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Diversity, seasonality, and egg parasitism of hemipteran (Coreidae and Pentatomidae) from a cowpea crop in northeastern Brazil

Kátia Kaelly A. Sousa¹, Nadja Nara P. Silva¹, Ranyse B. Querino^{2,*}, Paulo Henrique S. Silva², and Jocelia Grazia³

Abstract

We report here on the diversity and composition of Coreidae and Pentatomidae species, as well as their egg parasitoids collected on cowpea (*Vigna unguiculata* [L.] Walp) (Fabaceae) plants from a field in Teresina, central-northern Piauí State, Brazil. Weekly sweep net sampling was performed during the phenological cycle of this crop in the rainy and dry seasons. In the pentatomid collections, 14 species were identified from 3 subfamilies (Asopinae, Edessinae, and Pentatominae). Five species of Coreidae also were collected from the subfamily Coreinae. We found that *Euschistus heros* (F.), *Crinocerus sanctus* (F.), *Chinavia ubica* (Rolston), and *Piezodorus guildinii* (Westwood) (all Hemiptera: Pentatomidae) were the most abundant hemipteran species associated with cowpea. Generally, species richness and diversity of individuals from this order were higher in the rainy season than in the dry season. The parasitoid species identified from field-collected hemipteran egg masses were: *Anastatus coreophagus* Ashmead (Hymenoptera: Eupelmidae), *Neorileya flavipes* Ashmead (Hymenoptera: Eurytomidae), *Ooencyrtus anasae* (Ashmead) (Hymenoptera: Encyrtidae), *O. submetallicus* (Howard) (Hymenoptera: Encyrtidae), and *Trissolcus urichi* (Crawford) (Hymenoptera: Platygastridae). We found that about 52% of hemipteran egg masses collected from the cowpea field were naturally parasitized by the above parasitoids, whereas nearly 10% of *C. sanctus* and *C. ubica* sentinel egg masses were parasitized.

Key Words: egg parasitoid; biological control; Chalcidoidea; Platygastridae; Heteroptera

Resumen

Se informa sobre la diversidad y composición de especies de Coreidae y Pentatomidae, así como de los parasitoides de sus huevos recolectados en plantas de caupí (*Vigna unguiculata* [L.] Walp) de un campo en Teresina, en el norte central del estado de Piauí, Brasil. Se realizó un muestreo semanal con redes de barrido durante el ciclo fenológico de este cultivo en la estación lluviosa y la estación seca. En las colecciones de pentatomidos, se identificaron 14 especies de 3 subfamilias (Asopinae, Edessinae y Pentatominae). También, se recolectaron cinco especies de Coreidae de la subfamilia Coreinae. Encontramos que *Euschistus heros* (F.), *Crinocerus sanctus* (F.), *Chinavia ubica* (Rolston) y *Piezodorus guildinii* (Westwood) fueron las especies de hemípteros más abundantes asociadas con el caupí. En general, la riqueza de especies y la diversidad de individuos de este orden fueron mayores en la estación lluviosa que en la seca. Las especies de parasitoides identificadas a partir de las masas de huevos de hemípteros recolectados en el campo fueron: *Anastatus coreophagus* Ashmead, *Neorileya flavipes* Ashmead, *Ooencyrtus anasae* (Ashmead), *O. submetallicus* (Howard) y *Trissolcus urichi* (Crawford). Encontramos que aproximadamente el 52% de las masas de huevos de hemípteros recolectados del campo sobre caupí fueron parasitados naturalmente por los parasitoides mencionados anteriormente, mientras que casi el 10% de las masas de huevos centinelas de *C. sanctus* y *C. ubica* fueron parasitados.

Palabras Clave: parasitoides del huevo; control biológico; Chalcidoidea; Platygastridae; Heteroptera

The cowpea, (*Vigna unguiculata* [L.] Walp) (Fabaceae), is a legume that originated in Africa and India (Phillips et al. 2003; Freire Filho et al. 2005). This agronomic crop is among the most economically important food sources produced in the tropical and subtropical regions of the world. In Brazil, cowpeas are traditionally grown in the northern portion of the country. However, production of this legume is rapidly spreading into the northeastern and central-western Cerrado regions, either as a primary crop or a late harvest after soybeans or rice (Ribeiro 2002; Freire Filho 2011).

Several insect pests feed on cowpea causing significant damage at different phenological stages of the plant. Some phytophagous hemip-

terans, e.g., *Crinocerus sanctus* (F.), *Piezodorus guildinii* (Westwood), and *Nezara viridula* (L.) (Coreidae and Pentatomidae) attack *V. unguiculata* at the flowering and grain ripening stage (Ribeiro 2002; Silva et al. 2005). All these species damage cowpea in a similar way by feeding on buds, new leaves, and pods causing deformities that can reduce the size and yield of grains. Moreover, Ribeiro (2002) reported that hemipteran pests can inject toxins directly into the plants, further reducing productivity of the crop (Ribeiro 2002).

Generally, Pentatomidae are widely distributed throughout most of Brazil, where 605 species have been described (Grazia & Fernandes 2012; Panizzi & Grazia 2015), but little is known about this fauna in the

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northeastern part of the country. Distribution records for some genera are limited to single studies or species of agricultural importance. However, Firmino et al. (2017) recently conducted a study in fragments of the tropical Atlantic Forest in northeastern Brazil and found that the richness of the Pentatomidae species in this ecosystem was comparable with those from subtropical southern Brazil.

