

Bionomic data and larval density of Scarabaeidae (Pleurosticti) in sugarcane in the central region of Mato Grosso do Sul, Brazil

Gilmar Vieira Coutinho¹, Sérgio Roberto Rodrigues¹, Edna Cristina da Cruz² & Alfredo Raul Abot¹

¹Universidade Estadual de Mato Grosso do Sul, Rodovia Aquidauana, CERA km 12, 79200-000 Aquidauana-MS, Brasil.
gilmarcoutinho@hotmail.com; sergio@uems.br; arabot@uems.br

²Companhia Brasileira de Açúcar e Alcool/Unidade de Sidrolândia, Estrada Quebra Coco, km 9, 79170-000 Sidrolândia-MS, Brasil.
edna.cruz@cbaa.ind.br

ABSTRACT. Bionomic data and larval density of Scarabaeidae (Pleurosticti) in sugarcane in the central region of Mato Grosso do Sul, Brazil. Phytophagous larvae of Scarabaeidae cause damage to diverse crops. Information on these pests is scarce; therefore, the objective of this study was to determine biological aspects and larval density of species occurring in an area of sugarcane. The studies were developed in Sidrolândia from April 2009 to March 2010. Scarab beetle larvae were collected in sugarcane roots every fifteen days, taken to the laboratory and reared to obtain the adults and determine biological parameters. A total of 2,656 larvae were collected, being 162 *Liogenys fuscus*, 120 *Cyclocephala verticalis*, 37 *Cyclocephala forsteri*, and 2337 *Anomonyx* sp. In January, 53.65 larvae m⁻² were obtained, and the most abundant species was *Anomonyx* sp, representing 87.99% of the total larvae collected. From November to March, the greatest densities of *Anomonyx* were observed in the field. The adults of this species occurred from May to September, and egg laying from September to November. Eggs measured 1.1 x 1.7 mm, and incubation period last 15.4 days. First instar larvae were observed mainly in October; second instar larvae from November to April; and third instar from January to July. Pupae were observed from May to August. The most abundant scarab beetle, *Anomonyx* sp. in roots of sugarcane presents one generation per year in Sidrolândia, MS.

KEYWORDS. Insect biology; *Saccharum officinarum*; Scarabaeoidea; soil pests.

RESUMO. Dados bionômicos e densidade larval de Scarabaeidae (Pleurosticti) em cultura de cana-de-açúcar na região central de Mato Grosso do Sul, Brasil. Larvas fitófagas de Scarabaeidae causam danos em diversas culturas. Entretanto as informações sobre essas pragas são bastante escassas. Assim, o objetivo deste estudo foi determinar aspectos morfológicos, biológicos e densidade larval de escarabeídeos em área de cana-de-açúcar. Os estudos foram desenvolvidos em Sidrolândia, MS, de abril de 2009 a março de 2010. As larvas presentes nas raízes de cana-de-açúcar foram coletadas quinzenalmente, levadas para o laboratório e criadas até a obtenção de adultos e avaliação de parâmetros biológicos. Foram coletadas 2.656 larvas, sendo 162 de *Liogenys fuscus*, 120 de *Cyclocephala verticalis*, 37 de *Cyclocephala forsteri* e 2337 *Anomonyx* sp. Em janeiro, foram registradas 53,65 larvas m⁻², sendo *Anomonyx* sp. a espécie mais abundante, representando 87,99% do total. De novembro a março, foram observadas as maiores densidades de *Anomonyx* no campo. Os adultos foram observados de maio a setembro. A postura ocorreu de setembro a novembro. Os ovos mediram 1,1 x 1,7 mm, com período de incubação de 15,4 dias. As larvas de primeiro instar foram observadas em outubro, as de segundo instar de novembro a abril e as de terceiro de janeiro a julho. As pupas ocorreram de maio a agosto. A espécie de Scarabaeidae mais abundante na cana-de-açúcar é *Anomonyx* sp., que apresenta uma geração por ano.

PALAVRAS-CHAVE. Biologia de inseto; pragas-de-solo; *Saccharum officinarum*; Scarabaeoidea.

Phytophagous beetles of the family Scarabaeidae are important pests in various crops. Damage is caused mainly by the larvae that chew on the roots of several gramineae (Poaceae). Sugarcane production is in rapid expansion in the central-west region of Brazil and some scarab species are reported as pests, including *Ligyris* sp., *Stenocrates* spp. and *Euethola humilis* (Burmeister, 1847) (Gallo *et al.* 2002) and *Strategus aloeus* (L., 1758) (Pereira *et al.* 2004). Despite the importance of Scarabaeidae as a crop pest, information on the association of this group with sugarcane is scarce in Brazil.

