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TECHNICAL NOTE

Attractive food in the sampling and seasonality of insects in soybean-oats succession

Atrativo alimentar na amostragem e sazonalidade de insetos em sucessão soja-aveia

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ABSTRACT: The objective of this work was to evaluate the fluctuation and population density of different families of insects by means of attractive food based on oleoresins and sugars in an area under soybean-oat succession. The experiment was carried out in the municipality of Cruz Alta, RS, according to Koppen type Cfa. During the months of March to September, 9 traps were installed with the alimentary attraction around an area of 10.5 hectares, the samplings in the traps were realized every two weeks, being the number of insects belonging to each family accounted for and used for data analysis. The families identified were Curculionidae, Scarabaeidae, Coccinellidae, Noctuidae, Apidae, Chrysomelidae, Syrphidae, Tenebrionidae, Chrysopidae and Pentatomidae. Among the most populous are: Curculionidae, Scarabaeidae and Noctuidae. The Bootstrap estimators (10.75), Jackknife 1 (10.07) and Chao 2 (9.44) indicated proximity between the number of families observed (10) and estimated only for the Jackknife 2 estimator (13.95), there were more families. The soybean-oat succession provides a population increase of herbivores to the detriment of natural enemies. Food-attractive traps based on oleoresins and sugars serve to monitor local entomofauna in areas of soybeans and oats in succession.

RESUMO: *O trabalho teve por objetivo avaliar a flutuação e densidade populacional de diferentes famílias de insetos por meio de atrativo alimentar à base de oleoresinas e açúcares em área cultivada na sucessão soja-aveia. O experimento foi realizado no município de Cruz Alta, RS, de acordo com Koppen do tipo Cfa. Durante os meses de março a setembro foram instaladas 9 armadilhas com o atrativo alimentar no entorno de uma área de 10,5 hectares, as amostragens nas armadilhas foram realizadas a cada duas semanas, sendo o número de insetos pertencentes a cada família contabilizados e utilizados para análise de dados. As famílias identificadas foram Curculionidae, Scarabaeidae, Coccinellidae, Noctuidae, Apidae, Chrysomelidae, Syrphidae, Tenebrionidae, Chrysopidae e Pentatomidae. Sendo das mais populosas: Curculionidae, Scarabaeidae e Noctuidae. Os estimadores de riqueza Bootstrap (10,75), Jackknife 1 (10,07) e Chao 2 (9,44) indicaram proximidade entre o número de famílias observadas (10) e estimadas; apenas para o estimador Jackknife 2 (13,95) verificou-se maior número de famílias. A sucessão soja-aveia propicia aumento populacional de herbívoros em detrimento dos inimigos naturais. Armadilhas com atrativo alimentar à base de oleoresinas e açúcares servem para o monitoramento da entomofauna local em áreas de soja e aveia em sucessão.*

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1 Introduction

The equilibrium of an agroecosystem requires the occurrence of several species of insects divided into different guilds (phytophagous, predators, parasitoids, pollinators and herbivores) (Showalter, 2006). These concomitant insects limit the uncontrolled population growth of weeds and pests of economic importance. In this way knowledge of the populations and species present in agroecosystems is of fundamental importance for the definition of management strategies, aiming at the suppression of some species and preservation of others (Aguiar & Zanella, 2005).

Sampling defines the population of insects present in a particular area of cultivation, being a presupposition for decision making under the precepts of Integrated Pest Management (Guedes et al., 2006; Riffel et al., 2012). Different techniques to know the population of a certain species of insect-plague or natural enemy are spent by technical assistants and producers, the most known and used are: direct observation, pinworm, entomological net, light trap and sexual pheromone trap (Silva et al., 2014; Pasini et al., 2015; Storck et al., 2016; Garlet et al., 2016).

The efficiency of the different sampling techniques is still widely discussed and is directly related to the number of replicates (sampled area), morphological aspects of the host plant, climatic variables and the intrinsic characteristics of the species to be sampled (Storck et al., 2016; Engel et al., 2017; Pasini et al., 2018). In this way, new tools for insect sampling are being launched every year, and the entomofaunistic studies are still necessary to know their real efficiency and environmental impact.

Recently, the use of sampling techniques using food attractants has been used within fruit and vegetable crops (Pasini et al., 2015, Costa et al., 2016), but within the large crops (soybean, corn, wheat and cotton) their use is still limited and its efficiency little known. In order to study the effects of the insecticides and their effects on the environment, a study was carried out to investigate the effects of insecticides on insect pests. Therefore, knowing the entomofauna associated to a certain food attraction is a key factor in the applicability of this tool to a culture.

