

Full Length Research Paper

Occurrence of green lacewings (Neuroptera: Chrysopidae) in two coffee cropping systems

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Received 23 August, 2013; Accepted 16 April, 2014

The aim of this study was to explore the diversity of lacewings in two coffee (*Coffea arabica* L.) cropping systems, located in the southwestern region of Bahia State, Brazil, and to study the structure of their communities and the seasonal occurrence of the species. These studies were conducted from December 2003 to November 2004, with coffee plants that were either shaded or unshaded by silky oak trees (*Grevillea robusta* A. Cunn.) at a property located in the municipality of Barra do Choça, Bahia State. Monthly collections were carried out with insect nets and traps baited with mango juice and hydrolyzed protein. The characterization of the Chrysopidae community was calculated by faunal indices, relative frequency, constancy, dominance, richness and diversity. The study on the species seasonal occurrence was conducted with the total number of specimens within each collection time and sampling. In order to assess the effects of climatic factors, only species classified as constant were considered. The occurrence of the following 15 species, in association with coffee plants, was recorded: *Ceraeochrysa cubana*, *Ceraeochrysa cincta*, *Ceraeochrysa dislepis*, *Ceraeochrysa everes*, *Chrysoperla externa*, *Chrysopodes spinella*, *Leucochrysa guataparensis*, *Leucochrysa cruentata*, *Leucochrysa intermedia*, *Leucochrysa rodriguezi*, *Leucochrysa santini*, *Leucochrysa scomparini*, *Leucochrysa cidae*, *Leucochrysa annae* and *Leucochrysa* sp.4. There was a considerable difference in community structures regarding the occurrence of different species and abundance of individuals. The species *C. cincta*, *L. guataparensis*, *L. cidae* and *L. sp.4* occurred exclusively on shaded coffee plants, while *L. cruentata*, *L. intermedia*, *L. scomparini* and *L. annae* were found only on unshaded plants. On the other hand, *C. externa* and *L. rodriguezi* stood out in both environments. *C. externa* was the most frequent and dominant species in both cropping systems, as it was considered constant on unshaded coffee plants and accessory on shaded plants. *C. everes*, *C. externa* and *C. spinella* occur during the day; *C. cincta*, *C. dislepis*, *L. guataparensis*, *L. rodriguezi*, *L. cidae*, *L. cruentata*, *L. intermedia*, *L. santini*, *L. scomparini* and *L. annae* occur during the night; and only the species *C. cubana* was collected during both the day and night.

Key words: Faunal analysis, biodiversity, *Coffea arabica*, predator.

INTRODUCTION

The globalization of the world trade has been determining changes in agricultural production systems, requiring

more quality, food safety and sustainability of agroecosystems in order to reach ecological, economic

and social stability. In this sense, there is the integrated production, whose principles take into consideration the use of integrated management based on decision-making for crop protection. The integrated production aims at the minimization of pesticide use and prioritization of cultural, biological and biotechnological methods to control pests and diseases, therefore preserving natural enemies and supporting the introduction of predator species and parasitoids.

Among several biological control agents that act on the population control of arthropods, lacewings are highlighted (Insecta: Neuroptera: Chrysopidae). Lacewings are considered key natural enemies in several integrated management programs due to their predatory activity during larval stage, wide geographic distribution, easy mass rearing and adaptive potential on different crops (Núñez, 1989). Characterized as generalist predators, lacewings generally prey on small-size arthropods of thin cuticle such as aphids, scale insects, thrips, whiteflies, eggs and larvae of moths, mites and small spiders (Freitas and Fernandes, 1996). They assume, though, an important role in the biological control in some economically important crops, like fruits, vegetables, cotton and coffee (Freitas, 2001).

Bioecological studies on lacewings have been carried out in several parts of the world, showing significant advances in recent decades. In Brazil, there is still much to be learned about these predators in order to widely use them in agriculture. Different studies have presented new species (Cardoso et al., 2003; Scomparin, 1997; Souza et al., 2004) and some recently described ones (Freitas and Penny, 2001; Freitas, 2003, 2007), which certainly magnifies the richness of this group under Brazilian conditions.

Regarding the ecological, climate and soil conditions in Bahia State, Brazil, few studies have been carried out to enhance the knowledge about predators. From these, the reports on the occurrence of *Chrysopodes divisa* (Walker, 1853) (Adams and Penny, 1985). In southwestern Bahia, consolidated crops, such as irrigated fruits and coffee, have been presenting pest problems. In coffee, for instance, the leaf miner (*Leucoptera coffeella* Guérin-Méneville, 1842), which is a key pest of systematic occurrence, is a potential prey for lacewings (Ecole et al., 2002).

