INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
17–1408/2018/20–5–1247–1250
DOI: 10.17957/IJAB/15.0613
http://www.fspublishers.org

Short Communication

Predation Rates of a Beetle (*Canthon virens*) that Kills Female Leaf-Cutting Ants (*Atta* spp.)

Priscila Sales Rodrigues Aquino[1], Flávio Gonçalves de Jesus[2], Ednaldo Cândido Rocha[1], Terezinha Maria Castro Della Lucia[3], José Cola Zanuncio[3] and Márcio da Silva Araújo[1]*
[1]*Universidade Estadual de Goiás, Ipameri, GO, 75780-000, Brasil*
[2]*Instituto Federal Goiano, Urutaí, GO, 75790-000, Brasil*
[3]*Universidade Federal de Viçosa, Viçosa, MG, 36570-000, Brasil*
*For correspondence: marcio.araujo@ueg.br

Abstract

The vast majority of *Atta* females that leave their original nests in a nuptial flight do not give rise to adult nests. This occurs because of unfavorable climatic conditions for nest building and maintenance of the future colonies, and due to the impact of biotic factors, such as predators. The predation of *Atta* spp. (Hymenoptera: Formicidae) females by *Canthon virens* (Mannerheim) (Coleoptera: Scarabaeidae) was investigated during their nuptial flight for eight consecutive years in the Cerrado biome of Goiás State, Brazil on bare soils (prepared for annual crop planting) and soil covered with vegetation (perennial crops). The highest numbers of *Atta* females were found excavating initial nests on bare soil immediately post nuptial flight; however, the predation rates by *C. virens* were higher in areas covered with vegetation, where fewer females tried to establish their colonies. This report is important for proposing natural biological control programs, especially in perennial crop areas where these predators are established.

Keywords: Biological control; Attini; Scarabaeidae; Females; Nuptial flight

Introduction

Failure of *Atta* spp. to start a new colony is associated with high female mortality (99.95% of the foundresses are not successful) (Autuori, 1950). This can be attributed to high rainfall, soil microorganisms, and predation by animals, including insects; the ants may also be used as food or fishing bait by humans (Rodrigues *et al.*, 2010; Araújo *et al*., 2015; Silva *et al.*, 2016).

Predation behavior is uncommon in Scarabaeidae, but *Canthon virens* (Canthonine) and *Deltochilum valgum* Burmeister are specific predators of *Atta* females and millipedes, respectively (Silveira *et al*., 2006; Larsen *et al*., 2009). Female foundresses of *Atta* spp. are preyed on, decapitated, and taken to underground nests as food for *C. virens* larvae (Rinaldi *et al*., 1993; Hertel and Colli, 1998; Araújo *et al*., 2011). This behavior is mainly exhibited by *C. virens* males, which perhaps use the prey to attract females for mating (Silveira *et al*., 2006). *Canthon virens* adults also feed on mammal feces and on mature fruits, but prefer *Atta* queens over any other food (Vaz-de-Mello *et al*., 1998).

Leaf-cutting ants, mainly *Atta*, are the major insect pests of the cultivated forests in Latin America, Mainly Brazil. The elimination of brush vegetation under such plantations can reduce populations of birds and predators of insect pests (Zanetti *et al*., 2000), which increases the success rate in establishing new ant nests by the founding queens after the mating flight. Bare soil or soils devoid of vegetation cover is preferred by insects for establishing new colonies (Araújo *et al*., 2003; Corrêa *et al*., 2006).

The objective of this study was to quantify, for eight consecutive years, the predation rate of *Atta* spp. females by *C. virens* in the Cerrado region of Goiás State, Brazil after the nuptial flight and to analyze the effect of soil cover on this rate.

Material and Methods

Experimental Area

The experiment was conducted during the mating seasons of *Atta* spp. from 2007 to 2016 at the Experimental Farm of the State University of Goiás, Ipameri, Goiás State, Brazil (17°43′19″N, 48°09′35″E, Altitude 773.0 m).

Treatments

The number of founding queens digging nests after the nuptial flight and those preyed on by *C. virens* were evaluated in two 40 × 50 m areas. The first area had most soil covered by bush vegetation [*Hancornia speciosa* Gomes and *Campomanesia pubescens* (DC.) O. Berg.] and had bare sites around cultivated plants. The second area was devoid of vegetation (plowed and prepared for annual crop planting). Ant females were counted by scanning the area (by eight people) after they lost their wings and were searching for places to start excavating their nest.