The correct use of these sampling procedures allows a better adjustment at the moment of control, reducing the unnecessary applications of pesticides, providing greater sustainability of the environment. In view of this, the objective of this work was to evaluate the entomofauna in the soybean-oat succession by means of the sampling method using traps with food appeal.

2 Material and Methods

The work was conducted in the Experimental Area of the University of Cruz Alta, in the municipality of Cruz Alta, RS, according to the classification of Koppen type Cfa (Kuinchtner & Buriol, 2016), with annual mean temperature of 18.9°C and 1736 mm of annual average rainfall (Figure 1).

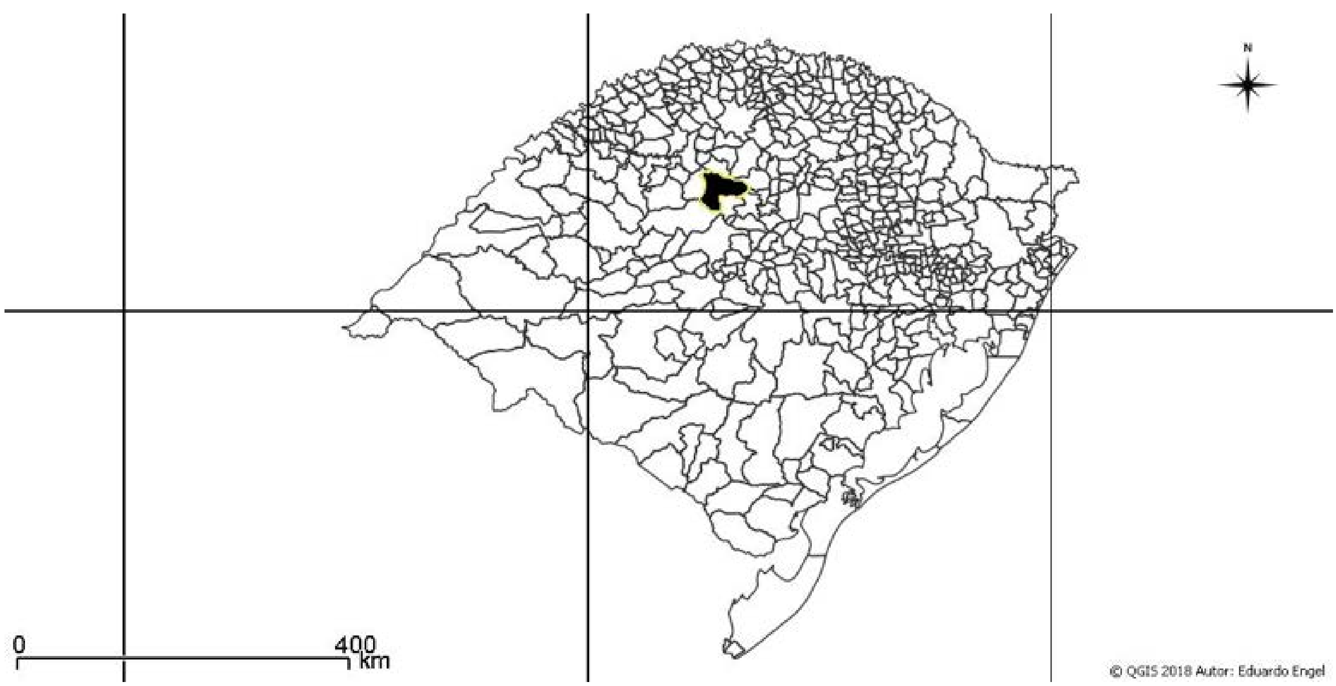

Figure 1. View of the municipality of Cruz Alta (Black polygon) in the Rio Grande do Sul state

Figura 1. Vista do município de Cruz Alta (Polígono preto) dentro do estado do Rio Grande do Sul

During the months of March to September of 2017 nine traps with food attraction of the brand NOCTOVI® were installed and sampled every 14 days in an area with 10.5 hectares. The traps were arranged around the area along its entire perimeter (Figure 2). The data obtained from the number of insects collected were separated by family of each insect. After the data were submitted to the Anderson-Darling normality test, for the data that did not meet the assumption of the test, were transformed from the function $\sqrt{X+0{,}5}$. From the normalization of the data, these were submitted to analysis of variance (ANOVA).

