Predator and parasitoid insects associated with soybean cultivation (*Glycine max* L. Merrill, 1917) in the District Architect Tomás Romero Pereira, Itapúa, Paraguay

Insectos depredadores y parasitoides asociados al cultivo de soya (*Glycine max* L. Merrill, 1917) en el Distrito Arquitecto Tomás Romero Pereira, Itapúa, Paraguay

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Abstract

In commercial crop of soybeans (*Glycine max* L. Merrill), in the Arq. Tomás Romero Pereira District, Department of Itapúa, Paraguay, Pedatory insects and parasitoids associated with the crop were collected. The insect trapping was carried out in two strata; the traps were placed 100 cm above the ground and directly on the ground. The normal harvest ran from October 2016 to March 2017, while the late harvest ran from February 2017 to June 2017. The collected insects were separated, identified, quantified and ordered at the level of order and family. In normal harvest, a total of 257 predatory and parasitoid insects were collected, determined in 7 orders, 92 specimens of Coleoptera, 75 of Hemiptera, 48 of Diptera, 35 of Himenoptera, four of Neuroptera, two of Odonata, and one of Dermaptera; and in late harvest 1692 insects were collected, distributed in 4 orders, 855 specimens Diptera, 553 Coleoptera, 245 of Hemiptera and 39 of Hymenoptera.

Key words:
biologic control; pest; IPM

Resumen

En parcelas comerciales de soya (*Glycine max* L. Merrill), del Distrito Arq. Tomás Romero Pereira, departamento de Itapúa, Paraguay, se recolectaron insectos depredadores y parasitoides asociados al cultivo. El trampeo de los insectos fue realizado en dos estratos; las trampas se colocaron a 100 cm de altura del suelo y directamente en el suelo. En zafra normal la recolecta se realizó a partir de octubre de 2016 a marzo de 2017, mientras que en la zafra tardía abarcó desde febrero a junio de 2017. Los insectos recolectados fueron separados, identificados, cuantificados y ordenados a nivel de orden y familia. En zafra normal se recolectaron un total de 257 insectos predadores y parasitoides, determinados en siete órdenes: 92 especímenes de Coleoptera, 75 de Hemiptera, 48 de Diptera, 35 de Hymenoptera, cuatro de Neuroptera, dos de Odonata y uno de Dermaptera. En zafra tardía se recolectaron 1692 insectos, distribuidos en 4 órdenes: 855 especímenes Diptera, 553 Coleoptera, 245 de Hemiptera y 39 de Hymenoptera.

Palabras clave:
control biológico; plagas; MIP

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Introduction

In Paraguay, soybean is the main agricultural export item, ranking sixth in world soybean production; antecedent to the USA, Brazil, Argentina, China, and India; likewise, it is the fourth world exporter; anteceding Brazil, the USA, and Argentina (MAG, 2008). According to CAPECO (2017), the area of soybeans planted in Paraguay in the 2016-2017 harvest is 3,388,709 ha, with a production of 10,664,613 tons and a harvest per hectare of 3,147 kg. Sismeiro (2012) states that during the whole cycle, in both normal and late harvest, the soybean crop is attacked by different species of insects that, in high quantities, cause significant losses in production. The natural method is a fundamental tactic for pest control in an efficient integrated pest management program. This consists of the use of beneficial organisms to inhibit the population of pests and, therefore, reduce the damage they could cause. Generally all insects and mites have a natural enemy; however, not all are effective in reducing the pest population.

In many cases, natural enemies are the first regulating force of the pest population, since biological management can be used against all types of pests, including vertebrates, phytopathogens, weeds, as well as insects (Stoner, 1998; Charlet, 2001). In annual crops such as soybean, in early stages, natural enemies have the potential to reduce the pest population, before reaching high population levels (Chang and Kareiva, 1999).This is due to the high densities of natural enemies in the first six weeks of the crop (McPherson *et al.*, 1982). Learning to recognize, manage and conserve natural enemies can help reduce their population and keep them below economic levels, to reduce crop losses and the necessary costs in control measures that also cause undesirable effects on the environment. (Michaud *et al.*, 2008).

The population of natural enemies in soybean agroecosystems may differ due to factors such as climate, planting season, crop phenology and crop management practices (Cividanes and Yamamoto 2002; Liu *et al.*, 2012).

