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Seasonal changes of the Orthoptera (Insecta) community at the Research Center of Universidad Estatal Amazónica

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Graphical Abstract

Abstract

This work explores the richness and abundance of the Orthoptera family observed at the Center for Research, Graduate Studies and Amazon Conservation (CIPCA), which is located in the Arosemena Tola county, Napo Province, Ecuador. Pitfall traps were used to collect invertebrates in two plots used for forest restoration purposes, with 36 replicates in each one of them. The samples were set in three seasons: the rainiest season (April), the lowest rainy season (September) and a shoulder precipitation season in July. The Orthoptera collected were identified at the family level, and data was processed using R for statistical analyses, with the ARTool package. The results showed a total amount of 897 individuals divided into four Families: Acridiidae, Gryllidae, Romaneidae, and Stenopelmatidae. The highest richness was collected in April, followed by September and July. Acridiidae showed significant variations throughout seasons ($F=204.61$, $p=<0.0001$) and plots ($F=135.7$, $p=<0.0001$), being significantly higher on April in the higher plot (PA) with 11.03 individuals on average ($p=<0.0001$).

Gryllidae presented similar patterns as Acridiidae, seasons ($F= 10.45$, $p=0.0001$), and plots ($F= 9.95$, $p=<0.01$). However, April here was barely significant in PA, with 1.5 individuals ($p=0.05$). Finally, Romaneidae indicated strong changes among seasons ($F= 49.7$, $p=<0.0001$) and plots ($F=123.78$, $p=<0.0001$). Its abundance was also significantly higher in PA on April with an average of 3.86 individuals ($p=<0.0001$). These results provide a meaningful insight about collection seasons. Although a multiyear comparison would be required to analyze the process of forest restoration, this sample give a robust consideration for future sampling seasons towards the finding of bioindication through Orthoptera.

Keywords: Orthoptera, CIPCA, abundance, traps.

Introduction

The order Orthoptera, etymologically means (*ortho=straight; ptera=wings*). They are animals with two pairs of wings, which are place above the thorax in resting conditions. Orthoptera is a group of heterogeneous species known as: locust, grasshoppers, and crickets (Moyano, 2014). This order reach about 20 000 species around the world. They are divided in two main suborders: Ensifera that includes the Gryllidae, Stenopelmatidae (crickets), and Tettigonidae (long-horn grasshoppers) families, and Caelifera, which includes Acrididae (short-horn grasshoppers). The females lay their eggs in different substrates such as leaves, litter, soil, trunks or small bushes. Orthoptera abundance increses in tropical latitudes, due to the high vegetation variability (Triplehorn and Johnson, 2005).

Most of the Orhopterans are fitophagus, although some are predators and others feed on debris, being a few onmivorus. The fitophagous, a big part of it, are considered harmful for agricultural activities, most of which belong to the Acridoidea superfamily (Barrientos-Lozano, 2004). Gryllidae is a family with poor agricultural importance, generally ovnivoruos or fitophagus with noctural habbits. However, some Gryllidae can cause damage to maize, rice, and others crops, with especies that may be eatable (Zumbado and Azofeifa, 2018). The Romaleidae family, with long antenae, feeds on dicotyledons and graminoids species (Martínez and Zerbino, 2008).

Orthopterans are bioindicators of great importance on biodiveresity management and conservation in various ecosystems around the globe. It is been shown that Orthopteran individuals are more abundant in rainy periods, used widely as indicators and food due to their heterogeneity and reproductive abundance (Hlongwane, 2018). Regardless their abundance in rainy conditions, its hábitat has been experimenting a continous reduction casued by anthropogenic disturbances that trigger negative effects and the extintion of some populations (Chown and Terblanche, 2006).

The most popular techniques to capture Orthoptera from the soil are pitfall traps, transects, Winkler traps, among others (Luna, 2005). Among all of them, the most utilized methodology are the pitfalls, a technique that provides relative abundances of ground dwelling organisms. (Ríos Guayasamín, *et al*, 2018). Pitfall traps report the best rates of capture when used without baits in protected forests (Rohyani and Ahyadi, 2017). This was the technique used to conduct the present study.