Coffee plants are cultivated in several Brazilian regions that often do not present the ideal climatic conditions for a good crop development. Locations characterized by water deficit determine fruit malformation and drop, which causes low coffee yields. In Brazil, arboreal components are used at coffee plantations as windbreaks, with effectiveness that has been proven by the crop management (Baggio et al., 1997). However, coffee

afforestation, with the aim to reduce the effects of unfavorable climatic conditions at certain times of the year, is an old and common practice in tropical countries (Jaramillo-Botero et al., 2006). Coffee plants cultivated under agroforestry systems have been found in southwestern Bahia as a way to reduce the effects of long periods of drought. The main cultivated trees, in association with coffee, are silky oak (*Grevillea robusta* (Cunn.)), avocado (*Persea americana* Mill) and inga (*Inga* sp.). Coffee afforestation determines changes in yield (Beer et al., 1998; Miranda et al., 1999), agroecosystem microclimate and leaf morphophysiology (Gomes et al., 2008). In this sense, it is possible to hypothesize that the occurrence of pests and their natural enemies on coffee plants may be influenced by the agroecosystem management, as some authors have already described (Campanha et al., 2004; Resende et al., 2007). The agroforestry system affects the main coffee pest (*L. coffeella* (Guérin-Méneville, 1842) and, also, the predation indices by wasps as demonstrated by Lima (2010) and Souza (2012).

It is believed that studies on lacewings may be useful to plan and implement programs of integrated production in local agroecosystems, which include strategies of either natural biological control (conservation) or applied biological control (inundative releases). Also, it could contribute to agricultural development according to the

global production trends and knowledge enhancement concerning lacewings in Brazil. Hence, this work aimed to understand the diversity of lacewings in two different coffee (*Coffea arabica* L.) cropping systems – shaded and unshaded, located in southwestern Bahia as well as to study the community structure and seasonal occurrence of the species.

MATERIAL AND METHODS

The area of study is located in Barra do Choça, southwestern Bahia, Planalto da Conquista, latitude 14°52' S and longitude 40°34' W, 892 m above sea level, with an annual mean temperature of 21°C and annual mean rainfall of 1,300 mm.

The area for the study was selected due to the presence of crops which either had or had not received insecticide treatment, as well as the proximity of other crops and native bushlands. In a property, we delimited two 10-year old plots cultivated with the *Catuai Amarelo* coffee variety, spaced 2 m between plants and 4 m between rows. The plots were approximately 350 m far from each other; one was exposed directly to the sun while the other was forested with silky oak trees (*G. robusta* A. Cunn.). The silky oak tiers were arranged with 11 m between plants and rows. The surroundings presented other coffee crops and native bushlands (characterized as Mata-de-Cipó – deciduous forest – a transitional biome between the Atlantic Rainforest and Caatinga).

The collection with traps was performed between December 2003 and November 2004, comprising 12 collections for each

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cropping system. McPhail traps were used, with two kinds of food baits: 7% BioAnastrepha® hydrolysed protein based, and mango juice from the homogenization of 500 g of *in natura* Haden mango pulp; plus 250 g of crystal sugar and 1,500 mL of water. The hydrolysed protein was selected for this study as it is an attractive feed used for the official monitoring of the Program of Fruit Flies of Bahia State. An area of 1 ha was delimited at each experimental plot, where eight plants were marked at the distance, between them, of approximately 50 m and 10 m from the border. The traps were then installed at 1.5 m height in the plant canopies. Four traps, out of eight, were baited with mango juice and, the other four, with 250 mL of hydrolysed protein. The differently baited traps were distributed alternatively in the area from 6 am to 6 pm on pre-established days during the month. After 12 h in daylight, the biological material was collected, baits exchanged, and traps replaced at the same sampling points. After nightfall (from 6 pm to 6 am), the capture material was collected again and traps removed to be reinstalled 30 days later. The trap contents were placed in plastic flasks and spilled on a sieve, washed with water and put on white trays. The lacewing individuals found on the tray were carefully removed with a paintbrush and deposited into a becker filled with water to be washed once more. Subsequently, the individuals were laid on filter paper to remove the excess of humidity and then transferred to petri dishes identified according to time, type of crop, date and trap code for conservation under freezing temperatures.

Collections using insect nets were carried out between March and November 2004 after verifying that traps were really helping to collect a unique genus of lacewings during the first three months (from December 2003 to February 2004). Thus, nine collections were performed with insect nets. This method was used only during daylight – from 7:30 to 8 am, and from 4 to 4:30 pm, at the same places and dates as the bait trap collections – to collect adults by hitting the net against both coffee plants and vegetation at the inter-rows. The captured individuals were taken to the laboratory, transferred to petri dishes, labelled and sacrificed by freezing them in freezers, where they were stored.

