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# Foraging activity and food preferences of the samsum ant, *Pachycondyla sennaarensis*

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## Abstract

To grow and reproduce well, animals facing fluctuations in abiotic conditions must adjust their physiology, activity rhythms, and foraging behavior accordingly. The foraging activity and food preferences of the samsum ant *Pachycondyla sennaarensis* (Mayr) (Hymenoptera Formicidae Ponerinae) were investigated both in the field and in the laboratory. Foraging activity was examined in the field for two years (2008-2009) and through all four seasons. Ant foraging activity was recorded over a twenty-four hour period along with ambient temperature and relative humidity to examine possible correlations with ant activity patterns. The results of the study indicate that foraging activity may be influenced by time, temperature and relative humidity. During the spring, the activity of the workers during the daytime was at a maximum at 12:00 at 16-21 °C and a relative humidity of 52-58%. However, in the summer, when the temperature was generally higher, foraging activity was greater during cooler times of the day and night. Foraging activity decreased during the autumn and winter. The study found no seasonal shifts in food preference in the foraging ants. *P. sennaarensis* consistently preferred protein and carbohydrate rewards to lipids. However, the results indicated that minced meat was consumed significantly more than other proteinaceous foods. Lipids were generally ignored by *P. sennaarensis*.

**Key words:** samsum ant, macronutrient choice, foraging activity, behaviour, temperature, humidity.

## Introduction

Ants in the subfamily Ponerinae often have small colonies with workers that exhibit solitary foraging (Peeters and Crewe, 1987). Because ponerine ants are armed with a sting and many species have powerful mandibles, they are usually considered predators. Nonetheless, a diversity of feeding habits and foraging modes have been reported for members of this subfamily, which include hunting for food on ground and foliage substrates, scavenging for dead arthropods, gathering plant and insect exudates, and collecting fleshy fruit (Duncan and Crewe, 1994; Déjean and Suzzoni, 1997, Blüthgen *et al*., 2003; Oliveira and Freitas, 2004; Dutra *et al*., 2006). Additionally, although many ponerines feed opportunistically on a diversity of food types, some specialized species can be extremely specific in the type of prey that they consume (Freitas, 1995; Leal and Oliveira, 1995). Foraging strategies may range from solitary to cooperative hunting, with varying degrees of recruitment behaviour among nestmates (Peeters and Crewe, 1987).

The samsum ant, *Pachycondyla sennaarensis* (Mayr), is a widespread, conspicuous ant in the savannas and open forests of sub-Saharan Africa and the Middle East. This ant is also common in villages and cities, where it is well known for its powerful sting that sometimes leads to anaphylactic shock in humans and even death (Wetterer, 2013). In natural habitats, *P. sennaarensis* is most common in savannas and open forests where it preys on insects and collects seeds (Levieux and Diomande, 1978; Déjean and La-Chaud, 1994, Lachaud and Déjean, 1994). This species also does well in urban areas, feeding on human food products and rubbish (Collingwood *et al*., 2004). In many parts of its range, *P. sennaarensis* is very common, particularly in disturbed areas. Arnold (1915) wrote that *P. sennaarensis* "is the commonest Ponerine ant around Bulawayo" in Zimbabwe. Regarding *P. sennaarensis*, Weber (1940) reported that: "Through-out the Sudan from Port Sudan to the Nile and south to the Belgian Congo and Uganda borders, this ant was found to be one of the commonest insects, nesting abundantly in many areas". *P. sennaarensis* was the most frequently collected ant in surveys in Burkina Faso (Nissim *et al*., 2003) and on Qeshm Island, Iran (Rafinejad *et al*., 2009). Lindsay *et al*. (1989) found *P. sennaarensis* to be the most common ant captured using sticky traps under beds in Gambia. In Yemen, Collingwood and Agosti (1996) found that *P. sennaarensis* "thrives around human settlements". Dib *et al*. (1995) reported that *P. sennaarensis* is common in all urban areas of the UAE and has a strong presence in gardens and buildings. Similarly, Collingwood *et al*. (1997) reported that in the UAE, *P. sennaarensis* is "found along all major road-side developments, oases, plantations, and urban areas". The samsum ant has been recorded in Saudi Arabia (Collingwood, 1985; Al-Khalifa *et al*., 2010). It is established in urban and rural areas and is closely tied to human activity. Because of its ability to sting, this ant is of medical importance (Tirgari *et al*., 2004). Samsum ants are a recognized public health hazard because their sting has resulted in a few cases of fatal anaphylactic shock (Dib *et al*., 1992; 1995). A case of anaphylactic shock also has been reported in KSA (Al-Shahwan *et al*., 2006). Additionally, of several Saudi anaphylaxis cases following samsum ant stings that were reported to local clinics, some were critical (Al-Anazi *et al*., 2009).

