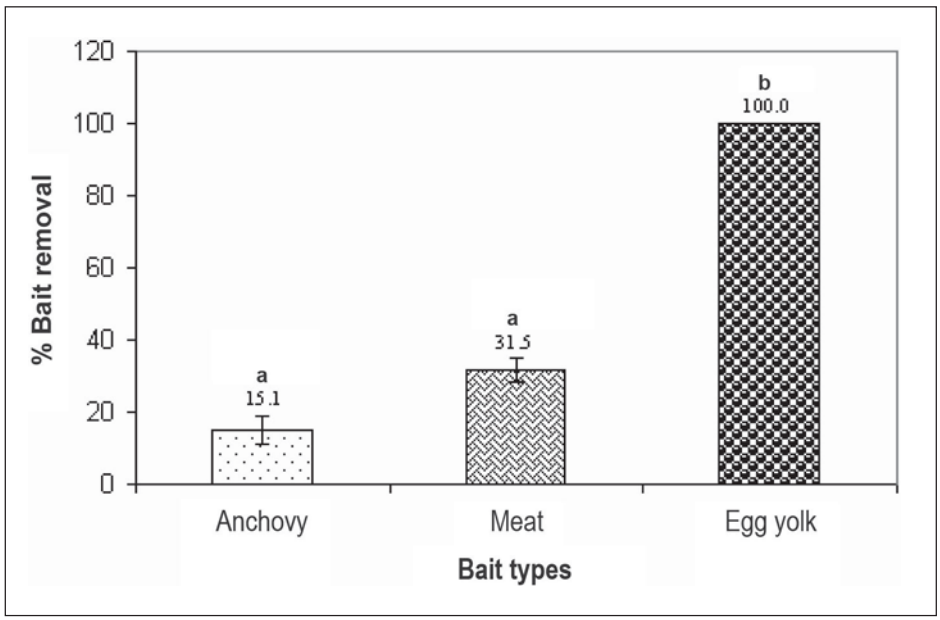

Figure 2. Average percentages of food removal indicate proteinnaceous food preferences of *S. geminata.* The vertical bars represent the standard error of means. Means followed by the same letter are not significantly different.

In our study, we found that only a few of the workers of *S. geminata* would come out from their nest to forage and sometimes no workers could be seen outside their nest during the day. That is why in our study, we found that the foraging activity started four hours before sunset (1500 hours) when the ground temperatures began to decrease. In Malaysia, the outdoor temperature averages 25ºC at night while day temperature averages 33ºC, but can reach as high as 35ºC (Lee, 2002). However, a study done by Lee (2002), on foraging activity pattern of *M. pharaonis*, *P. longicornis* and *S. geminata* were negatively correlated with ambient temperature and the foraging activity of *S. geminata* was in agreement with our result.

Ants are, in general, omnivorous organisms that feed on any available material in the environment, whether animal or vegetable (Wiliams 1994). Nutrients, especially protein, is important to social insects like ants. Protein food was required by growing larvae and egg-laying queens (Howard & Tschinkel, 1981). Sorensen *et al.* (1983) said that when food in the colony was less than 10mg, the larvae received incoming protein more rapidly than did the nurses, queens, reservers or foragers. When the quantity of protein available to the colony was increased, the rates at which caste members' accumulated food changed, so that the queen accumulated food more rapidly than did the reservers, foragers, larvae or nurses. Through our study on proteinaceous food preferences; anchovy, meat and egg yolk, we found that the *S. geminata* preferred the egg yolk more than meat and anchovy. Sorensen *et al.* (1983) also found that worker ants of *S. invicta* showed a high response to solid egg yolk powder by making repeated trips to the food, leaving most of it in the nest periphery or passing it on to the reserves. The reserves will relay this food to the nurses who, in turn, feed the larvae. A previous research conducted by Hooper & Rust (1997), found that the anchovy diet were well accepted to the southern fire ant (*S. xyloni*) because the anchovy diet contained a large amount of animal protein (47% wt:wt) (Hooper & Rust, 1997). However, our result in this study showed that the anchovy diet was the last choice and was less attractive to *S. geminata*

although we used this diet to determine foraging pattern previously. We believe that the use of the anchovy does not affect the result of the foraging pattern because the ants were only exposed to one diet and therefore had no other choice but to remove the exposed food. Meat was the second diet preferred by the workers of *S. geminata*, because it is a good source of protein and lipid. Lipids, a source of energy and food reserves, are taken mainly by workers and some larvae, while proteinaceous foods are directed towards the larvae and queen (Sorensen *et al*., 1983). This pattern suits the nutritional needs, since larvae and the queen require proteins for structural growth and egg production respectively (Sudd, 1967; Howard & Tschinkel, 1981). The most important factor is that the food brought to the nest must include vitamins (Brian, 1983). Thus, the fire ant preferred the egg yolk because it is a good source of protein, iron, vitamin A & D, and also high in cholesterol (213mg/egg). A study on food preferences of fire ant is important to find a better way to control this ant species. Because the fire ants actively forage at night, the control of this ant should be done during the night to increase the probability of ants contacting the bait. Formulation of the bait should include egg yolk as an ingredient in order to obtain better control of the ants.

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