The objective of the present work was to compare the abundance and richness of the predatory and parasitoid insects associated with the cultivation of soybeans (*Glycine max* L. Merrill) in normal and late harvest in the District of Tomás Romero Pereira. As a hypothesis of the study, it was expected to collect a more significant number of insects in the late harvest, without variation in the richness of insect families.

Materials and methods

The work was carried out in two adjoining commercial areas of one and a half hectares respectively, located in the Arq. Tomás Romero Pereira District, Itapúa, at the coordinates S 26 ° 30 ‘01, 0 ‘’ and O 55 ° 14’14, 6 ‘’. The study period ran from October 2016 to March 2017 for the normal harvest; while for the late harvest it ran from February to June 2017. In the parcels, the management of the soybean crop (fertilization, weed and disease management) was carried out, except for the application of insecticides.

The sampling was carried out with ‘water traps’ consisting of plastic containers 20 cm high by 30 cm wide, with a mixture of 1000 mL of water and 0.20 mL of non-phosphate detergent. The traps were placed in two heights: on the ground and 100 cm from the ground, which were distributed in the plots in the form of ‘zig-zag’; a total of 30 traps, 15 in each height, in each plot.

The samplings were made during the whole crop cycle, in the normal and late harvest, from the emergency. Once the traps were installed, the insects were collected 24 hours later, deposited in flasks with 70 % ethanol and taken to the laboratory for classification. For the taxonomic determination at the order and family level, a comparison was made with specimens deposited in the Entomological Collection of the Plant Protection Area of the Faculty of Agrarian Sciences of the National University of Asunción. The results were recorded in forms where the date, location of the trap, phenological status of the crop, number of families and the number of insects collected. The faunal indices of dominance, abundance, frequency, and constancy were calculated employing the computer program of Faunal Analysis (ANAFAU, by its acronym in Spanish) developed in the Department of Entomology, Phytopathology and Zoology of the Higher School of Agriculture Luis Queiroz, University of San Pablo (Moraes *et al.*, 2003). The criteria for frequency, dominance, abundance, and constancy, according to Silveira-Neto *et al.* (1976), were the following:

Frequency (percentage of individuals of a species in relation to the total of individuals), where super frequent (SF) means: frequency higher than the upper limit of the CI at 1%; Very frequent (VF): frequency higher than the upper limit of the CI at 5%; Frequent (F): frequency located within the CI at 5% and infrequent (I): frequency lower than the lower limit of the CI at 5%.

Dominance (is the action exercised by the dominant individuals of a community), where Super dominant (SD) means: number of individuals greater than the upper limit of the CI at 5%; Dominant (D): number of individuals located within the IC to 5% and non-dominant (ND): number of individuals lower than the lower limit of the CI to 5%.

Abundance (refers to the number of individuals per unit area in volume and varies in time and space), where Superabundant (SA) means: number of individuals greater than the upper limit of the CI at 1%; Very abundant (VA): number of individuals located between the upper limits of the CI at 5% and 1%; Common (c): number of individuals located within the IC a%; Dispersed (d): number of individuals located between the lower limits of the CI at 5% and 1% and Rare (r): number of individuals less than the lower limit of the CI at 1%.

Proof (percentage of species present in the collected samples), where Constant (W): present in more than 50% of the collections; Accessory (Y): present between 25 and 50% of the samples and Accidental (Z): species present in less than 25% of the collections.

Among the population abundance (number of individuals), the wealth (number of families) of predatory and parasitoid insects associated with soybean cultivation (normal and late harvest) and the sampling heights (in the soil and 100 cm above the ground), compared by means of a T-test for independent samples with the statistical program Infostat version 2008. The data were transformed with log 10 (x + 1), to fulfill the assumption of normality.

Results

In the normal harvest, a total of 257 beneficial insects identified in 13 families were collected, distributed in seven orders (Coleoptera, Hemiptera, Hymenoptera, Diptera, Odonata, Neuroptera and Dermaptera). The most frequent families were Reduviidae with 74 individuals, followed by Coccinellidae with 47, Carabidae with 45, Dolichopodidae with 44 and Braconidae with 22 individuals (figure 1). Less frequently, the Halictidae family was identified with nine individuals, followed by Tachinidae with four and Chrysopidae, also with four individuals. Very low-frequency Vespidae with three insects, followed by Libellulidae with two; Forficulidae, Pentatomidae and Ichneumonidae with an individual, respectively.

