Insect diversity in organic rice fields under two management systems of levees vegetation

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Abstract

Simplified environments characterize agroecosystems, reducing the diversity of associated plants, which are not cultivated for economic purposes, causing unbalances that can promote the emergence of cultivated plants pests, as well as the reduction of their natural enemies. Management systems that increase diversity in agroecosystems can extend the action of natural enemies of pests. Studies to understand the diversity of insects associated with rice cultivation and determine their ecological guilds can provide information about the composition and structure of such ecosystems, which can be applied to integrated pest management. Therefore, the study aimed to describe and compare groups of insects in irrigated rice fields, with organic management using two different systems of levees vegetation management, and relate them to the phenological states of rice cultivation (seedling, vegetative, and reproductive). Samples were taken in a plantation located in Águas Claras district of Viamão, RS. The total area of 18 ha was divided into two. A subarea called not cut (NC), where wild vegetation of levees was maintained, and the subarea named cut (C), where monthly cuts were made to levees vegetation, from the beginning of soil preparation until the harvest. From October 2012 to March 2013 were held weekly collections in quadrats randomly located in both the rice fields and the levees. A total of 800 insects were collected, 429 in the C subarea and 371 in the NC. There were identified 97 morphospecies in the C and 108 in NC, being 54 shared between the subareas. The captured insects were grouped into guilds: saprophages (C = 38.2%; NC = 27.5%), phytophagous (C = 28.5%; NC = 33.2%), entomophagous (grouping parasitoids and predators) (C = 29.4%; NC = 35%) and finally other insects (C = 4 %; NC = 4.3%). The peak abundance of phytophagous and entomophagous was registered in the vegetative stage of rice. At the same stage the UPGMA analysis showed that similarity in species composition was greater than 90% in the groups obtained in the paddy fields of C and NC subareas. The vegetation of levees can positively influence the presence of entomophagous in the field. Although the abundance did not change clearly, the greatest diversity in the NC areas of all the groups, may contribute to the maintenance of ecological services expanding the system resilience.

Keywords: organic rice, Insecta, diversity, richness, abundance.

Diversidade de insetos em arroz irrigado orgânico sob dois manejos da vegetação das taipas

Resumo

Os agroecossistemas se caracterizam por ambientes simplificados, com redução da diversidade de plantas associadas, que não são as cultivadas para fins econômicos, causando desequilíbrios que podem levar ao surgimento de insetos nocivos, assim como a diminuição de seus inimigos naturais. Sistemas de manejo que priorizem o aumento da diversidade no agroecossistema podem ampliar a ação de inimigos naturais de pragas. Estudos que busquem entender a diversidade de insetos associados ao cultivo de arroz irrigado, bem como determinar as guildas ou grupos ecológicos aos quais pertencem, podem trazer informações sobre a composição e estrutura dos ecossistemas que possam ser aplicadas no manejo integrado de pragas. Neste sentido, o estudo objetivou conhecer e comparar a diversidade de insetos entre áreas de cultivo orgânico de arroz irrigado, diferenciadas pelo manejo da vegetação das taipas e relacionar com os estádios fenológicos da cultura. As amostragens foram realizadas no distrito de Águas Claras, município de Viamão, RS. A área total de 18 ha foi subdividida em duas. Numa subárea, denominada não roçada (NR) a vegetação espontânea das taipas foi mantida, na outra, roçada (R), foram feitas roçadas mensais das taipas, desde o início do preparo do solo, até a colheita. Entre outubro de 2012 a março de 2013 realizaram-se coletas semanais, em *quadrats*, situados aleatoriamente tanto nas quadras de arroz quanto nas taipas. Foi coletado um total de 800 insetos, 429 na R e 371 na NR. Foram identificadas 97 morfoespécies na R e 108 na NR, das quais 54 foram compartilhadas entre as subáreas. As guildas registradas foram: saprófagos (R = 38,2%; NR = 27,5%), fitófagos (R = 28,5%; NR = 33,2%), entomófagos (reunindo parasitoides e predadores) (R = 29,4%; NR = 35%) e outros (R = 4%; NR = 4,3%). O pico de abundância de fitófagos e entomófagos foi registrado na fase vegetativa do arroz. Nesta mesma fase, a análise de UPGMA apontou que a similaridade na composição de espécies foi superior a 90% nos grupos obtidos nas lavouras das subáreas R e NR. A vegetação das taipas pode influenciar positivamente a presença de insetos entomófagos no campo. Embora a abundância não tenha variado significativamente entre as áreas, a maior diversidade na área não roçada em todos os grupos, pode contribuir na manutenção de serviços ecológicos aumentando a resiliência dos sistemas.

Palavras-chave: arroz orgânico, Insecta, diversidade, riqueza, abundância.

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important grains for human nutrition, being the staple food of more than three billion people (SOSBAI, 2012). In Brazil, the rice is grown in two systems: irrigated (75% of production) and mountain (25% of production), both with potential expansion (IRRI, 2013). The irrigated rice cultivation, practiced in Southern Brazil contributes, on average, with 54% of national production, being Rio Grande do Sul State, Brazil's largest producer (IRRI, 2013).

Rice fields are considered temporary wetlands characterized by rapid physical, chemical and biological changes that contain greater biodiversity, especially arthropods, compared with other agricultural crops. In these ecosystems, arthropods are found in an intermediate position in the food chain and include herbivores, saprophytes, parasites and predators of other animals (Fritz et al., 2011).

Ecologically complex communities provide a broader spectrum of niches and sustain larger and more diverse population of predators and parasitoids than simpler ones. Thus, the promotion and maintenance of biological diversity turn out to be one of the main targets in the search for sustainable management in agroecosystems (Edwards and Wratten, 1981). In agroecosystems, the associated biota (unplanned) can perform important ecological services, like pollination and biological control, with the increase in planned diversity, particularly in the area of agricultural pest management (Gliessman, 2001).