To determine the sample effort, we used the rarefaction technique and the Bootstrap, Jackknife 1, Jackknife 2 and Chao 2 estimators using equations 1, 2, 3, 4 and 5.

$$E(S)=\sum_{i=1}^{s}\left[1-\frac{\left(\frac{N-N_i}{n}\right)}{\left(\frac{N}{n(N-n)}\right)}\right] \quad (1)$$

What where *E(S)* is the expected number of species in a random sampling, S is the total number of species recorded, *N* is the total number of individuals registered, N_i is the number of individuals of the species *i*, and n is the standardized sample size chosen.

$$S_b = s + \sum (1-p_i)^n \quad (2)$$

What where *Sb* is the estimated wealth, *s* is the observed wealth, and *pi* is the proportion of samples *n* containing the species *i*. This step was repeated 500 times.

$$S_j = s + Q_1 \frac{n-1}{n} \quad (3)$$

$$S_j = s + \frac{Q_1(2n-3)}{n} - \frac{Q2(n-2)^2}{n(n-1)} \quad (4)$$

What where *Sj* is the estimated wealth, *s* is the observed wealth, *Qj* is the number of species occurring in exactly *j* samples, and *n* is the number of samples.

$$S_c = S + \frac{Q_1^2}{2Q_2} \quad (5)$$

What where *Sc* is the estimated wealth, *s* is the observed wealth, *Qi* is the number of species that have exactly *i* individuals in all samples.

To identify the contrast between the families of insects trapped in the traps, we used the T-test. Pearson's correlation was used to detect positive and negative relationships between captured families. In all analyzes, the significance level $p < 0.05$ was used. The statistics were performed using Excel® software and the faunal indexes were estimated using Past® software.

3 Results and Discussions

During the experiment, 956 individuals belonging to 10 families were captured: Curculionidae, Scabaeidae, Coccinellidae, Noctuidae, Apidae, Chrysomelidae, Syrphidae, Tenebrionidae, Chrysopidae and Pentatomidae. It was observed by the rarefaction technique and the wealth estimators Bootstrap (10.75), Jackknife 1 (10.07) and Chao 2 (9.44) a proximity between the wealth of observed and estimated families, only for the Jackknife 2 (13.95) estimator there was a distance, in which this one apparently indicated a greater number of families to be observed (Figure 3).

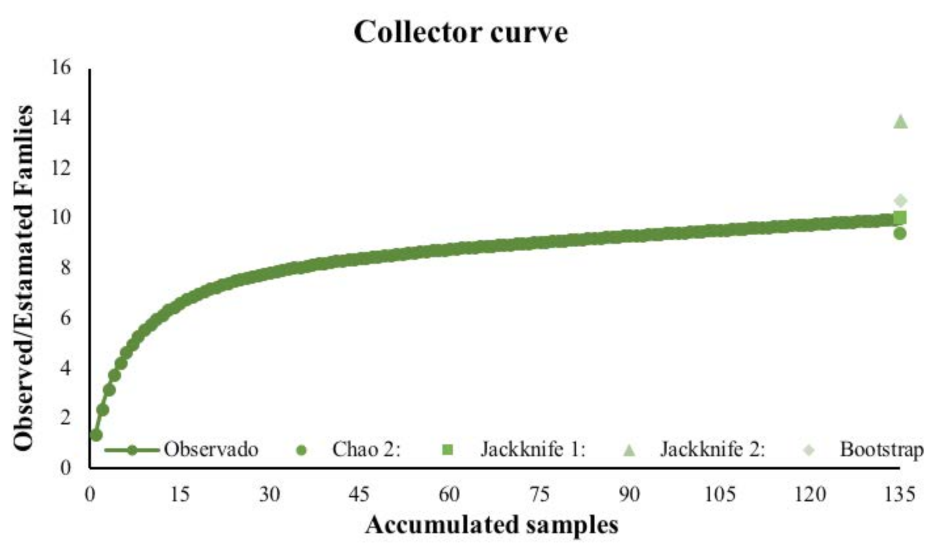

Figure 2. Collector curve estimated by the rarefaction technique and adjusted to different wealth estimators

Figura 2. Curva do coletor estimada pela técnica de rarefação e ajustada a diferentes estimadores de riqueza

The determination of sample adequacy is important for decision-making and correct use of sampling methods to estimate an insect population within the cultivated area (Resende et al., 2014). During the months of March, April, the end of August and the beginning of September, there was an increase in the population of individuals of the Curculionidae families, Scarabaeidae, Syrphidae and Noctuidae. Other individuals presented population variation with lower expression (Figure 4).

