Research, Society and Development, v. 10, n. 8, e54710817763, 2021
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v10i8.17763

Diversity and Similarity *Gomphocerinae* (*Orthoptera: Acrididae*) Communities in the Brazilian Amazon

Diversidade e Similaridade Comunidades de *Gomphocerinae* (*Orthoptera: Acrididae*) na Amazônia Brasileira

Diversidad y Similitud *Gomphocerinae (Orthoptera: Acrididae*) Comunidades en la Amazonia Brasileña

Received: 06/30/2021 | Reviewed: 07/06/2021 | Accept: 07/07/2021 | Published: 07/17/2021

Walmyr Alberto Costa Santos Junior
ORCID: https://orcid.org/0000-0002-3340-1658
Universidade Federal do Amapá, Brasil
E-mail: walmyrjr@gmail.com
Christiane França Martins
ORCID: https://orcid.org/0000-0002-8177-0458
Universidade Federal de Goiás, Brasil
E-mail: franh.chris@gmail.com
Raimundo Nonato Picanço Souto
ORCID: https://orcid.org/0000-0002-8795-1217
Universidade Federal do Amapá, Brasil
E-mail: rnpsouto@unifap.br

Abstract
Inventories of Amazon invertebrates are relatively incipient and fragmented. The state of Amapá is one of the Amazonian states with a large knowledge gap regarding invertebrate biodiversity. Also, there is no record in the literature of systematic studies that focus mainly on the Acridofauna. Therefore the goal of this study was to understand the diversity and abundance of grasshoppers (Gomphocerinae) of the Environmental Protection Area of the Curiaú river, Macapá - AP. Twelve samples were collected from October 2011 to September 2012 using the active search technique with sweep nets. A total of 508 Gomphocerinae individuals were sampled and classified into five genera and twelve species. The floristic composition of sites A1 and A3, and sites A5 and A6, are considered more similar since the locusts are closely related to the vegetation. This is the first study assessing the diversity of orthopteroides in the state of Amapá. However, this pioneering study is expected to be the basis of future studies.
Keywords: Gomphocerinae; Grasshoppers; Mapping; Amapá.

Resumo
Os inventários de invertebrados amazônicos são relativamente incipientes e fragmentados. O estado do Amapá é um dos estados amazônicos com grande lacuna de conhecimento sobre a biodiversidade de invertebrados. Além disso, não há registro na literatura de estudos sistemáticos que enfoquem principalmente a Acridofauna. Portanto o objetivo deste estudo foi compreender a diversidade e abundância de gafanhotos (Gomphocerinae) da Área de Proteção Ambiental do rio Curiaú, Macapá - AP. Doze amostras foram coletadas de outubro de 2011 a setembro de 2012 usando a técnica de busca ativa com redes de varredura. Um total de 508 indivíduos de Gomphocerinae foram amostrados e classificados em cinco gêneros e doze espécies. A composição florística dos locais A1 e A3, e dos locais A5 e A6, são considerados mais semelhantes, uma vez que os gafanhotos estão intimamente relacionados com a vegetação. Este é o primeiro estudo avaliando a diversidade de ortopteroides no estado do Amapá. No entanto, espera-se que este estudo pioneiro seja a base de estudos futuros.
Palavras-chave: Gomphocerinae; Gafanhotos; Mapeamento; Amapá.

Resumen
Los inventarios de invertebrados amazónicos son relativamente incipientes y fragmentados. El estado de Amapá es uno de los estados amazónicos con un gran vacío de conocimiento sobre la biodiversidad de invertebrados. Asimismo, no existe registro en la literatura de estudios sistemáticos que se enfoquen principalmente en la Acridofauna. Por lo tanto, el objetivo de este estudio fue conocer la diversidad y abundancia de chapulines (Gomphocerinae) del Área de Protección Ambiental del río Curiaú, Macapá - AP. Se recolectaron doce muestras desde octubre de 2011 hasta septiembre de 2012 utilizando la técnica de búsqueda activa con redes de barrido. Se muestrearon un total de 508

individuos de Gomphocerinae y se clasificaron en cinco géneros y doce especies. La composición florística de los sitios A1 y A3, y de los sitios A5 y A6, se considera más similar ya que las langostas están estrechamente relacionadas con la vegetación. Este es el primer estudio que evalúa la diversidad de ortopteroides en el estado de Amapá. Sin embargo, se espera que este estudio pionero sea la base de estudios futuros.
Palabras clave: Gomphocerinae; Saltamontes; Cartografía; Amapá.

1. Introduction

The main representatives of the order Orthoptera are commonly known as grasshoppers, crickets and bush-crickets. This order has approximately 25,000 species described worldwide (Naskrecki & Otte 1998) and is recognized primarily for its ecological and economic importance. The Orthoptera are ecologically important for being defoliators (primary consumers), contributing directly to the introduction of organic matter into the soil, and for stapling food for many vertebrates (frogs, lizards, birds, monkeys, etc.) and invertebrates (especially other insects), for this reason, they are considered essential elements in the food chain. The economic importance of Orthoptera is due to the fact that some species have a gregarious habit, forming "clouds" of locusts that can devastate crops in a short period of time (Song et al., 2018 and Cigliano et al., 2018).