Few studies, however, have demonstrated how the abundance and diversity of natural enemies, such as parasitoids and predators, contributes to biological arthropod pest control in different stages of paddy crop (Gangurde, 2007). In this context, this study aims to evaluate the diversity of terrestrial insects in two areas of organic rice crops differentiated by the presence or absence of wild vegetation in the surrounding levees.

2. Material and Methods

This study was performed in an area with rice plantation that is part of the Movements of Landless Rural Workers Settlement "Filhos de Sepé" (30°03'S, 50°52'W) located in the Environmental Protection Area (APA) Banhado Grande, Águas Claras district, Viamão, RS, Brazil. These rice crop have been managed with organic practices since 2007 (COOPAN, 2014).

The sample area, which was approximately 18 ha and planted with cultivar Epagri 108, was subdivided in two subareas. Each subarea comprised about 15 frames of approximately 6,000 m^2, delimited by earth levees to ensure the maintenance and management of water for rice flooding. In one of the subareas, the wild vegetation from the levees was cut (C) on a monthly basis since the beginning of the planting period, (October/2012) until the harvest (March/2013); in the other subarea, the wild vegetation was not cut (NC). The vegetation of the C area was mainly of grasses (Poales) of low height that were pruned, hardly reaching their reproductive stage. In the NC area occurred several species of herbaceous plants of different families, who were collected and identified. Asteraceae was the most frequent family followed by Poaceae, Cyperaceae, Pontederiacea, Convolvulaceae and Malvaceae. The specimens with flowers were properly stored in exsiccatae.

Considering the difficulty in find more three similar areas with the same size (18 ha) and conditions, we have decided evaluate the date, in each subarea, through four pseudoreplics in the levees of two frames (Figure 1). The sampling occurred from rice planting, both in paddy fields and in levees. At each sampling occasion were drawn

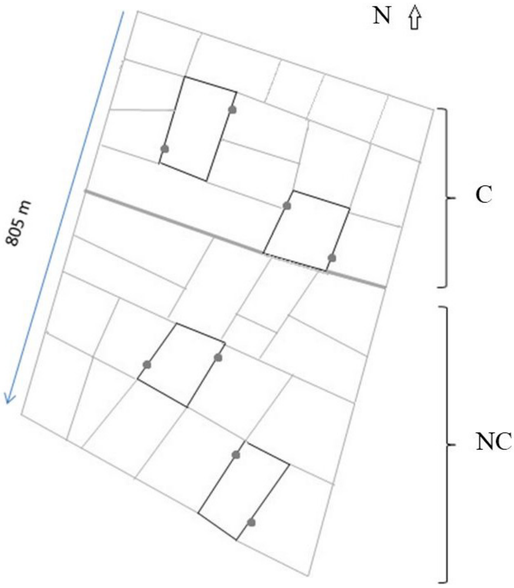

Figure 1. Sampling area, showing the subareas cut (C) and not cut (NC), in organic irrigated rice field under organic management at Águas Claras, Viamão, RS, Brasil. Means followed by the same letter indicates no significant difference (p > 0.05).

four points (pseudoreplics), two in paddy fields and two in levees, for each subarea, where a quadrat of 1 m^2 was placed in order to proceeded with visual inspection, simultaneously by two samplers for ten minutes, and collecting the insects. The insects were caught with a small sweep net and placed in plastic bags containing 70% alcohol.

The insects were screening by the microscope and identified to the family level using the keys presented by Triplehorn and Johnson (2011), on Insect Biology, Ecology, and Biological Control Laboratory (BIOECOLAB) of the Federal University of Rio Grande do Sul (UFRGS). Subsequently the samples were sent to experts for identification to the species level when possible. Unidentified individuals to this level were designated as morphospecies.

The insects were grouped into functional guilds: saprophages, phytophagous, entomophagous (grouping parasitoids and predators) and others (include hematophagous, muscivorous and nectarivorous), considering the preferred eating habits of the lower taxonomic level identified. It was recorded the number of individuals (N) and the morphospecies (S) at each sampling time, for each of area in the various stages of crop development. Alpha diversity was measured by rarefaction method (Gotelli and Colwell, 2011). The species accumulation curve, estimators and rarefaction curves were adjusted by EstimateS 8.2.0 software (Colwell, 2013).

The species composition (Beta diversity) was compared between the subareas and crop stages using cluster analysis (the UPGMA algorithm with Morisita's index). To detail the taxa that held greater importance between the subareas, a similarity percentage analysis (SIMPER) was performed (Clarke and Warwick, 2001) via the Past software (Hammer et al., 2001).

The average number of insects caught in each guild was compared between levees and crop and between different managements (C and NC) in rice development stages, using analysis of variance (Kruskal-Wallis test) and compared by Dunn using BioEstat 5.3 software (Ayres et al., 2007). The analysis level of significance was 5%.

3. Results

A total of 800 individuals, 429 in C subarea and 371 in NC were collected.

There were identified 97 morphospecies in the C and 108 in NC, being 54 shared between the subareas. The captured insects were grouped into guilds: saprophages (C = 38.2%; NC = 27.5%), phytophagous (C = 28.5%; NC = 33.2%), entomophagous (grouping parasitoids and predators) (C = 29.4%; NC = 35%) and finally other insects (C = 4 %; NC = 4.3%) in which the hematophagous habits as well muscivorous and nectarivorous were considered (Table 1 and 2).

The average number of collected individuals per square captured by sampling occasion was similar among subareas C (18 ± 2.65) and NC (17 ± 1.26) (H = 0.9654; df = 1, p = 0.3258). There was a significant difference between the averages of insects caught in the phytophagous guild

Table 1. Insects list collected from irrigated organic rice cultivation on the crop (R) and levees (L) in subareas not cut (NC) and cut (C) and relative frequencies (%) recorded between October/2012 to March/2013, Viamão, RS, Brazil.