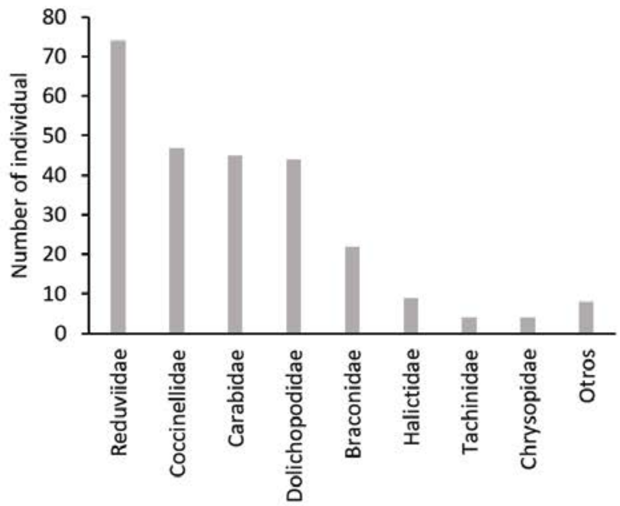

Figure 1. Families of predators and parasitoids captured during the whole soybean crop cycle in normal harvest, Arq. Tomás Romero Pereira District. 2016/2017 period.

During the normal harvest, the families Coccinellidae, Dolichopodidae, and Reduviidae appeared as dominant, very abundant, frequent and accessory when they were collected in traps placed in the soil. When the traps were set 100 cm above the surface of the ground, the families Coccinellidae and Reduviidae were dominant, very abundant, frequent and accessory (table 1).

In the late harvest, a total of 1692 beneficial insects identified in nine families were collected, which belong to orders Coleoptera, Hemiptera, Hymenoptera and Diptera. The families Dolichopodidae and Carabidae were dominant (figure 2), very abundant, frequent and constant in traps placed in the ground; whereas, in the traps set on the surface of the ground, the Carabidae family maintained the same dominance faunal indices, Very abundant, Very frequent and constant (table 2).

When comparing the diversity of families, it is observed that only in the traps placed in the ground during the first harvest an average diversity was found, while in late harvest, in both traps; in harvest, with traps on the ground, diversity was low. Considering the sowing seasons (normal and late), higher abundance was observed in the late harvest ($T = 6.42$, $P < 0.05$) and richness ($T = 3.07$, $P < 0.05$). Regarding the sampling heights, however, there was no difference in the richness ($T = 0.57$, $P > 0.57$), but greater abundance was observed in the traps placed in the soil.

Table 1. Faunal analysis of the families collected during the 2016/2017 harvest in the soybean crop in the Architect Romero Pereira District, Department of Itapúa, Paraguay 2018. D: Dominant; ND: Not dominant; VA: Very abundant; c: Common; d: Dispersed; R: Rare; VF: Very frequent; F: Frequent; I: infrequent ; W: Constant; Y: Accessory; Z: Accidental

Sample height	Family	Dominance	Abundance	Frequency	Constancy
On the ground	Coccinellidae	D	va	VF	Y
	Pentatomidae	ND	r	I	Z
	Vespidae	ND	r	I	Z
	Chrysopidae	ND	r	I	Z
	Halictidae	ND	c	F	Z
	Dolichopodidae	D	va	VF	Y
	Carabidae	D	va	VF	W
	Reduviidae	D	va	VF	Y
	Forficulidae	ND	d	I	Z
	Tachinidae	ND	r	I	Z
	Libelluilidae	ND	c	F	Z
At 100 cm from the ground	Coccinellidae	D	va	VF	W
	Vespidae	ND	d	I	Z
	Chrysopidae	ND	d	I	Z
	Halictidae	ND	c	F	Z
	Dolichopodidae	D	c	F	Y
	Carabidae	D	c	F	W
	Reduviidae	D	va	VF	W
	Forficulidae	ND	d	I	Z
	Tachinidae	ND	d	I	Z
	Libelluilidae	ND	d	I	Z

Table 2. Faunal analysis of the families collected during the 2016/2017 late harvest in the soybean crop in the district of Architect Romero Pereira, Department of Itapúa, Paraguay. D: Dominant; ND: Not dominant; va: Very abundant; c: Common; d: Dispersed; r: Rare; VF: Very frequent; F: Frequent; I: infrequent; W: Constant; Y: Accessory; Z: Accidental.