The characterization of the lacewing community was done using faunal indices, such as relative frequency, constancy, dominance, richness, diversity and similarity, calculated for each sampling method. Frequency was calculated by the formula $f = n/N \times 100$, where f = frequency percentage, n = number of individuals of the same species, and N = total number of individuals in the sample (Silveira Neto et al., 1976). Constancy was calculated by the occurrence percentage of the collected species, using the formula $C = p/N \times 100$, where C = constancy percentage, p = number of collections containing the species, and N = total number of collections. The species were then separated into categories: constant species (W) – present in more than 50% of the collections; accessory species (Y) – present in 25-50% of the collections; and accidental species (Z) – present in less than 25% of the collections (Silveira Neto et al., 1976). Richness (S) was obtained by the total number of species observed in the community (Silveira Neto et al., 1976). One species is considered dominant when it presents a frequency superior to $1/S$, where S is the total number of species in the community (Uramoto, 2002). Diversity was measured by the Shannon index proposed by Krebs (1985) – $H' = -\sum (p_i)(\log_2 p_i)$, where H' = diversity index, S = number of species, and p_i = proportion of individuals belonging to that certain species. Quotient of similarity (QS) was based on Sorensen (Silveira Neto et al., 1976) – $QS = 2j/a+b$, where a = number of species in area A, b = number of species in area B, and j = number of collections containing both species.

The study concerning the seasonal occurrence of lacewing species was carried out from the total number of specimens in each collection time according to the sampling method.

Information regarding the crop phenological stage (vegetative, flowering, fructification, postharvest) was registered for each system

as well as observations about the presence or absence of weeds in the inter-row area for each sampling.

RESULTS AND DISCUSSION

The lacewing survey in both areas (shaded and unshaded coffee plants) resulted in 148 individuals of 14 different species. In the shaded area, 16 individuals (35.5%) of seven species (43.7%) of lacewings were collected using traps while 29 individuals (64.4%) of four species (13.8%) were captured by the insect net, summarizing 6.6% of all captured individuals and 78.6% of the species. In the unshaded coffee area, the use of traps with mango juice captured 13 individuals (12.6%) of seven species (50.0%) while 90 individuals (87.4%) of three species (21.4%) were captured by the insect net. No lacewing was captured using traps with hydrolysed protein in any area (Table 1).

In shaded coffee, captures using the net (64.44%) indicated a richness consisting of four species while the specific richness provided by traps was seven, resulting in a total number of ten species on the crop. Only *Ceraeochrysa cubana* was common in both cultivation systems. From all captured species, *Leucochrysa rodriguezi* and *Chrysoperla externa* were the most frequent and the only species classified as accessory and dominant in the collection with net and traps, respectively. No species was predominant on this crop. The diversity indices were 1.91 for traps and 1.03 for the insect net (Table 2).

In unshaded coffee, ten species were sampled, from which seven (the highest richness) were obtained by traps. Regarding the other three species collected by the net, *C. externa* was predominant, presenting a relative frequency of 64.44% and occurring in more than 50% of the collections. Also, *L. rodriguezi* was the most frequent accessory and dominant species, followed by *Ceraeochrysa displepis* and *Leucochrysa scomparini*, with a frequency of 15.40% in the trap collections. Diversity was also higher for traps (2.48) in relation to nets (1.13) (Table 3).

Comparing the lacewing communities of the two cropping systems, we observed that, despite the proximity among communities, a significant difference was found in their structures regarding the occurrence of different species and abundance of individuals. The species *Ceraeochrysa cincta*, *Leucochrysa guataporensis*, *L. cidiae* and *L. sp.4* occurred exclusively on shaded coffee plants while *L. cruentata*, *Leucochrysa intermedia*, *L. scomparini* and *Leucochrysa annae* were found only on unshaded coffee plants. On the other hand, *C. externa* and *L. rodriguezi* occurred in both environments.

In general, considering both collection methods, we observed that richness was equal for both coffee cropping systems when using traps (seven), and higher for shaded coffee when using insect nets (four). Three

Table 1. Number (N°) and percentage (%) of individuals and species of lacewings collected on shaded and unshaded coffee plants according to the type of collection, between December 2003 and November 2004 (traps), and March and November 2004 (insect net). Barra do Choça, Bahia State, Brazil.