Taxon/ Habit	Non Cut				Cut			
	Levees	Crop	Total	%	Levees	Crop	Total	%
ENTOMOPHAGOUS								
Hymenoptera								
Formicidae								
Camponotus blandus (Smith, 1858)	48	0	48	12.9	1	41	42	9.3
Camponotus sp. Morphospecie 1	2	1	3	0.8	0	1	1	0.2
Pheidole diligens (Smith, 1858)	5	0	5	1.3	1	4	5	1.1
Eulophidae								
Eulophidae morphospecie 1	0	1	1	0.3	0	0	0	0
Eulophidae morphospecie 2	1	0	1	0.3	1	1	2	0.4
Eulophidae morphospecie 3	2	0	2	0.5	0	1	1	0.2
Mymaridae								
Mymaridae morphospecie 1	1	0	1	0.3	0	0	0	0
Mymaridae morphospecie 2	1	0	1	0.3	0	0	0	0
Eucharitidae								
Eucharitidae morphospecie 1	0	0	0	0	1	0	1	0.2
Ceraphronidae								
Ceraphronidae morphospecie 1	1	0	1	0.3	0	0	0	0
Braconidae								
Braconidae morphospecie 1	0	0	0	0	0	2	2	0.4
Braconidae morphospecie2	1	0	1	0.3	0	0	0	0
Braconidae morphospecie 3	0	0	0	0	0	1	1	0.2

Table 1. Continued...

Taxon/ Habit	Non Cut				Cut			
	Levees	**Crop**	**Total**	**%**	**Levees**	**Crop**	**Total**	**%**
Fitigidae								
Fitigidae morphospecie 1	1	0	1	0.3	0	0	0	0
Platygastridae								
Macroteleia sp. Morphospecie 1	0	0	0	0	0	2	2	0.4
Trissolcus sp. Morphospecie 1	0	1	1	0.3	0	0	0	0
Chalcididae								
Chalcididae morphospecie 1	0	0	0	0	0	1	1	0.2
Odonata								
Libellulidae								
Erythrodiplax paraguayensis (Förster, 1904)	16	10	26	7	6	16	22	4.9
Erythrodiplax sp. Morphospecie 1	0	0	0	0	1	0	1	0.2
Coenagrionidae								
Coenagrionidae morphospecie 1	0	2	2	0.5	2	0	2	0.4
Ischnura fluviatialis (Selys, 1876)	0	8	8	2.2	7	0	7	1.5
Coenagrionidae morphospecie 2	0	8	8	2.2	1	0	1	0.2
Orthoptera								
Tettigoniidae								
Conocephalus morphospecie 1	0	4	4	1.1	2	0	2	0.4
Conocephalus morphospecie 2	2	3	5	1.3	7	2	9	2
Conocephalus morphospecie 3	0	2	2	0.5	10	0	10	2.2
Diptera								
Dolichopodidae								
Chrysotus sp. Morphospecie 1	1	1	2	0.5	2	1	3	0.7
Paraclius sp. Morphospecie 1	0	0	0	0	1	0	1	0.2
Tachinidae								
Tachinidae morphospecie 1	0	0	0	0	1	0	1	0.2
Bombyliidae								
Bombyliidae morphospecie 1	2	0	2	0.5	0	2	2	0.4
Neuroptera								
Chrysopidae								
Chrysoperla sp . morphospecie 1	0	0	0	0	1	0	1	0.2
Coleoptera								
Lampyridae								
Lampyridae morphospecie 1	0	0	0	0	1	0	1	0.2
Chauliognatus octomaculatus (Pie,1915)	1	0	1	0.3	1	1	2	0.4
Staphilinidae								
Aleocharinae sp. Morphospecie 1	0	0	0	0	0	0	0	0
Philonthus sp. Morphospecie 1	1	0	1	0.3	0	1	1	0.2
Hidrophillidae								
Hidrophillidae morphospecie 1	0	0	0	0	1	0	1	0.2
Ditiscidae								
Hydaticus sp. Morphospecie 1	0	0	0	0	2	0	2	0.4
Coccinellidae								
Coleomegilla quadrifasciata (Schönherr, 1808)	0	0	0	0	2	0	2	0.4
Dermaptera								
Forficulidae								
Forficulidae morphospecie 1	0	0	0	0	0	0	0	0
Forficulidae morphospecie 2	1	0	1	0.3	0	1	1	0.2

Table 1. Continued...

Taxon/ Habit	Non Cut				Cut			
	Levees	Crop	Total	%	Levees	Crop	Total	%
Hemiptera								
Nabidae								
Nabidae morphospecie 1	0	1	1	0.3	0	0	0	0
Naucoridae								
Naucoridae morphospecie 1	0	0	0	0	1	0	1	0.2
Mesoveliidae								
Mesoveliidae morphospecie 1	0	0	0	0	1	0	1	0.2
Pentatomidae								
Asopinae morphospecie 1	1	0	1	0.3	0	1	1	0.2
	88	**42**	**130**	**35.0**	**54**	**79**	**133**	**29.4**
PHYTOPHAGOUS								
Coleoptera								
Byrrhidae								
Byrrhidae morphospecie 1	1	0	1	0.3	0	0	0	0
Curculionidae								
Anthonomus sp. Morphospecie 1	1	0	1	0.3	0	0	0	0
Pheloconus sp. Morphospecie 1	2	0	2	0.5	0	0	0	0
Lixus sp. Morphospecie 1	1	0	1	0.3	0	0	0	0
Hypselus ater Boheman, 1843 morphospecie 1	0	3	3	0.8	0	5	5	1.1
Oryzophagus oryzae (Costa Lima, 1936)	0	2	2	0.5	2	9	11	2.4
Chrysomelidae								
Eumolpinae morphospecie 1	5	0	5	1.3	1	0	1	0.2
Oediopalpa plaumanni (Uhmann, 1940)	0	1	1	0.3	0	0	0	0
Lema (Neolema) sp. Morphospecie 1	1	0	1	0.3	2	0	2	0.4
Systena tenuis (Bechyné, 1954)	1	0	1	0.3	5	0	5	1.1
Charidotella vinula Boheman, 1855	2	0	2	0.5	0	0	0	0
Cassidinae morphospecie 1	5	0	5	1.3	2	0	2	0.4
Megacerus reticulatus (Sharp, 1885)	1	0	1	0.3	1	0	1	0.2
Galerucinae-Alticini morphospecie 1	0	0	0	0	1	0	1	0.2
Hemiptera								
Aphididae								
Rhopalosiphum rufiabdominale (Sasaki)	1	0	1	0.3	0	0	0	0
Aphididae morphospecie 2	3	0	3	0.8	2	1	3	0.7
Cicadellidae								
Tretogonia bergi Young, 1968	1	0	1	0.3	1	0	1	0.2
Agrossoma sp. Morphospecie 1	1	2	3	0.8	3	2	5	1.1
Reticana lineata Burmeister, 1839	3	1	4	1.1	3	1	4	0.9
Delphacidae								
Delphacidae morphospecie 1	1	0	1	0.3	0	0	0	0
Delphacidae morphospecie 2	0	0	0	0	6	2	8	1.8
Membracidae								
Cyphonia clavigera (Fabricius, 1803)	2	0	2	0.5	0	0	0	0
Ceresa brunnicornis (Germar, 1835)	8	1	9	2.4	3	2	5	1.1
Cercopidae								
Deois (Fennhia) flexuosa (Walker, 1851)	1	0	1	0.3	0	0	0	0
Cixiidae								
Cixiidae morphospecie 1	0	0	0	0	4	0	4	0.9
Rhyparochromidae								
Pseudoparomius slateri Dellapé &Coscarón, 2005	2	1	3	0.8	1	1	2	0.4

