NECTAR FEEDING BY THE ANT *CAMPONOTUS MUS*: DECISION-MAKING PROCESS DURING FORAGING FOR DIFFERENT BODY SIZES

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ABSTRACT

We addressed the question of whether the decision-making process during nectar foraging is modified according to the body size of the nectivorous ant *Camponotus mus*. Individual foragers collected sucrose solution (30%w/w) in three different reward conditions: 1) *ad libitum*, 2) at a regulated flow feeder (1□l/min) and 3) *ad libitum* with addition of tilose, which increases the viscosity of solution while keeping the concentration constant. For all series there was no limit in the food volume offered, such that only the individual decision of abandoning the arena determined the time spent in foraging and the final volume loaded.
Feeding time increased with ant weight in all three treatments. The highest increase was found in the tilose treatment. In this series the difference in feeding time between smaller and larger ants was more pronounced than in other series. In the regulated flow experiment, the pauses while feeding tended to be longer for larger ants. Pause time was shorter in the *ad libitum* condition independently of ant body size. The crop load attained at the end of the foraging visit increased with ant weight in all series. Only for the regulated flow condition did larger ants decrease their relative crop load (Burden) compared to that of smaller ants.
In the ant *Camponotus mus*, both the time invested at the food source and the crop load attained at the end of the foraging bout vary with ant weight as a response to different characteristics of the nectar source. The differences found in the behavioral responses recorded could thus be indicative of a foraging specialization dependent on ant size.

INTRODUCTION

Camponotus mus ants feed on insects and carbohydrate solutions obtained from Homopteran honeydew and extrafloral nectaries. In such a foraging context, the concentration of the sucrose solution collected affects the behavior of the ants, in particular the time spent at the food source and the crop load attained in a foraging bout (Josens *et al*., 1998).
Camponotus mus presents a broad range of body sizes. The largest ants can be five times heavier than the smallest ones. Differences due to forager body size in ants have been extensively studied in the context of foraging activity, but little is known for nectar loads. When feeding on an *ad libitum* sucrose solution (60% w/w), the ants' crop load increases with the ants' weight, which is an indicator of body size. However, for the same concentration of sucrose solution, no relationship between feeding time and ant weight was found (Josens, 2002).
In experiments with sugar solution sources where there is no limit in the volume offered to individual ants, the decision of abandoning the arena determines the time spent in foraging and especially, the final volume loaded. For example, small scouts of *Lasius niger* seem to have a criteria based on the volume ingested. This has been observed in ants foraging at two different nectar sources (*ad libitum* and through a cotton-wool cork), which attain in both cases the same volume, but stay three times longer feeding at the cotton source (Mailleux *et al*., 2000). The interplay between ant size, decision-making and food source profitability during nectar collection, is a topic that remains elusive, as well as the decision criteria for ending the visit to different food sources, which could vary with the recruited forager sizes.
The goal of this work is therefore to analyze the decision-making and the behavioral responses of workers with different body sizes while foraging on sucrose sources of different characteristics.
In our work, the conditions of the feeding source were presented by three different ways. Firstly, solution was offered in a 30%w/w *ad libitum* source. The profitability was varied either

by changing the flow rate of a sucrose solution delivered by an regulated rate feeder or by adding tilose to the sucrose solution in order to increase its viscosity. In all treatments the gustative input was kept constant as the same concentration (30%) was used. We measured variations in foraging behavior in ants of different sizes as depending on food source conditions.