Ponerine ants vary widely in their strategy used to for-

age, ranging from solitary hunting without any cooperation during search and food retrieval to different levels of cooperative foraging mediated by varying degrees of recruitment communication between nestmates (Peeters and Crewe, 1987; Hölldobler and Wilson, 1990). Moreover, variation in biotic (e.g., competition, natural enemies) and abiotic (e.g., temperature, humidity) factors are also likely to affect ant foraging activity both daily and seasonally (Carroll and Janzen, 1973; Traniello, 1989; Orivel and Dejean, 2001; Hahn and Wheeler, 2002). Temperature, moisture, and food availability are known to mediate daily and seasonal activity shifts in many insect groups (Heinrich, 1993). Although ant colonies may behaviorally control microenvironmental conditions, each species tends to function within a clear temperature-humidity range (Hölldobler and Wilson, 1990).

Many ponerine species are opportunistic in their choice of food items, whereas others are very prey-specific (Peeters and Crewe, 1987; Fresneau, 1985; Pratt, 1989; Brown, 1992; Leal and Oliveira, 1995; Freitas, 1995; Ehmer and Hölldobler, 1995; Fourcassié and Oliveira, 2002). The food preference of *P. sennaarensis* varies in different parts of the world. In Africa, it is generally granivorous (Dejean and Lachaud, 1994), whereas in Qeshm, Iran, the species feeds mainly on human food and waste (Rafinejad *et al*., 2009). In such situations, it can be considered a commensal species. It appears that this habit is dependent on the environmental factors, fauna and flora of the region, and more importantly, on the availability of food. However, the species generally can be described as omnivorous, feeding on every available food source, such as food waste, various fruits, nectarines, homopteran honeydew, small arthropods and dead animals. In urban areas, they prefer to feed on human food (Rafinejad *et al*., 2009).

A good understanding of the food preferences and foraging behavior of *P. sennaarensis* is essential for planning effective management strategies against this venomous species. Moreover, information on its foraging activity will assist in executing better monitoring programs. This study was conducted to investigate the foraging activity and food preferences of *P. sennaarensis.*

## Materials and methods

### Ant foraging activity

To study the daily activity of the ants (the number of foraging ants), two sites were chosen at King Saud University, Kingdom of Saudi Arabia (one beside the College of Sciences building and the other at the university farm). The mean number of ants was recorded by several digital images captured daily using a camera (Nikon Coolpix 2500, Japan Optical Industries Corporation), six times every 5 minutes at 6, 12, 18 and 24 hours for two weeks during each season for a full year (2008-2009). The temperature and the relative humidity were recorded together with a thermo hygrometer. The numbers of ants at each site were counted on the computer from the captured images.

To study the foraging activity of a *P. sennaarensis* population over 72 hours, the same two sites were chosen at King Saud University. Minced meat was used as a food attractant and placed inside a 9-cm Petri dish. The dish was placed between several nest entrances that were densely concentrated in a limited zone, and digital images using a Nikon Coolpix 2500 camera were captured every two hours up to 72 hours during the summer (during July 2009 with an interval of three days between each replicate), which was the time when the ants were more active according to the results from the first experiment. The temperature and relative humidity were recorded. To ensure freshness, the food attractant was replaced every 24 hours during the 72-hour experimental period. The numbers of ants in each Petri dish were counted from the images captured on the computer. The experiment was replicated three times at each site at the same nest.

