

Bioassay

Diversity of stink bugs (Pentatomidae) in *Chloris distichophylla* Lag. (Poaceae) overwintering

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Abstract. The objective of this study was to evaluate the diversity and abundance of stink bugs in *Chloris distichophylla* Lag (Poales: Poaceae) during the soybean and corn off-season. The work was carried out in the municipality of Cruz Alta, Rio Grande do Sul state, over the soybean and corn off-season between 2014 and 2018. 3543 adults were identified into six species: *Euschistus heros* (Fabricius, 1798), *Dichelops furcatus* (Fabricius, 1775), *Dichelops melacanthus* (Dallas, 1851), *Edessa meditabunda* (Fabricius, 1794), *Edessa ruformaginata* (De Geer, 1773) and *Piezodorus guildinii* (Westwood, 1837) (Hemiptera: Pentatomidae). *E. heros* was the most abundant, followed by *D. furcatus*. The diameter of the clumps directly affects the population density of the stink bugs. Finally, *C. distichophylla* is shown as favorable to the maintenance of the stink bug populations over the soybean and corn off-season.

Keywords: Integrated Pest Management, Host plant, Alternative plant, Migration, Survivorship.

Among the main pests of soybean and corn, stink bugs are highlighted due to their capacity of damage (Panizzi et al. 2012). In the soybean crop, these insects, directly and indirectly, generate losses through seed and sap sucking, therefore reducing grain weight, lowering the physiological quality of seeds besides causing pod abortion (McPherson 2018). In corn, its damage is significant at the beginning of development, where it causes a reduction in the population stand of the plants using the so-called "leaf rolling" of the plant, making its development impossible (Crosariol Netto et al. 2015).

In addition to crop damage, another factor that determines the adaptive success of these insects is their ability to survive on associated plants during the off-season crop, either to their feeding and completion of their cycle or to hibernate (Panizzi 1997, Klein et al. 2013, Smaniotto & Panizzi 2015). Several stink bug species have associated plants of the Poaceae family dependence during the off-season (Panizzi 1997, Klein et al. 2013, Pasini et al. 2018, Engel et al. 2018). Thus, the knowledge about the plants associated with these insects during the off-season crop becomes of extreme importance for integrated pest management.

Knowledge of the diversity of stink bugs that occur in the agricultural landscape is of great value for Integrated Pest Management (IPM). For this, it is necessary to use techniques that allow the determination of sampling sufficiency and distribution of abundances among individuals, thus defining which are the dominant and rare species, this allows the diagnosis of species with potential to become pests (Southwood & Henderson 2000, Magurran 2004, Bianchi et al. 2019).

For Link & Grazia (1987), the knowledge of the host plants helps in the studies of ecology, management, and prediction of species that cause harm to the cropped plants. In this context, the objective of this study was to determine the diversity and abundance of stink bug species associated with *Chloris distichophylla* Lag (Poales: Poaceae) during the soybean and corn off-season.

The experiment was conducted at the University of Cruz Alta, Cruz Alta, Rio Grande do Sul state, (Time Zone 22S, 244138.; 6835737 UTM). According to the classification of Köppen, the climate in the region is classified as Cfa, with average temperature less than 18°C (mesothermic) in the coldest month, and average temperature higher

than 22°C in the hottest month, with hot summers, occasional and tendency of rainfall concentration in summer; however with no defined dry season (Kuinchtner & Buriol 2016) during the off-season (June – September) in the cropped area in soybean-corn succession in 2014, 2015, 2016, 2017 and 2018.

Plants with 5, 10, 15, 20, and 25 centimeters of clump diameter were sampled. The individuals occurring inside the clumps were counted, for the unidentified insects, which were taken to the Laboratory of Entomology at the University of Cruz Alta for identification based in Garbelotto & Campos (2014) and five individuals of each species were assembled and stored in the entomological collection of the University of Cruz Alta. In each off season 50 plants were sampled, being subdivided between the respective diameter of clumps (5 to 25±5cm), totaling 250 plants sampled at the end of the experiment. Each plant evaluated was at a maximum distance of 15 meters from the edge of the cultivation area and a minimum distance of 20 meters between the plants.