The family Coreidae includes several polyphagous species that feed on monocotyledons and dicotyledons, although more commonly associated with the latter. In the Neotropics, the most common species of coreids are *C. sanctus*, *Anisoscelis foliacea* (F.), *Holhymenia histrio* (F.), *Leptoglossus gonagra* (F.), *Leptoglossus zonatus* (Dallas), *Phthia picta* (Drury), *Anasa tristis* (De Geer), and *Spartocera dentiventris* Berg (Panizzi & Grazia 2015). Information on the distribution of Coreidae on agronomic plants in Brazil is very limited. Only 2 species of coreids have been associated with cowpea: *L. zonatus* and *C. sanctus*. *Crinocerus sanctus* is a pest of this crop in northeastern Brazil, causing reductions in yield by feeding during pod formation that adversely affects seed filling. Because this feeding damage considerably affects grain quality and production, this species has been designated as a primary economic pest of this crop (Silva et al. 2005).

Many microhymenopteran species attack the eggs of phytophagous hemipterans that could be important natural biocontrol agents against these pests. Moreover, several parasitoid species in this order have been observed by some workers to be responsible for maintaining populations of these pests below economically damaging levels (Corrêa-Ferreira 1986; Pacheco et al. 1999). In Brazil, 23 species of microhymenopterans have been reported as egg parasites of hemipteran pests of soybean, the most commonly cited ones being *Telenomus podisi* (Ashmead) and *Trissolcus basalus* (Wollaston) (Hymenoptera: Platygasteridae) (Loiácono 1980; Corrêa-Ferreira & Moscardi 1995; Loiácono & Margaria 2002). Studies on egg parasitoids are critical for identifying possible agents for use in biological control programs, particularly identifying those that impact agricultural pests in the local fauna because parasitoid-host diversity varies among crop systems and geographic regions.

The fauna of Coreidae and Pentatomidae on cowpea in Brazil is little known. Because of the recent expansion of cowpea production into the cerrado (savannah) areas of the country, it is critical that identification of phytophagous hemipterans on this crop be conducted, including any associated egg parasitoids. Therefore, we conducted a study to measure the diversity and composition of phytophagous Coreidae and Pentatomidae, as well as their egg parasitoids on cowpea in dry and rainy seasons in northeastern Brazil.

Materials and Methods

STUDY SITE

This study was conducted in northeastern Brazil near the city of Teresina located in the north-central portion of the state of Piauí, situated on the right bank of the Parnaíba River, in the middle course of its catchment basin. According to the Köppen classification system, climate in the area is tropical with seasonal rainfall concentrated in the summer-autumn months; vegetation in this area is primarily sub-deciduous forest characterized by cerrado and caatinga-like habitats. Caatinga means “white forest” in the native Tupi language, and is typified by small trees, thorny brush, arid grasses, and thorny, often leafless, scrub vegetation in the dry season. This ecosystem commonly occurs in areas of minimal rainfall in northeastern Brazil. The cerrado ecosystem is a tropical savanna composed of vast grassland with scattered trees.

The cowpea field used in this study was located on an experimental field owned by Embrapa Meio-Norte in Teresina (5.039266°S, 42.789566°W). Two fields were planted with the BRS Maratoã variety of cowpea, totaling 500 m² with 0.70 m of spacing between rows. For the crop grown during the rainy season, plant emergence started on 26 Mar 2015, whereas a second crop (grown during the dry season) started emergence on 25 Aug 2015. During the experiments, cowpea crops in each field were cultivated similarly using accepted crop production practices. Irrigation was performed during the dry season by sprinkling every 2 d. The only insecticide used on plants for control of defoliating caterpillars was a commercial *Bacillus thuringiensis* product. Weeds were managed by mechanical removal. Weekly climatic data, i.e., rainfall, relative humidity, and temperature, were obtained from the meteorological station at Embrapa Meio-Norte in Teresina, in the same vicinity where the experiment was conducted.

POPULATION SURVEY OF COREIDAE AND PENTATOMIDAE SPECIES

Weekly sampling was performed during the cowpea phenological cycle during the rainy (Apr–Jun 2015) and dry seasons (Sep–Nov 2015). Hemipterans were collected using a sweep net, with 10 sweeps at each of the 36 sample locations arranged along linear transects. Samples were stored in plastic containers filled with 70% ethanol, tagged, and placed in a freezer. Specimens were separated later into morphotypes, counted, and photographed (Choate 2000). Identification to the species level used the taxonomic keys of Rolston and McDonald (1980, 1984), Thomas (1992), Packauskas and Schaefer (1998), and Grazia and Schwertner (2008), including assistance from Pentatomoidea taxonomists Jocelia Grazia (Federal University of Paraná) and José Antônio Marin Fernandes (Federal University of Pará).

HEMIPTERAN EGG PARASITISM

Naturally occurring parasitism by Hymenoptera was assessed by collecting hemipteran eggs in the field and setting out sentinel egg masses. Egg masses were hand collected from the cowpea field, identified, stored in containers, and maintained in a growth chamber (PR-LABOR, model 4102, Cascavel, Paraná State, Brazil) at 25 ± 2 °C, 70 ± 10% RH, and 12:12 h (L:D) photoperiod until parasitoids emerged. As an additional measure of parasitoid activity in the field, sentinel egg masses (previously deposited on paper cards in Petri dishes) also were affixed to cowpea plants. Sentinels were produced from adult *C. sanctus* and *Chinavia ubica* Rolston (Hemiptera: Pentatomidae) previously reared in the laboratory from field-collected eggs. After 72 h, cards were retrieved and placed in growth chambers until parasitoids emerged. Parasitoids from all egg masses were identified to species according to Johnson (1984a, 1984b, 1985, 1987a, 1987b) and Noyes (1985, 2010). Voucher specimens were deposited in the Entomology Collection at Embrapa Meio-Norte, Teresina, Piauí, Brazil.

DATA ANALYSIS

Faunistic analysis of collection data for abundance, diversity, species richness, and uniformity or evenness was performed using the ANAFU software (Moraes et al. 2003). Climatic data were obtained from the weather station at Embrapa Meio-Norte in Teresina, and were used to analyze the relationship among hemipteran abundance, humidity, temperature, and precipitation, applying the Pearson correlation coefficient (*r*) (Ludwig & Reynolds 1988).