MATERIALS AND METHODS

In order to analyze how food source profitability modifies the behavior of workers of different body size we recorded different behavioral variables during feeding. The colony was kept in the laboratory for one year, with a natural light-darkness cycle and an ambient temperature of 25 ± 3^{o} C. Ants could freely move inside their nest and had access to an *ad libitum* water source. Between experiments, the colony was fed with honeywater solution and freshly killed insects (cockroaches and honeybees). All measurements were performed with the colony being deprived of carbohydrates for a week. Each assay was commenced by connecting the tray to a small foraging arena by a wooden bridge, allowing the access of a small group of foragers (around 6 ants). Once the foraging group returned to the nest carrying sucrose solution, single recruited ants were allowed access to the bridge. Starting from this point, individual foragers were weighted before and after foraging at the arena where the 30% sucrose solution was offered. For each individual ant, we recorded the feeding time (s) (the time during which the mandibles of the ant contacted the sucrose solution), the pause time (s) (time between two contacts with the solution in the same visit) and the crop load (µl) attained at the end of the foraging bout. The latter was obtained from the difference between the final and the initial ant weight and by dividing the net load weight by the density of the solution obtained from tables. To measure transport capacity, the Burden Index (Rissing, 1982) was calculated as [(load weight + ant weight)/ ant weight]. This index has a minimum value of 1, and increases with the load transported. Behavioral variables were analyzed in relation to ant weight.

At the foraging arena, ants found a 30%w/w sucrose solution offered in a volume as much as ant fed, i.e. the volume offered never was the limit that determined the end of a feeding bout. Three different experimental series were done to have three different source conditions: 1) **AL** (*ad libitum):* ants could drink unrestrictedly from the 30% sucrose solution; under similar condition ants (between 4 and 13 mg) presented an average intake rate of approximately 3 ml/min (Josens *et al*., 1998); 2) **RF** *(regulated flow):* ants had access to an regulated feeder (Núñez, 1966) whose flow rate was set at 1µl/min, i.e. at a value that is the third of the average intake rate for an *ad libitum* situation; 3) **T** *(tilose)*: ants had access to a 30% sucrose solution to which a minimum amount of tilose was added. This polysaccharide (PM: 10.000) can increase significantly the viscosity of a solution without appreciably affecting its density. Tilose was added until the viscosity of a 60% sucrose solution was attained (Farina & Josens, 1994). This viscosity value reduces in average the intake rate at the level of the RF Series (Josens *et al*., 1998).

The **AL** series gave a reference for the values of the behavioral variables recorded when the profitability of the source was maximal. Intake rates for a 60% w/w sucrose solution increases with ant body size (Josens, 2002). If we assume that the same tendency applies to a 30% solution, then the **RF** series with a low flow rate at the source should affect more strongly larger ants than smaller ones because their intake rate would be relatively more reduced than that of smaller ants. Finally, the **T** series was performed to assess the effect of viscosity on the foraging behavior of ants of different sizes. As smaller ants are likely to posses a food canal with a smaller radius, we expected that an increase in viscosity should affect them more than larger workers.

RESULTS

In all three series, the *feeding time* increased with ant weight. The **T** series yielded the steepest slope while **AL** series yielded the less pronounced one. When the solution was *ad libitum* but its viscosity was increased (**T** series), the difference in feeding time between

smaller and larger ants was greater than in the other two series. Moreover, the proportion of feeding time related to the time spent at the source seems to decrease with the decrease of ant size.
The *pause duration* varied with the characteristics of the offered food source. The shorter pauses were found for the **AL** series, where no relationship between ant body size and pause duration was found. The **RF** series yielded an increment of pause duration compared to AL series. This increment tends to be more pronounced for larger ants. However for the **T** series, in spite of a great variability, it seems that minor ants showed the most increased pause time.
The *crop loads* attained at the end of the foraging visit increased with the ant weight in all three series. The relative load achieved (*burden*) was highest for the **AL** condition, although we could not find any relationship with ant body size. The same happened with the **T** series although the average burden values were lower than those in the **AL** series. In the **RF** series, the burden decreased with increase body size.

CONCLUSIONS

Our results show that in the ant *Camponotus mus*, both the time invested at the food source and the crop load attained at the end of the foraging bout varied with ant weight as a response to different characteristics of the nectar source. The differences found in behavioral responses indicate that workers of different body-sizes assign different relevance to different behavioral parameters during nectar foraging according to the profitability of the food source exploited. The differences in the decision-making recorded could be indicative of a foraging specialization dependent on ant size.
Our next step is to study whether differences in feeding dynamics and foraging behavior in relation to body size are associated with a division of labor and task flexibility whose aim would be to increase foraging efficiency of the colony.

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