Type of collection	Shaded coffee plants				Unshaded coffee plants			
	Individuals		Species		Individuals		Species	
	N°	%	N°	%	N°	%	N°	%
Trap with mango extract	16	35.5	7	43.7	13	12.6	7	50.0
Trap with hydrolysed protein	0	0	0	0	0	0	0	0
Insect net	29	64.4	4	13.8	90	87.4	3	21.4

Table 2. Lacewing faunal analysis according to the sampling method in the shaded coffee agroecosystem, between December 2003 and November 2004 (traps), and March and November 2004 (insect net). Barra do Choça, Bahia State, Brazil.

Species	Trap				Insect net			
	N	F	C	D	N	F	C	D
<i>Ceraeochrysa cincta</i> (Schneider, 1851)	1	6.25	Z	nd	-	-	-	-
<i>Ceraeochrysa cubana</i> (Hagen, 1861)	1	6.25	Z	nd	3	10.34	Z	Nd
<i>Ceraeochrysa dislepis</i> (Freitas and Penny)	1	6.25	Z	nd	-	-	-	-
<i>Ceraeochrysa everes</i> (Banks, 1920)	-	-	-	-	2	6.90	Z	Nd
<i>Chrysoperla externa</i> (Hagen, 1861)	-	-	-	-	23	79.31	Y	D
<i>Chrysopodes spinella</i> (Adams e Penny nova espécie)	-	-	-	-	1	3.45	Z	Nd
<i>Leucochrysa guataporensis</i> (Freitas and Penny, 2001)	1	6.25	Z	nd	-	-	-	-
<i>Leucochrysa rodriguezi</i> (Navás, 1913)	10	62.5	Y	d	-	-	-	-
<i>Leucochrysa cidae</i> (Freitas, 2007)	1	6.25	Z	nd	-	-	-	-
<i>Leucochrysa</i> sp.4	1	6.25	Z	nd	-	-	-	-
Total	16	100.00	-	-	29	100.00	-	-
Percentage			35.55				64.44	
S			7				4	
H'			1.91				1.03	

N: total number of individuals; F: relative frequency; C: constancy, constant (W), accessory (Y) and accidental (Z); S: richness; D: dominance, dominant (d) and non-dominant (nd); H': diversity index.

species out of 14 were predominant in both cropping systems: *C. externa* (on shaded and unshaded coffee plants), *Chrysopodes spinella* and *L. rodriguezi* (on unshaded and shaded coffee plants). Outstanding species in frequency and dominance were: *C. externa* and *L. rodriguezi* on shaded coffee plants; *C. externa*, *C. dislepis* and *L. rodriguezi* on unshaded coffee plants (Tables 2 and 3).

Five species were common to both cropping systems: *C. cubana*, *C. dislepis*, *C. externa*, *C. spinella* and *L. rodriguezi*. From these, *C. externa* and *L. rodriguezi* stood out as either predominant or dominant while *C. cubana* and *C. spinella* were accidental.

Studies on the analysis of lacewing communities are rare, especially in Brazil. One of them that should be highlighted was conducted by Scomparin (1997) in rubber tree plantations in Mato Grosso State, Brazil. From 39 species captured by Scomparin, 25 (64%) had never been recorded. Among the species that had

already been described, nine were also found in southwestern Bahia as a result of this survey. According to Scomparin (1997), ten species were constant and ten dominant; *C. externa* was dominant and *L. rodriguezi* predominant (constant and dominant). Such results corroborate the studies concerning the diversity of lacewings carried out in coffee plantations, pastures and forest fragments in the region of Alto do Rio Grande, Minas Gerais State, Brazil, which evidenced the occurrence of *C. externa* in the three sampled areas (Souza et al., 2004). Cardoso et al. (2003) also observed that *C. externa* was the most common species in *Pinus* crops. Souza et al. (2004) observed the presence of *C. externa*, *C. tucumana* (Navás, 1919) and *Ceraeochrysa* sp.2 on coffee plants in Minas Gerais State.

With respect to diversity, in terms of the highest absolute values, unshaded coffee plants presented a value of 2.48 against 1.91 from the shaded ones. Scomparin (1997), adopting the same model to estimate

Table 3. Lacewing faunal analysis according to the sampling method in the unshaded coffee agroecosystem, between December 2003 and November 2004 (traps), and March and November 2004 (insect net). Barra do Choça, Bahia State, Brazil.