Results

DIVERSITY OF PENTATOMIDAE AND COREIDAE

Pentatomids sampled from cowpea were represented by 3 subfamilies, from which 14 species were identified (Table 1, Fig. 1). The species from subfamily Pentatominae were: *C. ubica*, *Euschistus heros* (F.), *E. carbonerus* Rolston, *P. guildinii*, *Thyanta perditor* (F.), *Cyptocephala alvarengai* Rolston, *Mormidea notulifera* (Stål), *Dichelops melacanthus* (Dallas), and *D. furcatus* (F.). The specimens from the subfamily Edessinae were: *Edessa mediatubunda* (F.), *E. loxdalii* Westwood, and *E. tragulus* Breddin, and the subfamily Asopinae was represented by *Alcaeorrhynchus grandis* (Dallas) and *Podisus nigrispinus* (Dallas). Individuals of Coreidae collected from cowpea, represented by the subfamily Coreinae, consisted of *C. sanctus*, *Hypselonotus fulvus* (De Geer), *Phthia picta* (Drury), *Zoreva* sp., and an unknown Coreidae sp. 1 (Table 1, Fig. 1).

The hemipteran species collected in this study were classified into 2 trophic guilds (phytophagous and predator) based on diet-related functional groups. A greater number of phytophagous species was collected (17 species) compared with only 2 species of predator hemipterans. The richness of species and abundance of hemipteran populations varied across the phenological stages of cowpea. Pentatomidae species increased in abundance and richness from the start of the vegetative growing period during the rainy and dry seasons (Fig. 2a). Increased species richness and abundance of Coreidae populations occurred during the reproductive stage of the crops (Fig. 2b).

POPULATION FLUCTUATIONS AND SEASONALITY

There were major differences in the richness and diversity indices of hemipteran species between the 2 seasons (Table 2). During the rainy season, the predominant species in collections were: *C. ubica*, *C. sanctus*, *E. heros*, and *P. guildinii*. During the dry season, only 3 very

abundant species were found, i.e., *P. guildinii*, *E. tragulus*, and *H. fulvus*, although *P. guildinii* was collected more frequently than the other species during this time (Table 1). Hemipteran abundance was negatively correlated with temperature ($r = -0.47$; $P < 0.05$), weakly negatively correlated with precipitation ($r = -0.05$; $P > 0.5$), and positively correlated with humidity ($r = 0.43$; $P < 0.05$).

The most favorable climate factors for an increase in hemipteran populations, i.e., higher humidity and lower temperatures, occurred during the rainy season. Conversely, hemipteran population growth was hindered under extreme conditions of the dry season, due to high temperatures, low humidity, and near-zero precipitation (Fig. 3).

PARASITOID SPECIES ASSOCIATED WITH HEMIPTERANS

A total of 130 hemipteran egg masses were monitored for parasite emergence; of those 23 were collected from the field and the rest represented by sentinels. Natural parasitism occurred in 51.9% of egg masses collected from the field and 9.7% of sentinels. The parasitoid species identified from naturally parasitized field-collected egg masses were *Neorileya flavipes* Ashmead (Hymenoptera: Eurytomidae) (obtained from *C. ubica* and *Chinavia* sp. eggs), as well as 2 unidentified species from pentatomid eggs. *Trissolcus urichi* (Crawford) from eggs of *E. heros* and *C. ubica* also were recovered. Sentinel eggs of *C. ubica* were parasitized only by *N. flavipes*, and those of *C. sanctus* were parasitized by *Anastatus coreophagus* Ashmead, *Ooencyrtus anasae* (Ashmead), *O. submetallicus* (Howard), and *N. flavipes* (Fig. 4).

Discussion

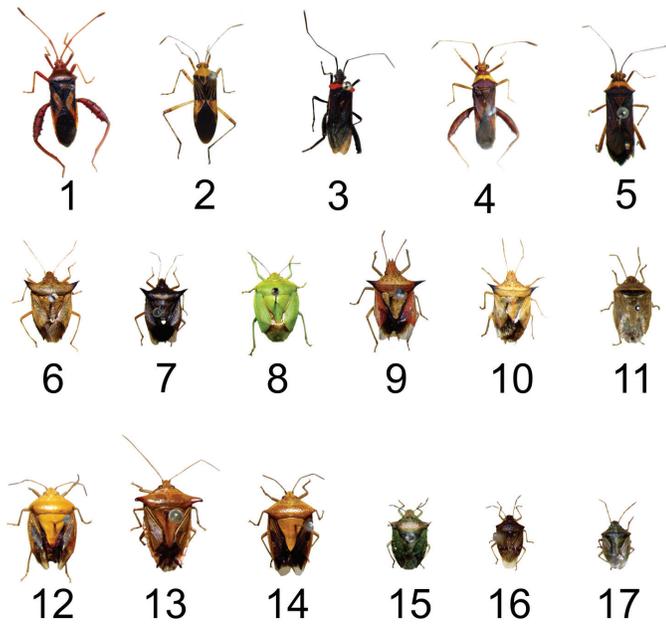
Our results showed that hemipteran species richness on cowpeas in northeastern Brazil was greater than other studies conducted in similar agronomic growing regions of the country. We collected a total of 14 species of Pentatomidae from 3 subfamilies and 5 species of Coreidae from the subfamily Coreinae. In a previous population sur-

Table 1. Species, abundance, and relative frequency of Pentatomidae and Coreidae from sweep net collections on cowpea in Teresina, Piauí, Brazil, 2015.