Table 1. Continued...

Taxon/ Habit	Non Cut				Cut			
	Levees	Crop	Total	%	Levees	Crop	Total	%
Pseudoparomius brailovskyi Dellapé & Coscarón, 2005	0	1	1	0.3	0	0	0	0
Paisana pampeana Dellapé, 2008	1	0	1	0.3	1	0	1	0.2
Pentatomidae								
Dichelops furcatus (Fabricius, 1775)	3	0	3	0.8	0	0	0	0
Oebalus ypsilongriseus (De Geer, 1773)	2	2	4	1.1	0	2	2	0.4
Edessa meditabunda (Fabricius, 1974)	2	0	2	0.5	0	0	0	0
Stictochilus tripunctatus Bergoth, 1918	2	0	2	0.5	0	0	0	0
Edessa sp. morphospecie 1	4	0	4	1.1	0	0	0	0
Pentatomidae morphospecie 6	0	0	0	0	1	0	1	0.2
Oebalus poecilus (Dallas, 1851)	3	5	8	2.2	0	1	1	0.2
Pentatomidae morphospecie 8	1	0	1	0.3	0	0	0	0
Pentatomidae morphospecie 9	0	1	1	0.3	0	0	0	0
Miridae								
Miridae morphospecie 1	1	0	1	0.3	0	0	0	0
Miridae morphospecie 2	2	0	2	0.5	0	0	0	0
Miridae morphospecie 3	0	1	1	0.3	0	0	0	0
Miridae morphospecie 4	0	0	0	0	0	2	2	0.4
Miridae morphospecie 5	1	0	1	0.3	0	0	0	0
Coreidae								
Spartocera morphospecie 1	0	0	0	0	3	0	3	0.7
Scutelleridae								
Orsilochides leucoptera (Germar, 1839)	1	0	1	0.3	0	0	0	0
Corixidae								
Sigara sp. morphospecie 1	0	0	0	0	0	2	2	0.4
Sigara chrostowskii (Jaczewski, 1927)	0	0	0	0	0	1	1	0.2
Colobathristidae								
Trichocentrus gibbosus Horvat,1904	1	0	1	0.3	0	0	0	0
Hymenoptera								
Formicidae								
Acromyrmex crassispinus (Forel, 1909)	1	0	1	0.3	17	0	17	3.8
Diprionidae								
Diprionidae morphospecie 1	1	0	1	0.3	0	0	0	0
Orthoptera								
Acrididae								
Paulinia acuminata De Geer, 1773	1	0	1	0.3	0	0	0	0
Stenopola sp. morphospecie 1	0	0	0	0	0	1	1	0.2
Dichroplus misionensis Carbonell, 1968	0	0	0	0	1	0	1	0.2
Dichroplus sp. morphospecie 1	0	0	0	0	0	1	1	0.2
Allotruxalis gracilis (Giglio-Tos, 1897)	0	0	0	0	0	1	1	0.2
Leptysma filiformes Serville	1	0	1	0.3	2	0	2	0.4
Ronderosi bergii (Stål, 1878)	1	0	1	0.3	3	0	3	0.7
Metaleptea adspersa (Blanchard, 1843)	1	0	1	0.3	7	1	8	1.8
Tucaya gracilis (Giglio-Tos, 1897)	2	7	9	2.4	3	4	7	1.5
Orphulella punctata (De Geer, 1773)	1	0	1	0.3	2	0	2	0.4
Gryllidae								
Gryllidae morphospecie 1	0	1	1	0.3	1	0	1	0.2
Gryllidae morphospecie 2	0	0	0	0	1	0	1	0.2
Gryllidae morphospecie 3	1	0	1	0.3	0	0	0	0
Gryllidae morphospecie 4	1	0	1	0.3	0	0	0	0

Table 1. Continued...