Species	Trap				Insect net			
	N	F	C	D	N	F	C	D
<i>Ceraeochrysa cubana</i>	-	-	-	-	4	4.44	Z	Nd
<i>Ceraeochrysa dislepis</i>	2	15.40	Z	d	-	-	-	-
<i>Chrysoperla externa</i>	-	-	-	-	58	64.44	W	D
<i>Chrysopodes spinella</i>	-	-	-	-	28	31.11	Z	Nd
<i>Leucochrysa cruentata</i> (Schneider, 1851)	1	7.70	Z	nd	-	-	-	-
<i>Leucochrysa intermedia</i> (Schneider, 1851)	1	7.70	Z	nd	-	-	-	-
<i>Leucochrysa rodriguezi</i>	5	36.46	Y	d	-	-	-	-
<i>Leucochrysa santini</i> (Freitas and Penny, 2001)	1	7.70	Z	nd	-	-	-	-
<i>Leucochrysa scomparini</i> (Freitas and Penny, 2001)	2	15.40	Z	nd	-	-	-	-
<i>Leucochrysa annae</i> (Freitas, 2007)	1	7.70	Z	nd	-	-	-	-
Total	13	100.00	-	-	90	100.00	-	-
Percentage		12.62				87.37		
S		7				3		
H'		2.48				1.13		

N: total number of individuals; F: relative frequency; C: constancy, constant (W), accessory (Y) and accidental (Z); S: richness; D: dominance, dominant (d) and non-dominant (nd); H': diversity index.

lacewings' diversity, and presented an index of 4.73 in rubber tree plantations – greater than that obtained in this work. According to Krebs (1985), in Shannon's model, the information about diversity depends not only on the number of individuals and total of species but on the proportion of the number of individuals of each species, increasing therefore the difficulty to establish comparisons among values obtained from distinct sampling universes.

In this work, coffee crops were classified as environments with little or no similarities. Afforestation can be one of the factors responsible for such conditions as it eases the temperature range, decreases evapotranspiration during dry periods and reduces the wind action (Matsumoto et al., 2003). The change of abiotic ecological factors, such as temperature, humidity and wind, can affect insect development, distribution and abundance (Silveira Neto et al., 1976).

In this study, the highest number of lacewings was obtained on unshaded coffee plants. The proximity of this crop to an area of native forest may be another relevant factor in the differences of lacewing abundance found between both coffee cultivation areas. Only *C. externa* (on unshaded coffee plants) was classified as constant while the other 13 species were either accessory or accidental with sporadic occurrence throughout the experimental period. All species captured using traps, with the exception of *L. rodriguezi*, occurred at low population density and only in December (*L. sp.4* and *L. cidae*), July (*C. dislepis*), September (*C. cincta*) and October (*C. cubana*). *L. rodriguezi*, the most abundant species, occurred in February, April and July. Regarding

those four species captured with nets, all occurred in August; *C. externa* also occurred in July, October and November, and *Ceraeochrysa everes*, in November.

In general, no species were captured in January, March or June. The highest number of species was observed during the partial flowering and fructification periods.

C. cubana and *C. spinella* were collected using nets in, May, and June and October, respectively, on unshaded coffee plants. The other species occurred sparsely throughout the year indicating the presence of at least one individual in each sample.

The results for *C. externa* were quite similar to those obtained by Scomparin (1997) and Souza and Carvalho (2002) in Mato Grosso and Minas Gerais states, respectively, where they observed that the main population peaks occurred between June and September – a period of lower temperatures for the studied regions.

Minimum temperature has been mentioned as one of the factors which change the occurrence of *C. externa*. Citrus orchards in Minas Gerais State also showed a significant increase in the number of captured adults according to the decrease of the minimum temperature (Souza and Carvalho, 2002). Such authors highlight that the temperature is the climatic factor that most influences the population dynamics of *C. externa*, since cool and dry periods imply an increase in population density. However, *C. externa* occurred throughout the entire year of study, evidencing that, in certain times, the climatic conditions allow the population to survive but may hinder the species in their growth, development and reproduction.

During the collection with insect nets, a greater concentration of lacewings of the species *C. externa* was

found on the grass at the inter-rows, what was reduced when the grass was dry – an observation that corroborates the results of collections carried out in pastures of *Brachiaria decumbens* Stapf in the Alto de Rio Grande region, Minas Gerais State, Brazil, where only *C. externa* was collected (Souza et al., 2004).