The aim of this work is to compare the most abundant Orthopteran morphospecies along a year of measurements that were made in three representative periods. With is effort it is proposed to elucidate the best capture period, based on Orthoptera richness, and abundance as a baseline for future studies.

Materials and methods

Study area: The samples were taken at the Center of Research, Graduate Studies and Amazon Conservation (CIPCA), which is located in the Arosemena Tola county, part of the Napo province, in Ecuador. CIPCA is located in the 44Km on the Puyo-Tena road (UEA, 2019). All sampling seasons are based on precipitation periods[1] averaged since 2008 to 2015. The precipitation periods were: April (444mm, the rainiest period), July (377mm, a shoulder precipitation period), and September (261mm, the lower precipitation period). The sampling localities were two plots (each one with 36 subplots of 100 m^2, 10mX10m). These plots belong to the Project of Forest restoration and bioindicators identification in the Ecuadorian Amazon -ReFIIBiC- (Ríos Guayasamín, 2018). The plots are located in a Colluvial soil at 580 m.s.n.m. (PA - 1º 14` 31" S y 77º 53`30" W), and an Alluvial soil at 560 m.s.n.m. (PB - 1º 14`35" S y 77º 53`58" W)

Field phase: Orthopteran individuals were captured with pitfall traps without a bait, in containers of 10 cm in diameter by 6 cm in height. Each of the subplots had one pitfall trap, with a total of 72 réplicates (36 for plot A and 36 for plot B) per sampling period (April, July, and September). The containers were placed at floor level during three consecutive days, after which samples were collected in containers with 90% alcohol and taken to the Natural and Applied Tropical Ecology Laboratory (LETNA) for sorting and identification.

Laboratory phase and data proccesing: Once at LETNA, samples were clasified and stored, isolating the individuals correspondign to the Orthoptera Order. Identification was done using taxonomic keys (Llucià Pomares, 2002; Triplehorn and Johnson, 2005; Westerduijn and Cadena-Castañeda, 2014). The results were processed with the R program, using the vegan package (Oksanen *et al.*, 2019) for the richness figures, the ARTool package (Wobbrock *et al.*, 2011) for statistical data processing, and the sciplot package (Morales, 2019) for graphical representation of the statistical analyses.

Results and Discussion

Figure 1 shows the richness of morphospecies of each sampling period. April, the rainiest period presented the highest richness (19 morphospecies). A similar result was seen for September, the driest period, with 18 morphospecies. The shoulder precipitation period, July, presented the lowest richness, counting only 14 morphospecies. Acrididae, Gryllidae and Romaleidae oviposit in the soil, and climatic conditions (cold and hot temperature) affect the individual development. (Barrientos-Lozano, 2004). This particular feature may be related with the temprature of each collecting month. April is one of the months with high temperature (23.9°C,

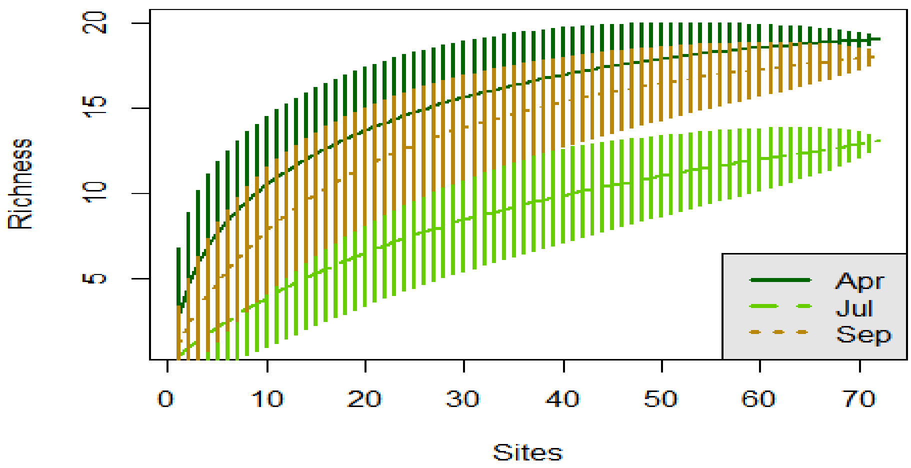

Figure.1. Cumulative morpho-species richness curve of Orthptera

[1] INHAMI, meteorological yearbooks 2008-2015: https://abeltran94.wixsite.com/inamhi/productos

with the maximum temperature registered for november - 24.5 °C), while July reports the lowest temperature for the whole period (23.1°C)[2]