In order to determine the effect of clump diameter on population density, linear regression analysis was used. Quantitative data were analyzed through the alpha diversity (diversity and distribution of species abundance - SAD). The suitability of SAD was tested in four models: geometric, broken-stick, log-series, and log-normal. The sampling sufficiency curve for the abundance of *C. distichophylla*-associated pentatomids was obtained with 999 randomizations and compared with the non-parametric richness estimators Chao 1, Chao 2, Jackknife 1 and Jackknife 2 to determine the sampling efficiency, according to the methodology used by Bianchi et al. (2019). Each richness estimator takes into account a different parameter, that is, the occurrence of singletons, doubletons, unique, and duplicates. All analyses were performed using the software PAST 3.34 (Hammer et al. 2001).

A total of 3543 individuals belonging to the six species were collected. The most abundant species were *Euschistus heros* (Fabricius, 1798.), *Dichelops furcatus* (Fabricius, 1775) and *Edessa meditabunda* (Fabricius, 1794). The sum of these species corresponded to 94% of the individuals sampled (Tab. 1).

Table 1. Species, abundance (N) and frequency (F) of stink bug (Pentatomidae) sampled in *Chloris distichophylla* Lag. (Poales: Poaceae) over soybean and corn off-season from 2014 to 2018 in Cruz Alta, Rio Grande do Sul, Brazil.

Species	N	F (%)
<i>Euschistus heros</i> (Fabricius, 1798.)	1837	51.8
<i>Dichelops furcatus</i> (Fabricius, 1775)	1019	28.8
<i>Dichelops melacanthus</i> (Dallas, 1851)	33	0.9
<i>Edessa mediatubunda</i> (Fabricius, 1794)	467	13.2
<i>Edessa rufomarginata</i> (De Geer, 1773)	27	0.8
<i>Piezodorus guildinii</i> (Westwood, 1837)	160	4.5
Total	3543	100

For the analysis of the abundance distributions among species, it was found a significance for the geometric model (Fig. 1). A trend towards asymptote from the thirtieth sample was observed through the rarefaction curve. This trend suggests a stabilization of the number of species to be sampled, indicating sample sufficiency. For all species richness estimators (Chao 1, Chao 2, Jackknife 1 and Jackknife 2), a value equal to that observed, reinforcing the idea of sufficiency in species sampling in the evaluated plants (Fig. 2).

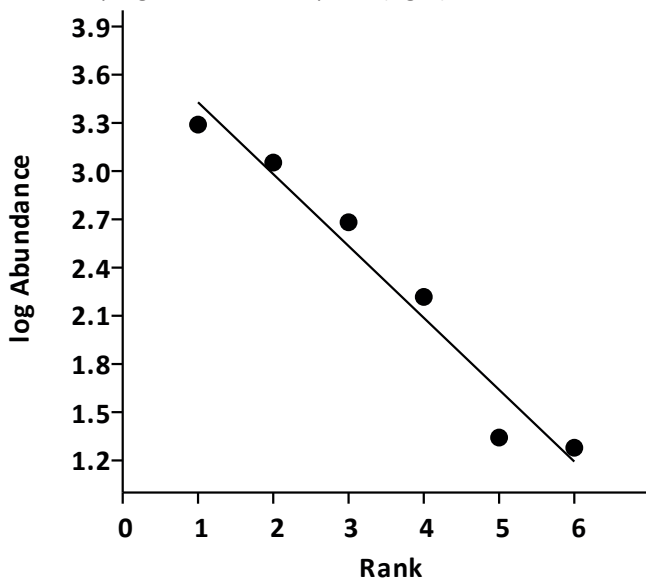


Figure 1. Distribution of the abundances of pentatomid bugs sampled in *Chloris distichophylla* Lag. (Poales: Poaceae) in the soybean and corn off-season crop between 2014 and 2018. Cruz Alta, Rio Grande do Sul, Brazil.