The Gomphocerinae are distributed along the Neotropics and can be found from the southern United States to Argentina (Otte 1981 and Cigliano et al., 2018). Among this subfamily, the genus Rhammatocerus Saussure 1861 has been the least studied, with a wide geographical distribution in Brazil, and has a known record of nine species (Assis-Pujol 1997). The species Rhammatocerus schistocercoides (Rehn 1906), in particular, is a leading locust in the attack of plantations in the state of Mato Grosso (Batistella et al., 1997).

Invertebrate inventories in Amazon are relatively incipient and fragmented. The demand for biodiversity information, monitoring and quantification of the effect of impacts on biodiversity is huge and diverse. Such demands may range from economic and ecological zoning to conservation planning, bioprospecting, the development of alternative scenarios, natural resource management and monitoring of natural impacts (Matiotti da Costa et al., 2015).

This study tried to answer some important questions regarding a taxon of ecological and economic importance, which had not previously been systematically studied in the state of Amapá. Therefore, the goal of this study was to evaluate the diversity and abundance of grasshoppers (Gomphocerinae) of the EPA of the Curiaú River, (Macapá, State of Amapá), identifying the composition of species sampled in the study area and diversity estimates. The state of Amapá is one of Brazilian Amazon states with a large knowledge gap regarding invertebrate biodiversity. No systematic studies that focus primarily on the Acridofauna of the state have been reported in the literature, especially in the Environmental Protection Area of the Curiaú River (Área de Proteção Ambiental do Rio Curiaú - EPA of the Curiaú River).

2. Material and Methods

The study was conducted in the Environmental Protection Area of the Curiaú River. This area is located 8 km north of Macapá (between 00º00'N and 00º15'N; 51°00'W). Two environments were sampled: Pasture and Amazon Savannah, both within the Cerrado morphoclimatic dominion. A total of three sites were sampled in each environment. Each sampling site was represented by a plot of 100m x 100m. The three sites sampled at the Pasture Environment were sites A1 (00°09'38" N; 51º01'01" W), A2 (0 º 09'49 .1" N; 51 º 01 '03" W) and A3 (0º09'36" N; 51º00'54" W), all within the Tábua Branca farm. The sites selected for the Amazon Savannah Environment were sites A4 (0º07'45" N; 51º03'40" W), A5 (0º07'28" N; 51º03'76" W) and A6 (0º07'17" N; 51º03'72" W).

The data were collected in 12 sampling campaigns using the active search technique for 60 minutes, with sweep nets, according to Borror & DeLong (1988) and Triplehorn & Johnson (2011) this is the most efficient type of collection for

orthopteroids. Thus, a total of 144 samples were collected for each sampling site in the EPA of the Curiaú River, between October 2011 and September 2012. All material collected was identified to species and morphospecies levels using identification keys (Otte 1979a, 1979b, 1981; Otte & Jago 1979; Donato & Cigliano 2000; Donato 2003; Assis - Pujol 1997; and Carbonell 1995) and through comparison of previously identified specimens from the IEPA (Institute of Scientific and Technological Research of the State of Amapá). Part of the identified specimens was labeled and stored in the scientific collections of IEPA and the teaching collection of the Federal University of Amapá (Universidade Federal do Amapá – UNIFAP). All data was stored in a metadata file.

Monthly averages of air temperature (C°), relative humidity (%), and accumulated precipitation for EPA of the Curiaú River were obtained by consulting the database of the National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais - INPE), and National Environmental Data System (Sistema Nacional de Dados Ambientais - SINDA) available at http://sinda.crn2.inpe.br.

The statistical analyses were performed using the statistical package BiodiversityR of R software, version 2.15.2 (R Development Core Team 2011). Richness, abundance and diversity analyses were conducted following previously established parameters (Kindt & Koe 2005). Species richness was calculated to assess the effectiveness of Gomphocerinae sampling at the two environments, and to perform the analyses regarding species richness (Colwell & Coddington 1994; Chao & Lee 1992).

The indexes used were Shannon-Wiener (H') and Uniformity (U) (Krebs 1999). The Bray-Curtis distance was calculated to compare the similarities between each sampling site. The Kolmogorov-Smirnov test was used to assess if the samples follow a normal distribution ($p>0.100$). The Jaccard similarity index was used to evaluate the degree of similarity in species composition among areas.

3. Results

A total of 508 Gomphocerinae specimens were sampled and classified into five genera and twelve species. The following species were identified: *Amblytropidia mysteca* (Saussure 1861), *Amblytropidia* sp, *Compsacris pulcher* Bolivar 1890 *Orphulella concinnula* (Walker 1870), *Orphulella punctata* (De Geer 1773), *Rhammatocerus brasiliensis* (Bruner 1904), *Rhammatocerus pictus* (Bruner 1900), *Rhammatocerus pratensis* (Bruner 1904), *Rhammatocerus pseudocyanipes* Assis-Pujol 1997, *Rhammatocerus schistocercoides* (Rehn 1906), *Rhammatocerus suffusus* (Rehn 1906) and *Silvitettix nigriceps* (Descamps & Amédégnato 1970).