In Mexico, Aragón-García & Morón (2000) reported the occurrence of *Cyclocephala lunulata* Burmeister, 1847 and *Phyllophaga brevidens* (Bates, 1888) associated with sugarcane. Gordon & Anderson (1981) registered the occurrence of *Phyllophaga latifrons* (LeConte, 1856), *Anomala marginata* (F., 1972), *Cyclocephala parallela* Casey, 1915,

Dyscinetus morator (F., 1798), *Ligyris subtropicus* Batchley, 1922 and *Euphoria sepulchralis* (F., 1801) in sugarcane crops in Florida, USA. In Japan, Arakaki *et al.* (2004a,b) related *Dasylepida ishigakiensis* (Nijima & Kinoshita, 1927) and *Anomala albopilosa sakishimana* Nomura, 1964 causing damage to the root system of sugarcane plants and Oyafuso *et al.* (2002) also studied and reported Scarabaeidae species as pests to sugarcane.

In order to control these pests and minimize adverse effects, it is necessary to obtain information of their biological aspects in regions of interest. Therefore, it is initially necessary to identify the species and determine basic biological parameters. Next, population dynamics should be evaluated, considering host plants, control agents and environmental factors responsible for mortality (Aragón-García & Morón 2000).

Taking into consideration that areas cultivated with sugarcane are in expansion in Brazil and there is little information on phytophagous Scarabaeidae occurring on this culture, the objective of the present study was to evaluate biological aspects and density of larvae of scarab beetles in sugarcane, in Sidrolândia, in the central region of Mato Grosso do Sul, Brazil.

MATERIAL AND METHODS

The experiment was conducted in a commercial sugarcane field in the county of Sidrolândia, in the central region of the state of Mato Grosso do Sul, Brazil (20°47'S; 55°05'W; 300 m in altitude), managed by Companhia Brasileira de Açúcar e Álcool. Two stands were selected, one with an area of 49.90 ha planted with cultivar SP81 3250 (medium maturation cycle and susceptible to nematodes) and the other measuring 41.14 ha and planted with cultivar RB867515 (late maturation cycle). Harvesting was performed in the second half of September for cultivars SP81 3250 and by the end of November of 2009 for cultivar RB867515. The plants were burned and manually cut.

From April 2009 to March 2010, 48 soil samples measuring 25x25 cm and 30 cm deep were randomly collected from each stand near the root system, every 15 days (methodology adapted from Silva & Loeck 1996; Silva & Costa 1998). Therefore, the 48 samples of each stand represented an area of 3 m². The soil samples were sieved and the scarab beetle larvae removed and quantified. For identification of the Scarabaeidae complex, the larvae were taken to the Laboratory of Entomology of the Universidade Estadual de Mato Grosso do Sul, in Aquidauana, MS, Brazil and reared individually in 500 mL plastic recipients containing soil and sugarcane sprouts to obtain the adults (method adapted from Aragón-García & Morón 2000; Pardo-Locarno *et al.* 2005).

The rearing recipients were maintained at 26± 2°C and inspected twice a week. When the sugarcane sprouts began to wither and dry out they were replaced. The following parameters were evaluated: time of egg incubation, width of the larval cephalic capsule, body width, body length and larval weight (adapted from Rodrigues *et al.* 2010).

Larvae quantities were grouped in each sampled month and after that they were subjected to analysis of variance. The monthly averages were compared using the Tukey test ($P < 0.05$).

Some species were identified by comparison with the entomological collection of insects at the State University of Mato Grosso do Sul, in Aquidauana, MS.

RESULTS AND DISCUSSION

A total of 2,656 larvae, five pupae and four adults were obtained from the soil samples during 12 months of sampling. Four species of phytophagous Scarabaeidae were identified; *Liogenys fuscus* Blanchard, 1850, *Anomonyx* sp, *Cyclocephala forsteri* Endrodi, 1963 and *Cyclocephala verticalis* Burmeister, 1847.

Scarabaeidae larvae have three larval instars (Rodrigues *et al.* 2008; Santos & Avila 2007), and in this experiment the scarab larvae were found during the entire year, with population peaks from November to March and only few specimens from April to October.

Significant differences were observed in larval density, the greatest being in January, with a mean of 53.65 larvae m⁻² (Fig. 1). High larval density observed from November to March followed the period of intensive adult activities and reproduction in October and November. According with Rodrigues *et al.* (2008), Rodrigues *et al.* (2010) and Santos & Ávila (2007), the reproduction peak for *L. fuscus*, *C. verticalis* and *C. forsteri* is from September to November, resulting in the high larval density observed in the following months.