**Table 1.** The interactions between the activity of the samsum ants and the seasons of the year (N = 3).

| Season | Time | Mean temperature (°C) ± S.E.M. | Mean humidity ± S.E.M. | Mean number of ants ± S.E.M. |
|---|---|---|---|---|
| Summer | 6 | 28.07 ± 1.58 | 65.07 ± 4.51 | 33 ± 4.18 |
| | 12 | 43.50 ± 1.17 | 17.33 ± 2.43 | 12.78 ± 0.92 |
| | 18 | 39.43 ± 1.22 | 17.83 ± 1.29 | 33.33 ± 7.53 |
| | 24 | 27.07 ± 1.12 | 54.07 ± 4.58 | 35.44 ± 6.49 |
| Autumn | 6 | 17.47 ± 0.98 | 58 ± 6.54 | 9.11 ± 1.08 |
| | 12 | 34.11 ± 1.13 | 21.58 ± 1.82 | 5.22 ± 0.28 |
| | 18 | 24.07 ± 1.53 | 48.2 ± 2.11 | 10 ± 1.81 |
| | 24 | 22.18 ± 1.78 | 42.8 ± 3.38 | 11.66 ± 2.66 |
| Winter | 6 | 20.38 ± 1.51 | 45.22 ± 2.53 | 6.44 ± 0.67 |
| | 12 | 27.63 ± 1.19 | 41.24 ± 1.91 | 8.88 ± 0.88 |
| | 18 | 21.6 ± 0.98 | 47.6 ± 2.27 | 5.77 ± 0.49 |
| | 24 | 17.5 ± 0.82 | 84.7 ± 5.98 | 0.77 ± 0.26 |
| Spring | 6 | 20.21 ± 1.21 | 62.7 ± 3.51 | 13.33 ± 3.57 |
| | 12 | 28.58 ± 1.56 | 48.5 ± 2.73 | 16.5 ± 4.68 |
| | 18 | 24.43 ± 1.18 | 62.68 ± 4.52 | 16.33 ± 5.72 |
| | 24 | 21.2 ± 1.29 | 61.4 ± 3.48 | 18.16 ± 5.53 |

### Ant food preference

The natural diet of *P. sennaarensis* in the studied sites were seeds, human food products and rubbish. Choice tests were conducted on a colony in the laboratory using foods (2 g per each) in the categories of carbohydrates, proteins and lipids. The carbohydrate items were mixed fruit jam, strawberry jam, marmalade, raspberry jam, pineapple jam (Halwani Bros), fruit juice (Almarai), and aqueous solutions of maltose (20%), sucrose (20%), fructose (20%), and glucose (20%). The proteinaceous food items were dried fish, chicken sausage, tuna fish, cockroaches (animal protein), minced meat, wheat, beans, groats, rice, sesame and lupine (vegetal proteins). Sunflower oil, fish oil, olive oil and sesame oil were evaluated as lipid sources. All proteinaceous food items were prepared in the form of dried ground powder. Each of the candidates from each food class (carbohydrates, proteins or lipids) was placed in a 6-cm diameter plastic Petri dish and every three candidates were positioned near one another in randomized order. The dishes were placed in the nest foraging area for 30 minutes. After 30 minutes, digital images were captured with a camera (Nikon Coolpix 2500), and the number of ants on each plastic dish was counted from the images. The experiment was replicated 3 times. The results obtained were subjected to an analysis of variance. These variables were transformed to comply with the normality and homoscedasticity assumptions of the ANOVA. The differences between individual mean values were analyzed with Tukey's HSD (significance threshold = 0.05) using Statistix® 7.0 software (Analytical Software, Tallahassee, FL).

Based on the choice test, two candidates from each food class (carbohydrate, protein and lipid) were chosen for a field experiment to study the changes in food preferences over 20 weeks. All the candidates from the three food classes were positioned near one another in randomized order on ant trails. Digital images were captured after 30 minutes, and the number of ants in each image was counted. This experiment was conducted in two more places weekly for 20 weeks from May to September 2009.

## Results

### Ant foraging activity

Seasonal foraging activity studies in the field revealed that the activity of the ants increased during the spring and summer in 2008 and 2009 and declined during the autumn and winter. Additionally, in this experiment there were no significant differences in activity rhythm between the two sites, so the counts for the two different sites were pooled (table 1). Analysis of the relationship between the seasons of the year and the hours of the day showed that the foraging activity of the ants was greatest during the spring at 12:00. During the summer, when temperatures were generally higher, foraging activity was greater at cooler times of the day and night. It is noteworthy that the association between the seasons of the year and the temperature of the air was also significant. The greatest activity was found during the summer when the temperature was 34-39 °C. Evaluation of foraging activity with respect to the hour of the day, the air temperature and the relative humidity of the soil showed that the foraging level was highest at 24:00, at 16-21 °C and a relative humidity of 52-58%.