To cite this paper: Aquino, P.S.R., F.G.D. Jesus, E.C. Rocha, T.M.C.D. Lucia, J.C. Zanuncio and M.D.S. Araújo, 2018. Predation rates of a beetle (*Canthon virens*) that kills female leaf-cutting ants (*Atta* spp.). *Int. J. Agric. Biol*., 20: 1247–1250

In another experiment outside the 40 x 50 m plots and with the same experimental conditions, forty de-winged *Atta* spp. females were trapped with metal clips (Fig. 1A) along a 50 m-long transect in each area. The predation rate of these females by *C. virens* was evaluated during the mating flight period of this insect, the initial nest excavation, and 24 h after ending the flight with continuous observation to confirm predation by *C. virens.*

Statistical Analysis

Nest establishment and founding queen predated by *C. virens* in both the areas were compared by non-parametric tests (Chi-Square and Spearman's Correlation at $p<0.01$).

Results

A higher number of recently fertilized females *Atta* spp. began nest excavation in bare soil than in soil covered with vegetation ($\chi^2 = 596.47$; d.f. = 7; $p = 0.0000$). The predation rate was higher ($\chi^2 = 52.75$; d.f. = 7; $p = 0.0000$) in this latter situation (Experiment 1 with free females) (Table 1A). The correlation between number of females trying to establish their nests in the area and predation acts by *C. virens* showed positive correlation (Spearman) during the eight years of study (soil with vegetation: $r = 0.48$, $p< 0.01$; bare soil: $r = 0.36$, $p<0.01$).

The number of *Atta* females fixed to the soil and decapitated by *C. virens* was also higher in areas covered with vegetation compared to those on bare soil ($\chi^2 = 11.32$; d.f. = 7; $p = 0.037$) (Table 1B). A similar situation was found with the predation rate after 24 h regarding trapped ant queens ($\chi^2 = 14.83$; d.f. = 7; $p = 0.0011$).

The predation rates of leaf-cutting ant queens by *C. virens* on bare soil or covered by vegetation, after 24 h of being fixed to the soil, were 3.13 and 11.66, respectively.

Discussion

The majority of *C. virens* attacked was observed in areas covered with *H. speciosa* and *C. pubescens* crops and spontaneous vegetation, emphasizing the importance of perennial plants for maintaining populations of this beetle. In our study, on bare soil, almost all *C. virens* attacks on *Atta* females also occurred near the intersection between crops and bare soil areas. This suggests that vegetation favors predation rates and protects this predator.

Despite the great numerical variation of predators and prey over the years, in our study only a regular relationship was verified between densities of prey and predator (Spearman correlation); however, in their studies, Forti *et al.* (1999) reported a non-linear relationship between numbers of the predator *C. virens* and the predated *Atta* females. According to these authors, others factors, both isolated and combined, including climatic conditions, alternative food for this predator and food competitors, may limit the predation.

Fig. 1: Some images recorded during the experiment: A) *Canthon virens* overflying and awaiting the exit of its prey, the female of *Atta* spp., which was digging its initial nest after the nuptial flight. B) *Atta* spp. female attached to the ground by a metal clip, at a time when the predator was positioned to decapitate it. C, D and E) Records of individual and collective predator attacks. F) *C. virens* digging their nest to bury their prey. G) External appearance of the predator's nest after its prey was buried. H) The depth of constructed chamber was about 20 cm. Ipameri, Goiás, Brazil

Predation rarely occurs outside the period between landing after the nuptial flight and nest excavation. The absence of a typical low-flight altitude of this predator 24 h after imprisoning the female with a metal clamp was not observed, suggesting that the predators were already satiated.