Taxon/ Habit	Non Cut				Cut			
	Levees	Crop	Total	%	Levees	Crop	Total	%
Romaleidae								
Xyleus discoideus (Serville, 1831)	1	0	1	0.3	0	0	0	0
Lepidoptera								
Pyralidae								
Pyralidae morphospecie 1	1	0	1	0.3	0	0	0	0
Pyralidae morphospecie 2	2	0	2	0.5	0	0	0	0
Pyralidae morphospecie 3	1	3	4	1.1	2	3	5	1.1
Lycaenidae								
Lycaenidae morphospecie 1	0	1	1	0.3	0	1	1	0.2
Hesperiidae								
Urbanus sp. morfoespecie 1	1	0	1	0.3	0	0	0	0
Diptera								
Cecidomyiidae								
Cecidomyiidae morphospecie 1	1	0	1	0.3	0	0	0	0
Coelopidae								
Coelopidae morphospecie 1	0	1	1	0.3	0	0	0	0
Chloropidae								
Chloropidae morphospecie 1	0	0	0	0	0	3	3	0.7
Chloropidae morphospecie 2	0	0	0	0	0	1	1	0.2
Chloropidae morphospecie 3	0	0	0	0	0	1	1	0.2
Thysanoptera								
Phlaeothripidae								
Phlaeothripidae morphospecie 1	2	0	2	0.5	0	0	0	0
Aeolothripidae								
Aeolothripidae morphospecie 1	1	1	2	0.5	0	0	0	0
	88	**35**	**123**	**33.2**	**81**	**48**	**129**	**28.5**
SAPROPHAGES								
Diptera								
Sarcophagidae								
Oxysarcodexia varia (Walker, 1836)	0	2	2	0.5	2	0	2	0.4
Oxysarcodexia culmiforceps Dodge, 1966	2	1	3	0.8	1	2	3	0.7
Oxysarcodexia marina (Hall, 1938)	2	2	4	1.1	5	3	8	1.8
Chironomidae								
Chironomidae morphospecie 1	1	15	16	4.3	5	20	25	5.5
Chironomidae morphospecie 2	6	61	67	18.1	35	69	104	23
Carnidae								
Carnidae morphospecie 1	1	0	1	0.3	0	4	4	0.9
Bibionidae								
Bibionidae morphospecie 1	0	0	0	0	18	0	18	4
Faniidae								
Faniidae morphospecie 1	1	0	1	0.3	0	0	0	0
Faniidae morphospecie 2	1	0	1	0.3	0	0	0	0
Drosophilidae								
Drosophilidae morphospecie 1	0	0	0	0	1	1	2	0.4
Drosophilidae morphospecie 2	0	0	0	0	1	0	1	0.2
Drosophilidae morphospecie 3	1	0	1	0.3	1	0	1	0.2
Tipulidae								
Tipulidae morphospecie 1	0	0	0	0	0	1	1	0.2

Table 1. Continued...

Taxon/ Habit	Non Cut				Cut			
	Levees	Crop	Total	%	Levees	Crop	Total	%
Blatodea								
Oxyhaloidae								
Oxyhaloidae morphospecie 1	0	0	0	0	1	0	1	0.2
Epilampridae								
Epilampridae morphospecie 1	3	0	3	0.8	1	0	1	0.2
Epilampridae morphospecie 2	1	0	1	0.3	0	0	0	0
Panchloridae								
Panchloridae morphospecie 1	1	0	1	0.3	0	0	0	0
Coleoptera								
Tenebrionidae								
Tenebrionidae morphospecie 1	0	0	0	0	2	0	2	0.4
Hymenoptera								
Formycidae								
Pseudomyrmex elongatus (Mayr, 1870)	1	0	1	0.3	0	0	0	0
	21	**81**	**102**	**27.49**	**73**	**100**	**173**	**38.19**
OTHERS								
Diptera								
Culicidae								
Culicidae morphospecie 1	0	0	0	0	0	1	1	0.2
Culicidae morphospecie 2	1	0	1	0.3	0	0	0	0
Culicidae morphospecie 3	1	0	1	0.3	3	0	3	0.7
Tabanidae								
Acanthocera exstincta Wiedemann, 1828	2	0	2	0.5	1	0	1	0.2
Lepiselaga albitarsis Macquart, 1850	0	0	0	0	1	0	1	0.2
Corethrellidae								
Corethrellidae morphospecie 1	1	3	4	1.1	2	2	4	0.9
Corethrellidae morphospecie 2	0	1	1	0.3	0	1	1	0.2
Corethrellidae morphospecie 3	0	1	1	0.3	0	0	0	0
Corethrellidae morphospecie 4	0	1	1	0.3	0	0	0	0
Ceratopogonidae								
Ceratopogonidae morphospecie 1	1	0	1	0.3	0	0	0	0
Ceratopogonidae morphospecie 2	0	0	0	0	1	0	1	0.2
Ceratopogonidae morphospecie 3	0	0	0	0	0	1	1	0.2
Ceratopogonidae morphospecie 4	0	0	0	0	0	1	1	0.2
Ceratopogonidae morphospecie 5	0	0	0	0	0	1	1	0.2
Syrphidae								
Syrphidae morphospecie 1	1	0	1	0.3	0	0	0	0
Trichoptera								
Beraeidae								
Beraeidae morphospecie 1	0	3	3	0.8	0	3	3	0.7
	7	**9**	**16**	**4.3**	**8**	**10**	**18**	**4.0**
Total	204	167	371	100	216	237	453	100

within the cutting subarea when compared levees with the crop (Table 2). The largest number of phytophagous insects caught in C subarea took place on Nov/19 in the growing season of the crop, while in NC, this peak was observed in Feb/28, in the reproductive stage (Figure 2). The largest number of entomophagous caught was in Jan/28 in subarea NC in the growing season and the peak for the C subarea was in Feb/14 at the reproductive period of crop (Figure 3).

Considering all the rice development period, the average number of phytophagous did not differ between subareas, however, evaluating occasions individually at the beginning and end of the growing season was a significantly higher number in C, while in the reproductive phase there was only

Table 2. Mean number of collected insects (± SE), by guild and total, in irrigated organic rice crop (R) and in levees (L) in subareas not cut (NC) and cut (C), recorded between October/2012 to March/2013, Viamão, RS, Brazil.