Species	Rainy Season			Dry Season		
	N ^a	%	rf (%) ^b	N ^a	%	rf (%) ^b
PENTATOMIDAE						
<i>Euschistus heros</i> (F., 1794)	34	18.8	12.9	0	0.0	0.0
<i>Chinavia ubica</i> (Rolston, 1983)	32	17.7	12.9	0	0.0	0.0
<i>Piezodorus guildinii</i> (Westwood, 1837)	31	17.1	11.3	12	85.7	71.4
<i>Edessa mediatubunda</i> (F., 1974)	6	3.3	8.1	0	0.0	0.0
<i>Thyanta perditor</i> (F., 1794)	4	2.2	4.8	0	0.0	0.0
<i>Alcaeorrhynchus grandis</i> (Dallas, 1851)	3	1.7	1.6	0	0.0	0.0
<i>Cyptocephala alvarengai</i> Rolston, 1986	3	1.7	3.2	0	0.0	0.0
<i>Edessa loxdalii</i> Westwood, 1837	3	1.7	1.6	0	0.0	0.0
<i>Podisus nigrispinus</i> (Dallas, 1851)	3	1.7	4.8	0	0.0	0.0
<i>Mormidea notulifera</i> Stål, 1860	2	1.1	3.2	0	0.0	0.0
<i>Dichelops melacanthus</i> (Dallas, 1851)	1	0.6	1.6	0	0.0	0.0
<i>Dichelops furcatus</i> (F., 1775)	1	0.6	1.6	0	0.0	0.0
<i>Euschistus carbonerus</i> Rolston, 1984	1	0.6	1.6	0	0.0	0.0
<i>Edessa tragulus</i> Breddin, 1903	0	0.0	0.0	1	7.1	14.3
COREIDAE						
<i>Crinocer sanctus</i> (F., 1775)	33	18.2	12.9	0	0.0	0.0
<i>Hypselonotus fulvus</i> (De Geer, 1773)	18	9.9	8.1	1	7.1	14.3
Coreidae sp. 1	4	2.2	6.5	0	0.0	0.0
<i>Phthia picta</i> (Drury, 1770)	1	0.6	1.6	0	0.0	0.0
<i>Zoreva</i> sp.	1	0.6	1.6	0	0.0	0.0

^aN = number of individuals. ^brf (%) = relative frequency.

Phytophagous



Predators



Fig. 1. Diversity of hemipterans collected from cowpea crops in Teresina, Piauí, Brazil: (1) *Crinocerus sanctus* (F.); (2) *Hypselonotus fulvus* (De Geer); (3) *Phthia picta* (Drury); (4) *Zoreva* sp.; (5) Coreidae sp.; (6) *Euschistus heros* (F.); (7) *Euschistus carbonerus* (Rolston); (8) *Chinavia ubica* (Rolston); (9) *Dichelops melacanthus* (Dallas); (10) *Dichelops furcatus* (F.); (11) *Piezodorus guildinii* (Westwood); (12) *Edessa mediatubunda* (F.); (13) *Edessa tragulus* (Breddin); (14) *Edessa loxdalii* (Westwood); (15) *Thyanta perditor* (F.); (16) *Mormidea notulifera* (Stål); (17) *Cyptocephala alvarengai* (Rolston); (18) *Alcaeorrhynchus grandis* (Dallas); (19) *Podisus nigrispinus* (Dallas).

vey conducted by Fazolin (1995) on cowpea crops (in the city of Rio Branco, state of Acre, Brazil), 4 species of Pentatomidae were found, namely *Euschistus* sp., *Oebalus poecilus* (Dallas), *O. ypsilongriseus* (De Geer), and *P. guildinii*, as well as 2 species of Coreidae, *C. sanctus* and *L. zonatus*. That study also observed higher abundance of *Euschistus* sp., *P. guildinii*, and *C. sanctus* in their collections for this crop, just as we observed in our study. In addition, Marsaro Junior and Pereira (2013) assessed population fluctuations of the main pests of cowpea in the state of Roraima during the months of Aug to Oct 2006 (using a beating cloth), and were able to identify 4 species of hemipterans associated with cowpea production, namely *N. viridula*, *P. guildinii*, *E. heros*, and *C. sanctus*, the first species being the most abundant. Moreover, the hemipteran diversity on cowpea in our study was similar to that found on other crops, such as soybean in the state of Maranhão, in which 7 species were found (5 were common on cowpea), namely *E. heros*, *T. perditor*, *C. ubica* (= *Acrosternum ubicum*), *P. guildinii*, and *E. mediatubunda* (Panizzi 2002).

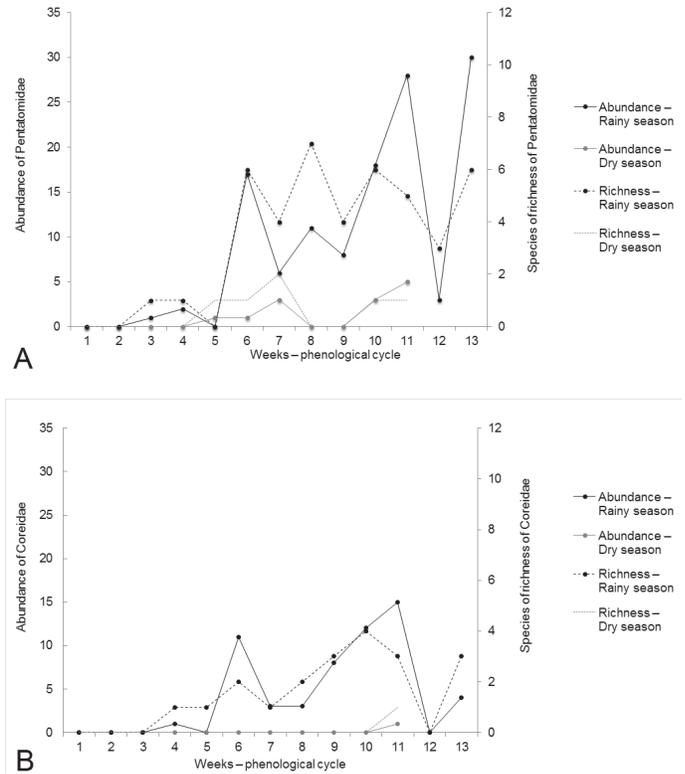


Fig. 2. Seasonal abundance (total) and species richness of (A) Pentatomidae and (B) Coreidae collected from cowpea in Teresina, Piauí, Brazil, 2015.