Foraging activity studies in the field over 72 hours during the summer showed that the activity of *P. sennaarensis* was influenced by time, ambient temperature and relative humidity. The counts for the two different sites were pooled because we found that there were no significant differences in activity rhythm between the two sites (figure 1). According to figure 1B, the maximum foraging activity appeared to occur between 05:00-07:00 and 12:00-16:00, or approximately between 04:00 and 18:00 and was lower during the night.

**Table 2.** Mean number of *P. sennaarensis* foragers attracted to candidate carbohydrate foods (N = 3).

| Food | Mean % of ants ± S.E.M. |
|---|---|
| Fruit juice | 10.667 ± 1.2 b |
| 20% Sucrose solution | 1.1 ± 0.2 b |
| 20% Maltose solution | 10.667 ± 0.88 b |
| 20% Fructose solution | 1.190 ± 0.3 b |
| 20% Glucose solution | 0.93 ± 0.2 b |
| Mixfruit jam | 60.941 ± 10.254 a |
| Raspberry jam | 20.944 ± 1.42 b |
| Strawberry jam | 70.444 ± 10.25 a |
| Pineapple jam | 1.667 ± 1.4 b |
| Marmalade | 10.278 ± 1.4 b |

Mean values followed by the same letter are not significantly different ($p > 0.05$; Tukey's HSD).

**Table 3.** Mean number of *P. sennaarensis* attracted to candidate proteinaceous foods (N = 3).

| Proteinaceous food | Mean (%) of ants ± S.E.M. |
|---|---|
| Tuna fish | 10.29 ± 0.57 d |
| Dried fish | 10.00 ± 0.5 d |
| Chicken sausage | 5.00 ± 0.189 d |
| Cockroaches | 80.00 ± 12.13 c |
| Minced meat | 230.00 ± 30.96 a |
| Wheat | 10.38 ± 1.38 d |
| Beans | 80.29 ± 12.21 c |
| Groats | 160.00 ± 3.7 b |
| Rice | 10.75 ± 0.62 d |
| Sesame | 270.43 ± 15.2 a |
| Lupine | 10.00 ± 1.22 d |

Mean values followed by the same letter are not significantly different ($p > 0.05$; Tukey's HSD).

### Ant food preference

The initial food preference studies conducted with carbohydrate, protein and lipid food samples indicated a significant preference for proteins over carbohydrates and lipids (figure 2). Lipids were completely ignored by the ants. Therefore, the carbohydrate and proteinaceous food items were chosen for the preference tests.

The *P. sennaarensis* populations exhibited significant feeding preferences for particular carbohydrate foods (table 2). The ants preferred mixed fruit jam and strawberry jam to the other carbohydrate foods. *P. sennaarensis*

