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A scientific note on the founding and the early growth of new nests of the stingless bee *Plebeia remota*

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The stingless bees are the most diverse group of all the eusocial bees (Camargo and Pedro 2007), with perennial colonies composed of a few hundreds to thousands of workers and generally of a single, once-mated queen (Peters et al. 1999). New colonies are founded by fission in a gradual process, wherein a young queen departs from the parental nest accompanied by a swarm of workforce. During this period of days up to a few months, workers transport building materials and food resources from the mother colony to the new site (Nogueira-Neto 1954). Although this process was first described by Nogueira-Neto (1954), since then, few quantitative analyses have been undertaken to address questions about the initial growth of the daughter colony and the egg laying by a newly mated queen (e.g. van Veen and Sommeijer 2000). In order to fill this gap and considering that the swarming frequency in stingless bees is pretty low (i.e. it takes place once a year or less frequently), here, we report the foundation process of four *Plebeia remota* (Holmberg 1903) colonies.

Like the majority of stingless bee species, *P. remota* L. is highly dependent of cavities to build their nests and wooden nest boxes that are perfect to attract swarms (Whiting 1943). In November 2004, three swarms of *P. remota* occupied three wooden nest boxes covered with glass lids in the Bee Laboratory at the University of São Paulo. At that moment, these nest boxes were empty but had previously housed other heterospecific colonies, *Melipona bicolor* and *Schwarziana quadripunctata*. We observed a fourth swarming process (S4) that happened in February 2005 when it occupied a homospecific nest box. In order to record the brood cell construction of the newly swarmed colonies, we conducted video-assisted behavioural observations almost continuously during 30 days for the first three swarms, and for the fourth one, we took photographs daily, also for a month. In order to access the daily oviposition rate by the queens, we counted the number of brood cells constructed every 24 h. We performed the same method 2 years later for the colonies that survived and were well-developed, and then we compared our data using the Kruskal-Wallis test. The α level of significance was $P \leq 0.05$. In order to evaluate the worker and sexual production, we sampled the first brood combs from S1, 2 and 3, as described previously (Alves et al. 2009).

During the founding phase, building materials from the dead hetero- and homospecific nests were

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always reused by *P. remota* workers, as was also observed for other species (Nogueira-Neto 1954). Indeed, we did not observe transport of building materials from the parental nest to the daughter colony (but see Terada 1972; Wille and Orozco 1975; Inoue et al. 1984; van Veen and Sommeijer 2000). Probably, there was sufficient building material that may have provided conditions for the development of the colonies without the need of transport of these supplies from the mother nest. Concerning the food supply, the workers constructed new pots to storage the resources collected in the field or brought from the mother colony before the queens started to lay their eggs.

The newly mated queens took from 4 up to 13 days (S1, 8; S2, 13; S3, 6; S4, 4) to start their egg-laying activities. The daily mean rate of oviposition, measured in number of cells, by the queen in each colony was different ($H=52.0567$; $P<0.05$; S1, 22.2 ± 16.8 ; S2, 35.7 ± 25.6 ; S3, 74.2 ± 31.7 ; S4, $85.3\pm$

42.5 ; Dunn's pairwise comparison: S1 vs S2, $P>0.05$; S1 vs S3, $P<0.05$; S1 vs S4, $P<0.05$; S2 vs S3, $P<0.05$; S2 vs S4, $P<0.05$; S3 vs S4, $P>0.05$). The queen from S4 had the highest rate of oviposition, followed by the queens from S3, S2 and S1. As the mean number of cells constructed per day, the growth of the colonies was highest in S4, followed by S3, S2 and S1 (Figure 1). Also, there is a significant correlation between the time when the queens started to lay eggs and the mean size of their brood comb during the first 30 days of oviposition ($r_s=-1.000$, $P<0.05$, $n=4$). Thus, the colonies did not have the same pattern in their initial growth, and the queen's vigour might be reflected by her physiological maturation and the conditions of the nests (i.e. food stored) where such queens were.

These data are particularly interesting because they show the initial brood cell production by the swarm workforce. The model of Oster and Wilson (1978) states that during the foundation stage, the growth of a social insect colony is exponential and

Figure 1 Cumulative curve of the growth (total number of cells) in the first 30 days of queen oviposition of four newly swarmed colonies of *Plebeia remota* (S1 to S4). The information on the legend of the figure correspond to the parameter estimates for the logistic equation of growth fitted for the total number of cells oviposited by *Plebeia remota* with respect to time (days) in each of the four swarms. Standard errors of parameter estimates are in parentheses. $N_{\max}$ is the asymptotic number of cells. The model had highly significant fits, as the associated probability was $P<0.00005$ for each colony. The 95 % confidence interval for $N_{\max}$ is also presented (95 % CI).

then it slows down when the energy available for each worker decreases. However, our data contrast with this classical model. The initial growth of *P. remota* colonies fit a logistic model [with very high coefficients of determination, which were all greater than 97 % (Figure 1)], the growth rate did not decline and the maximum colony size (asymptotic value for colony size) was not reached. It might be that *P. remota* newly founded colonies just following the pattern of Oster and Wilson later after 30 days. Interesting enough, S1, S2 and S3 just produced workers in their first brood comb, which indicate that the daughter colonies were investing in workforce in this initial phase.

The evaluation of the number of food pots and number of brood cells present in S2, S3 and S4 after 2 years of colony's existence showed that colony 4 had the highest number of food pots (222) and brood cells (3,299 cells in four combs). S3 had 160 storage pots and 2,594 cells (in five combs) and S2 had 25 food pots and 1,857 brood cells (in five combs).

It is worthy pointing out that survivorship of newly established *P. remota* colonies was 0.75 (3 out of 4), which was the same for wild *Tetragonisca angustula* colonies (0.75) and similar for other stingless bee species (0.86; Slaa 2006). After the first study period, we observed a 'swarming fight' in which conspecific invaders killed the mother queen and usurped the nest from S1. Since the nest cavity is a limiting resource for stingless bees (Hubbell & Johnson 1977, Eltz et al. 2003), the benefits to usurp a nest, with stored food and building materials (Cabral de Castro et al. 2009), may be higher than the costs of the attack (Gloag et al. 2008). A swarming fighting also took place in the nest site occupied by S2, but its 'defenders' were successful in defending themselves against conspecific intruders. However, this fight had a bad effect on the colony since the S2 stopped the cell construction on the 29th day (Figure 1), but its mother queen was not killed and this colony survived.

The factors that determine the success and development of swarms might depend on the resources available to the newly swarmed colony. Nevertheless, a better understanding of the process leading to swarming might well end up providing new insights into the rules that command the colony reproduction in social insects.

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Note scientifique sur la fondation et le développement initial de nouveaux nids de l'abeille sans aiguillon *Plebeia remota*

Eine wissenschaftliche Notiz zur Gründung und zum frühen Wachstum von neuen Nestern der stachellosen Biene *Plebeia remota*

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