A variety of pentatomids have been reported to feed on different host plants in addition to cowpea in northeastern Brazil. A study by Panizzi (2002) found that *E. heros* comprised 82.4% of the phytophagous he-

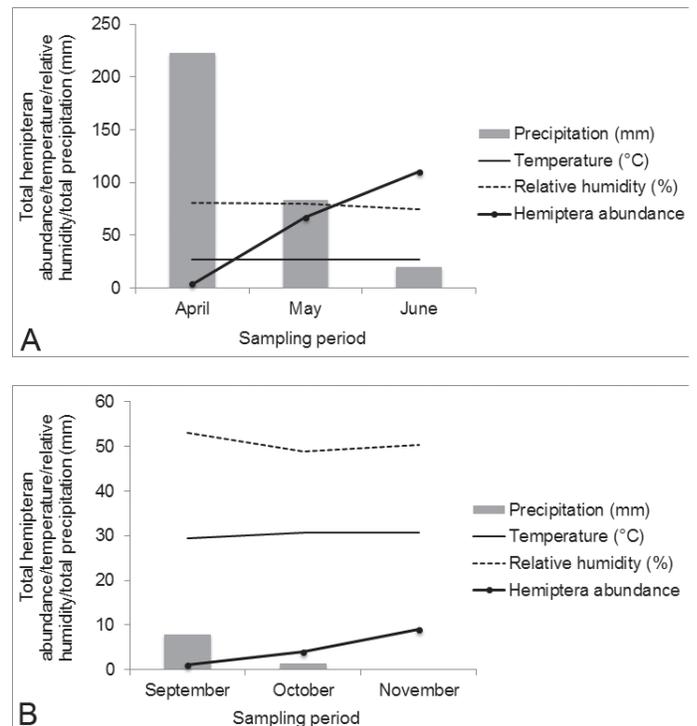


Fig. 3. Total abundance of hemipterans, and associated environmental parameters, in collections during (A) rainy season and (B) dry season throughout the phenological cycle of cowpea in Teresina, Piauí, Brazil, 2015.

