Observations on relocation of a nest by a colony of Red Honey Ants (*Melophorus bagoti*)

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Abstract

The desert-dwelling Australian Red Honey Ant (*Melophorus bagoti*) rarely moves from one nest site to another. We observed the relocation of one colony of this ant at a field site about 10 km south of Alice Springs. This relocation, which was 36 m from the old nest, took 17 days to complete with the relocation of the brood itself taking only 1 to 2 days. During this unexpected move, we observed a large amount of outdoor activity by guard ants and physical contact between guard ants, as well as between guard ants and foragers. This amount of contact between the guard ants and foragers has never been described before. The relocation apparently resulted from experimental changes around the nest site above ground, a conclusion that differs from that of the only other study on this species which suggested that interference with the actual nest underground triggered the relocation.

Introduction

Nest relocation in ants is an activity wherein all the members living within a nest colony co-ordinate their activities to move from one location to another in a collective manner. Various factors trigger nest relocation in different species of ants. Colonies of the Argentine Ant (*Linepithema humile*) are seasonally polydomous, and changes in humidity drive nest movement (Heller & Gordon 2006). Flooding is another major reason for nest relocation (Scholes & Suarez 2009). In the case of a severe flood, *L. humile* relocates faster than during a typical move. During a flood, this species also chooses a safe location more often than does the Odorous House Ant (*Tapinoma sessile*) of North America, which often splits its colonies into two when flooding is high. A *T. sessile* colony splits because some workers move rapidly to a new location while others remain in the nest and move deeper into the lower chambers by preference (Scholes & Suarez 2009). External and internal factors influence emigrations in the surface-adapted bivouac-forming species of doryline ants of the genus *Aenictus* (i.e. *A. laeviceps* and *A. gracilis)*. Usually within 20 minutes after the first signs of excitement, emigration starts in the bivouac. The external factor stimulating the emigration activity is the raiding on an *Aenictus* colony by *Eciton* ants, whereas internally, food-depleted larvae initiate the intra-bivouac excitation of the colony (Schneirla & Reyes 1969). Funnel Ants (*Aphaenogaster barbigula*) make their nests in aeolian soils that are usually dry and prone to erosion. These ants change the location

of their nests twice a year on average. During the construction of nest entrances in a new location, workers repack the soil, a process called bioturbation (Eldridge & Pickard 1994). Only two observations of nest relocation have been made on desert-living ants to date – on the Spanish *Cataglyphis iberica* (Dahbi *et al.* 2008) and on the Australian Red Honey Ant (*Melophorus bagoti*) (Schultheiss *et al.* 2010).

The endemic Australian *Melophorus bagoti* is a thermophilic ant, occupying an equivalent ecological niche to the African/Saharan genus *Cataglyphis* and the Namibian genus *Ocymyrmex* (Wehner 1987; Conway 1992). *Melophorus bagoti* colonies are widespread in the Central Australian desert, with the ants making their nests in sandy soil. The vegetation around the nest area is dominated by low shrubs and Spinifex and Buffel Grass tussocks. One single colony of *M. bagoti* contains approximately 2800 ants consisting of workers, queens, males and repletes (Conway 1992). *Melophorus bagoti* colonies exhibit polymorphism; the ants having large differences in their body size (Conway 1992). The repletes are also known as 'honey pots' because their gaster is distended as they store liquid food in their abdomen, hence the species is commonly called the Red Honey Ant. Their most common nickname throughout the course of history was Ituny Ituny (which means sun sun); yet now they are also referred to as Furnace Ants since they forage in the hottest time on summer days (Cheng *et al.* 2014). Furthermore, there is often a clear division of responsibilities between different morphs of workers. Large workers, guard ants or soldiers, often guard their nest by patrolling the entrance, whereas the other younger workers (which are smaller in size) run outside to forage during the hottest time of the day (Conway 1992). *Melophorus bagoti* shares the surrounding physical habitat with other arthropods, but specialises in its temporal niche. Whilst workers search for food individually during the hottest part of summer days, they stop foraging in winter. Outbound and homebound activities depend largely on the soil surface temperature (Conway 1992). During natural foraging in the summer months, when the soil surface temperature reaches about 50°C, these ants become active and continue to forage up to 70°C (Christian & Morton 1992; Conway 1992; Muser *et al.* 2005; Schultheiss & Nooten 2013). They forage solitarily during the hot summer day, running on their long legs for food. They mostly scavenge dead insects but also collect seeds, sugary plant exudates and other miscellaneous items (Muser *et al.* 2005).

