Predation on *Atta laevigata* (Smith 1858) (Formicidae Attini) by *Canthon virens* (Mannerheim 1829) (Coleoptera Scarabaeidae)

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Received 19 August 2004, accepted 25 July 2005

We present observations on the predation and burying of *Atta laevigata* (Smith 1858) by *Canthon virens* (Mannerheim 1829) in Brazil. A specialized sequence of burying behavior was observed in 2 consecutive years. No relationship was found between predator and prey size. Up to eight beetles can attack a single ant simultaneously. Both male and female beetles prey on ants, but only males attack alone. For the first time we report ants successfully removing beetles from their backs. This behavior may account for the low predation efficiency of *C. virens*.

KEY WORDS: leaf-cutter ants, cerrado, dung beetle, nesting behavior.

INTRODUCTION

Adult dung beetles (Scarabaeinae) are known to feed upon soft food, as their mouth pieces do not allow them to ingest large particles nor to cut them (Halffter & Matthews 1966, Holter et al. 2002). Despite this, predation on diplopods

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and ants has been documented in a few species of *Canthon* Hoffmannsegg 1818 and *Deltochilum* Eschscholtz 1822 (Halffter & Matthews 1966, Cano 1998, Hertel & Colli 1998).

Although adults of *C. virens* (Mannerheim 1829) feed upon the faeces of some mammals, dead insects and ripe fruits (Vaz-de-Mello et al. 1998), predation on ant species of the genus *Atta* Fabricius 1804 has also been frequently documented in cerrado vegetation (an open seasonal Brazilian savanna dominated by a herbaceous layer with sparse trees and shrubs) and appears to be related to the beetle’s nesting behavior (Borgmeier 1937, Navajas 1950, Halffter & Matthews 1966, Vaz-de-Mello et al. 1998). Halffter & Matthews (1966) commented on unpublished observations made by E. Navajas, reporting that *Canthon* attack both male and female *Atta* using the clypeus to cut the ant’s integument, and that nesting occurs only with copulated *Atta* females while males and virgin *Atta* females are used only for adult feeding.

Hertel & Colli (1998) described a specialized behavioral sequence for *C. virens* predation on females of *Atta laevigata* Smith 1858 after their nuptial flight: the beetle approached the ant, mounted its back and firmly held its position by grasping the remnants of the ant’s wings with its third pair of legs; then the beetle severed the ant’s head from the thorax. They also suggested an obligatory relationship between *C. virens* and *A. laevigata*. Furthermore, a positive relationship between the female ant density and the number of *C. virens* has been found, suggesting that density-dependent predation may occur (Forti et al. 1999).

We provide additional information on the predation and burying of *A. laevigata* ants by *C. virens* in a cerrado vegetation of Brazil and examine whether there is any relationship between predator and prey size. We hypothesized that a positive relationship between ant body size and beetle body size should be found, since small beetles should be less able to prey on large ants or could even be injured by them.

**METHODS**

Observations took place at the Estação Ecológica de Pirapitanga (EEP) in Três Marias, Minas Gerais state, southeastern Brazil. The EEP is 1100 ha island (18°20’S to 18°23’S and 45°17’W to 45°20’W) whose primary vegetation is cerrado. The altitude of the study area varies from 560 to 630 m, mean annual temperature from 20 to 22 °C, and the mean annual precipitation is 1600 mm (Gonçalves-Alvim & Fernandes 2001).

Field observations were conducted with the unaided eye, following “sequence sampling” (sensu Altmann 1974) and took place on 12 December 2003, beginning at 16:00 hr and finishing at 18:20 hr due to lightning strikes. The mean temperature was 30 °C and the sky was partly cloudy with heavy rains occurring at the end of the observation period. Additional data were obtained on 9 December 2004.

When *C. virens* successfully attacked an ant, removing its head, we considered both predator and prey a successful pair. When an ant was able to remove the beetle from its back, the pair was classified as unsuccessful. In the laboratory we recorded the biometrics of both members of unsuccessful and successful pairs collected in 2003 (n = 14). For *C. virens* we measured total body length, pronotal width and body weight, while for *A. laevigata* we recorded total body length, thorax length, abdomen length, head width and total weight. To observe the post-predation behavior we placed 14 beetle-ant pairs into glasses with soil from EEP to simulate the natural environment. Regression analyses were used to examine the relationships
between the C. virens and A. laevigata data (Zar 1999). In 2004, ants with their associated predators were collected and the predator sex was determined in the laboratory (n = 19). We also sampled C. virens adults not associated with ants for sex determination.