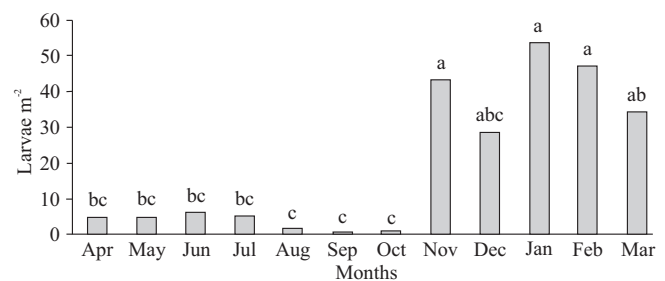


Fig. 1. Mean density of larvae m⁻² of phytophagous Scarabaeidae sampled in sugarcane, in Sidrolândia, MS, from April 2009 to March 2010. Means followed by the same letter do not significantly differ by the Tukey test ($P < 0.05$).

The high density of scarab larvae in soybean crops has been reported in the state of Paraná by Oliveira *et al.* (1997). They observed an average of 20 larvae m⁻² during the sowing period. *Phyllophaga cuyabana* was the species causing the most damage.

In both sugarcane cultivars similar quantities of larvae were sampled, being 1,223 larvae in the SP81 3250 cultivar and 1,433 larvae in the RB867515 cultivar. The larvae dynamic in the two stands was similar, and the highest average was 86.70 larvae m⁻² in the cultivar RB867515 (Fig. 2).

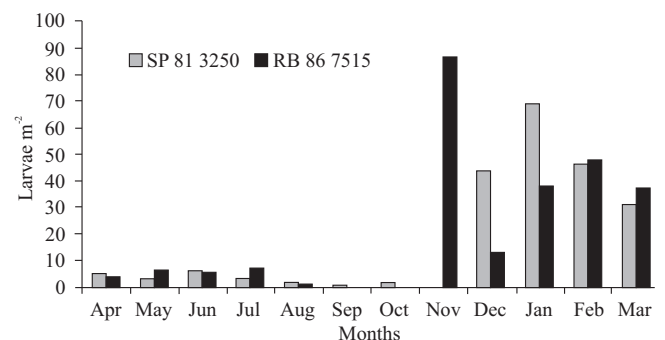


Fig. 2. Mean density of larvae m⁻² of phytophagous Scarabaeidae sampled in two sugarcane varieties, in Sidrolândia, MS, from April 2009 to March 2010.

Based on morphological characteristics, the third instar larvae can be differentiated from the others larval instars. *L. fuscus* presents mean cephalic capsule width of 3.77 mm (3.3–4.1mm) and body length of 23.44 mm, and the raster possesses two rows of palidia with 3 to 4 large setae (ranging from 2 to 4 setae by pali) (Fig. 3). In *C. verticalis* the width of the cephalic capsule is 4.25 mm (4.0–4.7 mm) and body length is 26.11 mm. The raster presents one row of palidia and two to four bifid pairs of setae (2–4 bifid setae by pali) (Fig. 3).

Larvae of *C. forsteri* has cephalic capsule width of 5.78 mm (5.3–6.2 mm) and mean length of 33.23 mm. In the region of the raster various setae are observed, however there is no palidia (Fig. 3). The larvae of *Anomonyx* sp, present mean cephalic capsule width 3.05 mm (2.6–3.8 mm) and body length of 19.53 mm. The raster possesses two rows of palidia with mean of 12 a 13 setae on each (10–14 setae by pali) (Fig. 3).

Some biological and behavioral aspects of each species were observed, as follows (Table I).

***Liogenys fuscus*.** From April to September, 116 larvae of *L. fuscus* were collected, from these 27 reached the pupal stage and 13 adults emerged in the laboratory. The larvae collected during this period were in the third instar, and 94.4%

were in pre-pupa stage. These pre-pupae presented white bodies and remained for an average of 92.4 ± 17.0 days in this stage ($n = 9$) (Table I).

In October and November no larvae were collected in the field. From December to March 46 larvae were sampled, usually in low density. In July the population increased and a mean of 6 larvae m^{-2} were recorded (Fig. 4).

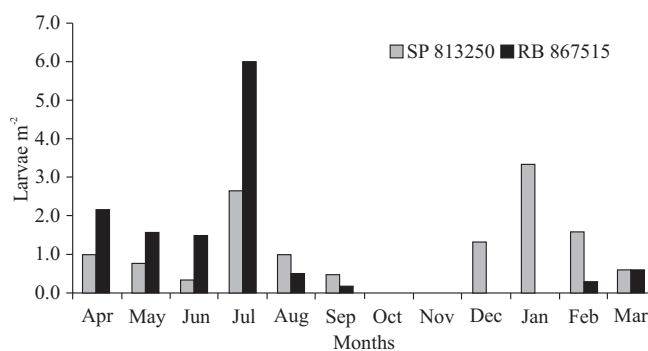


Fig. 4. Mean density of larvae m^{-2} of *Liogenys fuscus* sampled in two sugarcane varieties, in Sidrolândia, MS, from April 2009 to March 2010.