As mentioned above, one study has previously reported on the relocation of a *Melophorus bagoti* colony (Schultheiss *et al.* 2010). The authors concluded that *M. bagoti* nest moves were uncommon and the ants did not change the location of their nest for many years. However, the colony frequently relocated the entrance to the nest by 5 to 191 cm (average 73 cm) due to unknown reasons. When Schultheiss and his team accidentally opened one of the old entrances while cleaning up the area surrounding a nest for experimentation, they found that after eight days the whole colony relocated 17.75 m away from the old entrance to the nest (Schultheiss *et al.* 2010). These researchers assumed that the relocation of the nest was likely due to nest disturbances (Schultheiss *et al.* 2010).

When planning and performing experiments on the focal nest of *M. bagoti*, we witnessed the nest relocation of a colony. This process included ants searching for new sites, preparing a new nest, and finally moving the entire colony into the new home.

Materials and Methods

The study was conducted at a field site located about 10 km south of Alice Springs. The red soil at the study site was composed of sand sediments laid down by floods. The desert habitat's vegetation is dominated by Buffel Grass (*Pennisetum cenchroides*) plus a mosaic of *Acacia* bushes and *Eucalyptus* trees. We observed one particular colony's activities from 9–28 January 2018. Navigation and orientation in *M. bagoti*, as with other ant species, is primarily dependent on vision derived from terrestrial and celestial cues (Cheng *et al.* 2009; Wystrach *et al.* 2011; Freas *et al.* 2017; Deeti *et al.* 2020). In a proposed study related to the learning walks of naive *M. bagoti* individuals belonging to this colony, we removed the vegetation around the focal nest on 9 January. All the ants appearing outside the nest were marked with a dot of black paint on their gaster. Over a period of five days, 550–600 foragers were painted with the same colour. We then classified them as seasoned foragers and considered all the unpainted ants to be naive ants after this period. In the morning of the sixth day, we plotted a 1 m^2 grid around the nest (Figure 1C). Each naive ant was marked with a distinctively coloured dot of paint on its body on the sixth and seventh days to observe its learning walks. The nest became

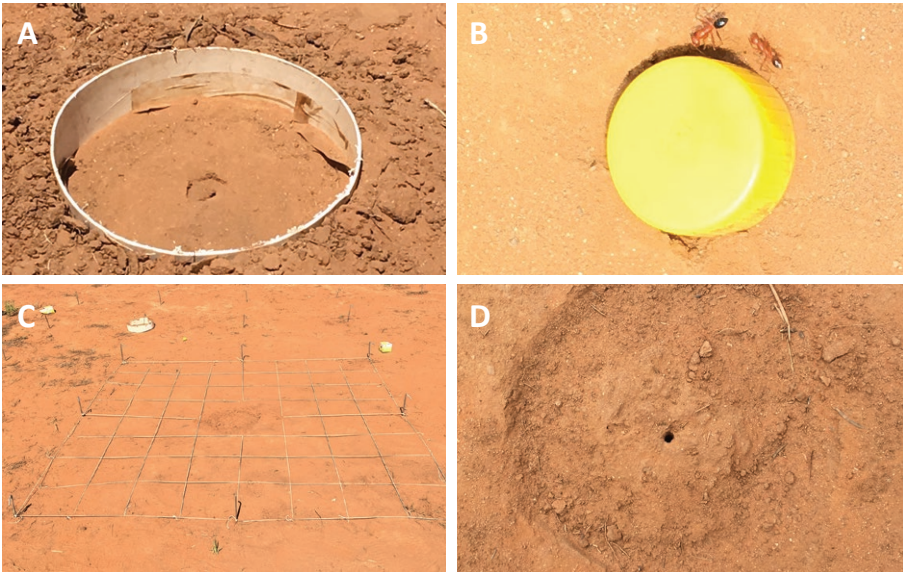

Figure 1. Overview of experimental disturbances around the nest. **A.** A plastic ring barrier covered with a sand ramp, **B.** a plastic cap on the nest to block the outbound and homebound runs, **C.** synthetic string forming a grid of 1m squares around the nest and **D.** removal of the plastic ring barrier from the nest surroundings to observe the learning walks.

inactive on the next two (i.e. eighth and ninth) days. On the tenth day, the ants opened a new entrance in the afternoon when the colony was less active and no foraging activity was being undertaken. They changed the entrance again on the eleventh day, a day on which we had painted the emerging unpainted ants (about 40) with a black dot. The relocation of the nest colony was observed to start on the sixteenth day (i.e. 24 January). All the ants coming out of the nest were documented by counting them during the relocation. We also occasionally videorecorded the traffic of the ants from the old nest.