	R C	L C	Total C	R NC	L NC	Total NC
Phytophagous	0.97 ± 0.25ns*	1.66 ± 0.22ns	2.64 ± 0.26ns	0.72 ± 0.17a**	1.83 ± 0.22b*	2.56 ± 0.30
Entomophagous	1.22 ± 0.24ns	1.14 ± 0.20ns	2.37 ± 0.32ns	0.87 ± 0.24ns	1.83 ± 0.35ns	2.70 ± 0.49ns
Saprophages	2.08 ± 0.62ns	1.52 ± 0.49ns	3.60 ± 0.88ns	1.68 ± 0.84ns	2.12 ± 0.88ns	1.5 ± 0.23ns
Others	0.20 ± 0.10ns	0.16 ± 0.04ns	0.37 ± 0.10ns	0.18 ± 0.11ns	0.14 ± 0.07ns	0.33 ± 0.11ns
Total	4.47 ± 1.21	6.14 ± 2.65	8.98 ± 1.56	3.45 ± 1.36	5.92 ± 1.52	7.09 ± 1.13

* ns = no significant difference ($p > 0.05$). ** means followed by unlike letters are significantly different (Dunn; $p < 0.05$).

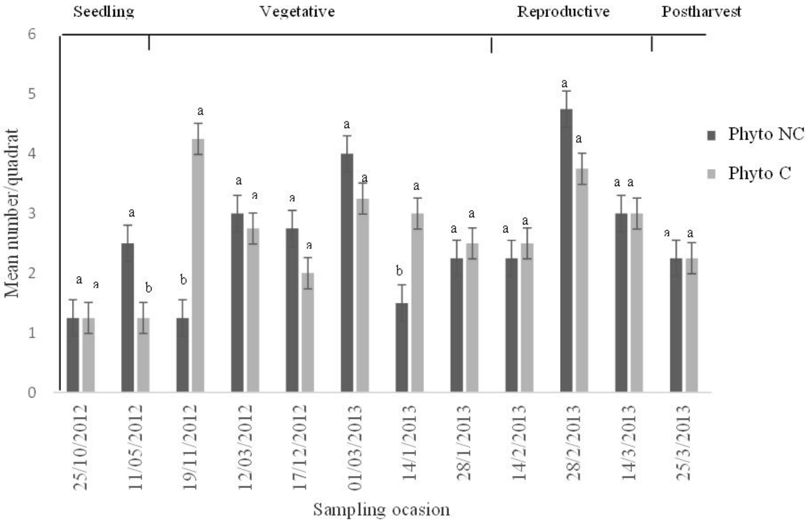

Figure 2. Mean number of phytophagous insects (± SE) collected in cut subarea (C) and not cut (NC) in organic irrigated rice, at phenological rice stages: seedling, vegetative, reproductive and postharvest, between October/2012 to March/2013, Viamão, RS, Brazil. Means followed by the same letter, no significant difference ($p > 0.05$).

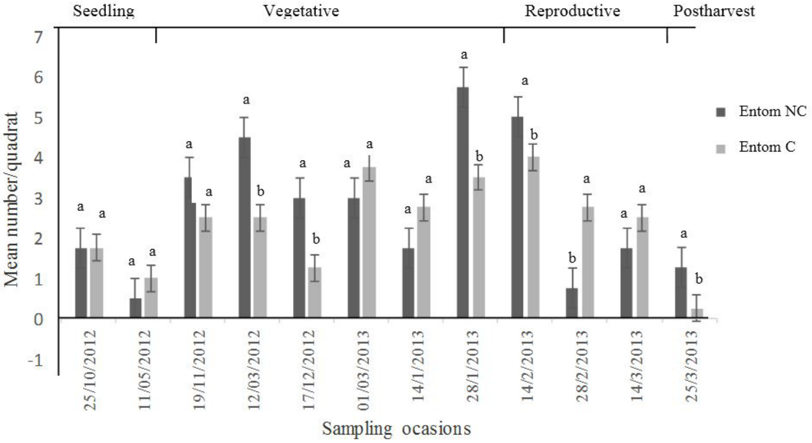

Figure 3. Mean number of entomophagous insects (± SE) collected in cut subarea (C) and not cut (NC) in organic irrigated rice, at phenological rice stages: seedling, vegetative, reproductive and postharvest, between October/2012 to March/2013, Viamão, RS, Brazil.

one occasion with the highest number of phytophagous in NC (Figure 2). For entomophagous guild, the number was higher in four occasions in NC during the growing season, whereas in the reproductive stage this had occurred only in the first date (Figure 3).

The most abundant families of phytophagous in the two subareas, were Acrididae with 39 individuals followed by Pentatomidae (29), Chrysomelidae (27), and Curculionidae (25). For entomophagous, the most abundant were Formicidae, with 86 individuals, then Tettigoniidae

(*Conocephalus* sp.) with 42, adults of Libellulidae (40) and Coenagrionidae (28). The parasitoids appeared in low numbers, being collected individuals of Eulophidae, Eucharitidae, Ceraphronidae, Mymaridae, Braconidae, Fitigidae and Chalcididae.

Considering all the guilds, 154 morphospecies were registered of which 52 are shared between the subareas. In C were found 98 morphospecies of 51 families and in NC, 109, distributed in 53 families. The richness was higher in phytophagous (41 in the C and 60 in NC), followed by entomophagous (33 in the C and 26 in NC), saprophages (14 in C and 13 in NC) and "others" (11 in C and 10 in NC).

In the two subareas, families with greater richness were Acrididae (10), followed by Pentatomidae (9) and Chrysomelidae (8).

In subarea C were observed 47 singletons, 16 doubletons, 55 uniques and 22 duplicates and in NC 63 singletons, 17 doubletons, 67 uniques and 19 duplicates. The estimated richness in the C subarea, as determined by the Bootstrap, Jack 1, and Chao 2 estimators, indicated that 81%, 65.64%, and 59.87% of the species, respectively, were sampled (Figure 4). In subarea NC, the same estimators indicated that 81%, 64.28%, and 50.50% of the species were sampled (Figure 5).