Six species were recorded at site A1, seven at A2, and eight at A3 (all located within the pasture environment). A total of eight species were recorded at site A4, and five at A5 and A6 (both sites located within Amazon savanna). The results showed that site A2 had the highest grasshopper abundance (209; 44%), followed by site A3 with 77 specimens (15%). At site A1, 59 locusts were collected, corresponding to 11% of the total number of individuals. For sites located within the Amazonian Savannah, 72 specimens (13%) were recorded at A4, 52 (9%) at A6, and finally, 39 specimens at A5 (8%) (Table 1).

The species *Amblytropidia* sp., *O. concinnula*, *O. punctata* and *R. brasiliensis* were recorded at all sampling sites, whereas *C. pulcher*, *R. pictus*, *R. pseudocyanipes*, *R. schistocercoides* and *R. suffusus* were recorded in only one. The other species were reported in more than one sampling site. In table I, the abundance of each species within the different sampling sites is shown.

The genus *Amblytropidia* was most abundant in site A2, the genus *Rhammatocerus* occurred in all sites and the species *R. brasilienses* was the only one that occurred in all sites. *R. brasilienses* was also had greater representation in site A2, and the

species *O. Concinnula* was the most abundant in most sampling sites. The species *O. Concinnula* exhibited the greatest overall abundance, followed by *O. punctata*. However, the species *R. pictus* and *R. pseudocyanipes* were less abundant.

Table 1. Show the Composition and abundance of species of the Gomphocerinae subfamily, for the sites sampled within the studied environments.

Sites	Species	Abundance
Site A1	*Amblytropidia* sp.	6
	Orphulella concinnula	11
	Orphulella punctata	28
	Rhammatocerus brasiliensis	11
	Rhammatocerus pictus	1
	Rhammatocerus pratensis	2
Site A2	*Amblytropidia mysteca*	44
	Amblytropidia sp.	32
	Orphulella concinnula	22
	Orphulella punctata	27
	Rhammatocerus brasiliensis	72
	Rhammatocerus suffusus	9
	Rhammatocerus schistocercoides	3
Site A3	*Amblytropidia mysteca*	4
	Amblytropidia sp.	2
	Orphulella concinnula	28
	Orphulella punctata	29
	Rhammatocerus brasiliensis	11
	Rhammatocerus pseudocyanipes	1
	Rhammatocerus pratensis	1
	Silvitettix nigricips	1
Site A4	*Amblytropidia mysteca*	16
	Amblytropidia sp.	1
	Compsacris pulcher	4
	Orphulella concinnula	31
	Orphulella punctata	12
	Rhammatocerus brasiliensis	1
	Rhammatocerus pratensis	2
	Silvitettix nigricips	5
Site A5	*Amblytropidia* sp.	1
	Orphulella concinnula	24
	Orphulella punctata	8
	Rhammatocerus brasiliensis	3
	Silvitettix nigricips	3
Site A6	*Amblytropidia* sp.	4
	Orphulella concinnula	29
	Orphulella punctata	5
	Rhammatocerus brasiliensis	2
	Silvitettix nigricips	12
	TOTAL	**508**

Source: Authors.

Mean monthly air temperature, relative humidity and accumulated precipitation values were obtained (Table 2). Temperature and Relative Humidity values showed no significant change along the sampling period. However, accumulated precipitation was lower from August to December than from March to June. The highest precipitation values were recorded from March to June, a characteristic period called more and less rainy in the Amazon region.

Table 2. Mean monthly air temperature, relative humidity and accumulated precipitation in the study period.

	2011			2012								
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Temperature	28 º C	27,5 º C	27 º C	26 º C	25,5 º C	25,5 º C	26 º	26 º C	26,5 º C	26 º C	27 º C	27,5 º C
Relative Humidity	75%	75%	75%	95%	95%	95%	95%	95%	95%	85%	85%	85%
Accumulated Precipitation	38 mm	50 mm	150 mm	300 mm	344 mm	400 mm	380 mm	350 mm	230 mm	170 mm	100 mm	45 mm

Source: INPE 2012.

The species *O. concinnula* and *O. punctata* were the only ones sampled throughout the sampling periods, whereas the other species were absent in some periods. Species of the *Orphulella* genus had the highest abundance recorded in the period with the highest precipitation.

The species *C. pulcher* (n = 4) was only recorded in April 2012 at site A4. The species *S. nigriceps* was only recorded in May and June 2012 at site A3, and *R. pictus* (n = 1) in December 2011 at site A1. The species *R. pseudocyanipes* (n = 1) was found only at site A3 in April 2012. The other species were found in more than a month, throughout the sampling periods (Table 3).

Table 3. Show the composition and abundance of species of the Gomphocerinae subfamily sampled in the Environmental Protection Area of the Curiaú River in each month of the study period.

