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Research Article

Nest Relocation and Colony Founding in the Australian Desert Ant, *Melophorus bagoti* Lubbock (Hymenoptera: Formicidae)

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Even after years of research on navigation in the Red Honey Ant, *Melophorus bagoti*, much of its life history remains elusive. Here, we present observations on nest relocation and the reproductive and founding stages of colonies. Nest relocation is possibly aided by trail laying behaviour, which is highly unusual for solitary foraging desert ants. Reproduction occurs in synchronised mating flights, which are probably triggered by rain. Queens may engage in multiple matings, and there is circumstantial evidence that males are chemically attracted to queens. After the mating flight, the queens found new colonies independently and singly. Excavation of these founding colonies reveals first insights into their structure.

1. Introduction

The Australian desert ant, *Melophorus bagoti* Lubbock, is a widespread species of arid Central Australia. It inhabits low-shrub and grassland deserts, where it builds fairly large underground nests [1]. The outdoor activity is mainly restricted to the hotter summer months, when the ants are active during the heat of the day. Foragers usually begin their activity at soil surface temperatures of about 50°C and continue to forage at temperatures above 70°C [2]. They forage solitarily for food such as dead insects, seeds, and sugary plant exudates ([3], personal observations) and are well known for their ability to store liquids in the abdomens of specialised workers, the so-called repletes or "honey pots" (hence their common name "Red Honey Ant" and indeed the genus name *Melophorus*, meaning "honey carrier"). This method of food storage is also adopted by several other seasonally active ants, for example, *Cataglyphis* [4] of North Africa, *Camponotus* [5] of Australia, and *Myrmecocystus* [6] and *Prenolepis* [7] of North America (the latter store fat, not sugar).

In the recent years, *M. bagoti* has attracted increasing attention for its navigational abilities (e.g., [8–13]; for a review see [14]), thus making a broader understanding of its behaviour and life history desirable.

2. Materials and Methods

The study site is located 10 km south of Alice Springs, NT, Australia, on the grounds of CSIRO Alice Springs. The area is characterised by an arid climate, with an average annual rainfall of 279.4 mm [15]. The soil consists of sandy flood plain alluvium [16], and the vegetation is a mosaic of *Acacia* low open woodland and *Triodia* low open hummock grassland [17], although much of the latter has been replaced by the invasive Buffel Grass *Cenchrus ciliaris*. *M. bagoti* is common in the area, and their nests occur at a density of ~3/ha, which is much lower than previously reported by Muser et al. [3] from a different location.

The observation of a nest move was made in December 2008, and colony founding was observed between December 2008 and March 2009. As these incidents were unpredictable, observations could not be made systematically. Due to unusually high rainfall in November 2008 (wettest November on record with 156 mm rain), much of the area was covered by fresh vegetation for most of the summer.

3. Results and Discussion

3.1. Nest Move. After a full week of rainy weather, some nests of *M. bagoti* reopened their entrance holes on 21 November

2008. In the following three weeks, 12 of 16 observed nests relocated the position of their entrances several times by 5–191 cm (average: 73 cm). This behaviour is usually displayed much rarer. Occasionally several entrances were in use at the same time. In preparation for other experiments, the area around one of these nests was cleared of vegetation on 25 November whereby a nest chamber very close to the surface was accidentally opened. In the following days, the nest relocated its entrance to this new opening (distance: 47 cm, bearing: 190°), closing the old entrance. On 3 December (partly cloudy, max. temp. 40.9°C) at 17.00 hour we noticed that this nest was in the middle of relocating to a new nest site (distance: 17.75 m, 205°). A continuous but sparse moving column of ants, including repletes, was observed between the two nest sites. The column was directed to the new nest in almost a straight line. Although most workers went from the old to the new nest, some were observed going the other way. The width of the column varied from a few cm to about 1 m but always seemed to consist of distinct trails. Most, but not all of the repletes, were pulled or pushed out of the old nest opening by workers and proceeded to move to the new nest on their own (see Supplementary Material), where some were dragged into the entrance by workers. Because foragers are usually the only ants that leave a nest, repletes are necessarily unfamiliar with the environment around the nest. They must therefore rely on other cues to find the direction and location of the new nest. There are three possible explanations. Other workers within the nest could convey the information, they might simply follow other ants on the trail, or they might use a system of chemical (olfactory) marking. Indeed, on several occasions workers were seen dragging the tip of their abdomen across the sandy soil (see Figure 1 and the Supplementary Material), a behaviour which has not been observed in *M. bagoti* or any other solitary foraging desert ant so far. These ants may be laying intermittent odour trails. If this conclusion holds true, it will have important implications for future studies on the navigational strategies of this ant species.

