Population Dynamics of Pests and Natural Enemies on Sugar Cane Grown in a Subtropical Region of Brazil

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Population dynamics of pests and natural enemies on sugar cane grown in a subtropical region of Brazil

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Abstract

Sugar cane production in the subtropical area of southern Brazil displays a different profile of growing conditions compared to other regions, and the population dynamics of both insect pests and their natural enemies are poorly documented. Monthly surveys were conducted in a subtropical sugar cane production area (29.003467°S, 53.235349°W) of Brazil. Samples were collected in a 15 ha field from Feb 2013 to Jan 2015, and the insects found on plants and inside culms were tabulated. The sugarcane borer, *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae) was found during all stages of plant development. These borers were most abundant during the cooler mo, when they reached a high level of infestation. The sugarcane mealybug, *Saccharicoccus sacchari* (Cockerell) (Hemiptera: Pseudococcidae), was found during most mo, but infestation levels were highest in Mar. The pink spittlebug, *Mahanarva fimbriolata* (Stål) (Hemiptera: Cercopidae), and sugarcane aphid, *Melanaphis sacchari* (Zehntner) (Hemiptera: Aphididae), were found mostly in warmer mo, and associated with higher accumulations of rainfall. The infestations by *M. fimbriolata* were below levels of economic damage, whereas *M. sacchari* infested up to 100% of the plants. The natural enemies observed were the parasitoid *Billaea claripalpis* (Wulp) (Diptera: Tachninidae) and the predators *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) and *Doru lineare* (Eschscholtz) (Dermaptera: Forficulidae). Their population dynamics clearly showed host/prey dependence. These results contribute to the monitoring and management strategies of pests in sugar cane grown in the subtropical conditions of southern Brazil.

Keywords: *Saccharum* spp.; Crambidae; Cercopidae; Aphididae; Coccinelidae; Forficulidae; Tachinidae

Resumo

A produção de cana-de-açúcar na área subtropical do sul do Brasil apresenta um perfil diferente das condições de cultivo em comparação com outras regiões, e a dinâmica populacional de pragas de insetos e seus inimigos naturais é pouco documentada. Avaliações mensais foram realizadas em uma área de produção de cana-de-açúcar em ambiente subtropical do Brasil (29,003467°S, 53,235349°W). As coletas foram realizadas em uma área de 15 ha, no período de fevereiro de 2013 a janeiro de 2015, e os insetos encontrados sobre as plantas e no interior dos colmos foram tabulados. A broca-da-cana, *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae) foi encontrada em todos os estádios de desenvolvimento das plantas. As larvas foram mais abundantes durante o período mais frio, quando atingiram um alto nível de infestação. A cochonilha-da-cana *Saccharicoccus sacchari* (Hemiptera: Pseudococcidae) foi encontrada durante a maior parte dos meses, mas os níveis de infestação foram maiores em março. A cigarrinha-das-folhas, *Mahanarva fimbriolata* (Stål) (Hemiptera: Cercopidae), e o pulgão *Melanaphis sacchari* (Zehntner) (Hemiptera: Aphididae) foram encontrados principalmente em periodos mais quentes e associadas a maiores acumulações de chuva. As infestações por *M. fimbriolata* foram inferiores aos níveis de dano econômico, enquanto *M. sacchari* infestou até 100% das plantas. Os inimigos naturais observados foram o parasitóide *Billaea claripalpis* (Wulp) (Diptera: Tachninidae) e os predadores *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae) e *Doru lineare* (Eschscholtz) (Dermaptera: Forficulidae). A dinâmica populacional dessas espécies mostrou claramente a dependência hospedeiro/presa. Esses resultados contribuem para as estratégias de monitoramento e manejo de pragas em cana-de-açúcar cultivadas nas condições subtropicais do sul do Brasil.

Palavras Chave: *Saccharum* spp.; Crambidae; Cercopidae; Aphididae; Coccinelidae; Forficulidae; Tachinidae

Sugar cane is one of the most important crops in Brazil, with approximately 10 million ha cultivated in 2017. The major producing states are located in southeastern and central-western Brazil. In the 2016/2017 season, these regions accounted for over 80% of the total area planted, and most of the sugarcane production was used as feedstock in the sugar and ethanol industry (CONAB 2017; Dias & Sentelhas 2018; IBGE 2018).