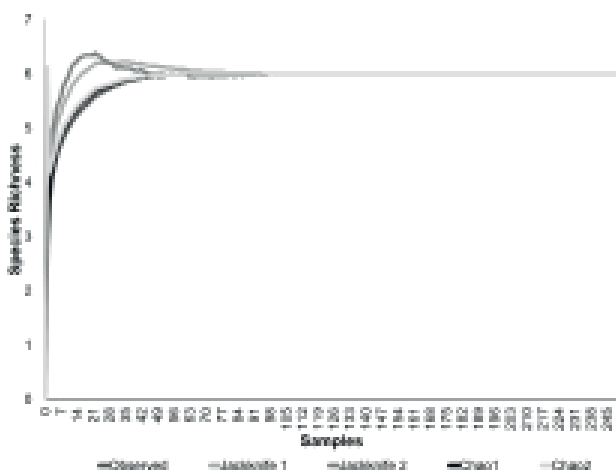


Figure 2. Rarefaction curve and species richness estimators for pentatomid bugs sampled in *Chloris distichophylla* Lag. (Poales: Poaceae) during the soybean and corn off-season from 2014 to 2018. Cruz Alta, Rio Grande do Sul, Brazil. 2014-2018.

A direct effect of the *C. distichophylla* clump diameter was observed on the population density of the sampled bugs (Fig. 3). No

nymphs were observed among the sampled individuals over the whole monitoring period, therefore, indicating no feeding and oviposition preference for the plant in question. Thus, its occupation was only for survival during the off-season crop.

Due to the large diversity of associated plants, the economic importance of stink bugs is related not only to their feeding behavior but also to their forms of survival (Smaniotto & Panizzi 2015, Pasini et al. 2018). Their wide geographical distribution makes them pests not only in Brazil, but in the world, either in the form of invasive or endemic species (McPherson 2018).

The knowledge of the different forms of survival and plants associated with pentatomids during the off-season allows the optimization of the management by identifying areas of control and infestation (Engel et al. 2018). This work identified the diversity of a stink bug assembly associated with *C. distichophylla* located in the border of the cultivation area during the off-season of soybean and corn crops for five consecutive years.

Several studies highlight the ways of survival of stink bugs in unfavorable periods. Medeiros & Megier (2009) found associated plants (Solanaceae) for *E. heros*, which served as a food source during the off-season. Klein et al. (2013) identified *Andropogon bicornis* L. (Poaceae) as a hibernacle of a series of stink bugs in off-season of rice crop. The same situation was observed by Pasini et al (2018), who also observed the occurrence of the stink bugs in *Andropogon lateralis* (Poaceae).

A series of species considered of economic importance was observed for *C. distichophylla*.; however, extensive dominance was observed for *E. heros*, *D. furcatus*. The factor explained by the crop system in succession with the soybean and corn crops, favoring the development and permanence of these insects in the cropping area (Silva et al. 2013, Chiesa et al. 2016).

It is also verified the influence that the clump diameter of the associated plants during the off-season has on the population density. Concerning *C. distichophylla*, a higher population density due to clumps with larger diameter was found. The volume of plant mass in associated plants may be related to the capacity of maintenance of the microclimatic conditions in clumps closest to the minimum temperature required by stink bugs. Therefore, plants with larger diameters of clump allow a higher survival chance for these insects (Howe & Jander 2008, Klein et al. 2013).

Considering the species of stink bugs found in the study, mainly those of economic importance (*E. heros*, *D. furcatus*, *D. melacanthus*, and *P. guildinii*), it was verified the importance of *C. distichophylla* plants for the maintenance of populations during the soybean and corn off-season. As a result, methods of management and sampling of this environment can be adopted in order to contribute to the population suppression of these organisms.

Author's Contributions

EE and MPBP, assisted in the bibliographic review, conduction of the experiment, data analysis, and scientific writing.