Sample height	Families	Dominance	Abundance	Frequency	Constancy
On the ground	Coccinellidae	D	va	VF	W
	Vespidae	ND	d	I	Z
	Chrysopidae	ND	d	I	Z
	Halictidae	ND	c	F	Z
	Dolichopodidae	D	c	F	Y
	Carabidae	D	c	F	W
	Reduviidae	D	va	VF	W
	Forficulidae	ND	d	I	Z
	Tachinidae	ND	d	I	Z
	Libelluilidae	ND	d	I	Z
At 100 cm from the ground	Coccinellidae	ND	va	F	Y
	Dolichopodidae	D	va	VF	W
	Carabidae	D	va	VF	W
	Nabidae	ND	va	F	Z
	Encyrtidae	ND	va	F	Z
	Halictidae	ND	va	F	Y
	Syrphidae	ND	va	F	Z

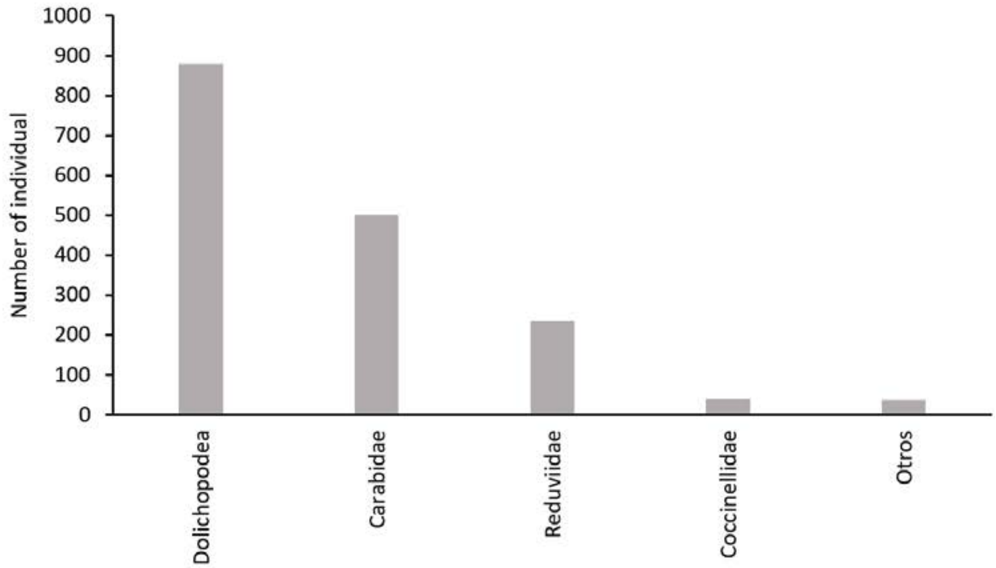

Figure 2. Families of predators and parasitoids captured during the whole cycle of soybean cultivation in a late harvest. Arq. Tomás Romero Pereira District. 2017 Period.

Discussion

It was observed that in the normal harvest insects appeared in smaller quantity, but a greater diversity of families; while in the late harvest a more significant number of specimens was collected, but in fewer families. Both in the normal harvest and in the late harvest, the amount of insects tends to decrease (McPherson *et al.*, 1982, Bazok *et al.*, 2010), which is not observed mainly in the family Reduviidae where the maximum point of captures was between week eight and ninth of the normal harvest (figure 3). While in the late harvest this behavior was observed in the Dolichopodidae family whose maximum capture point was in week nine (figure 4).

In the family Reduviidae, the most representative species was Zelus sp. that in a nymph state it feeds mainly on aphids, leafhoppers, thrips (Hagen *et al.*, 1999); while adults prey on aphids (Potin, 2008), larvae of Lepidoptera such as Heliothis virescens, Heliothis zea and Spodoptera exigua Hubner (Ali and Watson, 1978). Cycloneda sanguinea and Harmonia axyridis stand out in the Coccinellidae family; species that have been described as predators of a large number of pests such as aphids (Dreistadt *et al.*, 1996), larvae of Lepidoptera (Sánchez *et al.*, 1997), immature stages of whiteflies, thrips (Limonte *et al.* , 2015), mites (Ashraf *et al.*, 2016), and early stages of *Nezara viridula* (Massoni and Frana, 2006). Concerning the organisms of the Carabidae family, *Lebia* was highlighted to combat lepidopteran larvae, also prey on aphids and certain snails (Sánchez *et al.*, 1997). As for the Dolichopodidae family, *Condylostylus* sp. that usually feed on invertebrates of soft bodies such as Homoptera, collembola, thrips and acarids, small myriapods, eggs of odontous, blatodes, larvae of Coleoptera (Scolytidae and Curculionidae) and early stages of Lepidoptera (Hernández, 2007)