Results

Observations at the old nest site

The first observation was that after seven days of preparation to observe initial learning walks, the colony became inactive for two days (Table 1). During days eight and nine, only a single guard ant emerged at 11.30 hr on day eight, searched extensively by making a few forays around the nest, and then returned to the nest. The second observation was made on the afternoon of the tenth day: a new entrance (1st entrance) was opened by some of the workers 81 cm west from the old entrance. From midday that day until the colony closed the nest, about 10–15 painted worker ants went off foraging for short periods. No ants came out of the new entrance on the morning of the next (eleventh) day, and the colony opened another entrance (i.e. the second entrance) on the north-east side 114 cm from the original nest entrance. They closed the second entrance after an hour and became active through another entrance (i.e. the third entrance), opening 180 cm north-east of the old entrance to the colony. This third entrance remained active until the relocation of the colony.

On the eleventh day, around 11.00 hr, we observed a large number (about 40) of guard ants moving outside of the nest over a 30 minute period, and they were performing longer runs than normal. Usually only 5–10 guard ants performed outbound runs per day. Physical contacts were also observed during the same day between guard ants and foragers (Figure 2).

Table 1. Characteristics of emigration from *M. bagoti* nest.

Date and day number	Immigration activity
16/1/2018 to 18/1/2018 (days 8 to 9)	Inactive colony, only one outside guard ant activity was observed.
18/1/2018 to 19/1/2018 (days 9 to 11)	New entrances were found at the old nest at 81 cm and 114 cm from the original nest entrance.
20/1/2018 (day 12)	Continuous outward behaviour was observed in 30 to 40 guard ants.
20/1/2018 to 23/1/2018 (days 13 to 15)	Workers and guard ants found digging the new nest 36 m from the old nest.
24/1/2018 (day 16)	Emigration to the new site was observed and continued throughout the day.
25/1/2018 to 26/1/2018 (days 17 to 18)	Less immigration from the old nest and more functions of colony building were observed at the new site.
26/1/2018 to 28/1/2018 (days 18 to 20)	During this time, changes in the entrance were noticed twice.

Activities at the relocation site

Figure 2. A. *Melophorus bagoti* workers, replete with the inflated abdomen that varies in colour from amber to milky white, callow (yellow to orange colour), and larvae at the old nest entrance. **B.** Physical contact between ants during the relocation. In the above image, guard ants and foragers are found contacting each other with their antennae.

On the twelfth day, at 36 m north from the old nest, a few guard ants, foragers and painted naive ants were observed digging a new nest. The excavation activity continued throughout the day (between 09.00 hr and 18.00 hr) for four days. We noticed similar nest digging activity on the sixteenth day at 09.00 hr and we also observed moves on the same day at 09.30 hr. During the relocation process, we observed the complete cessation of foraging out of the old nest.

On the morning of the sixteenth day, the colony started relocating its nest. From our earlier observations, we had found that normally only 4-5 naive ants appeared daily; however, 15–20 naive ants were noticed/painted on the morning of 24 January between 09.00 hr and 09.30 hr. Suddenly, at 09.30 hr, a huge number of unpainted ants, painted foragers and guard ants started to appear. About 20 of the ants started moving towards the relocation site and the remaining foragers/workers and guard ants milled around the entrance. At the same time, unpainted ants came out of the nest. Some of them carried larvae in their mandibles, then left them outside the nest and returned inside again. Workers and unpainted ants (novices) continuously pulled the callows (identified by colour), eggs and larvae out to the entrance. Guard ants and experienced foragers that were moving around the nest were picking up the larvae and steadily moving them towards the new nest (Figure 2). A few unpainted ants were trying to get into the older nest with the help of foragers. Many repletes were also noticed and they were much larger, orange in colour, and most of their abdomens were filled. As previously described by Conway (1992), we discerned two forms of repletes – those with dark amber-coloured abdomens and those with milky white abdomens.