The total amount of individuals collected was 897, of which 537 belong to the Acrididae family, 162 to Gryllidae, 165 to Romaleidae, 5 to Stenopelmatidae, and 28 which had not distinctive features to be placed in any category (with broken antennae, broken legs and/or immature stages). Figure 2 shows that the highest mean Orthopteran abundance is hold by Acrididae, which is very abundant in the rainiest season. April is also the month where you found the highest abundance of Gryllidae and Romaelidae. This information contrast with other studies. In Indonesia is Gryllidae the most abundant family that was found in pitfall traps (Rohyani and Ahyadi, 2017), in China, however, is Catantopidae the most abudant family of Orthoptera collected by monoliths (Jiang *et al.*, 2015).

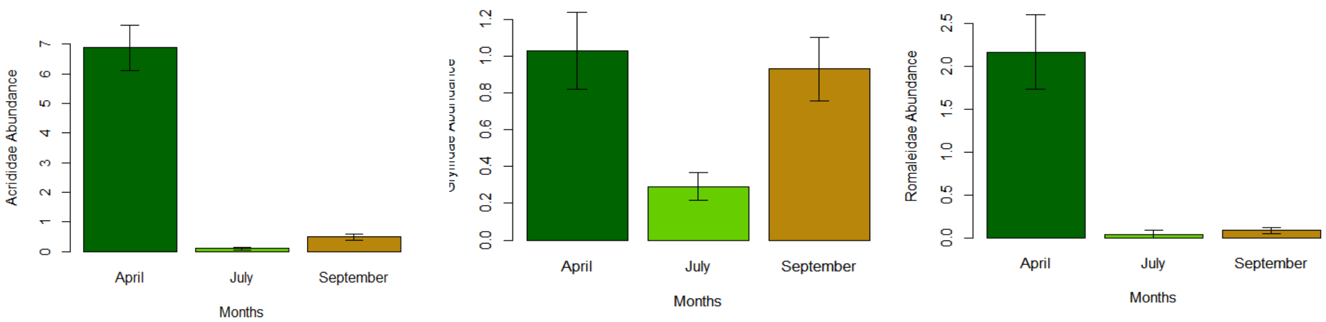

Figure 2. Seasonal variation of Orthoptera throughout the year.

Acrididae showed significant variations among precipitation periods ($F=204.61$, $p<0.0001$) and between study plots ($F=135.7$, $p<0.0001$). Gryllidae presented similar variations as Acrididae, for the precipitation periods ($F= 10.45$, $p=0.0001$), and also for the plots under study ($F= 9.95$, $p=0. 01$). Nonetheless, the F estimator was much smaller. The difference between plots is the most important for Romaleidae ($F=137.75$, p0.0001), even though the precipitation periods show a significant variation ($F=48.74$, $p=0.0001$), as it does the interation between the two factors under study ($F=56.57$, $p=0.0001$), which can be seen in Table 1.

Even when Acrididae species are considered an agricultural pest in many places around the world, in Ecuador are considered as eventual pest of maize, wheat, and barley, in spite of this, on the Amazon there are no records of agricultural infestations (Zumbado and Azofeifa, 2018). Our findings show the highest population of Orthoptera in the rainiest period (Figure 2, table 3). Similar results were reported from India, where Orthpoteran individuals presented the highest abundance and diversity at the monsoon season (Kuruvila, *et al.*, 2019)

Table 1. Orthoptera significance omnibus test for seasonal and plot variation with the ranks obtained with ARTool