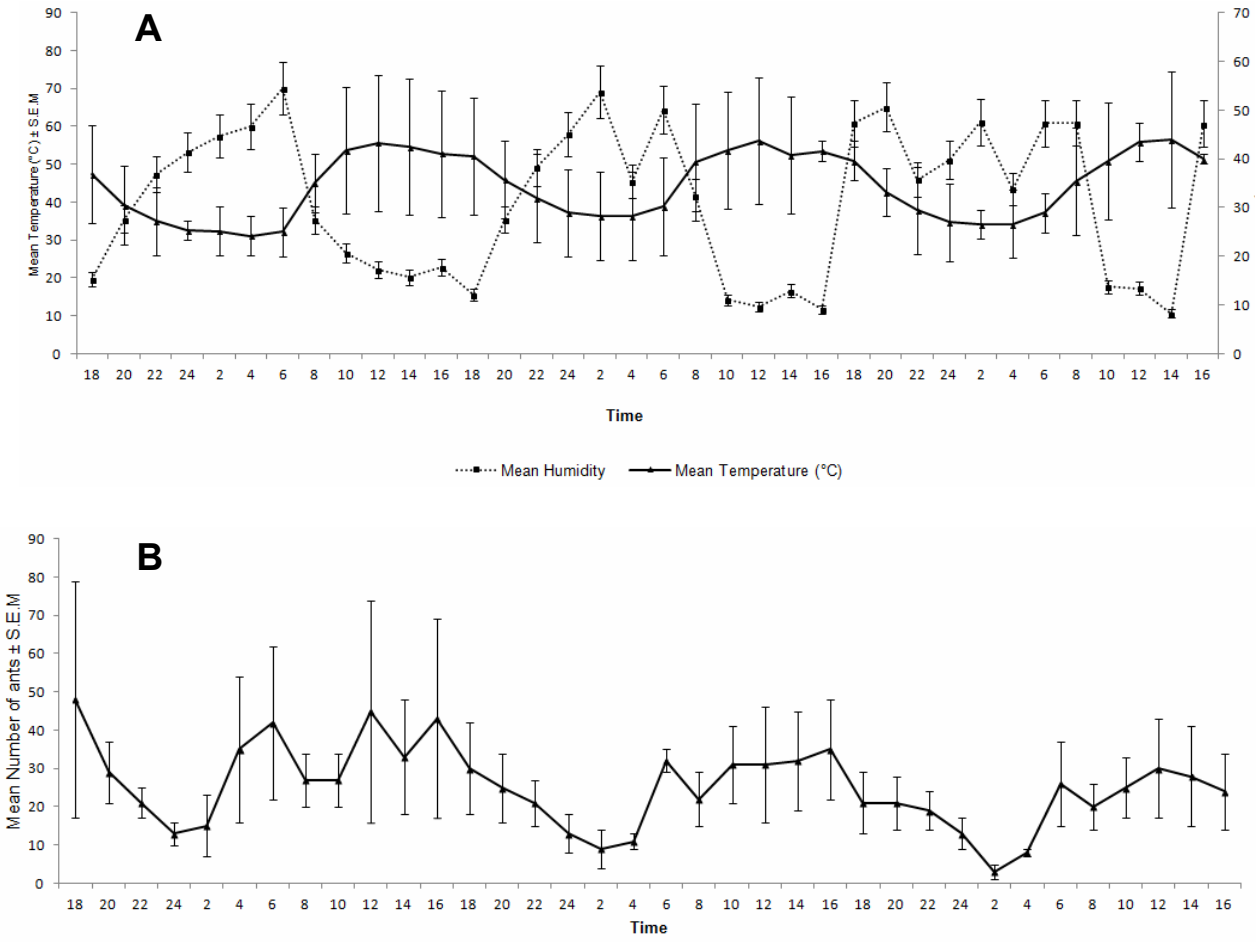


**Figure 1.** Foraging activity of a *P. sennaarensis* population over 72 hours (N = 3). **A**) Mean temperature and mean humidity; **B**) Mean number of ants.