The absence or reduction of vegetation at the coffee inter-rows from January to June, as a consequence of herbicide application, and fruit predominance, may be the cause of the decrease of species richness and number of individuals. On the other hand, on the unshaded coffee plants, the same management was applied to the inter-row vegetation and the phenology was the same; however, the species occurred during the entire year of study. An explanation for this fact would be the presence of native forest at the surroundings. Several works in the literature support the idea that landscape heterogeneity in the surroundings of agroecosystems increases diversity and may attract and shelter organisms (Santos et al., 2002; Santos and Perez-Maluf, 2012). The presence of these environments allows the dispersion of natural enemies so that the forest may act as a reserve or ecological corridor, allowing the flow and distribution of these insects, therefore enhancing the diversity of the species. Such justification is supported by Altieri (2004) who clearly present this hypothesis and mention that natural enemies tend to have bigger populations in diversified habitats where they can regulate their hosts by greater availability of pollen and nectar as well as alternative hosts for their adults.

The change in the microclimate may also be considered a beneficial effect for the crop. Shade may either increase or decrease the initial pest infestation; some authors have shown that insects present specific microclimatic preferences (Altieri et al., 1977). A study performed in Jaboticabal County, São Paulo State, Brazil, allowed us to relate some species of natural enemies of pest insects to the presence of some of the main weeds in different phenological stages. In respect to the neuropterans, the authors verified the association of lacewings and brown lacewings with peppergrass (*Lepidium virginicum* L.) and natal grass (*Rhynchelytrum repens* (Willd.)) during the flowering and maturation stages respectively (Martinelli et al., 1988).

Regarding the use of herbicides, Scomparin and Freitas (1996) verified the negative influence on lacewing population, implying in the predator population reduction not only on remaining plants but in citrus canopies.

"Weeds" play an active role in the constant changes in agroecosystems. Such plants, which are more frequent at the inter-rows, are an alternative food source (pollen and nectar) for natural enemies. The cover vegetation also promotes a friendly microclimate for natural enemies during extreme climatic conditions and may shelter alternative preys for predators (Landis et al., 2000; Oliveira et al., 2010, 2012; Venzon et al., 2006).

Mango extract was more attractive than hydrolysed

protein and, for this kind of study, traps should remain in the field at least 24 h for the collection of both diurnal and nocturnal species. Moreover, two sampling methods must be used concomitantly in lacewing surveys as they are complementary; in the current study, for instance, some species were collected only with insect nets.

The conservation of plant diversity in agroecosystems and surroundings makes the agroecosystem more heterogeneous – apparently, stimulating the maintenance of the population of natural enemies in the area. In this study, it is evidenced that there is a diversity of lacewing species in the studied agroecosystem, which may be associated with plant management at the inter-rows. The management of both lacewings and plants could then be adopted in integrated pest management programs for coffee crops.

Conclusions

For the first time, we registered the occurrence of *C. cubana*, *C. cincta*, *C. dislepis*, *C. everes*, *C. externa*, *C. spinella*, *L. guataporensis*, *L. cruentata*, *L. intermedia*, *L. rodriguezi*, *Leucochrysa santini*, *L. scomparini*, *L. cidiae*, *L. annae*, and *Leucochrysa* sp.4 in the municipality of Barra do Choça, Bahia State, Brazil, associated with coffee plants (*C. arabica* L.).

There was a considerable difference in their community structures regarding the occurrence of different species and abundance of individuals. The species *C. cincta*, *L. guataporensis*, *L. cidiae*, and *L. sp.4* occurred solely on shaded coffee plants while *L. cruentata*, *L. intermedia*, *L. scomparini* and *L. annae* were found only on unshaded plants. On the other hand, *C. externa* and *L. rodriguezi* stood out in both environments. The species *C. externa* is predominant in unshaded coffee crops.

The species *C. everes*, *C. externa*, and *C. spinella* occur during the day; *C. cincta*, *C. dislepis*, *L. guataporensis*, *L. rodriguezi*, *L. cidiae*, *L. cruentata*, *L. intermedia*, *L. santini*, *L. scomparini*, and *L. annae*, during the night; only *C. cubana* occurs during both the day and night.

Conflict of Interests

The author(s) have not declared any conflict of interests.

ACKNOWLEDGEMENTS

To FAPESB, for granting an MSc bursary to the first author; and to Professor Sérgio de Freitas (*In memoriam*), FCAV/UNESP, for species identification.

REFERENCES

- Adams PA, Penny ND (1985). Neuroptera of the Amazon basin. Part 11a. Introductions and Chrysopini. *Acta Amazonica*, 15(n ¾):413-79.