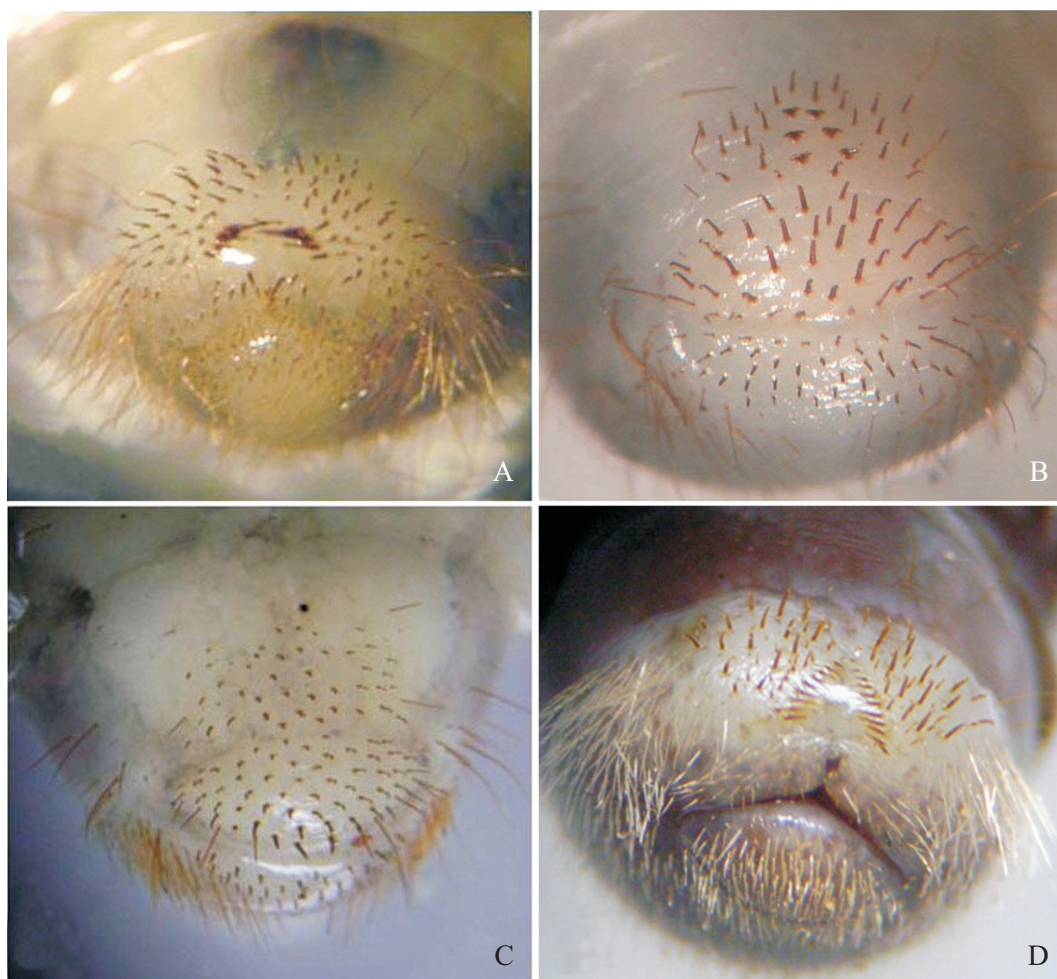


Fig. 3. Rasters of *Liogenys fuscus* (A), *Cyclocephala verticalis* (B), *Cyclocephala forsteri* (C) and *Anomonyx* sp. (D).

Table I. Biometrics and biological data of *Anomonyx* sp., *Liogenys fuscus*, *Cyclocephala forsteri* and *C. verticalis* sampled in sugarcane, in Sidrolândia, MS, from April 2009 to March 2010.