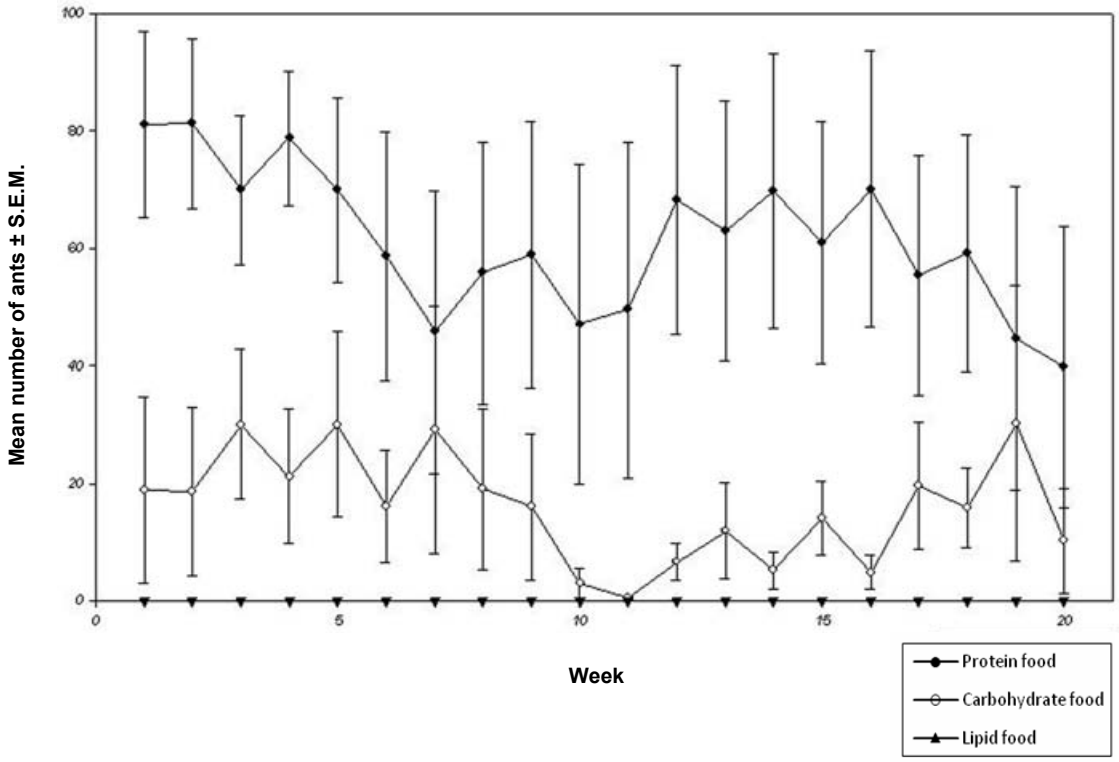


**Figure 2.** Periodic changes in food preference of *P. sennaarensis* over 20 weeks (N = 3).

**Table 4.** Periodic preference of *P. sennaarensis* for 2 proteinaceous and 2 carbohydrates foods over 20 weeks (N = 3).

| Week | Mixfruit jam | Strawberry jam | Sesame | Minced meet |
|---|---|---|---|---|
| 1 | 7.00 ± 0.58 | 5.33 ± 0.67 | 10.33 ± 0.88 | 10.67 ± 2.73 |
| 2 | 8.33 ± 1.45 | 8.33 ± 2.4 | 9.33 ± 1.45 | 7.67 ± 0.33 |
| 3 | 6.00 ± 0.58 | 6.00 ± 0.58 | 11.00 ± 1.57 | 10.67 ± 1.20 |
| 4 | 6.33 ± 0.88 | 7.33 ± 0.88 | 11.33 ± 0.88 | 13.33 ± 0.33 |
| 5 | 3.67 ± 0.67 | 8.67 ± 3.18 | 4.33 ± 1.20 | 5.67 ± 0.88 |
| 6 | 7.00 ± 0.58 | 7.33 ± 0.88 | 3.67 ± 0.33 | 7.67 ± 2.19 |
| 7 | 5.67 ± 1.2 | 6.00 ± 1.73 | 3.67 ± 0.67 | 7.33 ± 3.38 |
| 8 | 8.00 ± 3.61 | 6.67 ± 0.88 | 13.00 ± 0.58 | 7.33 ± 0.33 |
| 9 | 12.00 ± 0.58 | 13.33 ± 1.2 | 11.33 ± 1.20 | 8.00 ± 0.58 |
| 10 | 6.67 ± 0.33 | 7.00 ± 0.58 | 7.00 ± 0.58 | 6.67 ± 0.88 |
| 11 | 6.33 ± 1.2 | 6.67 ± 1.2 | 6.00 ± 0.58 | 4.33 ± 1.20 |
| 12 | 7.67 ± 0.88 | 13.33 ± 1.2 | 18.67 ± 5.46 | 10.00 ± 3.51 |
| 13 | 5.33 ± 1.2 | 11.00 ± 0.58 | 3.00 ± 0.58 | 9.00 ± 2.08 |
| 14 | 4.67 ± 0.88 | 4.33 ± 0.33 | 2.00 ± 1 | 9.33 ± 1.45 |
| 15 | 9.00 ± 2.89 | 3.00 ± 0.58 | 7.67 ± 3.28 | 6.67 ± 1.86 |
| 16 | 8.00 ± 2.52 | 5.67 ± 0.88 | 7.33 ± 3.38 | 3.00 ± 0 |
| 17 | 6.33 ± 2.03 | 6.00 ± 2 | 8.67 ± 2.40 | 6.33 ± 1.20 |
| 18 | 7.00 ± 0.58 | 8.00 ± 3.79 | 4.00 ± 1 | 7.33 ± 2.01 |
| 19 | 10.33 ± 1.2 | 7.00 ± 2.31 | 5.67 ± 1.45 | 7.67 ± 2.19 |
| 20 | 8.67 ± 1.2 | 9.33 ± 0.88 | 10.67 ± 1.86 | 8.00 ± 2.646 |