The UPGMA analysis, calculated by the Morisita index, indicated a greater similarity between the paddy fields of NC and C areas in the vegetative stage of the crop, followed by the levees of C area in the same period (Figure 6). The phases of seedling and post-harvest in the paddy fields showed the lowest similarity to other periods.

The SIMPER analysis indicated that 12 morphospecies have accounted for 50.21% of the groupings generated related to insect diversity between the stages of crop development. Morphospecies that most contributed to the groupings were two Chironomidae, *Camponotus blandus* (Smith, 1858) (Formicidae) and *Erythrodiplax paraguayensis* (Förster, 1905) (Libellulidae).

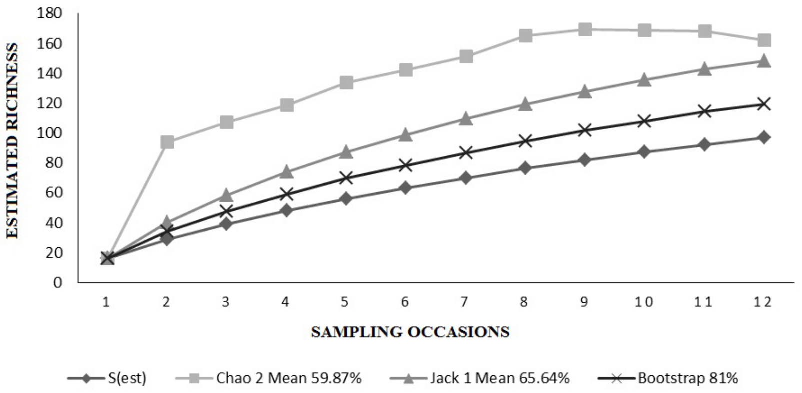

Figure 4. Curve sampling sufficiency (observed richness - Sobs) and estimated richness by Chao 2, Jacknife 1 e Bootstrap of insects (randomized 1,000 times) sampled in organic irrigated rice, in cut subarea (C), between October/2012 to March/2013, Viamão, RS, Brazil.

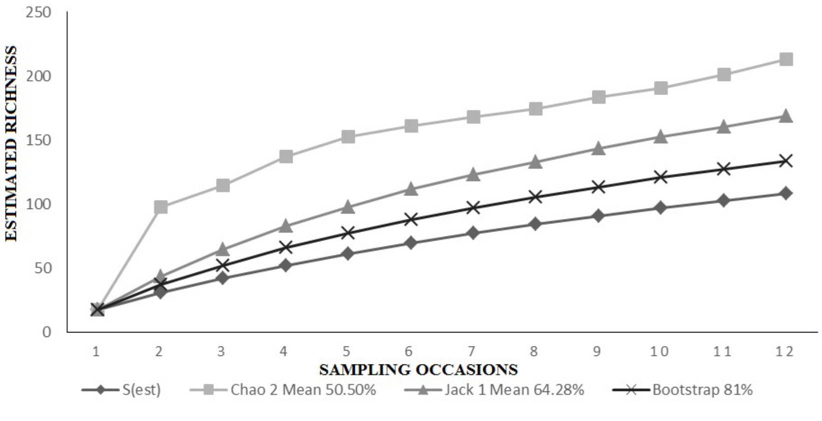

Figure 5. Curve sampling sufficiency (observed richness - Sobs) and estimated richness by Chao 2, Jacknife 1 e Bootstrap of insects (randomized 1,000 times) sampled in organic irrigated rice, in not cut subarea (NC), between October/2012 to March/2013, Viamão, RS, Brazil.

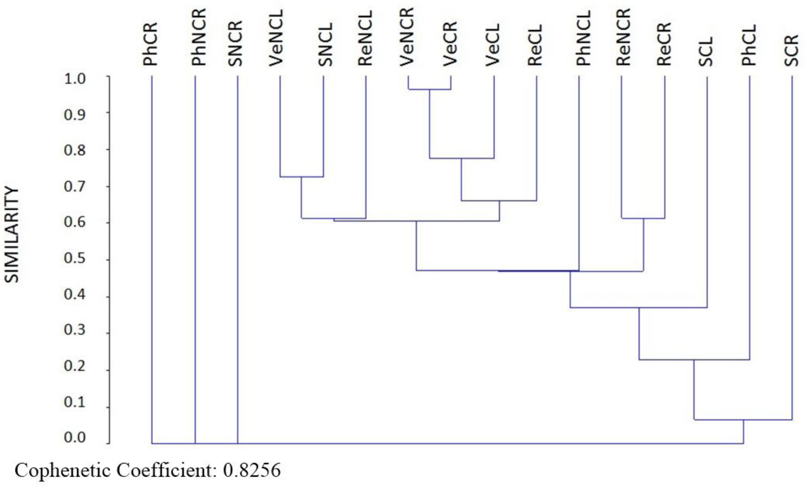

Figure 6. UPGMA cluster analysis of similarity (Morisita index) by species composition collected in organic irrigated rice, during phenological stages of crop, between October/2012 to March/2013, Viamão, RS, Brazil (S = seedling; Ve = vegetative; Re = reproductive and Ph = postharvest; C = cut subarea; NC = not cut; L = levees; R = rice crop).

4. Discussion

In our study, the percentage of captured phytophagous in both subareas was near to Bambaradeniya and Edirisinghe (2008) survey in rice fields in Sri Lanka, which identified 282 species of insects, among which 36.6% of these can be considered potential pests of rice. For entomophagous they registered 40%, being 30% predators and 10% parasitoids, being bigger than our findings.

Phytophagous guild had the most richness in the two subareas, however, only some of the species collected are considered rice pests, most of them are harmless, without records of damage to culture (Heinrichs et al., 1994).

The non pests phytophagous can act as prey or alternative hosts for entomophagous (Altieri and Nicholls, 2004). As demonstrated in a study in organic rice fields in China, of the 115 species of insects sampled, 34 were predators and 49 phytophagous whose abundance was dominated by chironomids (Zhang et al., 2013).