- Altieri MA, Van Schoonhoven A, Doll J (1977). The ecological role of weeds in insect pest management systems: a review illustrated by bean (*Phaseolus vulgaris*) cropping systems. *PANS*, 23(2):195-205.
- Altieri MA (2004). Agroecologia: a dinâmica produtiva da agricultura sustentável. 4. ed. Porto Alegre, UFRGS, P. 110.
- Baggio AJ, Caramori PH, Androcioli Filho A, Montoya L (1997). Productivity of southern Brazilian coffee plantations shaded by different stockings of *Grevillea robusta*. *Agroforestry Systems*, Dordrecht, 37:111-120. <http://dx.doi.org/10.1023/A:1005814907546>
- Beer JW, Muschler R, Kass D, Somarriba E (1998). Shade management in coffee and cacao plantations. *Agroforestry Systems*, Dordrecht, 38:139-164. <http://dx.doi.org/10.1023/A:1005956528316>
- Campanha MM, Santos RHS, Freitas GB, Martinez HEP, Finger FL, Garcia SRL (2004). Incidência de pragas e doenças em cafeeiros cultivados em sistema agroflorestal e em monocultivo. *Revista Ceres*, Viçosa, 51(295):391-396.
- Cardoso JT, Lázari SMN, Freitas S, Iede ET (2003). Ocorrência e flutuação populacional de Chrysopidae (Neuroptera) em áreas de plantio de *Pinus taeda* (L.) (Pinaceae) no sul do Paraná. *Revista Brasileira de Entomologia*, 47(3):473-75. <http://dx.doi.org/10.1590/S0085-56262003000300019>
- Ecole CC, Silva RA, Louzada JNC, Moraes JC, Barbosa LG, Ambrogi BG (2002). Predação de ovos, larvas e pupas do bicho-mineiro-do-cafeiro, *Leucoptera coffeella* (Guerin-Mèneville and Perrotet, 1842) (Lepidoptera: Lyonetiidae) por *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae). *Ciência e Agrotecnologia*, Lavras, 26(2):318-324.
- Freitas S (2001). O uso de crisopídeos no controle biológico de pragas. Funep, Jaboticabal, P. 21.
- Freitas S (2003). *Chrysoperla* Steinmann, 1964 (Neuroptera, Chrysopidae): descrição de uma nova espécie do Brasil. *Revista Brasileira de Entomologia*, 47(3):385-87. <http://dx.doi.org/10.1590/S0085-56262003000300004>
- Freitas S (2007). New species of Brazilian green lacewings genus *Leucochrysa* McLachlan, 1868 (Neuroptera: Chrysopidae). *An del Museo Civico di Storia Naturale, Ferrara*, 8:49-54.
- Freitas S, Fernandes OA (1996). Crisopídeos em agroecossistemas. In: *Simpósio de Controle Biológico, Foz do Iguaçu. Anais...Foz do Iguaçu, Embrapa-CNPSo* pp. 283-293.
- Freitas S, Penny N (2001). The green lacewings (Neuroptera: Chrysopidae) of Brazilian Agro-ecosystems. *California Academy of Sciences, California, abstracts*, 5:19, 2001. Disponível em: http://www.calacademy.org/research/scipubs/abstracts/v_52.html. Acesso em: jan. 2005.
- Gomes IAC, Castro EM, Soares AM, Alves JD, Alvarenga MIN, Alves E, Barbosa JPRAD, Fries DD (2008). Alterações morfofisiológicas em folhas de *Coffea arabica* L. cv. "Oeira" sob influência do sombreamento por *Acacia mangium* Wild. *Ciência Rural*, Santa Maria, 38(1):109-115. <http://dx.doi.org/10.1590/S0103-84782008000100018>
- Jaramillo-Botero C, Martinez RHS (2006). Características do café (*Coffea arabica* L.) sombreado no Norte da América Latina e no Brasil: Análise Comparativa. *Coffee Science*, Lavras, 1(2):94-102.
- Krebs CJ (1985). *Ecology: The experimental analysis of distribution and abundance*. Harpr and Raw, Publishers, P. 800.
- Landis DA, Wratten SD, Gurr GM (2000). Habitat management to conserve natural enemies of arthropod pests in agriculture. *Annu. Rev. pp.* 175-201. PMID:10761575
- Lima JM (2010). Influência da arborização na fisiologia de folhas de cafeiro, na infestação por *Leucoptera coffeella* (Guérin-Mèneville e perrotet, 1842) (Lepidoptera: Lyonetiidae) e nas interações tritróficas. 2010. 168f. Dissertação (Mestrado em Fitotecnia) Universidade Estadual do Sudoeste da Bahia. Vitória da Conquista, Bahia.
- Martinelli NM, Faifer WO, Durigan, JC (1988). Insetos associados a espécies de plantas daninhas em Jaboticabal - SP. *Ciência Plan Dan* 1(1):10-13.