In southern Brazil, sugar cane production differs from other regions with respect not only to the environment, but also to agronomic traits and its uses. First, the climate is subtropical, which leads to risk of frosts during fall, winter, and spring seasons, possibly interfering with planting or harvesting dates (Alvares et al. 2013; Silva et al. 2016). Additionally, most of the sugar cane is produced in smaller plots, and frequently is grown by smallholder farmers rather than corporations. The

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production is primarily used for food and beverage production, and as a supplementary food source for livestock (Silva et al. 2016). Regarding pest management, programs using either classic or augmentative biological control are less commonly used, as opposed to regions of greater sugar cane production.

In the past 10 yr, efforts have been made to increase sugar cane yields by selecting genotypes that are better fitted for subtropical areas (Nogueira et al. 2016; Morais et al. 2017). The impacts of recently introduced sugar cane genotypes, in combination with small crop areas and a pattern of lower temperatures on associated insects (pests and natural enemies), have not been investigated in southern Brazil. Therefore, this study describes the population dynamics of the principal insect pests and their natural enemies associated with sugar cane grown in a subtropical area of Brazil.

Materials and Methods

Surveys were carried out monthly in a 15 ha field growing the commercial sugar cane variety RB835089 in the municipality of Salto do Jacuí, Rio Grande do Sul, Brazil (29.003467°S, 53.235349°W), from Feb 2013 to Jan 2015. The crop season extended for 12 mo, beginning (planting and sprouting) in Sep and Oct. The survey covered a half of the 2012/2013 crop season (Feb–Aug 2013), the entire 2013/2014 season, and the initial portion of the following season (Nov 2014–Jan 2015). In the first yr of survey, the crop represented the second-ratoon cane cutting, and the following years the third and fourth-ratoon cane cutting, respectively, with 1.5 m spacing between rows.

ASSESSMENT OF PESTS AND NATURAL ENEMIES

The population survey for caterpillars of *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae) started when the crop emerged from the soil and produced the first internode. In each evaluation date, 1 ha of the crop and 2 points within this area were both randomly determined. At each point, every culm was evaluated along 2 parallel 5-m linear crop rows, totaling 20 linear m per ha. To evaluate the culms, cuts were made at the plant base, the stalks were clipped, and the straw was removed. The culms were then opened with a machete to quantify the total number of internodes, internodes attacked by borers (galleries), caterpillars, and pupae of *D. saccharalis*. During this process, the occurrence of natural enemies and other pests were investigated in the internal and external parts of the stem, leaf sheath, and leaves. Caterpillars of *D. saccharalis* were placed in flat-bottomed cylindrical glass tubes (2.5 cm diam × 8.5 cm high) containing artificial diet and plugged with hydrophobic cotton. The pupae were stored in acrylic tubes (3.0 cm diam × 8.0 cm high) containing a piece (2 cm) of moistened cotton. *Diatraea saccharalis* and its parasitoids were quantified in insects per culm. Predators were quantified by considering the number of insects per linear m of crop row. Aphid and mealybug abundance was determined based on percentage of infested culms.

To assess the presence of *Mahanarva fimbriolata* (Stål) (Hemiptera: Cercopidae), we used the methodology of the Sugarcane Technology Center (CTC) described by Almeida et al. (2008). We systematically evaluated 18 points per ha, with each point consisting of 1 linear m of growth along the row (planting furrow) and 0.5 m to each side, totaling 1 m^2 for each observation. For each sampling point, we evaluated and quantified the number of nymphs at the base of the sugar cane plant, and the number of adult *M. fimbriolata* in plant shoots per m^2 of planting furrow.

ASSESSMENT OF FINAL INFESTATION INDEX OF *DIATRAEA SACCHARALIS*

Before sugar cane harvesting (Aug), in addition to the last survey of insects, an evaluation of the final infestation index was conducted. In 5 sections of 1 ha, chosen randomly, groups of 25 stalks were collected randomly as a sample. Later, in the laboratory, the culms were opened with a machete to quantify the total number of internodes, and internodes attacked by borers. Infestation index (%) was calculated according to the formula (number of bored internodes/total number of internodes)*100.