RESULTS AND DISCUSSION

Although Canthon virens attack both male and female Atta (Halfter & Mattheis 1966), we observed C. virens attacking only copulated Atta females. Many A. laevigata males were observed in the field free of attack in both years. Most beetles landed directly on an ant from the air rather than attacking it from the ground (Fig. 1A-B). However, Hertel & Colli (1998) observed C. virens adults walking and mounting the ant’s back. Thus, C. virens may exhibit two different predation approaches, one by air and the other by land.

In 2003, we observed only one beetle per ant but in 2004 up to eight beetles attacked a single ant at the same time (n = 19 ants). Most attacks (58%), however, were performed by a single male beetle (only one female attacked an ant alone). Females seem to be opportunistic as they attack the ants only in the presence of at least one male. Moreover, the male:female ratio was higher for foraging beetles (1.09) than for non-foraging beetles (0.8), suggesting that males are more active foragers.

![Fig. 1. — Predation on Atta laevigata by Canthon virens. (A) Attack position from a dorsal view. (B) Attack position from a lateral view. (C) C. virens rolling the headless body of A. laevigata. (D) Burying behavior. (Drawings by Marcus Ferreira).](image-url)
For the first time (in 2003), we observed that ants can successfully remove beetles from their backs. One quarter of the ants successfully removed beetles from their backs. Afterwards, the ants moved away in a straight line and the beetles did not attempt to follow them. After one unsuccessful attack, a beetle entered the vacated burrow of the unsuccessfully attacked ant rather than attempt to attack the same ant again. The burrow was empty and the beetle quickly reemerged from it and appeared to continue searching for other preys along the path.

After decapitation, *C. virens* displayed a complex series of behaviors while burying the ant’s body (Table 1). Following the observation of a successful beetle-ant pair we observed post-attack and nest building behavior for over 2 hr (16:15-18:15). The beetle rolled the headless body of the ant 53 cm away from the attack site to a dead leaf, where it started to dig directly under the leaf and the ant body (Fig. 1C). The beetle proceeded to alternate between digging and returning to the surface in order to fit the ant’s body into the hole.

At 16:36, the beetle aligned itself vertically along a side of the ant’s body, still only partially in the hole, positioning its two hind legs up and its head down and performing a downward thrusting action. Within this set of movements *C. virens* periodically raised its hind legs alternately, holding each aloft for approximately 15-20 sec at a time and then repeating this behavior for the opposite leg (Fig. 1D). This behavior is similar to that described for males of the congeneric species, *C. cyanellus* LeConte 1859, emitting defense secretions against flies for brood balls (BELLÉS & FAVILA 1983), and for *Kheper nigroaeneus* (Boheman 1857) emitting sexual pheromones after finding a nesting resource (TRIBE 1975). Since males do not lay eggs, they may prey on ants and use them to attract *C. virens* females in order to copulate, although no females seemed to be attracted by the observed individual.

At 17:59, the ant was one centimeter below the soil surface. At 18:07, the beetle circled outside of the hole and returned inside it. At 18:09, the ant was visible in the shaft of the hole in a sideways fetal position still moving its legs until 18:15. Up to the end of the observation period, the constructed nest resembled a shallow pit similar to most telecoprid nests (HALFFTER & EDMONDS 1982).

In the laboratory, three beetles that successfully attacked ants in the field made two balls each, using the ant’s abdomen and thorax. Among the remaining eleven beetles, four beetles also used the ant’s thorax in addition to the ant’s abdomen in an unsuccessful attempt to form balls, although they may also have been used as a food resource.