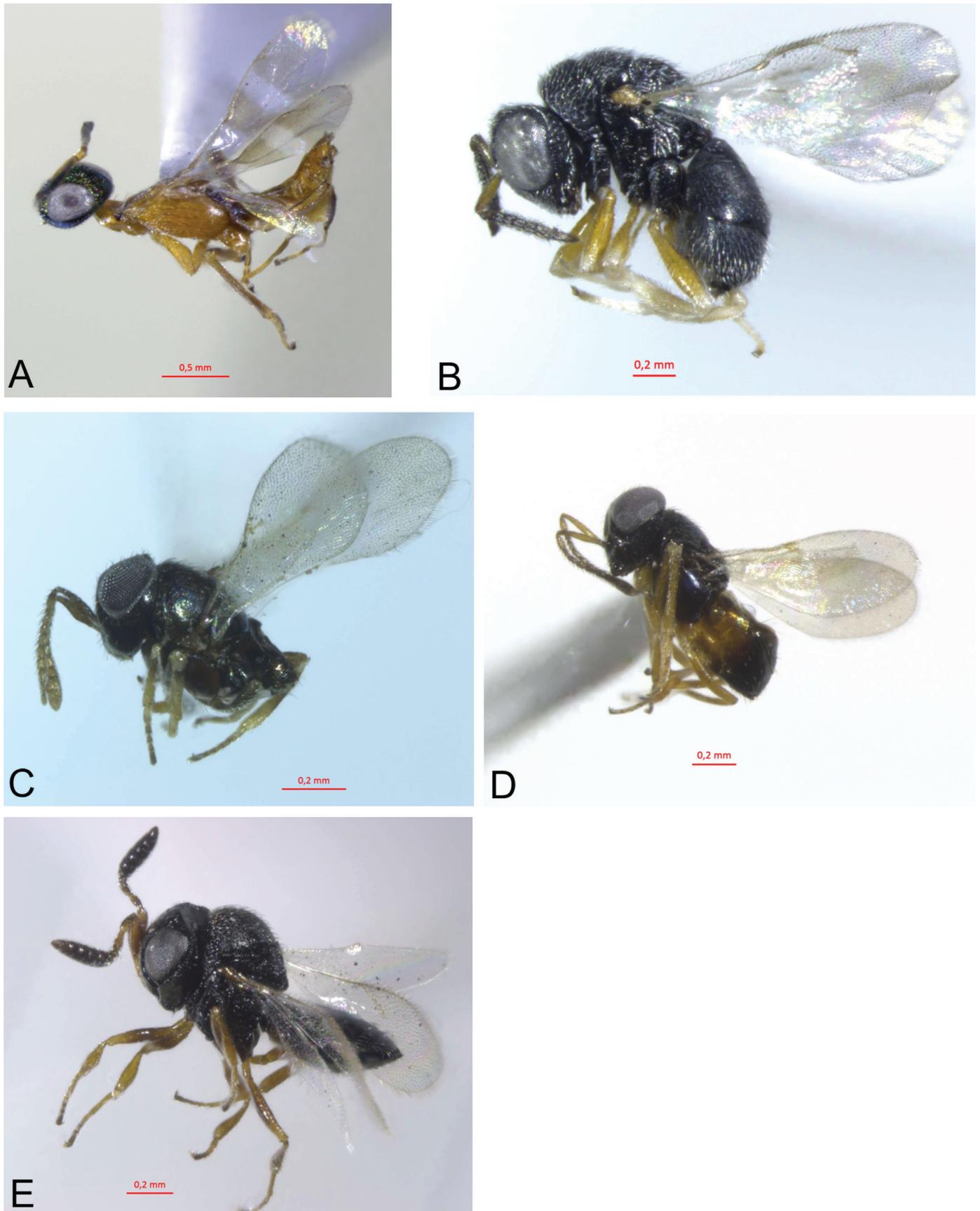


Fig. 4. Species of egg parasitoids reared from field-collected Coreidae and Pentatomidae on cowpea crops in Teresina, Piauí, Brazil, (A) *Anastatus coreophagus* Ashmead; (B) *Neorileya flavipes* Ashmead; (C) *Ooencyrtus anasae* (Ashmead); (D) *Ooencyrtus submetallicus* (Howard); and (E) *Trissolcus urichi* (Crawford).

Table 2. Community characteristics of hemipteran species during rainy and dry seasons on cowpea in Teresina, Piauí, Brazil.

Community Characteristics	Rainy Season	Dry Season
Diversity Index (Shannon-Weaver)	H = 2.2091	H = 0.5091
Confidence Interval of H ($P = 0.05$)	(2.1987–2.2194)	(0.3849–0.6333)
Richness Index (Margalef)	$\alpha = 3.2702$	$\alpha = 0.7578$
Uniformity or Evenness Index	E = 0.7643	E = 0.4634

mipterans collected from soybean in the state of Maranhão. This species is known also as the Neotropical brown stink bug. It is a ubiquitous polyphagous species across Brazil and one of the most abundant hemipterans found on cowpea. Native to the Neotropics, the principal host of *E. heros* is soybean, but this pest can feed on various other plants, including those of Fabaceae, Solanaceae, Brassicaceae, and Asteraceae (Panizzi & Oliveira 1998). Despite completing fewer generations than other species of soybean-infesting pentatomids, *E. heros* is the most abundant among them, particularly in warmer regions (Cividanes & Parra 1994; Degrande & Vivan 2010). Our results were similar to those of the above study as mean temperatures at our collection sites were high during the dry and wet seasons when this species was collected.

Although several species of *Chinavia* have been reported in northeastern Brazil, only 2 species have been found previously on cowpea in this region, namely *C. impicticornis* (Stål) and *C. ubica* (Rolston); however, both species have not yet been reported in the state of Piauí (Schwertner & Grazia 2006, 2007). *Chinavia ubica* has been collected on cowpea in the state of Pernambuco, on common bean (*Phaseolus vulgaris* L.) (Fabaceae) in Rio de Janeiro, and on pigeon pea (*Cajanus cajan* [L.] Huth) (Fabaceae) in the states of Bahia and Rio de Janeiro (Schwertner et al. 2002). Currently, the relationship of *C. ubica* with its host plants and the damage caused to agronomic crops in northeastern Brazil remains unknown. Also, it should be noted that *N. viridula* was not collected in our study, even though this species was first reported in northeastern Brazil by Panizzi and Corrêa-Ferreira (1997). However, given the morphological similarities between *N. viridula* and *C. ubica* (and the lack of in-depth taxonomic studies) incorrect identification is very likely to have occurred in the past (Schwertner & Grazia 2007).

Despite the scarcity of studies on Pentatomidae in northeastern Brazil, new species of *Chinavia* and *Dichelops* have been reported in that region, including *C. cearensis* Schwertner & Grazia in the state of Ceará, *C. tuiucauna* Schwertner & Grazia on cocoa plants in the state of Bahia (*Theobroma cacao* L.), and *D. caatinguensis* Grazia & Poock-da-Silva collected in the states of Bahia, Pernambuco, and Piauí (Schwertner & Grazia 2006; Poock-da-Silva et al. 2013). *Piezodorus guildinii* (collected in our study) also is considered to be a major pest of soybeans, beans, peas, and alfalfa, with occasional reports of it feeding on coffee (Rubiaceae), cotton (Malvaceae), guava (Myrtaceae), and sunflower (Asteraceae) in nearby Maceio City, Alagoas State (Firmino et al. 2017).

The polyphagous hemipteran *C. sanctus* is considered an important pest of cowpea in northern and northeastern Brazil. It was first reported in Brazil in 1984 in the state of Ceará where fairly large populations of this species were collected during the cowpea fruiting stage (Araújo et al. 1984). In our study, this species was observed at the beginning of the fruiting stage but only during the rainy season; no specimens of *C. sanctus* were found during the dry season.

We collected *A. grandis* and *P. nigrispinus* in our sweep net samples. Both species are predators that could be used in integrated pest management programs against phytophagous hemipterans. These 2 species belong to the subfamily Asopinae and have been shown by other workers to have strong potential for use as efficient population regulating agents against lepidopteran and coleopteran pests (Ruberson et al. 1986; Grazia et al. 1999; Lemos et al. 2005).

We observed that parasitoids *A. coreophagus*, *O. anasae*, and *O. submetallicus* were associated exclusively with Coreidae egg masses, whereas *T. urichi* was associated exclusively with Pentatomidae eggs. *Neorileya flavipes* was found infesting eggs of both families. These results expand the known range of hemipteran egg parasitoids in northeastern Brazil. This is also the first report of *C. sanctus* egg parasitism by *A. coreophagus* and *O. submetallicus* in Brazil, and the first report of *C. sanctus* (Coreidae) as a host for *N. flavipes*, the latter a parasitoid that has been previously reported only in eggs of Pentatomidae by Paz-Neto et al. (2015).