Weather data, i.e., temperature (°C), relative humidity (%), and precipitation (mm), were obtained from the National Institute of Meteorology (INMET), in the municipality of Cruz Alta, Rio Grande do Sul, Brazil (Table 1).

Results

POPULATIONS OF INSECT PESTS

The crop was sampled 24 times during the study period, and we observed 4 species of insect pests: sugarcane borer, *D. saccharalis*; sugarcane spittlebug, *M. fimbriolata*; pink mealybug, *Saccharicoccus sacchari* (Cockerell) (Hemiptera: Pseudococcidae); and sugarcane aphid, *Melanaphis sacchari* (Zehntner) (Hemiptera: Aphididae).

The first infestation of *D. saccharalis* was observed in Feb 2013, but it was more abundant from May to Aug in each crop (2012/2013 and 2013/2014). In Jun and Jul, populations peaked at 1.14 and 0.65 caterpillars per culm, respectively, which is directly related to the greater number of internodes infested in the culms evaluated (Fig. 1A).

The greatest infestation of *M. fimbriolata* was observed during the warmer mo of the period evaluated, Dec to Mar, with the population peaking in Jan 2014, at 0.55 insects per m of furrow (Table 1, Fig. 1B). For *S. sacchari* and *M. sacchari*, the first infestations occurred from Feb onward. The highest percentages of *S. sacchari* infestation occurred during Mar, with an infestation of 89.09% and 78.89% for 2012/2013 and 2013/2014 crops, respectively, and the insects were present until harvest. *Melanaphis sacchari* displayed greater infestations in Mar, reaching 100% of culms, and the infestation ended in Apr (Fig. 1B).

POPULATIONS OF NATURAL ENEMIES

The natural enemies observed were the ladybird beetle *Harmonia axyridis* (Pallas) (Coleoptera: Coccinellidae), the earwig *Doru lineare* (Eschscholtz) (Dermaptera: Forficulidae), and the tachinid fly *Billaea claripalpis* (Wulp) (Diptera: Tachinidae) (Fig. 2). The earwig *D. lineare* was the natural enemy observed most frequently, with occurrence throughout the growing period evaluated except for Nov 2014. *Harmonia axyridis* was observed from Feb until harvest (2013) or from Dec to harvest (2014 and 2015). The parasitoid *B. claripalpis* was observed in larvae of *D. saccharalis* in 2013 and 2014 from Feb until harvest (Fig. 2).

Discussion

The surveys demonstrated the presence of important sugar cane pests and their natural enemies in a subtropical region of Brazil. *Diatraea saccharalis* was quite abundant, and the increase in caterpillar population followed plant growth (internode number) of the crop throughout the season. This was reported also in sugar cane grown in the state of Piauí, in northeastern Brazil; however, those authors assessed adults cap-

Table 1. Weather data from the municipality Cruz Alta[a], Rio Grande do Sul State, Brazil. (Source: National Institute of Meteorology [INMET]).

Year	Month	Air temperature (°C)		Relative humidity (%)		Rainfall (mm)
		Max.	Min.	Max.	Min.	
2013	Feb	22.69	21.25	82.00	75.52	127
	Mar	19.82	18.54	82.40	76.88	204
	Apr	19.66	18.12	73.26	66.75	124
	May	15.94	14.66	79.66	74.33	122
	Jun	14.35	13.24	86.65	82.10	70
	Jul	13.20	11.92	80.85	75.11	73
	Aug	12.38	11.16	81.85	76.42	183
	Sep	16.02	14.70	80.52	74.79	127
	Oct	19.08	17.56	74.23	67.34	129
	Nov	22.96	21.31	67.89	61.07	140
	Dec	25.03	23.41	69.49	62.41	144
2014	Jan	24.49	23.00	80.12	73.09	195
	Feb	24.24	22.71	77.77	70.56	158
	Mar	21.27	19.85	79.20	72.95	139
	Apr	19.97	18.64	77.38	71.81	142
	May	15.62	14.48	85.79	81.11	245
	Jun	14.05	13.12	87.03	83.20	349
	Jul	14.39	13.22	81.94	76.55	167
	Aug	15.64	14.30	78.24	71.78	81
	Sep	17.48	16.43	85.91	81.26	349
	Oct	20.98	19.59	76.07	70.15	217
	Nov	22.86	21.24	67.62	60.89	77
	Dec	23.21	21.82	74.27	68.46	155
2015	Jan	23.32	22.00	83.32	77.38	177