The efficiency of *C. virens* in natural biological control may be reduced by its low reproductive potential (females deposit a maximum of three eggs) (Rinaldi *et al.*, 1993); by attacking prey in groups of males and females during a short period of food availability (Fig. 1A and B); by the fact that nuptial flights generally occur for only a few hours (Silveira *et al*., 2006); by the long time it takes to kill and transport prey to the nest (Fig. 1F, G and H) and by the fact that founding queens may remove

Table 1: (A) Number of nests established by *Atta* spp. and predatory acts by *Canthon virens* (Coleoptera: Scarabaeidae) in the sample areas of 40.0 x 50.0 m with soil covered by vegetation and bare soil, at the end of the nuptial flight.
(B) Predation of *Atta* females by *Canthon virens* (Coleoptera: Scarabaeidae) on soil covered by vegetation and bare soil at the end of nuptial flight. Ipameri, Goiás, Brazil

(A)

Year	"Free dealated females of *Atta*"			
	Number of excavated initial nests		Predation of females by *Canthon virens**	
	Bare soil	Covered soil	Bare soil	Covered soil
2007	175	131	5	23
2008	86	64	3	11
2009	40	17	2	5
2010	53	16	4	12
2011	106	27	1	9
2012	95	25	4	13
2013	35	20	3	7
2014	41	21	1	12
	$\chi^2 = 596.47$; p = 0.0000		$\chi^2 = 52.75$; p = 0.0000	

(B)

	"Dealated females of *Atta* trapped with metal clips on soil"					
	Predation by *C. virens* during nuptial flight		Decapitated females after 24 h		Predation rates	
	Bare soil	Covered soil	Bare soil	Covered soil	Bare soil	Covered soil
2007	1	3	2	4	5.0 %	10.0 %
2008	2	7	2	9	5.0 %	22.5 %
2009	1	4	2	5	5.0 %	12.5 %
2010	0	2	0	4	0.0 %	10.0 %
2011	1	3	1	4	2.5 %	10.0 %
2012	2	2	2	3	5.0 %	3.30 %
2013	1	5	0	3	0.0 %	7.50 %
2014	2	8	1	7	2.50 %	17.50 %
	$\chi^2 = 11.32$; p = 0,037		$\chi^2 = 14.83$; p = 0.0011		$\chi^2 = 37.11$; p = 0.000	

*The act of predation (individual attack or not) consisted of the visualization of the predator mounted on the prey or the prey decapitated next to the predator. In experiment 2, n = forty dealated *Atta* spp. females trapped with metal clips on soil in a transect

the predator from their back (Silveira *et al*., 2006). Probably, the leaf-cutting ant species will influence the predation rate of the beetle. In our study was not identified the specie of predated *Atta* female. However, the *Atta* species that occur in the study region are *A. laevigata* and *Atta sexdens rubropiolosa* (Silva *et al*., 2016).

The low number of prey attacked was found to be the most important factor in the low success seen when this predator was reared in Paraguay for the biological control programs of *Atta* spp. (Boaretto and Forti, 1997; Vieira-Neto *et al*., 2005). Even with low predation rates, the presence of *C. virens* preying on *Atta* females is documented. For example, a total of 34 predation acts on *A. laevigata* (Smith) females reported during flight and nest establishment was found to be 61.8% by *C. virens* in Uberlândia, Minas Gerais State, Brazil (also Cerrado region) (Vieira-Neto *et al*., 2005). However, in all these reported works, the authors do not characterize the environment in which the predator attacks occurred.

Conclusion

The higher predation rate of founding queens by *C. virens* on soil with vegetation indicates that this predator may be kept in areas of perennial crops even after prey mating flights. Preserving a sheltered environment for this and other natural enemies may reduce the establishment of leaf-cutting ant nests.

Acknowledgements

The authors are grateful to the Universidade Estadual de Goiás and CNPq for facilitating this research through research grants (programs BIP/UEG and PIBIC/CNPq) and Global Edico, India for reviewing the English version of the manuscript.

References

Araújo, M.S., C.A. Rodrigues, M.A. Oliveira and F.G. Jesus, 2015. Controle biológico de formigas-cortadeiras: o caso da predação de fêmeas de *Atta* spp. por *Canthon virens*. *Rev. Agric. Neotrop*., 2: 8–12

Araújo, M.S., J.M.M. Pereira, M.M.R. Ribeiro and M.A. Oliveira, 2011. Predadores e outros organismos associados aos ninhos de formigas-cortadeiras. *In: Formigas-cortadeiras: Da Biologia ao Manejo*, pp: 311–320. Della Luca, T.M.C. (ed.). UFV, Viçosa, MG, Brazil