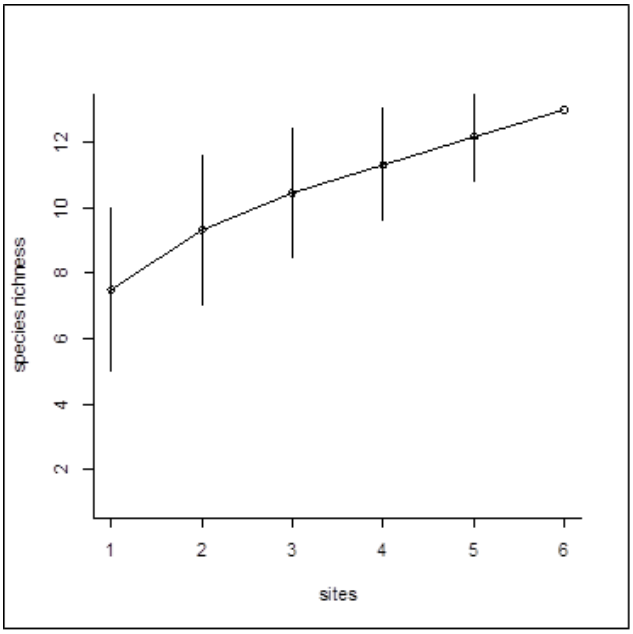
Species	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Total
Amblytropidia mysteca	1	0	1	1	0	0	7	5	8	6	9	11	49 (9,67%)
Amblytropidia sp.	46	0	2	3	5	0	0	2	3	0	0	0	61 (12,01%)
Compsacris pulcher	0	0	0	0	0	0	0	0	4	0	0	0	4 (0,8%)
Orphulella concinnula	**3**	**6**	**4**	**14**	**3**	**4**	**23**	**24**	**28**	**24**	**8**	**4**	**145 (28,54%)**
Orphulella punctata	16	4	3	7	12	6	22	14	7	7	5	6	109 (21,45%)
Rhammatocerus brasiliensis	2	0	6	5	2	0	10	32	14	13	7	9	100 (19,68%)
Rhammatocerus pictus	0	0	1	0	0	0	0	0	0	0	0	0	1 (0,19%)
Rhammatocerus pratensis	0	0	0	0	0	0	2	2	1	0	0	0	5 (0,98%)
Rhammatocerus pseudocyanipes	0	0	0	0	0	0	1	0	0	0	0	0	1 (0,19%)
Rhammatocerus shistocercoides	0	0	1	3	1	0	0	0	0	0	3	1	9 (1,77%)
Rhammatocerus suffusus	0	0	1	1	1	0	0	0	0	0	0	0	3 (0,59%)
Silvitettix nigricips	0	0	0	0	0	0	0	12	9	0	0	0	21 (4,13%)
Total	**68**	**10**	**19**	**34**	**24**	**10**	**65**	**91**	**74**	**50**	**32**	**31**	**508**

Source: Authors.

A total of 12 species were found in the sites studied. The highest species richness was observed in pasture environments. Site A3 had the highest species richness (S= 8), followed by site A2 (high species richness; S= 7) and site A1 (S= 6). For the Amazonian Savannah, high species richness was found at site A4 (S= 8), followed by sites A5 and A6, which had lower species richness (S = 5). Site A2 was the most abundant (n = 209), followed by site A3 (n = 77), A4 (n = 74), A1 (n = 59), and A6 (n = 52). Site A5 had the lowest abundance among the sampling sites with 39 sampled individuals.

The species accumulation curve is shown in Figure 1. For the Pasture environment an estimate of 16.7 species was given by the First order Jaccknife, and 36.5 by the first order Chao. For the Savana environment, the Jackknife gave an estimate of 12.3 species and Chao of 9 species. However, even showing that the pasture environment had higher species richness, it is noteworthy that the species accumulation curve did not reach its asymptote.

Figure 1. Species accumulation curve recording the cumulative number of species of organisms detected for EPA of the Curiaú River.



Source: Authors.

Site A2 had the highest diversity given by the Shannon Index (H' = 1:53), followed by A4 (H' = 1:47). In contrast, A5 had a diversity value (H' = 1.25) lower than A1 (H' = 1:39). To confirm the values obtained previously, the Simpson index was observed. Site A2 had the highest Simpson's diversity value (D= 0.696), and sites A4 (D= 0.682), A6 (D= 0.655) and A5 (D= 0.642) had the smallest (Table 4).

Table 4. Indicates the Shannon`s and Simpson's diversity index, highlighting the Shannon`s index, which gives greater weight to species richness than the Simpson index.

	Shannon	**Simpson**
Site A1	1.39	0.673
Site A2	1.53	0.696
Site A3	1.41	0.675
Site A4	1.47	0.682
Site A5	1.25	0.642
Site A6	1.3	0.55

Source: Authors.

Tests carried out using the Bray-Curtis distance can confirm the existence of differences in the biological distance among sampling sites. Tests confirmed that the composition/abundance of species found in the pasture environment (sites A1, A2 and A3) differed from the savannah environments (sites A3, A4 and A5).

The Bray-Curtis distance test indicated that site A2 (site with the highest abundance) was closer to sites A1 and A3 (all within the Pasture environment). In turn, site A4 (site with the second-largest species richness) was closer to sites A5 and A6 (all comprising the savannah environment), as shown in Table 5.