In summary, our study adds to the knowledge of phytophagous hemipteran diversity and associated egg parasitoids on cowpea in northeastern Brazil. Seasonal characterization of the pentatomid and coreid species complex on this agronomic commodity (including interaction of prey with parasitoids) helps to understand population fluctuations during the rainy and dry periods, which would aid in managing hemipteran phytophagous pests in this region of Brazil.

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References Cited

- Araújo JPP, Rios GP, Watt EE, Neves BP, Fageria NK, Oliveira P, Guimarães CM, Silveira Filho A. 1984. Cultura do caupi, *Vigna unguiculata* (L.) Walp., descrições e recomendações de cultivo. Goiânia, Goiás, Brazil EMBRAPA/CNPAP.
- Choate PM. 2000. Identification key to the principal families of Florida Heteroptera. Bulletin of the Florida Museum of Natural History 33: 495–535.
- Cividanes FJ, Parra JRP. 1994. Ecological zoning of *Nezara viridula* (L.), *Piezodorus guildinii* (West.) and *Euschistus heros* (Fabr.) (Heteroptera: Pentatomidae) in four soybean-producing states of Brazil. Anais da Sociedade Entomológica do Brasil 23: 219–226.
- Corrêa-Ferreira BS. 1986. Ocorrência natural do complexo de parasitoides de ovos de percevejos da soja no Paraná. Anais da Sociedade Entomológica do Brasil 15: 189–199.
- Corrêa-Ferreira BS, Moscardi F. 1995. Seasonal occurrence and host spectrum of egg parasitoids associated with soybean stink bugs. Biological Control 5: 196–202.
- Degrande PE, Vivan LM. 2010. Pragas da soja. Boletim de pesquisa de soja. Fundação MT. Rondonópolis 1: 152–215.
- Fazolin M. 1995. Levantamento dos insetos e flutuação populacional das pragas que ocorrem na cultura do caupi (*Vigna unguiculata* [L.] Walp., em Rio Branco (AC). Turrialba, Revista Interamericana de Ciencias Agrícolas 49: 137–142.
- Freire Filho FR. 2011. Feijão-caupi no Brasil: produção, melhoramento genético, avanços e desafios. Embrapa Meio-Norte, Teresina, Piauí, Brazil.
- Freire Filho FR, Lima JAA, Ribeiro VQ. 2005. Feijão-Caupi: Avanços Tecnológicos. Brasília, DF. Embrapa Informação Tecnológica. Embrapa Meio-Norte, Teresina, Piauí, Brazil.

