



SHORT NOTE

“The road to reproduction”: foraging trails of *Constrictotermes cyphergaster* (Termitidae: Nasutitermitinae) as maternities for Staphylinidae beetles

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Abstract

Corotoca (Coleoptera: Staphylinidae) beetles are known for their close integration in the nests of the termite *Constrictotermes cyphergaster* (Termitidae: Nasutitermitinae). Although this relationship is regarded as ancient, many details are still obscure, such as their reproduction and the processes that lead to the dispersal of new beetles. We observed the use of termite foraging trails by Staphylinidae females to deposit and disperse their larvae. We recorded the deposition of larvae of *C. melantho*, *C. fontesi*, and *C. sp. n.* on the dorsal surfaces of termite host workers. The workers continue to follow the foraging trail until the newborn larvae freed themselves and fell into the leaf litter, subsequently burrowing into the ground. Information regarding the life stages of those Staphylinidae larvae outside the termite nest is important to understanding their full lifecycle as those taxa have strong relationships with the nest environment but also require dispersal strategies.

Termite nests present sophisticated micro-environments compared to the external environment. The association of other insect orders, such as beetles and other termite species (Kistner, 1969; Grassé, 1986; Jacobson & Pasteels, 1992) can be linked to the abiotic conditions inside the nest (temperature, humidity, luminosity) (Kistner, 1979). The association with termite is important to beetles, as they provide protection and potential food resources (Noirot & Darlington, 2000), and have apparently evolved over millions of years (Cai et al., 2017). According to the particular types of insect-insect interactions (Kistner, 1969), the guests are referred to as inquilines (termite species that live inside other termite colonies), termitophilous (non-termite taxa that live in association with

termites colonies), or termitariophilous (other invertebrates/vertebrates that live in associations with the nest).

Staphylinidae is one of the largest beetle families, comprising approximately 61,300 described species (Newton, 2015). Although showing wide morphological variability, the group can be distinguished from other beetles by their small elytra (Newton et al., 2001). Additionally, numerous species within this family are physogastric, including those of the genus *Corotoca*. Species of *Corotoca* are only found in the nests of *Constrictotermes* spp. (Asenjo et al., 2013). Previous studies have shown that individuals of *C. melantho* show morphological congruency with the workers of its host species (Cunha et al., 2015), as well as chemical mimicry



through cuticular hydrocarbon compounds acquired from the host (Rosa et al., 2018). Those strategies allow beetles to live in close association with their hosts, although relatively little is known about the roles of each partner in that relationship, nor why, contrary to nearly all other groups of insects, those Coleopterans are so successful in their invasions of social insect colonies (see Yamamoto et al., 2016). Staphylinidae beetles have been observed walking among their ant and termite hosts on open foraging trails (Quinet, 1995), but it was not known why they left the nest to follow their hosts' trails. The present study therefore investigated the behavior of those beetles on the foraging trails of *Constrictotermes cyphergaster* Silvestri, 1901.

We monitored the foraging trails of 14 *C. cyphergaster* colonies from 18:00 to 06:00. Individuals of *Corotoca* spp. were observed and collected at the start of colony foraging events. Observations were carried out in October/2017 (three days; at four nests) at Fazenda Almas (RPPN Fazenda Almas), located in the municipality of São José dos Cordeiros (36°52'W; 7°28'S); and in November/2017 (three days; at five nests) and Janeiro/2018 (21 days; at five nests) at the São João do Cariri Experimental Station, located in the municipality of São João do Cariri (36°31'W; 7°22'S), both sites in Paraíba State, Brazil. We registered the occurrence of individuals of *C. melantho* ($N = 13$), *C. fontesi* ($N = 9$), and *C. sp. n.* ($N = 7$) in all colonies sampled. Additionally, 25 beetles were collected

from different nests, dissected and observed the presence of larvae inside their abdomen. Staphylinidae identifications were made by consulting Fontes (1977) and Zilberman (2018). Collected specimens were deposited as vouchers in the Termite Ecology Laboratory of the State University of Paraíba, Brazil.

The beetles only left the termitarium after the establishment of the foraging trails (Fig 1) and kept in the middle of the trails (among the workers); they were never observed at the trail edges where the soldiers stand. We recorded the presence of up to eight individuals of *Corotoca* from the same colony during a single foraging event.

During termite foraging events, the female beetles deposited a well-developed larva on the pronotal and heads of *C. cyphergaster* workers (Supplementary Material - Movie SM01). This was accomplished after traveling a short distance from the nest along the foraging trail (up to 50 cm), after which the females of *Corotoca* started to release their larval offspring (which remained attached to the end of the mother's abdomen). The female beetle was observed actively moving its antennae and moving towards the workers. A worker passing close to the beetle stop and beetle female deposited the larva; then the worker continuing along the foraging trail with the larva on its dorsal surface. Further along the trail, when the larva apparently detected the presence of leaf litter, it squirmed over the worker's back and detach itself – falling



Fig 1. Female of *Corotoca* sp. releasing its larva during the foraging of its host *Constrictotermes cyphergaster*.

to the ground and quickly burying itself into the soil.

After depositing the larva on the worker termite, the adult beetle returned to the nest (still pregnant). We could not determine whether the same *Corotoca* individual would leave the nest again during the same foraging event, on the same night, to deposit the second larva.

The comprehension of this termitophile's life cycle is essential to understanding the benefits of their termitoguest relationship. The Caatinga domain presents extreme environmental conditions (drought and high temperatures), and the survival of *Corotoca* beetles depends on the support of their hosts' nests. According to Costa and Vanin (2010), some species of beetles closely associated with termites can confuse their hosts using mimicry cues, and beetle larvae are recognized as "termites". We hypothesize that this strategy is essential to larval dispersal during foraging events. Furthermore, the existence of a lifecycle stage outside of the nest could require mimetic compounds to be acquired or produced by the larvae, as that mimicry would be required for the re-colonization of host nests (see Rosa et al., 2018).

The interactions between termites and Aleocharinae beetles have been studied by several authors, highlighting Seevers (1957) and Grassé (1986), but the full life cycle of *Corotoca* individuals is not yet clearly understood in regard to its reproduction and nest colonization. The present work provides important information concerning the interactions of *Corotoca* individuals and *C. cyphergaster* that will aid future studies with termitophilous species.

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