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digging: pulling dirt out of hole</td>
<td>5</td>
</tr>
<tr>
<td>Attempting to push the body into the hole, from the top</td>
<td>9</td>
</tr>
<tr>
<td>Digging: by pushing dirt up from within the hole</td>
<td>19</td>
</tr>
<tr>
<td>Pulling <em>A. laevigata</em> down into the hole for the first</td>
<td>21</td>
</tr>
<tr>
<td><em>C. virens</em> vertically along a side of the ant's body,</td>
<td>21</td>
</tr>
<tr>
<td><em>C. virens</em> vertically along a side of the ant's body,</td>
<td>21</td>
</tr>
<tr>
<td>Circling outside the hole and returning below ground</td>
<td>113</td>
</tr>
</tbody>
</table>

* See text for further explanation.
Predation on *Atta laevigata* by *Canthon virens*

Prey size strongly influences selection by carnivorous insects, with increasing prey sizes increasing predator preference (Endo & Endo 1994, Muller et al. 1996). Mean *C. virens* (8.45 mm ± 0.051 SD) and *A. laevigata* (21.57 mm ± 0.128 SD) body lengths were smaller than those found by Hertel & Colli (1998) (10 mm for *C. virens* and 25 mm for *A. laevigata*). We did not find any significant relationship between predator and prey sizes (n = 14, Table 2).

Many other unstudied factors could influence the selection of ants by *C. virens*. The probability of a prey being eaten by the predator depends on prey density, availability of other food resources, developmental stage of the prey, and predator learning processes (Price 1997). These factors, however, may not be important in this case as these beetles seem to use the ant females as the only resource for constructing brood balls. Also, the ant females are a fluctuating resource, except on the few days in which the nuptial flights occur (usually one or two days a year), when they are an extremely abundant resource. Hence, under these conditions, the beetles should forage for ants regardless of size because they are an extremely ephemeral resource during this short period. Low variance in prey size may have accounted for non-significance, but small sample size could also explain the non-significance in our study. Finally, an alternative hypothesis is that, given the large difference in size between scarabs and ants, any variation in scarab or ant size would not have a significant effect upon prey selection. These hypotheses could be tested with additional observations.

A potential application of this study concerns the negative impact leaf-cutting ants may have in natural cerrado (see Viana et al. 2004) and man-made habitats (Hernández & Jaffé 1995). The use of *C. virens* for biological control of *Atta* has already been suggested by Boaretto & Forti (1997). However, the low predation effectiveness (only about 10% of *Atta* are preyed on, Forti et al. 1999) could be related to the successful beetle removal by the ant, which was not recorded by Hertel & Colli (1998), as well as the possibility that the high ant abundance may not provide resource limitation for those beetles. Thus, a large abundance of ants in a short period (between nuptial flight and nest settling) could make time, rather than ant abundance, a more limiting resource for beetles. It is still unclear how many

| Table 2. Results of the regression analysis of *Atta laevigata* and *Canthon virens* traits. |
|-----------------------------------------------|---------------|--------------------------|
| **Canthon virens**                            |               |                          |
| **Body length**                               | F = 2.78; r² = 0.19; | F = 3.21; r² = 0.21; | F = 2.42; r² = 0.17; |
|                                               | P = 0.121     | P = 0.098               | P = 0.146              |
| **Thorax length**                             | F = 0.16; r² = 0.01; | F = 1.32; r² = 0.1; | F = 0.01; r² = 0.01; |
|                                               | P = 0.693     | P = 0.272                | P = 0.982              |
| **Abdomen length**                            | F = 0.20; r² = 0.01; | F = 0.11; r² = 0.01; | F = 0.274; r² = 0.02; |
|                                               | P = 0.666     | P = 0.747                | P = 0.610              |
| **Head width**                                | F = 0.08; r² = 0.01; | F = 0.01; r² = 0.01; | F = 0.99; r² = 0.1; |
|                                               | P = 0.778     | P = 0.983                | P = 0.347              |
| **Total weight**                              | F = 2.98; r² = 0.20; | F = 0.03; r² = 0.03; | F = 1.05; r² = 0.02; |
|                                               | P = 0.110     | P = 0.576                | P = 0.325              |
ants a single beetle can kill. However, if *C. virens* takes only one prey, and spends a long time burying its body and attracting a female, many other ants are able to escape attack, thus decreasing predation effectiveness.

**ACKNOWLEDGMENTS**

We thank E. Chrisite, F. Almeida, M. Hilarino and C. Mendes for field assistance, H.L. Vasconcelos and R. Silva for ant identification, I.B.M. Sampaio for statistical analysis, M. Ferreira for drawings and CNPq (304851/2004-3, 472491/2003-2, 140071/2003-2) for financial support. G. Halffter read first drafts and gave many valuable comments. We also thank the Estação Ecológica de Pirapitinga-IBAMA and ECMVS for logistical support.

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