

The allocation of foragers to a new foraging task in the stingless bee *Plebeia tobagoensis* (Hymenoptera, Meliponini)

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Social insect colonies can adjust the distribution of forager labour over different foraging tasks in three ways: 1) unemployed or new foragers can be recruited, 2) workers that are employed in certain tasks can be recruited to other tasks, or 3) workers already foraging on a task can be activated to work harder (Rotjan *et al.* 2002). In this study we examined how colonies of the stingless bee *Plebeia tobagoensis* adjust their foraging forces when a new foraging task occurs. So far, in stingless bees no extensive research had been done on any of the processes involved in forager allocation. We found that most of the labour for the new task was supplied by recruiting non-foragers to this task. In the stingless bee *P. tobagoensis* the flexibility of colony foraging behaviour seems to be largely dependent on the recruitment of non-active foragers and not on the flexible behaviour of individual active foragers. When we assume that the recruited foragers were mostly unemployed before, the activation of these foragers seems to be a low cost solution for forager allocation in the case of the occurrence of a new foraging task.

Keywords: foraging task, stingless bees

Stingless bees, like other social insects, can adjust their colony foraging activity in response to changes in resource availability (Seeley 1995, Biesmeijer 1997, Gordon 1996). Not only foraging activity in general, but also the distribution of workers over different foraging tasks, e.g. nectar or pollen collection, can be modified to the actual foraging situation (Seeley 1995, Biesmeijer 1997). Pollen and nectar are generally not equally available during the day, which results in a difference in allocation of foragers over these resources over the day in both honeybees and stingless bees (Seeley 1995, Biesmeijer 1997).

There are three ways in which a colony can adjust the foraging activity devoted to different foraging tasks: 1) unemployed or new foragers can be recruited to a task, 2) workers that are employed in a task can be recruited to another task (switching), and 3) workers already working on a certain task can be activated to work harder (Rotjan *et al.* 2002).

In honeybees it was found that the increase in pollen foraging activity, caused by experimentally induced pollen stress, was mostly the result of the recruitment of new foragers to the task of pollen foraging (Rotjan *et al.* 2002). Similarly, the increase of water collection in case of brood overheating in honeybees seemed to be the result of the recruitment of new foragers to the task of water

foraging instead of, for example, transferring nectar foragers to this job (Seeley 1995). So far, in stingless bees no extensive research has been done on any of the processes involved in forager allocation.

In this study we examined how colonies of the stingless bee *Plebeia tobagoensis* adjust their foraging forces when a new food source becomes available. Since, the introduction of this new food source resulted in a new foraging task, only the first two processes (recruitment of new foragers or task switching of active foragers) can result in adjustments of forager allocation.

MATERIALS AND METHODS

The experiment was performed in a climate-controlled greenhouse compartment of the Utrecht University Botanical Gardens. We used two colonies of the stingless bee *Plebeia tobagoensis* Melo (2003), with colony sizes of around 800 bees. On the first day of the experiment only sucrose solution (60%) feeders were placed in the compartment. Bees foraging on this food source were colour marked and counted. On the second day of the experiment we introduced, next to the sucrose feeder, a new source which contained pollen (5 *spatiphyllum* flowers, which offer exclusively and abundantly pollen). Bees visiting the food sources were colour-marked and counted. To analyse which foragers were visiting the new food source, the history of each forager visiting this source was taken into account (new foragers or old forager from the first day of the experiment). The experiment was done once with each *P. tobagoensis* colony.

RESULTS

When the new food source was introduced on the second day of the experiment we found that most of the foragers on this source were new foragers that had not

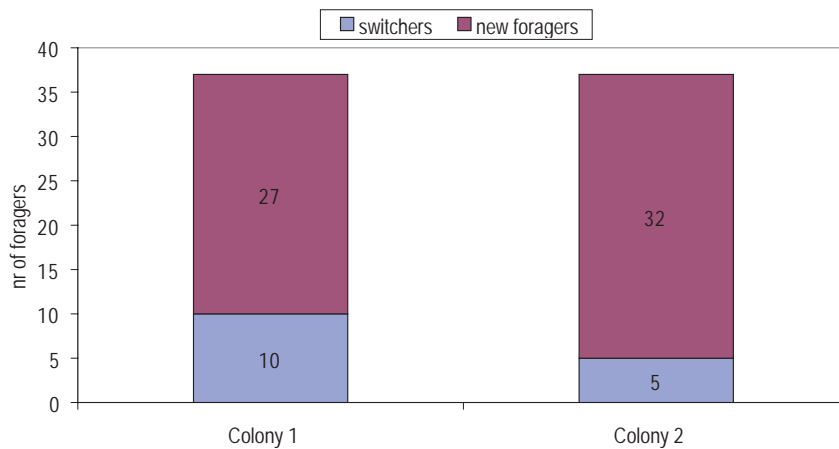


Figure 1. The allocation of switchers (bees collecting sucrose solution on the first day of the experiment) and new foragers (unemployed foragers on the first day of the experiment) over a newly introduced food source (pollen) on the second day of the experiment.