The relocation of the nest proceeded throughout the day with the highest rate in the morning and afternoon, dipping during the middle of the day, and stopping before sunset. The majority of the workers, guard ants, repletes, callows, larvae and eggs had

shifted themselves (or were transported to) the relocation site by 24 January (i.e. the sixteenth day) (Table 2). During the move, including even at mid-day, most of the experienced foragers and the guard ants moved back and forth between the old and the new nest to transport the brood and callows. The moves peaked from 09.30 hr to 10.30 hr and from 16.30 hr to 18.00 hr, with a maximal activity on the sixteenth day and minimal activity for the next two days. On the seventeenth day they did not open the nest entrance until 11.30 hr at the relocation site and that new entrance was 84 cm west of the new nest. At that time, about 30–40 workers and guard ants from the old nest were noticed waiting outside for the new nest's entrance to be opened. When the nest entrance was opened, 30–40 ants went inside, and during the day only 10 larvae were transported to the new nest. In that time no repletes or callows were observed. Some foragers and guard ants were seen walking into the old nest from the new nest and vice versa without carrying anything. Queens and males were not observed at all during this time, and it remains unclear whether they had remained in the old nest or had moved to the new site unobserved. The transport of the ants to the new site finished on the seventeenth day (i.e. 25 January), so that transportation of the brood was completed in 1 to 2 days.

Table 2. Estimated numbers of different worker castes of *M. bagoti* transported to the relocation site during the emigration.

Transport Date	Workers	Guard ants	Repletes	Callows	Larvae/ pupae/ eggs
21/1/2018	25-30	5-10			
24/1/2018	1400	120	90	40	118
25/1/2018	50	5			10

From 26 January (i.e. the eighteenth day) to 6 March, the activity at the new nest and its changes were inspected for one hour (8.30–9.30 hr) before the nest activity started for the day and for one hour (17.00–18.00 hr) after the activity had ended. During this period, the entrance was changed twice – firstly 87 cm away from the original entrance and secondly 10 cm away from the original entrance. The activity at the old nest, however, was sporadic after relocation, and occasionally a few ants took back-and-forth round trips between it and the new nest. During the subsequent study season, no activity was observed at the old nest site whatsoever.

Discussion

In summary, we had the good fortune to observe by chance the relocation of a nest by a colony of *Melophorus bagoti*. The ants excavated a new nest and moved all workers and the brood into the new nest. The ants accomplished all the brood transportation in just 1 to 2 days (Figure 2).

Many ant species explore for a while before moving their nest (Abraham & Pasteels 1980; Mallon *et al.* 2001). Soil-nesting ants have to build a nest before or during a move, which takes up to a week in *Atta colombica and Pogonomyrmex badius*. The ground-nesting desert ant *Cataglyphis iberica* does not need to explore or prepare nests as it is polydomous and has several nests ready to inhabit. Their multi-nest system shortens the time for

migration and decreases the risks faced by the colonies. Our *Melophorus bagoti* colony took four days to dig its new nest, probably because the population was large.

During the unexpected move of the *M. bagoti* colony, we observed a large amount of outdoor activity by guard ants and physical contact between guard ants as well as between foragers and guard ants. This amount of contact between the guard ants and foragers has never been described before. After this instance, the guard ants, along with foragers, were noticed at the new nest. We do not know whether, during their first discovery, the ants somehow marked the new nest site, and this possibility should be explored.

Schultheiss *et al.* (2010) suggested that the nest move that they observed in this species was triggered by accidental structural damage to one of the chambers underground. But it remains unclear why the nest they studied and the nest we studied moved in response to experimental disturbance, whereas many other nests over many years of experimentation at this field site did not do so. Since the study reported here, we have studied other colonies of the same species in the same season, painting numerous individuals and setting up grids, but no relocation has taken place in any of these other colonies.

Some species of ant spread their colony throughout the nesting season to several nests and contract to one or more nests during the dormant season (Heller & Gordon 2006; Buczkowski & Bennett 2008; Laskis & Tschinkel 2009). Nest emigration seems to be typical in forest-dwelling ant species (Smallwood 1982). However, it seems to be rare in the desert-dwelling *M. bagoti*, wherein generally a nest does not relocate over many years. Nonetheless, behavioural and ecological field studies are still sparse and more research is needed to understand the causes of nest relocation of these ants.

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