We could distinguish two types of repletes, as previously described by Conway [1]: ones with clear, amber-coloured abdomens and ones with milky white abdomens. The sizes of their inflated abdomens were variable. One dealate queen was also observed, and one winged male, but no eggs, larvae or pupae. The queen was dragged all the way from the old to the new nest (see the Supplementary Material). All activity ceased at 17.30 hour. Over the next few days we checked for activity sporadically. The old nest was now presumably abandoned. On one occasion some workers and one replete from another nearby nest (distance: 19.98 m) entered the old abandoned nest. However, no further activity was observed at the old nest after this incident. At the new nest excavating activity was at first very high, but during the following days the activity slowed down considerably and eventually came to a stop. The nest reopened on 8 January and remained active until the end of the season.

Although nest emigration behaviour seems to be common in forest-dwelling ant species [18], this does not seem to be the case for *M. bagoti*. Once a nest is established, its location usually does not change over many years (personal observation). In the described case the move was probably triggered by our disturbance.

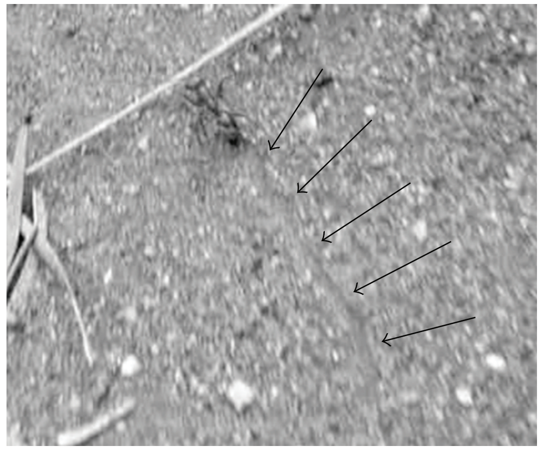


Figure 1: A worker of *M. bagoti* dragging her abdomen across the sandy surface during a nest relocation. Arrows indicate the track left behind in the sand. Still photo taken from a film sequence, credit A. Wystrach.

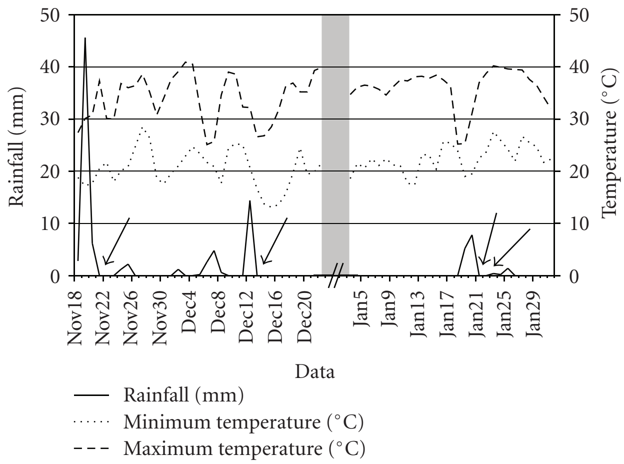
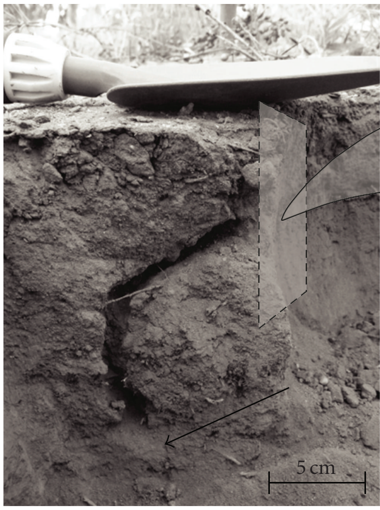


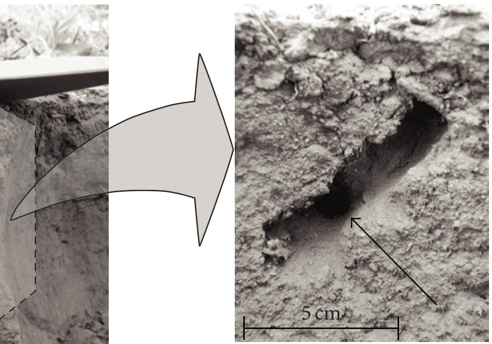
Figure 2: Timing of mating flights in *M. bagoti* during the summer 2008/09. Daily rainfall and temperature (min./max.) are shown for the time period from 18.11.08 to 31.01.09, excluding the period from 23.12.08 to 02.01.09 when no observations were made (indicated by grey bar). Arrows indicate observed mating flights. Climate data from [15].