Species	Phase	Duration (days)	Cephalic capsule (mm)	Length (mm)	Weight (mg)
<i>Anomonyx</i> sp.	Egg	15.40	–	1.70	–
	1 st instar	50.00	1.31 (1.0–1.6)	9.32	15.53 (2.4–20.2)
	2 nd instar	73.00	2.09 (1.7–2.5)	14.10	50.31 (24.3–97.0)
	3 rd instar	167.00	3.05 (2.6–3.8)	19.53	179.54 (113.3–319.7)
	Pre-pupa	15.00	–	–	–
	Pupa	28.80	–	–	–
<i>Liogenys fuscus</i>	2 nd instar	–	2.30	–	–
	Pre-pupa	92.40	3.77 (3.3–4.1)	23.44	402.20 (301,3–542.6)
	Pupa	25.30	–	–	–
<i>Cyclocephala forsteri</i>	Egg	17.00	–	–	–
	1 st instar	31.00	2.50	–	–
	2 nd instar	53.00	3.80	–	–
	3 rd instar	70.00	5.78 (5.3–6.2)	33.23	1378.41 (993.3–1662.0)
	Pre-pupa	65.50	–	–	–
	Pupa	20.50	–	–	–
	Adult	23.00	–	–	–
<i>Cyclocephala verticalis</i>	1 st instar	–	1.62 (1.5–1.7)	–	–
	2 nd instar	–	2.66 (2.2–3.1)	–	–
	3 rd instar	–	4.25 (4.0–4.7)	26.11	535.57 (432.4–840.7)
	Pré-pupa	32.76	–	–	–
	Pupa	17.38	–	–	–

Third larval instar presents cephalic capsule width of 3.77 mm (n = 100), body length of 23.44 mm (n = 73) and weight of 402.20 mg (n = 58). Pupae of *L. fuscus* were observed from August to September and pupal stage duration of 25.53 ± 9.3 days (n = 13) (Table I). Adults were found from August to October. Larvae of *L. fuscus* presented similar behavior in pasture areas, according to Rodrigues *et al.* (2008). Its behavior is also similar to that of *Liogenys suturalis* (Blanchard, 1851) in crop areas (Santos & Ávila 2009). Larvae in the second instar were obtained from December to February and have cephalic capsule width of 2.3 mm (n = 14).

Larvae of *L. fuscus* have been reported feeding on the roots of *Brachiaria decumbens* (Rodrigues *et al.* 2008) and adults occurring in areas of no-till soybeans (Costa *et al.* 2009). It has been verified that this species is very polyphagous, feeding on different crops, including sugarcane.

***Anomonyx* sp.** A total of 2,337 larvae of *Anomonyx* sp were sampled; 21 reached pupal stage and 7 adults emerged in the laboratory. Many larvae did not complete the biological cycle because they were injured during sampling and others probably did not adapt to the laboratory conditions. The quantity of *Anomonyx* larvae collected represented 87.99% of all larvae sampled in this sugarcane area.

From April to July, small quantities of larvae in the third instar were collected in the field, and from June to October the stand with cultivar RB867515 was not sampled (Fig. 5). From November 2009 to March 2010 the greatest densities of *Anomonyx* sp, larvae were sampled in the areas of sugar-

cane. In November, the stand of cultivar RB 867515 a density of 80.3 larvae m⁻² was recorded (Fig. 5). High densities of larvae during November coincided with the rainy season in the region of Sidrolândia, and resulted from the period of reproduction and oviposition in the previous two months. The populations of larvae remained at high densities until March, after that they decreased and kept low until October, probably due to the normal life cycle of species of *Anomonyx* and high mortality due to the action of predators or pathogens.

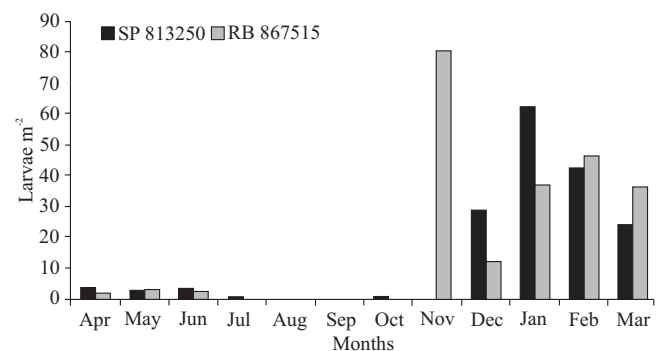


Fig. 5. Mean density of larvae m⁻² of *Anomonyx* sp. sampled in two sugarcane varieties, in Sidrolândia, MS, from April 2009 to March 2010.

On this subject Rodrigues *et al.* (2011) also reported a decrease in the larval density of Scarabaeidae in crop rota-

tion systems, being related to natural mortality, pathogens and predators action as causing this population decline.

Only one larva was observed alive in vials where 3 to 5 larvae were reared together, indicating cannibalism. Even in the field, this behavior may be observed when there are many larvae together, what may represent another factor of larval mortality.

Eggs of *Anomonyx* were observed in the field from September to November (Fig. 6). The eggs are deposited in groups of 3 to 5 ($n = 5$) or isolated in the soil ($n = 40$). In the laboratory it was recorded a mean of 38 eggs/female, and the incubation period lasted 15.4 days ($n = 20$). Each eggs were oval and measured 1.1 x 1.7 mm in average ($n = 15$) (Table I).