Araújo, M.S., T.M.C. Della Lucia, G.A. Ribeiro and C.M. Kasuya, 2003. Impacto da queima controlada da cana-de-acúcar na nidificação e estabelecimento de colônias de *Atta bisphaerica* Forel (Hymenoptera: Formicidae). *Neotrop. Entomol*., 32: 685–691

Autuori, M., 1950. Contribuição para o conhecimento da saúva (*Atta* spp. Hymenoptera-Formicidae). V- Número de formas aladas e redução dos sauveiros iniciais. *Arq. Inst. Biol.*, 19: 325–331

Boaretto, M.A.C. and L.C. Forti, 1997. Perspectivas no controle de formigas cortadeiras. *Sér. Téc. (IPEF)*, 11: 31–46

Corrêa, M.M., W.D. Fernandes and I.R. Leal, 2006. Diversidade de formigas epigéicas (Hymenoptera: Formicidae) em capões do Pantanal Sul Matogrossense: relações entre riqueza de espécies e complexidade estrutural da área. *Neotrop. Entomol*., 35: 724–730

Forti, L.C., I.M.P. Rinaldi, W. Yassu and M.A.S. Pinhão, 1999. Avaliação da eficiência de predação de *Canthon virens* (Coleoptera, Scarabaeidae). *Naturalia*, 24: 241–242

Hertel, F. and G.R. Coll, 1998. The use of leaf-cutter ants, *Atta laevigata* (Smith) (Hymenoptera: Formicidae), as a substrate for oviposition by the dung beetle *Canthon virens* Mannerheim (Coleoptera: Scarabaeidae) in central Brazil. *Coleop. Bull*., 52: 105–108

Larsen, T.H., A. Lopera, A. Forsyth and F. Génier, 2009. From coprophagy to predation: a dung beetle that kills millipedes. *Biol. Lett.*, 5: 152–155

Rinaldi, I.M.P., L.C. Forti and W. Yassu, 1993. Biologia de *Canthon virens* (Coleoptera, Scarabaeidae) predador de rainhas de *Atta* (Hymenoptera, Formicidae) em condições de campo. *In*: *Congresso Brasileiro de Entomologia*, pp: 14, Esalq, Piracicaba, SP

Rodrigues, A., A. Silva, A.M. Bacci Junior, L.C. Forti and F.C. Pagnocca, 2010. Filamentous fungi found on foundress queens of leaf-cutting ants (Hymenoptera: Formicidae*) J. Appl. Entomol.,* 134: 342–345

Silva, D.A.D., M.F. Luiz, F.G.D. Jesus, E.C. Rocha, M.A.D. Oliveira and M.D.S. Araújo, 2016. Post-fire effect of savannah vegetation on the establishment of new colonies of *Atta sexdens rubropilosa* (Hymenoptera: Formicidae). *Flor. Entomol*., 99: 744–749

Silveira, F.A.O., J.C. Santos, L.R. Viana, S.A. Falqueto, F.Z. Vaz-de-Mello and G.W. Fernandes, 2006. Predation on *Atta laevigata* (Smith, 1858) (Formicidae: Attini) by *Canthon virens* (Mannerheim, 1829) (Coleopptera: Scarabaeidae). *Trop. Zool.*, 19: 1–7

Vaz-de-Mello, F.Z., J.N.C. Louzada and J.H. Schoereder, 1998. New data and comments on Scarabaeidae (Coleoptera: Scarabaeoidea) associated with Attini (Hymenoptera: Formicidae). *Coleop. Bull.*, 52: 209–216

Vieira-Neto, E.H.M., H.L. Vasconcelos, F.M. Mundim and E.M. Bruna, 2005. Estradas alteram a dinâmica de colonização de um herbívoro chave do Cerrado brasileiro. *Congr. Ecol. Bras., pp: 7, Instituto de Biociências*, Caxambu, MG, Brazil

Zanetti, R., E.F. Villela, J.C. Zanuncio, H.G. Leite and G.D. Freitas, 2000. Influência da espécie cultivada e da vegetação nativa circundante na densidade de sauveiros em eucaliptais. *Pesq. Agrop. Bras*., 35: 191–1918

(Received 12 December 2017; Accepted 28 December 2017)