3.2. Colony Founding. The founding stage of an ant colony is usually characterised by the same sequence of events. The virgin queen leaves the nest in a mating flight and is inseminated by one or several males. She then looks for a new nest site and starts excavating a small nest, where she lays eggs and rears a small brood [19].

Several nuptial flights were observed during the summer of 2008/09, always after rainy days (see Figure 2) and always in the mornings. Heavy rain is a common trigger for the timing of mating flights in desert ants [19]. Sometimes queens and males left the nest together to fly off, at other



(a)



(b)

Figure 3: (a) Overview of an excavated founding colony of a *Melophorus bagoti* queen. Arrow indicates the location where the dead queen was found. (b) Close-up of the chamber encountered during excavation, the part of the channel leading to the chamber has been removed. Arrow indicates the channel leaving the chamber on the other side; see text for details. Photo credit P. Schultheiss.

times only queens did so. At about 10.30 hour on 21 January 2009, mating flights occurred at four nests simultaneously. As it had rained for the two previous days, it was humid, overcast, and warm (61% RH, 29°C at 9.00 hour). From this synchronised behaviour, we can surmise that mating occurs in swarms, although no such mating site could be located. One mating was actually observed: an already dealate queen was found on the ground, surrounded by several males, of which one copulated with the queen once for a few seconds.

The following day, a dealate queen was observed leaving a nest at 10.15 hour and was followed as she wandered around the area up to a maximum distance of 50 m from the nest entrance, regularly seeking thermal refuge on small plants and twigs. During this time, she copulated once with one male and three times with another male. On both occasions the queen had climbed onto a small plant and remained motionless while the male flew around her. This behaviour is somewhat reminiscent of the sexual calling behaviour of some ponerine ants [20]. The copulations lasted from a few seconds to about half a minute. As all the observed copulations involved dealate queens, they were obviously not regular matings; it seems though that queens readily mate even after they have broken off their wings and possibly even attract males chemically. After 1 hour 50 minutes we stopped following the queen; it is not known if she returned to the nest.

Another dealate queen was seen being followed by a flying insect (probably Diptera, Syrphidae, of which the subfamily Microdontinae has larvae that prey on ants in their nests; the adults are usually found in the vicinity of ant nests [21]). It followed the exact path the ant took at a constant distance of about 10 cm (see the Supplementary Material) until it eventually lost the ant and flew away after searching for a little while.

Queens founded new colonies independently and without the help of other queens or workers (haplometrosis, see [22]); this mode of colony founding is common in formicine ants [19, 23]. However, nothing is known about the number of queens in later colony stages or other populations of *M. bagoti*. For example, in North American ants of the genus *Myrmecocystus*, which can be regarded as the ecological equivalent to *Melophorus* [24], founding queens are often joined by other queens after they have excavated the first nest chamber alone [25]. Also, some desert ants in North America, including *Myrmecocystus*, display considerable geographic variation in their mode of colony founding [26]. We observed a total of 21 dealate queens at their attempts to establish new colonies (all on 21 January). Of these, only five were in a completely open place, while the remaining queens chose a spot in the shade of a little plant or twig. Here the queens started to dig at a shallow angle, using their mandibles (see the Supplementary Material). They continued digging for sometimes several hours. In one case, the queen had chosen a site that was close to an already existing nest (distance: 7.70 m), and workers from this colony apparently attacked and killed the queen. While several workers dragged the dead queen away, one worker closed the hole of the queen rapidly. After two days, 12 of the 21 holes were closed, rising to 15 after another four days; by 10 March, only one remained open (although obstructed by a branch). All colonies can thus be regarded as failed, for reasons unknown. Four of the closed founding colonies were then excavated. Three of these continued as a narrow channel underground for 2–10 cm, ending in a dead end with no remains of the queen, being wholly or partially filled with debris. The fourth hole started as a narrow channel, slowly sloping downward before opening into a small chamber (length: 7.5 cm). This was oriented at a right angle to the channel but diagonally to the surface, at a depth of 4–9 cm below ground (see Figure 3(b)). The channel then continued downwards at roughly 45° for another 8 cm, turned abruptly downward, and ended without a chamber at a total depth of 16 cm below ground (see Figure 3(a)). Remains of a dead queen were found at the end of the channel, and parts of the channel were filled with debris.

The fact that there was no nest chamber at the end of the channel indicates that the queen died before she had fully excavated the founding nest. Although the observations presented here are necessarily incomplete and many important questions remain unanswered, they do offer a fascinating insight into the early stages of an ant colony.

Acknowledgments

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