First instar larvae of *Anomonyx* were first collected in October at low densities in the stand with SP81 3250. In the cultivar RB867515, first instar larvae were observed at high densities until November. Second instar larvae were observed from November to until April. Third instar larvae occurred from January to March (Fig. 6).

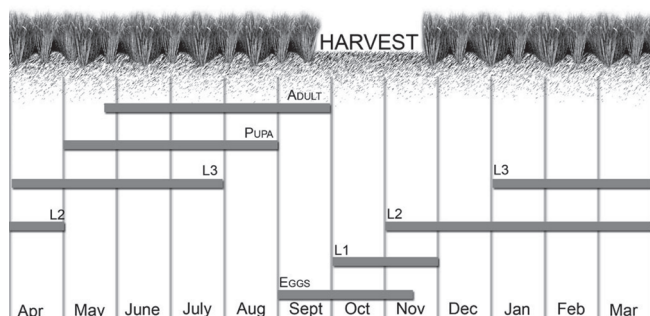


Fig. 6. Development phases of *Anomonyx* sp. in sugarcane in Sidrolândia, MS, from April 2009 to March 2010.

The cephalic capsule of first instar larvae presented a width of 1.31 mm ($n = 24$), body width of 9.32 mm ($n = 13$), weight of 15.53 mg ($n = 6$) and duration of 50 days ($n = 6$). Those in the second instar presented a capsule width of 2.09 mm ($n = 45$), length of 14.1 mm ($n = 45$), weight of 50.31 mg ($n = 11$) and duration of 73 days ($n = 4$). Larvae in the third instar had a cephalic capsule width of 3.05 mm ($n = 107$), length of 19.53 mm ($n = 92$), weight of 179.54 mg ($n = 56$) and duration of 167 days ($n = 4$) (Table I).

In the laboratory, larvae of *Anomonyx* developed on the roots of sugarcane sprouts, and penetrated into the tissues causing death of the plant what required substitution during the rearing period. Aragón-García & Morón (2000) studied Scarabaeidae as pests to sugarcane, collected larvae of *C. lunulata* and *P. brevidens*, and feed them with primary and secondary roots.

From May to July pre-pupae were recorded, and they remained in this stage for 15 days in average ($n = 14$). The pupae occurred from May to August in pupal cells in the soil and the pupal period lasted 28.8 days in average ($n = 7$). Adults emerged May to September (Fig. 6).

Mating of *Anomonyx* in the laboratory had a mean duration of 24 minutes (10–45) ($n = 7$). After mating, the male remained on top of the female for 15 minutes. This behavior was also observed for *L. fuscus* (Rodrigues *et al.* 2008) and *C. verticalis* (Rodrigues *et al.* 2010), and it is probably an attempt to avoid the female from mating with other males.

***Cyclocephala forsteri*.** From April to August 2009, 22 third instar larvae were collected and reared in the laboratory. From these only four completed their development and reached the adult stage. From September 2009 to January 2010 no larvae were collected in the field (Fig. 7). Larval population was low in all months, with the highest density in July (1.3 larva m^{-2}).

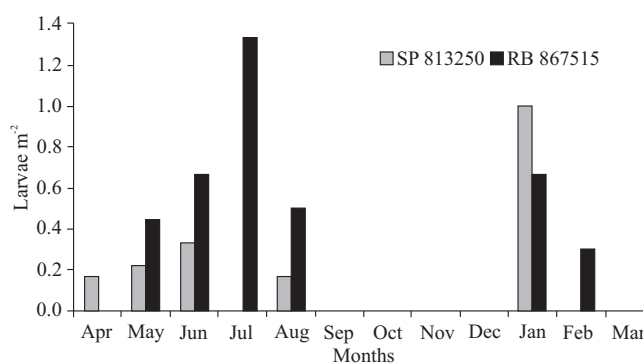


Fig. 7. Mean density of larvae m^{-2} of *Cyclocephala forsteri* sampled in two sugarcane varieties, in Sidrolândia, MS, from April 2009 to March 2010.

Pre-pupae occurred from June to September, followed by pupae from September to October. Pre-pupa lasted 65.5 days ($n = 4$) and the pupal phase lasted 20.5 days ($n = 4$).

In the laboratory, adults emerged from October to November, presenting an average longevity of 23 days. Females started to lay eggs in November and December. Incubation period lasted 17 days ($n = 15$) in average. The first instar larvae emerged in November and December, and the duration of this instar was 31 days in average. The second instar larvae lasted 53 days and the third 70 days in average (Table I).

In the field, first instar larvae were encountered in January and February of 2010, and those in the third instar again encountered at the end of January to March.