On the other hand it was observed in a survey in irrigated rice crops in Rio Grande do Sul, in which they identified eight orders and 18 families of arthropods divided into entomophagous (12%), phytophagous (71%) and others (17%), among which the most abundant were Tettigoniidae, followed by Pentatomidae and Curculionidae, indicating the importance of phytophagous for the maintenance of the populations of natural enemies (Machado and Garcia, 2010). Pentatomidae presents pest species important for rice crop (Santos et al., 2006). Although Tettigoniidae has been classified as phytophagous preferably in other studies, in this work was registered the genus *Conocephalus,* considered predatory of adult individuals of Sciomyzidae and eggs of the rice stink bug (Mello, 1981; Ito et al., 1995). Individuals of this genus were also observed preying on eggs of defoliators, stem borers, as well as nymphs and adult leafhoppers (Wongsiri et al., 1981).

The highest abundance of saprophages found in this study is similar to other surveys conducted in rice production systems (Settle et al., 1996; Ghahari et al., 2008; Zhang et al., 2013). These authors described as the most abundant organisms that feed on plankton and detritus, these being the basis of the initial food supply of generalist predators, which would allow the establishment of natural enemies in a stage prior to arrival of phytophagous and contribute to the success of biological control in crops.

The variations in the composition of species associated with rice agroecosystems in different places may be a result of differences in climate and geographical characteristics of the locations where the studies were conducted, as well of the influences exerted by native natural areas surrounding farming systems (Altieri, 1999). The diversity of natural enemies is an important factor in controlling herbivores, however, changes in the abundance and diversity of other arthropod guilds as well as the structure, chemistry and phenology of plants can change the functioning of the food web, potentially destabilizing the regulation of phytophagous (Chen and Bernal, 2011).

Although there was not detected any significant difference in mean abundance of capture between subareas, the greatest insects richness for phytophagous guild was found in NC, which can be attributed to the preservation of wild vegetation near the growing areas. Of these, however, only *Oryzophagus oryzae* (Costa Lima), *Oebalus poecilus* (Dallas) and *Rhopalosiphum rufiabdominale* (Sasaki) (Table 2) are considered pests of rice in Southern Brazil (SOSBAI, 2012). Thus, the phytophagous species can serve as alternatives to entomophagous prey. However, for entomophagous, the richness was greater in the C area, while the percentage of entomophagous captured on the total insects was higher in the NC. Similarly, a review of various studies evaluating the architecture of agricultural areas concluded that variations in plant composition associated with agricultural systems can increase the diversity of both, natural enemies and insects considered as pests (Bianchi et al., 2006).

Cut intensively vegetation that occurs in levees may have adverse effects on populations of predators and parasitoids insects, however, the presence of natural enemies can be increased by partially mowing the vegetation cover of levees, as well as keeping the stubble and wild vegetation after harvesting (Edirisinghe and Bambaradeniya, 2006).

The high number of singletons, doubletons, uniques and duplicates obtained in the samples indicates that there are many rare species, with a low abundance. The presence of singletons is prevalent in insects' assemblages and these often represent the highest class of abundance (Magurran, 2011).

The high percentage of rare species found in both NC and C areas, 69% and 73%, respectively, for entomophagous insects, and 76% and 64% for phytophagous, suggests an environmental support for a great diversity in organic rice areas. The values found in this study were even higher than those obtained in other surveys made in varieties of domesticated and wild rice and in irrigation canals in rice fields, where more than 25% of the collected insects were represented by only one genus or species (Chen and Bernal, 2011; Maltchik et al., 2011) pointing rice fields, especially with organic management, as an agroecosystem capable of supporting and maintaining a wide variety of insects.

The estimators indicated a much greater richness than collected in the area, which can be due to the large presence of rare morphospecies (singletons, doubletons, uniques and duplicates) as Jack 1 and Chao 2 are highly influenced by the presence of these (Moreno, 2001). This high richness in areas, even in those with cutting levees, could be a result of its location near a highly diverse natural area, which can generate a microclimate similar to the natural area, providing abundance and variety of food resources, oviposition sites and refuge for many insect groups (Perfecto et al., 1997).

Comparing an area of the same productive region, with native vegetation from a local reserve, Gonzáles et al. (2014) registered more than 40% of predatory species shared between the paddy fields and reserve, pointing that the latter may serve as a repository for the insect fauna in the farming area.

The high species richness may also be explained by the organic management in the area, which would favor the development of a wider diversity since in this cropping system does not occur the use of synthetic fertilizers and pesticides (Altieri and Nicholls, 2004).

This was observed in a study in Sri Lanka rice fields in which the richness and abundance of species and the diversity of all sampled arthropod groups, except Diptera, were significantly higher in organic rice area compared to the conventional (Madanayake et al., 2013). Thus, is reinforced that although the areas differ in levees management, both are conducted under organic production system since 2009 (Menegon et al., 2013)

The groupings registered by UPGMA are visibly more related to the stages of culture, especially the vegetative. Although the overall richness is higher in the subarea NC the crop development stages were the variables that contributed most to the similarity or dissimilarity between the groups. The plant architecture in different stages of development may have affected the richness and abundance of species. During plant development, the presence of leaves, buds, flowers and fruits, alters the architecture of the crop field influencing the diversity of phytophagous insects and hence of its natural enemies (Lawton, 1983; Lu et al., 2014).

According SIMPER analysis the greater abundance of four morphospecies in the vegetative stage of the crop, were the main responsible for the similarity between sub-areas and sites. In the seedling stage and post-harvest stage, instead, low proportions of the same morphospecies were responsible for the dissimilarity between the groups analyzed. This occurs because species with a high percentage of contribution are those that best discriminate between groups (Quinn and Keough, 2002).

We conclude that the vegetation of levees can influence the composition of functional guilds in the field. Although the abundance did not change clearly, the greatest estimated diversity in the NC area, may contribute to system resilience. The crop development period is clearly a factor that influences the composition of species in organic irrigated rice with or without management of levees vegetation.

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