- Matsumoto SN, Bebé FV, Moreira MA, Pimentel CAS, Ribeiro MS (2003). Efeito da arborização com grevileas em cafezais. In: *Seminário de Iniciação Científica*, 7, Vitória da Conquista. Anais... Vitória da Conquista-BA. pp. 37-40.
- Miranda EM, Pereira RCA, Bergo CL (1999). Comportamento de seis linhagens de café (*Coffea arabica* L.) em condições de sombreamento e a pleno sol no estado do Acre, Brasil. *Ciência e Agrotecnologia*, Lavras 23(1):62-69.
- Nú-éz ZE (1989). Chrysopidae (Neuroptera) del Perú y sus especies más comunes. *Rev. Per. Entomol.* 31:69-75.
- Oliveira SA, Souza B, Auad AM, Carvalho CA (2010). Can larval lacewings *Chrysoperla externa* (Hagen) (Neuroptera, Chrysopidae) be reared on pollen. *Rev. Bras. Entomol.* 54:697-700. <http://dx.doi.org/10.1590/S0085-56262010000400024>
- Oliveira SA, Auad AM, Souza B, Fonseca MG, Resende TT (2012). Population dynamics of *Chrysoperla externa* (Hagen) (Neuroptera:Chrysopidae) in a silvopastoral system. *Int. J. Biod. Conserv.* 4:179-182.
- Resende ALS, Santos CMA, Campos JM, Menezes EB, Aguiar-Menezes E (2007). Ocorrência de parasitoides do bicho mineiro infestando seis cultivares de café arábica em sistemas orgânico com e sem arborização. *Revista Brasileira de Agroecologia*, Londrina, 2:2.
- Santos GP, Zanoncio TV, Vinha E, Zanoncio JC (2002). Influência de faixas de vegetação nativa em povoamento de *Eucalyptus cloeziana* sobre população de *Oxydia vesulia* (Lepidoptera: Geometridae). *R. Árvore*, Viçosa-MG 26(4):499-504.
- Santos PS, Pérez-Maluf R (2012). Diversidade de himenópteros parasitoides em áreas de mata de cipó e cafezais em Vitória da Conquista-Bahia. *Magistra*, 24:84-90.
- Scomparin CHJ, Freitas S (1996). Interferência de tratos culturais na cobertura vegetal do solo, em citros, na dinâmica populacional de *Chrysoperla externa* (Neuroptera: Chrysopidae). In: *Simpósio de Controle Biológico, 1996, Foz de Iguaçu, Resumos... Foz de Iguaçu* P. 75.
- Scomparin CHJ (1997). Crisopídeos (Neuroptera, Chrysopidae) em seringueira (*Hevea brasiliensis* Muell. Arg.) e seu potencial no controle biológico de percevejo-de-renda (*Leptopharsa heveae* Drake and Poor) (Hemiptera, Tingidae). 1997. Dissertação (Mestrado em Entomologia Agrícola) - Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Jaboticabal. P. 147.
- Silveira Neto S, Nakano O, Vila Nova NA (1976). *Manual de Ecologia dos Insetos*. Piracicaba, SP: Ceres, P. 419.
- Souza B, Costa RIF, Louzada JNC (2004). Neuroptera, em fragmentos florestais e agroecossistemas. In: *Congresso Brasileiro de Entomologia*, 20., 2004, Gramado, RS, Resumos. Gramado, RS, P. 199.
- Souza B, Carvalho CF (2002). Population dynamics and seasonal occurrence of adults of *Chrysoperla externa* (Hagen, 1861) (Neuroptera: Chrysopidae) in citrus orchard in southern Brazil. *Acta Zoologica Academiae Scientiarum Hungaricae*, 48(2):301-10.
- Souza TP (2012). Ocorrência sazonal de *Leucoptera coffeella* (guérin-mèneville, 1842) (lepidoptera: lyonetiidae) em cafeeiros associados a grevileas: relações com predação, parasitismo e teores de clorofila e nitrogênio foliar. 2012. 86f. Dissertação (Mestrado em Fitotecnia) Universidade Estadual do Sudoeste da Bahia. Vitória da Conquista, Bahia.
- URAMOTO K (2002). Biodiversidade de moscas-das-frutas do gênero *Anastrepha* (Diptera: Tephritidae) no campus "Luiz de Queiroz". 2002. 85p. Dissertação (Mestrado) – Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, São Paulo.
- Venzon M, Rosado MC, Euzébio DE, Souza B, Schoederer JH (2006). Suitability of leguminous cover crop pollens as food source for the green lacewing *Chrysoperla externa* (Hagen) (Neuroptera: Chrysopidae). *Neotrop. Entomol.* 35(3):371-376. <http://dx.doi.org/10.1590/S1519-566X2006000300012>