The cephalic capsule of first instar larvae measured 2.5 mm wide; the second instar 3.8 mm; and the third instar 5.78 mm ($n = 17$) with length of 33.23 mm ($n = 13$) and weight of 1,378.41 mg ($n = 10$) (Table I). Similar measures of cephalic capsules were obtained for the first and second instar larvae of *C. forsteri* by Santos & Ávila (2007).

Biological and morphological data recorded for *C. forsteri* in sugarcane are similar to those studied for this species in soybeans, in the region of Dourados, MS, Brazil, by Santos & Ávila (2007).

***Cyclocephala verticalis*.** A total of 120 larvae were collected in the field and reared in the laboratory. From these, 23 pupated and only 16 adults emerged. Larvae of *C. verticalis*

were collected along the sampling period in the two stands, excepted for July when no larvae were observed. The greatest density (6.6 larvae m⁻²) was in March 2010 (Fig. 8).

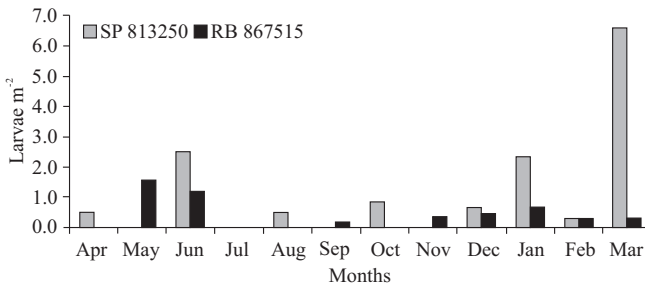


Fig. 8. Mean density of larvae m⁻² of *Cyclocephala verticalis* sampled in two sugarcane varieties, in Sidrolândia, MS, from April 2009 to March 2010.

Second instar larvae were collected in the field in April and May; the third instar appeared from May to August. The second instar presented 2.66 mm (n = 2) in the width of cephalic capsule. The third instar presented 4.25 mm (n = 8) in the width of cephalic capsule, with length of 26.11 mm (n = 8) and weight of 535.57 mg (n = 8) (Table I). The cephalic capsule was 3.5 mm wider than those observed by Rodrigues *et al.* (2010) for this same species fed *Brachiaria decumbens*.

The pre-pupae of *C. verticalis* reared in the laboratory had a duration of 32.76 days (n = 23), and pupa occurred from August to October, with an average duration of 17.38 days (n = 16). The adults emerged from August to October, and oviposition started in October. The first instar larvae started to hatch in October. Their cephalic capsule width measured 1.62 mm (n = 5) in average. In the field the second instar larvae were observed in November and had cephalic capsule width of 2.66 mm (n = 5). Size cephalic capsule of larvae of the first and second instar are similar to those obtained by Rodrigues *et al.* (2010) for *C. verticalis* created in the laboratory, which were 1.5 and 2.5 mm respectively.

The third instar larvae were observed in December. When these were manipulated, they expelled abundant secretion and moved frenetically, probably as a defense mechanism. In laboratory, larvae of *C. verticalis*, not only feed on roots of sugarcane sprouts, but also penetrate the seedpiece of stalk, where they construct a chamber. The seedling usually dies out from the injury caused by the larvae. Oyafuso *et al.* (2002) verified that third instar larvae of another scarab beetle, *Dasylepida* sp., also feed on roots and penetrate the seedpiece of sugarcane tunneling it.

In summary, the phytophagous Scarabaeidae recorded in the area of sugarcane in Sidrolândia were *L. fuscus*, *C. verticalis*, *C. forsteri* and *Anomonyx* sp., this last one being the most abundant. The biological cycle of the species of *Anomonyx* was completed in approximately 349.2 days, characterizing an univoltine insect. The morphological and biological data presented are fundamental for understanding the

biology of the whitegrubs attacking the sugarcane crop and for managing this group of soil insects.

ACKNOWLEDGMENTS

To Juarez Fuhrmann, for identification of *Anomonyx* sp. To Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT) for providing the Master's scholarship to the senior author.