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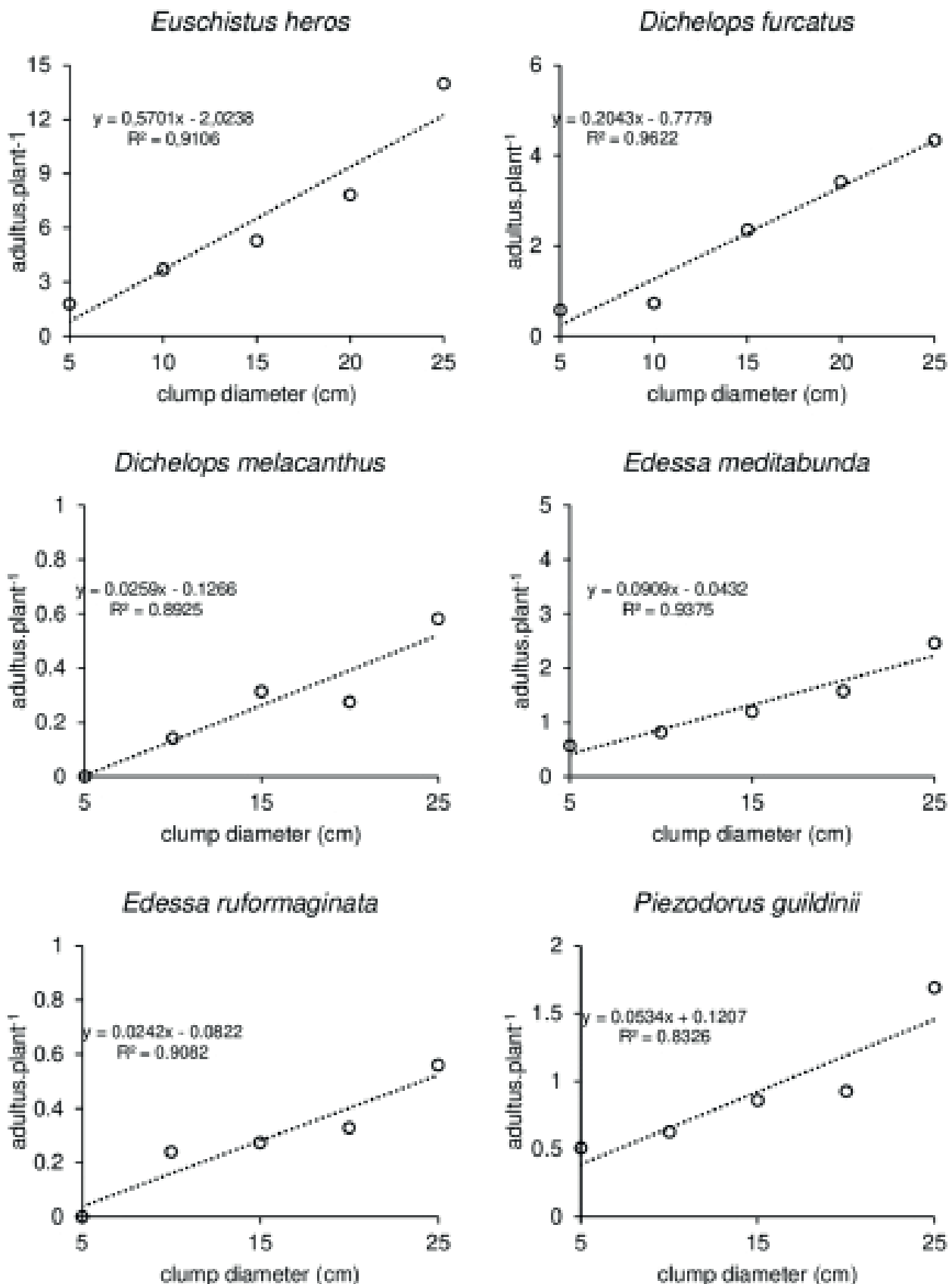


Figure 3. Population density of pentatomid bugs as a function of the clump diameter of *Chloris distichophylla* Lag. (Poales: Poaceae) during the soybean and corn off-season. Cruz Alta, Rio Grande do Sul, Brazil. 2014-2018.

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