[a]Nearest weather station

tured by light traps, and sugarcane borer adults were present throughout the developmental period of plants (Portela et al. 2010).

The continuity in population increase of *D. saccharalis*, even in colder mo (May to Aug), represents the opposite of what is generally observed with insects, namely that colder weather leads to a population reduction. Previous research has shown that the best development of *D. saccharalis* occurs between 20 and 25 °C (Melo & Parra 1988). However, in our study, during May to Aug the population of *D. saccharalis* remained in the crop during the colder mo and shorter photoperiods of the yr (compared to other regions of Brazil). This could be associated with physiological characteristics, such as diapause, or because caterpillars can reduce their metabolism, saving energy to withstand low temperatures and light time during this period (Parra et al. 1983). Similarly, pest population growth can be more related to plant development than to climatic parameters, because when caterpillars construct galleries inside the culm, they can provide a microclimate suitable for their development (Lima Filho & Lima 2003).

The high infestation index values of *D. saccharalis* observed during the crops grown in 2012/2013 (20.40%) and 2013/2014 (24.10%) may be related to cultivation of other host crops nearby, such as corn (Cruz 2007). This intensity of infestation under subtropical conditions is considered high because it is estimated that each 1% of infestation index causes a reduction of 650 g of sugar per ton of sugar cane (Yasem de Romero et al. 2008). Furthermore, it is important to consider that the presence of *D. saccharalis* during the sugar cane-growing season seems to be continuous, or even cumulative throughout crop development. However, the pre-harvest (in this case Aug) evaluation of final infestation index is essential to compare different varieties regarding susceptibility to *D. saccharalis*, because it represents an overall level of damage.

The abundance of *M. fimbriolata* was low when compared to other sugar cane production areas in Brazil. In the state of São Paulo, pest infestation can attain 14.60 spittlebugs per m of furrow (Dinardo-Miranda & Gil 2007). The seasonal occurrence of *M. fimbriolata* is clearly correlated with higher temperatures, particularly when combined with higher rainfall, as observed for other regions of the country (Barbosa et al. 2014).

Pink mealybug, *S. sacchari*, was found during most of the yr; however, little information is available about this insect in sugar cane in Brazil. This species has been reported worldwide in virtually all places with sugar cane cultivation, and the damage when highly infested is associated with a reduction in juice quality (brix, purity, and polarization), vigor and yield of culms (Gamal El-Dein et al. 2009). *Melanaphis sacchari* was most abundant in Mar, when 100% of plants were infested. This pest population density is influenced directly by temperature and precipitation, as observed in sorghum (Chang et al. 1982). Despite limited occurrence, population outbreaks are always a risk, due to the presence of a wide range of host plants in the family Poaceae, and also serve as an economic threat because they can be vectors of at least 3 persistent viruses (Singh et al. 2004).

Increased occurrence of *B. claripalpis* coincided with population peaks of *D. saccharalis*. This parasitoid is an important natural enemy of sugarcane borer, and is used on a commercial scale in other Latin American countries, alone or in association with other parasitoids, through mass releases (Vargas et al. 2015; Rivera-Escobar & Soto Giraldo 2017).