foraged on the first day of the experiment (col. 1: 73%, $\text{Chi}^2=7.81$, $p<0.01$; col. 2: 86%, $\text{Chi}^2= 47.68$, $p<0.01$) (Fig. 1). From the bees that foraged on the first day of the experiment (before the introduction of the new food source) only a small proportion switched to the new food source (pollen) on the second day of the experiment (col.1: 7%; col.2: 34%) (Fig. 2). From the bees that started foraging on the second day of the experiment, the vast majority was recruited to the new food source (pollen) (col. 1: 77%, $\text{Chi}^2=10.31$, $p<0.01$; col. 2: 80%, $\text{Chi}^2= 14.40$, $p<0.01$) (Fig. 3).

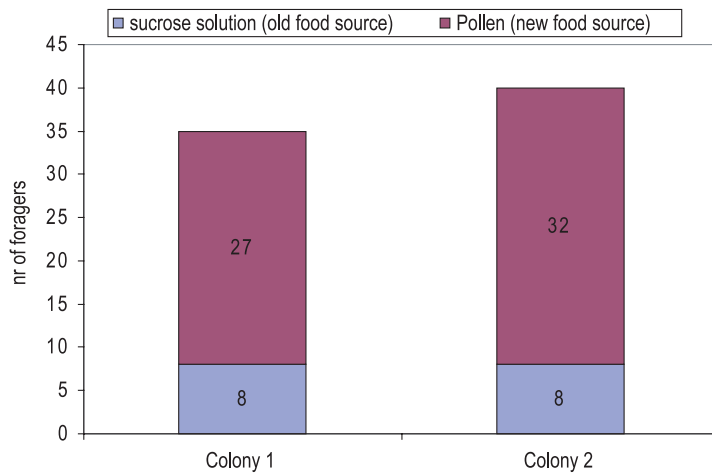


Figure 2. Allocation of new foragers (unemployed foragers on the first day of the experiment) over the old (sucrose solution) and new food source (pollen) on the second day of the experiment.

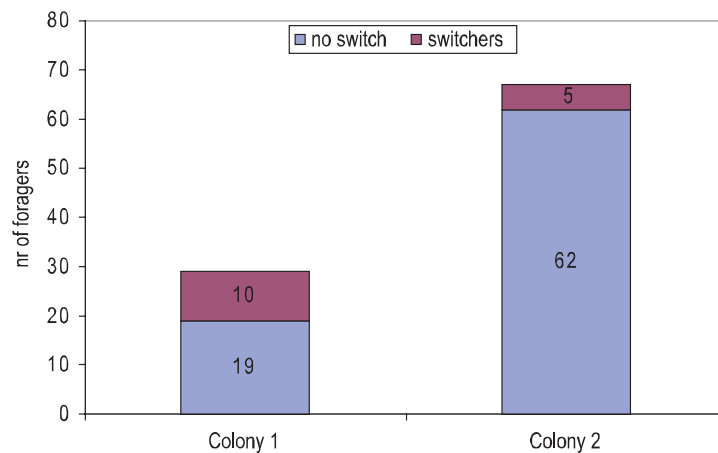


Figure 3. Proportion of foragers that switched from collecting sucrose solution on the first day of the experiment to pollen collection (newly introduced food source) on the second day of the experiment.

DISCUSSION

In social bee colonies the allocation of workers is dynamic, meaning that the individuals can switch foraging tasks, and the distribution of foragers over different foraging tasks can change with environmental conditions (Gordon 1996).

In this study, on the stingless bee *P. tobagoensis*, we analysed the processes, which are involved in the allocation of foragers when a new food source becomes available. We found that most of the labour for the new task was supplied by recruiting non-foragers to this task. This agrees with the results found for honeybees by Rotjan *et al.* (2002) and Seeley (1995). It should be noted, however, that the occurrence of new foragers on the second day of the experiment could also be the result of 'nest-bees' becoming older and shifting to the task of foraging. But the difference in the number of new pollen foragers and new sucrose foragers on the second day of foraging suggests that most of the new foragers were recruited because of the occurrence of a new foraging task.

Although some individuals switched from sucrose solution collecting to pollen collecting, this seemed not nearly as important for the allocation of foragers to the new food source as recruitment of new foragers. When we assume that the new foragers of the second day were mostly unemployed on the first day of the experiment, which has been found in honeybees (Seeley 1997), this seems to be a low cost solution. Switching might be costly, especially when foragers are successful on the first day of the experiment, as is the case in our study. By recruiting unemployed foragers, the other foraging tasks can continue without interruption. Recruiting unemployed foragers is only possible, however, when a colony has a reserve supply of labour. This might be the case in relatively large social insect colonies or when foraging activity is low. These unemployed bees might serve as 'labour in stock' for situations when sudden changes in colony needs or food availability occur.

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