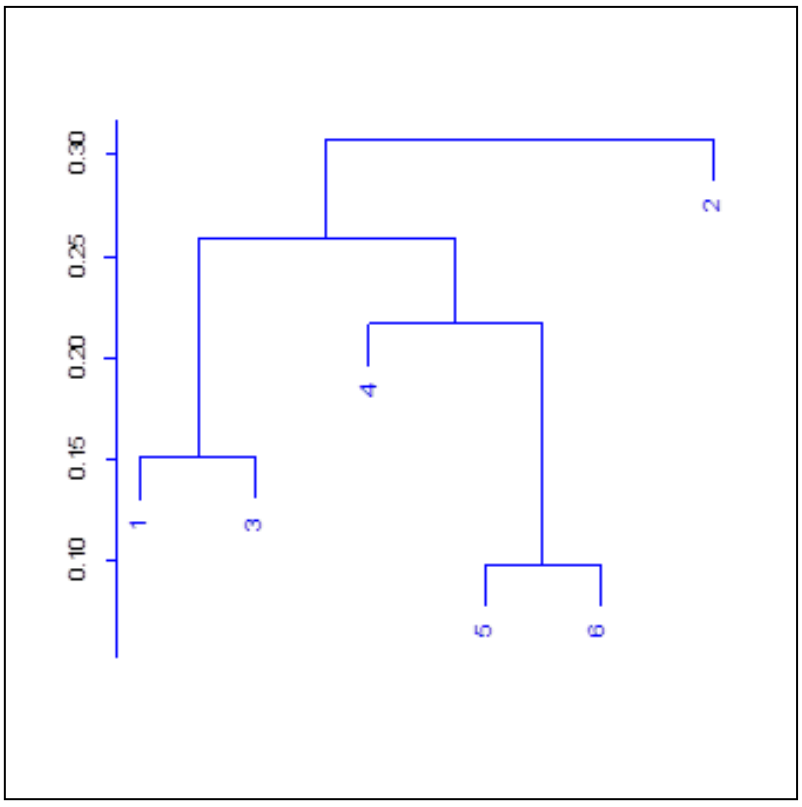
Table 5. Distance between sites according to the Bray-Curtis Test, expressing proportions of similarity or dissimilarity in species abundance.

	Site A1	Site A2	Site A3	Site A4	Site A5
Site A2	0.40112				
Site A3	0.18988	0.35325			
Site A4	0.38573	0.48864	0.31685		
Site A5	0.45068	0.53726	0.30625	0.34435	
Site A6	0.56697	0.55536	0.37406	0.37269	0.17285

Source: Authors.

Sites A1 and A6 had the largest biological distance between each other (D= 0.566974), considering all sites. In contrast, A5 and A6 had the most similar community structure (lowest Bray-Curtis distance). However, sites A2 and A4 were similar, once A4 was closer to sites of the Pasture environment than to sites of the savannah environment, as shown in Figure 2.

Figure 2. Dendogram of the distance between sampling sites, displaying the groups formed for each area observed for their similarity levels.



Source: Authors.

4. Discussion

This study shows that the species richness values recorded at the sampling sites across the physiognomies were significantly different among the sampling sites. However, the pasture environment is more species rich than the Amazon

savannah environment (Table 1 and Table 4). Thus, there was a similarity to studies carried out by Sánchez and Wysieck (1993) and Cigliano, Wysieckiv and Lange (2000) who found similar species richness values in pastures from Argentina.

However, in other studies, the species richness recorded seemed to be slightly higher than in this study. Kemp (1992) analyzed intraspecific associations of grasshoppers in a pasture environment of the Gallatin Valley, Montana, in the United States (from 1988 to 1990), and observed low species density in the region, and recorded high species richness for all sampling sites (Jaccknife and Chao index ranging from 10 to 17). Similar high species richness values were also found in a previous study carried out in Nebraska and northeastern Colorado (Joern & Pruess 1986; Capinera & Thomson, 1987).

It is noteworthy that grasshopper density was not reported in this study or in the studies cited, where species were recorded for over a year. However, there were 12 species at Curiaú. Thus, it is important to observe that sites A1, A2 and A3, consist of pasture environments and had the highest species richness (Table 1). This high species richness may be explained by the constant environmental changes made for grazing, cattle pasture and buffalo breeding on the Tábua Branca farm. In this farm there is a possible renewal of grass composition, favoring the high rate of species establishment in the three sites.

It is important to mention that among the pasture environment sites, A3 (site with the greatest species richness) is used less frequently than the other sites so that more time would be available for species establishment, favoring population growth. Site A2, the furthest point used for farming purposes, had a high species richness value (S= 7) even when being used. The high species richness value observed for site A2 indicated that, despite the constant environmental change, the Gomphocerinae species present are able to become established in this environment.

Site A4 exhibited the highest species richness for the Amazon savannah environment. This pattern may have been detected due to the proximity to highway EAP-070. There may be changes affecting the richness and composition of locusts from this area, leading to this high species richness index. Sites A5 and A6, had the lowest species richness in this study and can be characterized by being located in remote areas and suffering no environmental changes. Thus, there were no changes in the floristic composition of the environment, which directly influences the food supply of these insects and consequently changes the composition and richness of species present in these two sites.