The predators *H. axyridis* and *D. lineare* were found in every period of occurrence of *S. sacchari* and *M. sacchari*. In addition to being an important population regulator of aphids and mealybugs, these predators affect the survival of *D. saccharalis* by feeding on egg

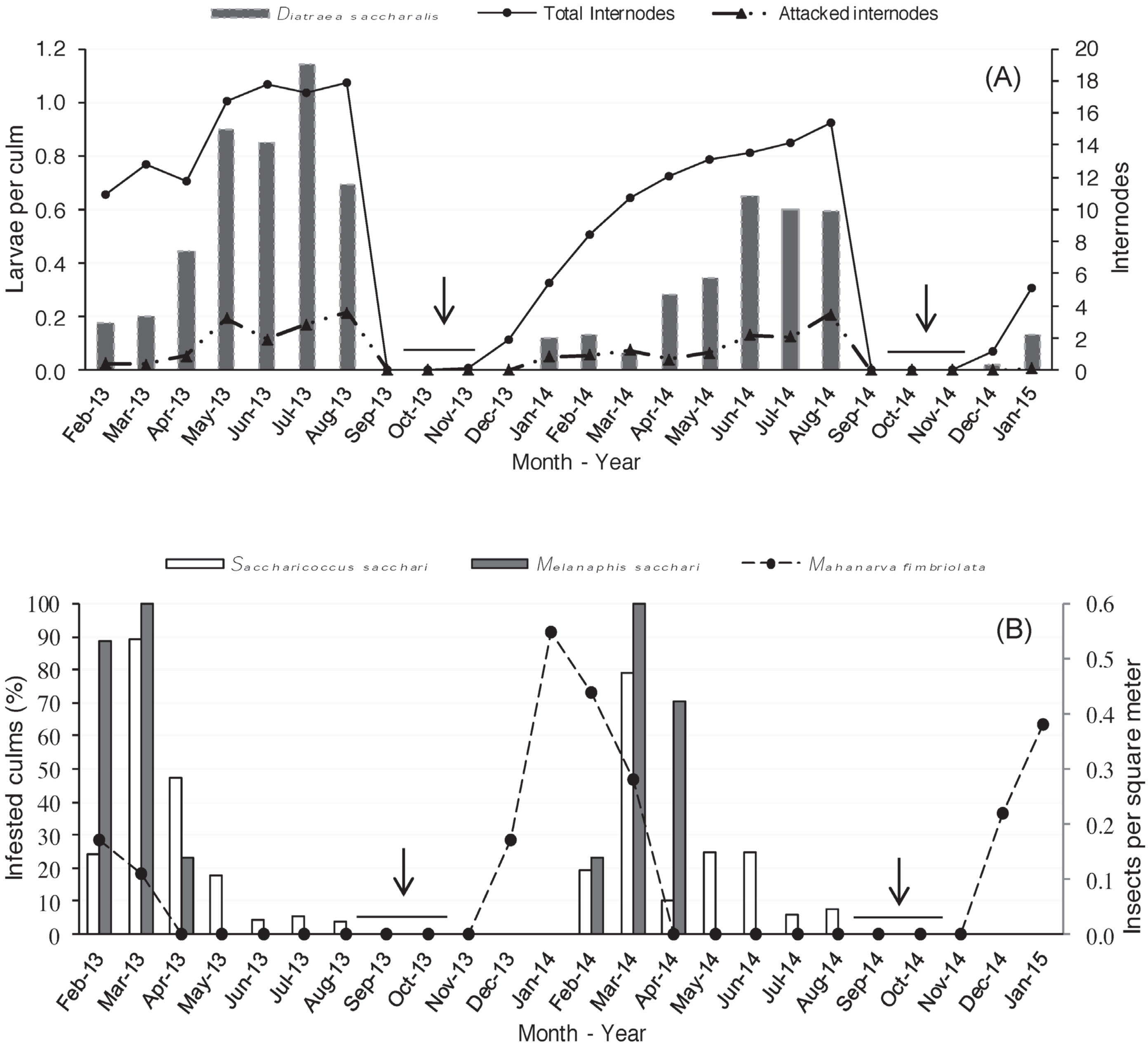

Fig. 1. Population dynamics of sugar cane pests from Feb 2013 to Jan 2015 in the municipality of Salto do Jacuí, Rio Grande do Sul State, Brazil: (A) Means of internodes, attacked internodes, and number of *Diatraea saccharalis* larvae per culm; (B) Insects of *Mahanarva fimbriolata* per square m, and infested culms (%) by *Saccharicoccus sacchari*, and *Melanaphis sacchari*. Arrows indicate the harvesting and budding periods.

masses in sugar cane and corn (Fuller & Reagan 1988; Cruz & Oliveira 1997; Almeida 2002). Thus, such natural enemies should be considered in IPM in sugar cane, by favoring practices that help to preserve these species through the use of selective chemicals.