significantly preferred vegetal proteins, such as sesame, and minced meat ($p < 0.05$) to the other 12 proteinaceous food candidates (table 3). The numbers of ants found foraging on the two candidates within each food class were combined and plotted over a period of 20 weeks (table 4). Additionally, *P. sennaarensis* showed alternate food preferences for mixed fruit jam and strawberry jam and for sesame and minced meat during the 20 weeks of the experiment (table 4).

## Discussion

Different foraging strategies are used by ants based on environmental changes and food density (Fowler, 1985; Herbers and Choiniere, 1996). Variation in abiotic (e.g., temperature, humidity) factors are likely to affect ant foraging activity both daily and seasonally (Carroll and Janzen, 1973; Traniello, 1989; Orivel and Dejean, 2001; Hahn and Wheeler, 2002). Samsum ants showed different levels of foraging activity at different times of the day and night. The foraging activity during the summer appeared to be affected by higher temperatures. However, the ants tended to forage in greater numbers at times of the day and night when the temperatures were cooler. The foraging activity during the cooler hours of the day during the summer was in contrast to the activity observed during the spring, when the ants foraged during the warmer hours of the day. The samsum ants did not show distinct peaks of foraging activity.

The daily activity schedule is one of the most distinctive characteristics among species of ants (Hölldobler and Wilson, 1990). Interspecific divergence in activity patterns results from particular morphological, physiological or behavioral traits that define the ecological tolerance of a species and thus determine its specific foraging period (Bernstein, 1979). The foraging activity of the ponerine ant *Gnamptogenys moelleri* (Forel) varies markedly between seasons. In the summer, more ants leave the nest to forage, and foragers go greater distances than in the cold season (Cogni and Oliveira, 2004). Seasonal variation in foraging range has previously been reported in other tropical ponerines, such as *Brachyponera senaarensis* (Mayr), *Pachycondyla marginata* (Roger), and *Pachycondyla striata* Smith (Dejean and Lachaud, 1994; Leal and Oliveira, 1995; Medeiros, 1997). More intense foraging activity by *G. moelleri* in the warm season corresponds with the period of greater quantities of broods in the colonies and increased abundance of arthropod prey in the environment.

A physiological explanation for these variable feeding habits is that predatory ant colonies require large quantities of animal protein for raising their immature stages, while whereas the adult stages require large quantities of carbohydrates for their maintenance activities (Medina, 1995). Diet can also interact with climate to determine the extent of ant foraging (Lachaud, 1990). The current study revealed that *P. sennaarensis* populations were most attracted to proteinaceous foods, and carbohydrate foods were the next most attractive items. The ants were not attracted by lipid foods. They did not alternate their preference between different food classes (i.e., carbohydrate and proteinaceous foods). Like *Ochetellus glaber* (Mayr) (Cornelius *et al*., 1996; Cornelius and Grace, 1997), *P. sennaarensis* was not attracted to lipid foods. Within the same food classes, *P. sennaarensis* showed alternate food preferences for mixed fruit jam and strawberry jam and for sesame and minced meat. Various species of large ponerine and ectatommine ants are known to depend largely on seeds and fruits to complement their diets (Berg, 1975; Horvitz and Beattie, 1980; Horvitz, 1981; Andersen, 1988; Pizo and Oliveira, 1998; Fourcassie and Oliveira, 2002).

In conclusion, the foraging activities of *P. sennaarensis* were influenced by time, ambient temperature and relative humidity. *P. sennaarensis* preferred both proteinaceous and carbohydrate food over a 20-week evaluation period but did not show any special preference toward any lipid foods. Sesame and minced meat were the most preferred choices among the proteinaceous foods.

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