Site A2 exhibited the largest relative abundance of species in the area studied, with 209 specimens sampled. This large abundance may also be related to the floristic composition in the area. It is acknowledged that grass composition in the environment influences species composition, richness and abundance, in other words, the locusts are directly influenced by the floristic composition of the environment. Grasses are the main food of locusts. Thus, grass composition is a decisive factor in locust population establishment (Descamps, 1978 and Carvalho et al., 2012).

According to Barrientos (1995), farmers planted wheat (during winter) and soybeans (during summer) in the northwest and southeast regions of Rio Grande do Sul, from 1970 to 1985. The authors also reported the continuous use of chemicals for pest control. In 1986, with the introduction of cattle in the same areas and the use of "Pensacola" (*Paspalum notatum* Fluegge var. *Saurae Parodi*) grass, there was a great proliferation of grasshopper populations. This high proliferation, in the absence of natural enemies, caused a population outbreak.

In Brazil, there are records of several species of grasshoppers that are directly influenced by climatic factors such as temperature and accumulated precipitation (Embrapa, 2007). Environmental changes, such as the recent introduction of agriculture in regions, or ecological imbalance generated by chemical use also influence this community. These factors are linked to the appearance or disappearance of grasshopper populations.

The floristic composition was not assessed in this study, but it is known for being important for grasshopper occurrence. With this, the abundance at site A3 (77 sampled specimens), A4 (with 72 sampled specimens), A1 (with 59 sampled specimens), A6 (with 52 sampled specimens) and site A5 (less abundant with 39 specimens) is explained.

The genus *Orphulella* was present in all samples and recorded throughout the study period. The species *O. concinnula* was the most abundant in the study, with 145 specimens, followed by *O. punctata* with 109 specimens. According to Matiotti da Costa et al., (2015), Serrao et al., (1997), Song (2010) and Rowell (2013), this genus has a wide geographical distribution, occurring from Canada to Argentina. *Orphulella* is one of the Gomphocerinae genera which is difficult to identify once its species are widespread and have phase polymorphism. The species *O. punctata* is known to be a fairly common Neotropical species, found in pastures and marginal forests from Central Mexico to Argentina (Matiotti da Costa et al., 2015, Otte 1978, Cigliano et al., 2018 and Song et al., 2018).

For Brazil, according to Silva et al. (1968), this genus can become pests of pastures and of Nicotiana tabacum. In São Carlos, Serrão et al. (1997) reported that this genus is found throughout the year without causing damage, showing that this species may show equilibrium patterns possibly related to the occurrence of predators and parasitoids. Tests were also carried out to identify the natural predators of this insect group, and predation mainly by spiders and lacewings was observed (Serrão et al., 1997).

A total of six species of the *Rhammatocerus* genus was recorded in this study. It is a so far rarely studied genus. However, it has a wide geographic distribution and a known record of 9 species in Brazil (Assis-Pujol 1997). The species *R. brasiliensis* was the third most abundant, with 100 individuals sampled. This species had a higher incidence from April to September 2012, suggesting that climatic conditions directly influence this species record. This occurrence pattern is explained, mainly by an increase in Accumulated precipitation in the same period, favoring population growth.

Importantly, the species *R. schistocercoides*, one of the major causes of damage to crops, was recorded among the species sampled. There are several studies reporting the damage this species causes to plantations. Lecoq (1991) reported that this species is causing damage to soybean, sugarcane and corn plantations in the states of Rondônia and Mato Grosso. Despite it being recorded only recorded at site A2, with the constant changes occurring in Curiaú until now, it may have not been possible for this species to experience a population outbreak able to generate economic damage. However, it is important to know that this species was recorded in the region studied. Another species recorded in this study, that so far shows no threat to crops, is the species *R. pictus*. The species *R. pictus* and *R. pseudocyanipes* had lower abundance and were only recorded once in December 2011 and in April 2012, indicating the existence of specificity of these species to climatic conditions that favor its appearance.

The species *Compsacris pulcher*, the only of the *Compsacris* genus recorded, occurred in only one site and during one month. This pattern suggests this species has specific requirements regarding the sampled environments, mainly for being sampled in environments near zones of transition between sites of open and closed vegetation structures (edge environments). Species occurrence may also have been influenced by the climate.

Grasshoppers may exhibit specificity to certain vegetation types. Descamps (1978) and Carvalho et al. (2012) show states that many Acridoidea species may show specificity to exclusively open, closed, or partially sunny environments due to their feeding requirements. This statement is based primarily on the fact that there will be plant species best adapted to environments with varying degrees of light input. Consequently, the grasshopper fauna will respond to the vegetation types. This observation confirms the record of *C. pulcher*, once it was found in forest edge vegetation (access roads to the edges of tall vegetation, or adjacent areas of low and open vegetation). Vegetation with a plant community adapted to the direct solar incidence of some periods of the day is typical of such environments. This statement may indicate that this grasshopper species (*C. pulcher*) occurs specifically in the vegetation of partially sunny environments.