Making a comparison with similar studies carried out in the country, it was observed that in other localities were collected natural enemies of the species *Geocoris* spp., *Lebia concina, Zelus* sp., *Cycloneda sanguinea, Podisus* sp., *Doru* sp., *Copidosoma* sp. and *Nabis* sp. (Pereira, 2016; Salinas, 2016; Zárate, 2015).

In the late harvest a greater abundance of predatory and parasitoid insects was observed, which is related to the increase in temperature and relative humidity which, in addition to allowing more favorable environmental conditions for the development of beneficial insects, also causes an increase in populations of insect pests (Zuil and Sosa, 2012; Netam *et al.*, 2013; Suyal *et al.*, 2018).

Temperature conditions also had an influence on the abundance of insects in the strata of the plant (Koona *et al.*, 2004), with a higher wealth in the sampling carried out at ground level, where the row spacing of 0.45 m causes a total coverage of soil and generates a microclimate more favorable for the development of insects and microorganisms at ground level, in comparison with the upper strata of the plant (Molestina, 1987; Bernays and Chapman, 2007).

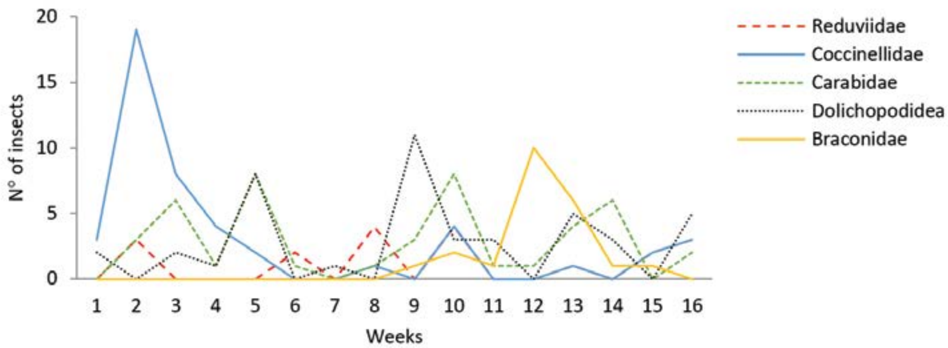

Figure 3. Number of insects per family captured throughout the soybean crop cycle in a normal harvest.

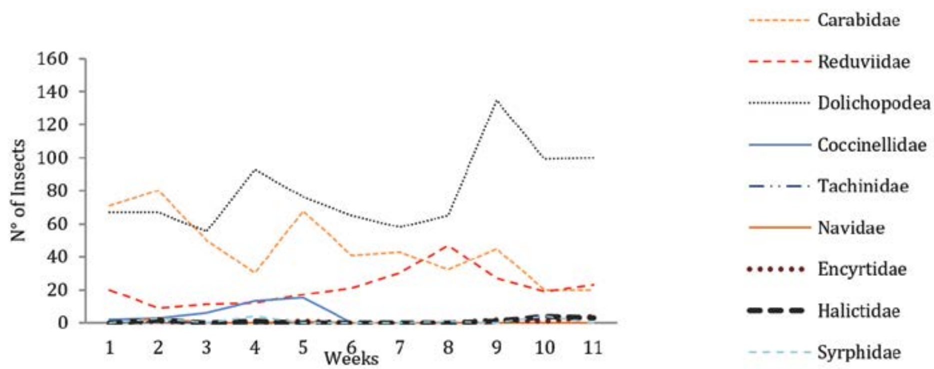

Figure 4. Number of insects per family captured during the entire soybean crop cycle in the late harvest district Arq. Tomás Romero Pereira, 2017 period.

Conclusion

In this study, a greater abundance and richness of predatory insects and parasitoids associated with soybean cultivation during the late harvest could be verified, in comparison with the normal sowing harvest, where a greater quantity of organisms was collected at ground level, compared to with sampling in upper strata of the plant.

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