Periods of occurrence and population peaks are fundamentally important in determining the sampling and monitoring of sugarcane pests in subtropical regions of southern Brazil, as well as for assessing their natural enemies. However, further studies on sugar cane pest management in this Brazilian region are needed. For example, an abundance of these insects can be affected by sugar cane genotype. Studies indicate that varietal resistance can provide a reduction of 48% on nymph survival of *M. fimbriolata* (Dinardo-Miranda et al. 2014). However, this information is not available for variety RB835089, nor other varieties cultivated in the region.

Results presented here will provide a baseline for monitoring and development of IPM strategies of sugarcane pests cultivated in a subtropical region of Brazil. We also suggest the importance of investigating the role of sugar cane varieties on survival mechanisms of pests during the colder seasons, particularly *D. saccharalis*.

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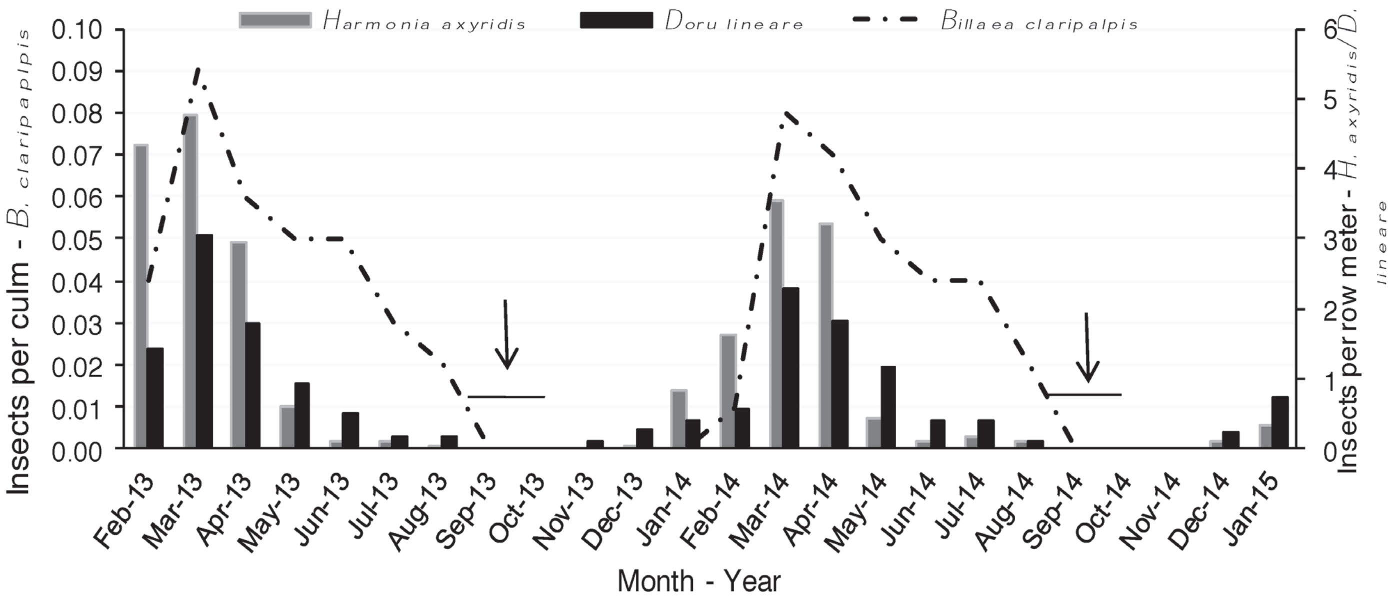

Fig. 2. Population dynamics of the natural enemies *Harmonia axyridis*, *Doru lineare*, and *Billaea claripalpis* in sugar cane from Feb 2013 to Jan 2015 in the municipality of Salto do Jacuí, Rio Grande do Sul State, Brazil. Arrows indicate the harvesting and budding periods.

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