Correlations of the temporal variation data of each species indicated a population growth (higher abundance) during the period with the most precipitation for most of the species sampled. Also, there were no other records of this higher abundance,

proving the specificity of locusts to the environmental and climate types, to which it is best adapted. The species *S. nigriceps* occurred in four of the six sampling sites, only in May and June 2012, showing the specificity of this species to climatic factors.

When evaluating species diversity according to the two indexes used in this study (Shannon and Simpson), site A2 was observed to have the highest diversity. This diversity can be explained by the high abundance recorded at this site mainly due to the environmental characteristics. Site A2 also had low species richness when compared with site A4, second in the diversity rank.

The floristic composition of sites A1 and A3, and A5 and A6 are more similar according to the analysis of similarity among sampling sites and considering that locusts are closely related to the vegetation. Also, de results of the dendrogram indicated similarity of 50% among these sites regarding Gomphocerinae species composition. This can be explained by the degree of human activity in each site (Carvalho et al., 2012). On the other hand, site A2 was similar only to site A4. Site A4 differed from sites A1 and A3. However, it exhibited biological proximity to sites A5 and A6, indicating a similarity in species composition among sites that belong to the same environment.

5. Conclusion

Currently, the knowledge regarding Orthopteroides in Brazil is still very limited, and most of the information is concentrated in the Northeast, Midwest, Southeast and Southern regions, where there is a larger problem with species that cause economic damage. Most studies carried out among the Brazillian regions are focused mainly near the states of Mato Grosso and Rondônia, due to the recently inserted soybean cultures. However, for the Northern region, little is known regarding the composition of this group. The information available became limited to the cities of Belém and Manaus. Besides, this information ends up being limited only to these two points. Other research centers have some difficulty.

This study was carried out to better understand the existing locust populations in the state of Amapá, and their patterns of diversity and similarity between different environments in the Brazilian Amazon. Therefore, it showed that the composition and distribution of these locusts need to be better evaluated. It is recommended that the sampling effort can be increased, as well as the number of study areas, with these changes, we believe that the composition and indices of the diversity of Gomphocerinae can be better understood.

Acknowledgments

We thank the Secretary of State for the Environment (Secretaria de Estado do Meio Ambiente - SEMA/AP) for collaborating and allowing sampling in the Environmental Protection Area of Curiaú River, the Office of Scientific Research and Technology of the State of Amapá – IEPA for enabling our work in the Entomological Collection, the residents surrounding Curiaú, and especially Mr. Mateus Costa for the conversations and for allowing us to use his property. This study received financial support from the Brazilian *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES) and *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq, National Council for Scientific and Technological Development).

References

Amèdégnato, C., & Descamps, M. (1978). Evolution des populations d´orthopteres d´amazonie du nord-ouest dans les cultures traditionnelles et les formations secondaires d´origine anthropique. *Acrida*, *9* (1), 2-33.

Assis-Pujol, C. V. (1997). Revisão das espécies brasileiras do gênero *Rhammatocerus* Saussure, 1861 (Orphoptera, Acrididae, Gomphocerinae, Scyllinini). *Tese de Mestrado. Universidade Federal do Rio de Janeiro- RJ*..1- 22.

Barrientos, L. L. (1995). The present state of the locust and Grasshopper problem in Brazil. *Journal of Orthoptera Research 4*, 61-64.

Batistella, M., Miranda, E., Lecoq, M., & Pierozzi Jr., I. (1996). Integração de dados georreferenciados no mapeamento dos biótopos do gafanhoto praga do Mato Grosso. *Anais VIII Simpósio Brasileiro de Sensoriamento Remoto*, Salvador, Brasil. Sp. 1- 3.

Branson, D. H. (2005). Effects of fire on Grasshoppers assemblages in a Northern Mixed-Grass Prairie. *Environmental Entomology* 34 (5): 1109-1113.

Borror, D. J., D. M. DeLong. (1988). Introdução ao estudo dos insetos. *Editora Edgard Blucher*. São Paulo, SP. 653 p.

Capineira, J. L., & Thompson, D. C. (1978). Dynamics and struture of Grasshoppers assemblages in Shortgrass Prairie. *Canadian Entomologist, 119* (1), 567 – 575.

Carbonell, C. S. (1995). Revision of the Tribe Scyllinini, Nov. (Acrididae: Gomphocerinae), with description of new genera and species. *American Entomological Society, 121* (3), 87-152.

Carvalho, N. L., Costa, E.C., Souza, D. B., & Garlet, J. (2012). Análisis faunístico de acridomorfos (Orthoptera: Acridoidea y Eumastacoidea) en São Sepé, RS, Brasil. *Revista Colombiana de Entomología, 38* (2), 299-305.

Cigliano, M. M., Wysiecki, M. L., & Lange, C. E. (2000). Grasshopper (Orthoptera: Acrididae) species diversity in the Pampas, Argentina. *Diversity An Distributions 6* (1), 81-91.

Cigliano, M. M., H. Braun, D. C. Eades, D. & Otte. (2018). Orthoptera Species File. Version 5.0/5.0. [10/6/2021]. http://Orthoptera.SpeciesFile.org.

Chao, A., Lee, S. M. (1992). Estimating the number of classes via sample coverage. *Journal of The American Statistical Association, 87*, 210-217.