REFERENCES

- Aragón-García, A. & M. A. Morón. 2000. Los coleopteros Melolonthidae asociados a la rizosfera de la cana de azucar en Chietla, Puebla, Mexico. **Folia Entomológica Mexicana** 108: 79–94.
- Arakaki, N.; Y. Sadoyama; M. Kishita; A. Nagayama; A. Oyafuso; M. Ishimine; M. Ota; T. Akino; M. Fukaya; Y. Hirai; K. Yamura & S. Wakamura. 2004a. Mating behavior of the scarab beetle *Dasylepida ishigakiensis* (Coleoptera: Scarabaeidae). **Applied Journal of Zoology** 39: 669–674.
- Arakaki, N.; M. Kishita; A. Nagayama; M. Fukaya; H. Yasui; T. Akino; Y. Hirai; S. Wakamura. 2004b. Precopulatory mate guarding by the male green chafer, *Anomala albopilosa sakishimana* Nomura (Coleoptera: Scarabaeidae). **Applied Journal of Zoology** 39: 455–462.
- Costa, R. B.; P. M. Fernandes; F. S. Oliveira; M. R. Rocha; M. A. Morón & L. J. Oliveira. 2009. Captura de adultos de *Liogenys fuscus* (Coleoptera: Melolonthidae) com armadilha luminosa em área sob sistema de plantio direto. **Bioscience Journal** 25: 1–8.
- Gallo, D.; O. Nakano; S. Silveira Neto; R. P. L. Carvalho; G. C. Baptista; E. Berti Filho; J. R. P. Parra; R. A. Zucchi; S. B. Alves; J. D. Vendramim; L. C. Marchini; J. R. S. Lopes & C. Omoto. 2002. **Entomologia Agrícola**. Piracicaba. FEALQ, 920 p.
- Gordon, R. D. & D. M. Anderson. 1981. The species of Scarabaeidae (Coleoptera) associated with sugarcane in South Florida. **Florida Entomologist** 64: 119–131.
- Oliveira, L. J.; A. Garcia; C. B. Hoffmann-Campo; J. R. B. Farias; D. R. Sosa-Gomez & I. C. Corso. 1997. **Coró-da-soja Phyllophaga cuyabana**. Circular Técnica n.º 20, Londrina, EMBRAPA-CNPSo, 30 p.
- Oyafuso, A.; N. Arakaki; Y. Sadoyama; M. Kishita; F. Kawamura; M. Ishimine; M. Kinjo & Y. Hirai. 2002. Life history of the white grub *Dasylepida* sp. (Coleoptera: Scarabaeidae), a new and severe pest on sugarcane on the Miyako Islands, Okinawa. **Applied Journal of Zoology** 37: 595–601.
- Pardo-Locarno, L. C.; J. Montoya-Lerma; A. C. Bellotti & A. V. Schoonhoven. 2005. Structure and composition of the white grub complex (Coleoptera: Scarabaeidae) in agroecological systems of Northern Cauca, Colombia. **Florida Entomologist** 88: 355–363.
- Pereira, P. R. V. S.; K. L. Nechetz; B. A. Halfeld-Vieira & M. Mourão Júnior. 2004. **Ocorrência da broca-da-raiz-do-coqueiro Strategus aloes (Linnaeus, 1758) (Coleoptera: Scarabaeidae) em coqueirais comerciais no Estado de Roraima**. Comunicado Técnico 16. Embrapa-Roraima, 5 p.
- Rodrigues, S. R.; C. L. Barbosa; A. Puker; A. R. Abot & S. Ide. 2008. Occurrence, biology and behavior of *Liogenys fuscus* Blanchard (Insecta, Coleoptera, Scarabaeidae) in Aquidauana, Mato Grosso do Sul, Brazil. **Revista Brasileira de Entomologia** 52: 637–640.
- Rodrigues, S. R.; G. A. L. Nogueira; R. R. Echeverría & V. S. Oliveira. 2010. Aspectos biológicos de *Cyclocephala verticalis* Burmeister (Coleoptera: Scarabaeidae). **Neotropical Entomology** 39: 15–18.
- Rodrigues, S. R.; J. I. Carmo; V. S. Oliveira; E. F. Tiago & T. L. Taira. 2011. Ocorrência de larvas de Scarabaeidae fitófagos (Insecta: Coleoptera) em diferentes sistemas de sucessão de culturas. **Pesquisa Agropecuária Tropical** 41: 87–93.

- Santos, V. & C. J. Ávila. 2007. Aspectos bioecológicos de *Cyclocephala forsteri* Endrodi, 1963 (Coleoptera: Melolonthidae) no estado do Mato Grosso do Sul. **Revista de Agricultura** **82**: 28–30.
- Santos, V. & C. J. Ávila. 2009. Aspectos biológicos e comportamentais de *Liogenys suturalis* Blanchard (Coleoptera: Melolonthidae) no Mato Grosso do Sul. **Neotropical Entomology** **38**: 734–740.
- Silva, M. T. B. & E. C. Costa. 1998. Tamanho e número de unidades de amostra de solo para amostragem de larvas de *Diloboderus abderus* (Sturm) (Coleoptera: Melolonthidae) em plantio direto. **Anais da Sociedade Entomológica do Brasil** **27**: 193–197.
- Silva, M. T. B. & A. E. Loeck. 1996. Ciclo evolutivo e comportamento de *Dioboderus abderus* Sturm (Coleoptera: Melolonthidae) em condições de plantio direto. **Anais da Sociedade Entomológica do Brasil** **25**: 329–337.