The understanding of the sampling adequacy for different sampling methods guarantees the correct population estimation during a certain period of sampling, according to the results obtained, traps with attractive food the base of oleoresins and sugars were efficient in the identification of the local entomofauna, serving with parameter of evaluation of the seasonality and population density of insects in the soybean-oat agroecosystem. Pasini et al. (2015) identified the efficiency of traps with food attraction for fig-fly, showing that this method is feasible for sampling of dipterous species of economic importance.

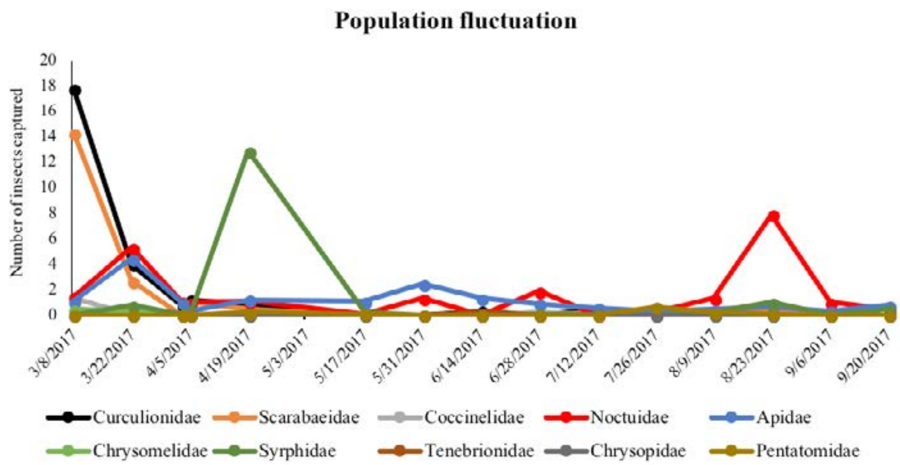

Figure 3. Population fluctuation of families of insects sampled with food appeal between March and September in an area with soybean and oat crops

Figura 3. Flutuação populacional de famílias de insetos amostradas com atrativo alimentar entre os meses de março e setembro em área com cultivos de soja e aveia

Phytophagous Insects. The families of phytophagous insects were represented by the species *Naupactus* spp. (Coleoptera: Curculionidae), *Macrodactylus* spp. (Coleoptera: Scarabaeidae), *Spodoptera frugiperda* (Lepidoptera: Noctuidae), *Spodoptera eridanea* (Lepidoptera: Noctuidae), *Pseudaletia sequax* (Lepidoptera: Noctuidae), *Helicoverpa armigera* (Lepidoptera: Noctuidae), *Chrysodeixis includens* (Lepidoptera: Noctuidae), *Euschistus heros* (Hemiptera: Pentatomidae), *Diabrotica speciosa* (Coleoptera: Chrysomelidae) and *Lagria villosa* (Coleoptera: Tenebrionidae).

Natural enemies. The families of biological controllers were represented by the species *Chrysoperla externa* (Neuroptera: Chrysopidae), *Cicloneda sanguinea* (Coleoptera: Coccinellidae), *Hipoddamia convergens* (Coleotpera: Coccinellidae), *Syrphus phaeostigma* (Diptera: Syrphidae). *Pollinators*. The pollinators of the family Apidae were represented by the species *Apis mellifera* (Hymenoptera: Apidae).

It was observed a higher number of phytophagous insects in comparison to natural enemies and pollinators (Figure 5), this is related to the predecessor and successor crop, the soybean-oat succession provides food available to these individuals throughout the year, having as a factor limiting only low temperatures during winter, however, insects with greater temperature range and are able to withstand foraging in lower temperature times (Oliveira et al., 2009).