- Firmino JVL, Mendonça MDS Jr, Lima IMM, Grazia J. 2017. Pentatomidae (Hemiptera: Heteroptera) in herbaceous and shrub strata of Atlantic forest remnants in northeastern Brazil. *Environmental Entomology* 46: 480–486.
- Grazia J, Fernandes JAM. 2012. Subordem Heteroptera, pp. 369–405 *In* Rafael JA, Melo GAR, Carvalho CJB, Casari AS, Constantino R [eds.], *Insetos do Brasil: Diversidade e Taxonomia*. Holos Editora, Ribeirão Preto, São Paulo, Brazil.
- Grazia J, Schwertner CF. 2008. Pentatomidae e Cyrtocoridae, pp. 223–234. *In* Claps LE, Debandi G, Roig-Juñent, S [eds.], *Biodiversidad de Artrópodos Argentinos*. Sociedad Entomologica Argentina, San Miguel de Tucumán, Tucumán, Argentina.
- Grazia J, Fortes NDF, Campos LA. 1999. Pentatomoidea, pp. 101–112 *In* Joly CA, Bicudo CEM [eds.], *Biodiversidade do Estado de São Paulo, Brasil: Síntese do Conhecimento ao Final do Século XX*. FAPESP, São Paulo, Brazil.
- Johnson N. 1984a. Systematics of Nearctic *Telenomus*: classification and revisions of the *podisi* and *phymatae* groups (Hymenoptera: Scelionidae). *Bulletin of the Ohio Biological Survey* 6: 1–113.
- Johnson N. 1984b. Revision of the Nearctic species of the *Trissolcus flavipes* group (Hymenoptera: Scelionidae). *Proceedings of the Entomological Society of Washington* 86: 797–807.
- Johnson N. 1985. Systematics of New world *Trissolcus* (Hymenoptera: Scelionidae) species related to *T. basalis*. *Canadian Entomologist* 117: 431–445.
- Johnson N. 1987a. Systematics of New World *Trissolcus*, a genus of pentatomid egg-parasites (Hymenoptera: Scelionidae): Neotropical species of the *flavipes* group. *Journal of Natural History* 21: 285–304.
- Johnson N. 1987b. The Neotropical telenomine genus *Phanuroopsis* Girault (Hymenoptera: Scelionidae). *Annals of the Entomological Society of America* 80: 660–663.
- Lemos WP, Serrão JE, Ramalho FS, Cola Zanon JC, Lacerda MC. 2005. Effect of diet on male reproductive tract of *Podisus nigrispinus* (Dallas) (Heteroptera: Pentatomidae). *Brazilian Journal of Biology* 65: 91–96.
- Loiácono MS. 1980. Nota sobre tres esceliónidos parasitoides de hemipteros de la República da Argentina y Brasil (Hymenoptera: Proctotrupeoidea). *Revista de la Sociedad Entomológica Argentina* 39: 173–178.
- Loiácono MS, Margaría CB. 2002. Ceraphronoidea, Platygastridae and Proctotrupeoidea from Brazil (Hymenoptera). *Neotropical Entomology* 31: 55–560.
- Ludwig JA, Reynolds JF. 1988. *Statistical Ecology*. John Wiley, New York, USA.
- Marsaro Junior AL, Pereira PRVS. 2013. Flutuação populacional de insetos-praga na cultura da soja no estado de Roraima. *Revista Acadêmica, Ciências Agrárias e Ambientais, Supl. 1*, 11: S13–S18.
- Moraes RCB, Haddad ML, Silveira Neto S, Reyes AEL. 2003. Software para análise faunística – ANAFU, p. 195 *In* 8th Simpósio de Controle Biológico, São Pedro, São Paulo, Brazil. <http://www.lea.esalq.usp.br/anafu/anafu.php> (last accessed 22 Dec 2017).
- Noyes JS. 1985. A review of the Neotropical species of *Ooencyrtus* Ashmead, 1900 (Hymenoptera: Encyrtidae). *Journal of Natural History* 19: 533–554.
- Noyes JS. 2010. Encyrtidae of Costa Rica (Hymenoptera: Chalcidoidea), 3. Subfamily Encyrtinae: Encyrtini, Echthroplexiellini, Discodini, Oobiini and Ixodiphagini, parasitoids associated with bugs (Hemiptera), insect eggs (Hemiptera, Lepidoptera, Coleoptera, Neuroptera) and ticks (Acari). *Memoirs of the American Entomological Institute* 84: 1–848.
- Packauskas RJ, Schaefer CW. 1998. Revision of the Cyrtocoridae (Hemiptera: Pentatomoidea). *Annals of the Entomological Society of America* 91: 363–386.
- Pacheco DJP, Corrêa-Ferreira BS, Oliveira MCN. 1999. Flutuação populacional dos percevejos pragas da soja e seus parasitoides de ovos em relação à fenologia da soja. *Arquivos do Instituto Biológico* 66: 1–8.
- Panizzi AR. 2002. Stink bugs on soybean in northeastern Brazil and a new record on the southern green stink bug, *Nezara viridula* (L.) (Heteroptera: Pentatomidae). *Neotropical Entomology* 31: 331–332.
- Panizzi AR, Corrêa-Ferreira BS. 1997. Dynamics in the insect fauna adaptation to soybean in the tropics. *Trends in Entomology* 1: 71–88.
- Panizzi AR, Grazia J. 2015. Introduction to true bugs (Heteroptera) of the neotropics, pp. 3–20 *In* Panizzi AR, Grazia J [eds.], *True Bugs (Heteroptera) of the Neotropics*. Springer, Dordrecht, The Netherlands.
- Panizzi AR, Oliveira EDM. 1998. Performance and seasonal abundance of the neotropical brown stink bug, *Euschistus heros* nymphs and adults on a novel food plant (pigeonpea) and soybean. *Entomologia Experimentalis et Applicata* 88: 169–175.
- Paz-Neto ADA, Querino RB, Margaría CB. 2015. Egg parasitoids of stink bugs (Hemiptera: Coreidae and Pentatomidae) on soybean and cowpea in Brazil. *Florida Entomologist* 98: 929–932.
- Phillips RD, McWatters KH, Chinnan J, Komey NS, Liu K, Mensa-Wilmot Y, Nnanna IA, Okeke C, Prinyawiwatkul W, Saalia FK. 2003. Utilization of cowpeas for human food. *Field Crops Research* 82: 193–213.
- Poock-Da-Silva P, Barão KR, Grazia J. 2013. Contributions to the knowledge of *Dichelops* Spinola: description of a new species of *Dichelops* (*Dicer-aeus*) and of the male of *Dichelops* (*Prodichelops*) *divisus* (Hemiptera: Heteroptera: Pentatomidae: Pentatominae: Carpocorini). *Zootaxa* 3609: 60–68.
- Ribeiro VQ. 2002. Cultivo do feijão-caupi (*Vigna unguiculata* (L.) Walp.). *Sistemas de Produção* 2. Embrapa Meio-Norte, Teresina, Piauí, Brazil.
- Rolston LH, McDonald FJD. 1980. Conspectus of Pentatomini genera of the western hemisphere: Part 2 (Hemiptera: Pentatomidae). *Journal of the New York Entomological Society* 88: 257–272.
- Rolston LH, McDonald FJD. 1984. A conspectus of Pentatomini of the western hemisphere. Part 3 (Hemiptera: Pentatomidae). *Journal of the New York Entomological Society* 92: 69–86.
- Ruberson JR, Tauber MJ, Tauber CA. 1986. Plant feeding by *Podisus maculiventris* (Heteroptera: Pentatomidae): effect on survival, development, and preoviposition period. *Environmental Entomology* 15: 894–897.
- Schwertner CF, Grazia J. 2006. Descrição de seis novas espécies de *Chinavia* Orian (Hemiptera, Pentatomidae, Pentatominae) da América do Sul. *Iheringia, Série Zoologia* 96: 237–248.
- Schwertner CF, Grazia J. 2007. O gênero *Chinavia* Orian (Hemiptera, Pentatomidae, Pentatominae) no Brasil, com chave pictórica para os adultos. *Revista Brasileira de Entomologia* 51: 416–435.
- Schwertner CF, Albuquerque GS, Grazia J. 2002. Descrição dos estágios imaturos de *Acrosternum* (*Chinavia*) *ubicum* Rolston (Heteroptera: Pentatomidae) e efeito do alimento no tamanho e coloração das ninfas. *Neotropical Entomology* 31: 571–579.
- Silva PHS, Carneiro JS, Quindaré MAW. 2005. Pragas, pp. 369–400 *In* Freire Filho FR, Lima JAA, Ribeiro VQ [eds.], *Feijão-caupi: Avanços Tecnológicos*. Embrapa, Brasília, Distrito Federal, Brazil.
- Thomas DB. 1992. Taxonomic synopsis of the Asopinae Pentatomidae (Heteroptera) of the Western Hemisphere. *Thomas Say Foundation Monographs*, Entomological Society of America, Lanham, Maryland, USA.
- Vivan LM, Panizzi AR. 2006. Geographical distribution of genetically determined types of *Nezara viridula* (L.) (Heteroptera: Pentatomidae) in Brazil. *Neotropical Entomology* 35: 175–181.