Colwell, R. K., & Coddington, J. A. (1994). Estimating terrestrial biodiversity through extrapolation. *Philosophical Transactions Of The Royal Society (Series B), 345*, 101-118.

Descamps, M. (1978). Étude Dês Ecosystemes Guyanais Iii – Acridomorpha Dendrophiles (Orthoptera – Caelifera). *Annales de la Société Entomologique de France, 14* (3), 301-349.

Donato, M, & Cigliano, M. M. (2000). Revision of the Genus Metaleptea Brunner Von Wattenwyl (Orthoptera, Acridinae, Hyalopterygini). *Transactions of the American Entomological Society*, 126 (2), 145-173.

Donato, M. (2003). Revision of the South American Genera Allotruxalis Rehn and Eutryxalis Bruner (Orthoptera: Acrididae: Hyalopterygini). *Publicasiones del Museu de la Plata, 25* (2), 381 – 402.

Goteteli, N. J., & Colwell, R. K. (2001). Quantifyning biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters 4*, 379-391.

Joern, A., & Pruess, K. P. (1986). Temporal constancy in Grasshoppers assemblies (Orthoptera: Acrididae). *Ecological Entomology, 11*, 379 – 385.

Kemp, W. P. (1992). Temporal variation in Rangeland Grasshoppers (Orthoptera: Acrididae) in Montana: Aplication of markovian priciples. *Journal of Economic Entomology, 80*, 1100 – 1105.

Krebs, C. J. (1999). Ecological Methodology. (2a ed.), Menlo Park, *Addison-Welsey Educational*. 620p.

Kindt, R., & Coe, R. (2005). Tree diversity analysis. A manual and software for common statistical methods for ecological and biodiversity studies. Nairobi: World Agro-Forestry Center (Icraf).

Lecoq, M. (1991). Gafanhotos do Brasil: Natureza do Problema e Bibliografia. Brasília, Embrapa, 157p.

Matiotti da Costa, M. K., Martins, L. P., Zefa, E., Redü, D. R., Morselli, J. P., & Mello, F. A. G. (2015). Checklist of Grasshoppers (Orthoptera: Acridoidea) from Reserva Florestal Adolpho Ducke, State of Amazonas, Brazil, and new records for the country. *Journal of Orthoptera Research, 24*(2), 59-65.

Naskrecki, P., & Otte, D. (1998). Orthoptera Species File. http://orthoptera.speciesfile.org/HomePage/Orthoptera/HomePage.aspx (Acessed 12 October 2012).

Otte, D. (1979). A comparative study of communicative behavior in Grasshoppers. University of Michigan Museum of Zoology Miscellaneous Publ. *The Quarterly Review of Biology, 141*, 1-168.

Otte, D. (1979). Revision of The Grasshoppers Tribe Orphulellini (Gomphocerinae: Acridicade). *The Academy of Natural Science of Philadelphia*. Usa, *131*, 25-88.

Otte, D., & Jago, N. D. (1979). Revision of the grasshoppers genera Silvitettix and Compsacris (Gomphocerinae: Acrididae). *The Academy of Natural Science Of Philadelphia, 131*, 257-288.

Otte, D. (1981). The North American Grasshoppers. Acrididae: Gomphocerinae And Acridinae. *Harvard University Press*, Volume 1, 275 p.

R Development Core Team. (2011). R: a language and environment for statistical computing. R foundation for statistical computing, Vienna, Austria.

Rowell, C. H. F. (2013). The Grasshoppers (Caelifera) of Costa Rica and Panama. The Orthopterists Society: *Publications on Orthopteran Diversity*.

Sánchez, N., & Wysiecki, M. L. (1993). Abundancia y diversidad de acridios (Orthoptera: Acrididae) em pastures de la Provincia de la Pampa, Argentina. *Revista Invest Agropecuarias, 24*, 29-39.

Silva, A. G. D., Gonçalves, C. R., Monteiro, D. M., Gonçalves, A. J. L., Gomes, J., Silur, M. N., & Simoni, L. (1968). Quarto catálogo dos insetos que vivem nas plantas do Brasil. Rio De Janeiro. *Escola Nacional De Agronomia*, 622p.

Serrão, J. E., Silva, M., Souza-Silva, C. R., & Pacheco, J. M. (1997). Uso de serologia na identificação de predadores de *Orphulella Punctata* (De Geer) (Orthoptera: Acrididae). *Sociedade Entomologica do Brasil*, *26* (2), 375-378.

Song, H. (2010). Grasshopper systematics: Past, present and future. *Journal of Orthoptera*, *19*(1), 57–68.

Song, H., Mariño-Pérez, R., Woller, D. A., Cigliano, & M. M. (2018). Evolution, diversification and biogeography of grasshoppers (Orthoptera: Acrididae). *Insect Systematics and Diversity*, *2*(4), 1–25.

Triplehorn, C. A, & Johnson, N. F. (2011). Estudos dos insetos – Tradução da 7ª edição de Borror e Delong`s – Introduction to the study of insects. *Cengage Learning*. São Paulo, SP. 816p.