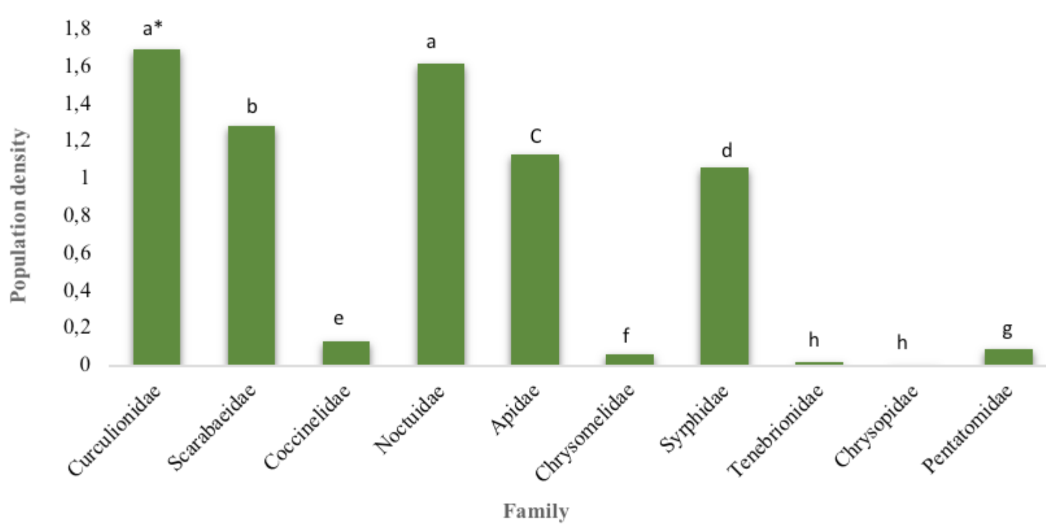

Figure 4. Average of families trapped by food trap during the months of March to September in an area cultivated with soybean-oat succession. * Different letters in the columns differ statistically by the T test (p> 0.05)

Figura 4. Média de famílias capturadas por armadilha com atrativo alimentar durante os meses de março a setembro em área cultiva com sucessão soja-aveia. * Letras diferentes nas colunas diferem significativamente pelo teste T (p>0,05)

Due to the great number of individuals belonging to the family Noctuidae and Curculionidae, it is possible to be said that the trap with attractive alimentary base of oleoresinas and sugars works as agroecological tool in the combat to defoliant insects, interfering in its cycle, once the adults are captured (Pasini et al., 2015). Also its functionality is highlighted by the alert system, detecting the presence of the first adult defoliants in the area, indicating monitoring for decision making.

Pearson's correlation analysis showed positive and negative relationships among the sampled families, with positive correlations between coleopteran families, Lepidoptera and Hymenoptera (Noctuidae and Apidae). This is explained by the dispersion characteristics of these individuals and sampling time, occurring concomitantly in the same sample (Aguiar & Zanella, 2005).

The concomitant occurrence of different insect species identifies the biodiversity pattern of an area, areas with lower biodiversity tend to have a small number of species and with high populations (Specht et al., 2005), this can be observed by the abundant number of species noctuids and curculionids in the studied area, the succession of the soybean and oat cultures make the population pattern of this area defined. Through the results obtained, traps of the attractive food type consisting of oleoresins and sugars aided in the identification of the biodiversity pattern of the study area, identifying the harmful species and natural enemies present, providing a better basis for decision making and the construction of plans for integrated pest management.

Table 1. Pearson's linear correlation coefficient for families sampled with food-attractive trap in cultivated area in soybean-oat succession

Tabela 1. Coeficiente de correlação linear de Pearson para famílias amostradas com armadilha do tipo atrativo alimentar em área cultivada na sucessão soja-aveia

	Curculionidae	Scarabaeidae	Coccinellidae	Noctuidae	Apidae	Chrysome-lidae	Syrphidae	Tenebrionidae	Chrysopidae	Pentatomidae
Curculionidae	-									
Scarabaeidae	0,91	-								
Coccinellidae	0,40	0,44	-							
Noctuidae	0,19	0,17	0,02	-						
Apidae	0,04	0,04	0,04	0,26	-					
Chrysomelidae	0,17	0,12	0,12	0,26	0,20	-				
Syrphidae	-0,02	0,00	-0,02	0,07	0,14	0,01	-			
Tenebrionidae	-0,02	-0,02	-0,02	-0,04	0,08	-0,01	-0,01	-		
Chrysopidae	-0,02	-0,02	-0,02	-0,04	-0,03	-0,01	-0,01	-0,01	-	
Pentatomidae	-0,05	-0,04	0,02	-0,08	-0,05	-0,03	-0,03	-0,02	-0,02	-

4 Conclusions

Food-attractive traps with oleoresins and sugars aided in raising the local entomofauna in the soybean-oat succession. The families with the highest population density were: Noctuidae and Curculionidae, followed by Scarabaeidae, Apidae, Syrphidae, Coccinellidae, Chrysomelidae, Pentatomidae, Tenebrionidae and Chrysopidae.

The succession of soybean-oat provided maintenance and growth of herbivorous populations to the detriment of natural enemies and pollinators.

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