	Acrididae				Gryllidae				Romaleidae			
	F	Df	Df.res	Pr(>F)	F	Df	Df.res	Pr(>F)	F	Df	Df.res	Pr(>F)
Seasons (S)	204.610	2	208	< 0.001 ***	10.4544	2	208	< 0.001 ***	49.739	2	208	< 0.001 ***
Plots (P)	135.709	1	208	< 0.001 ***	9.9488	1	208	< 0.01 **	123.788	1	208	< 0.001 ***
S:P	79.923	2	208	< 0.001 ***	4.1374	2	208	< 0.05 *	56.569	2	208	< 0.001 ***

[2] INHAMI, meteorological yearbooks 2008-2015: https://abeltran94.wixsite.com/inamhi/productos

The famililes of Orthoptera also shown meaninful variations due to the soil type (plot A=Coluvial soils and Plot B=Aluvial soil). Acrididae (10.4), Gryllidae (1.5) and Romaleidae (4.9) presented the highest amount of individuals in Plot A on the rainiest month. Only Gryllidae showed a slightly similar abundance between the two plots in the month with the lowest precipitation (PA=1.1, PB=0.9). This may be related with its reproductive mode. Many Orthoptera are directly affected by the soil conditions due to their oviposition habit. This is evident for Gryllidae, a family whose individuals deposit the eggs in the soil (Rohyani and Ahyadi, 2017), a pattern which is also important for some Acrididae species (Triplehorn and Johnson, 2005).

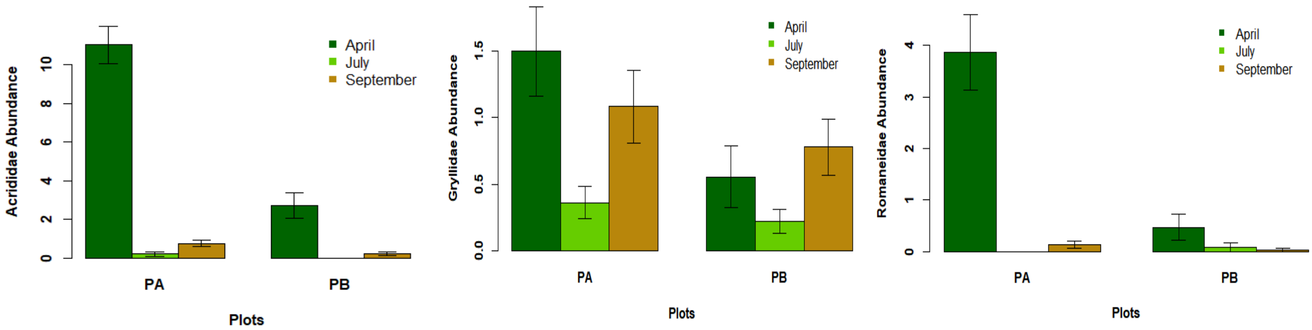

Figure 3. Seasonal variation of Orthoptera for every plot in study

In the interaction tests, it is evident that the rainiest period shows significant values for Acrididae ($p<0.001$, PA=397, PB=98 – Table 3) and Gryllidae, when compared with the other sampling periods (Table 2). Even when Gryllidae only shows statistical differences between the rainiest and the intermediate-precipitation-periods among Colluvial and Alluvial soil conditions ($p<0.05$).

Table 2. Orthoptera test of interactions between levels of seasons and plots using ARTool

	Acrididae				Gryllidae				Romaleidae			
	Value	Df	Chisq	Pr(>Chisq)	Value	Df	Chisq	Pr(>Chisq)	Value	Df	Chisq	Pr(>Chisq)
Apr-Sep:PA-PB	153.028	1	103.1206	<0.001 ***	36.083	1	3.3957	N.S. (0.13)	128.722	1	78.9303	< 0.001 ***
Apr-Jul: PA-PB	174.806	1	134.5598	<0.001***	55.500	1	8.0334	< 0.05 *	137.750	1	90.3899	<0.001 ***
Sep-Jul : PA-PB	21.778	1	2.0885	N.S. (0.14)	19.417	1	0.9832	N.S. (0.32)	9.028	1	0.3882	N.S. (0.53)

Finally, Romaleidae ($p<0.001$) presented the same results as Acrididae. These results exhibit that the rainiest period may be considered as an important period for Orthoptera evaluation, aiming at displaying the abundance and richness variation of these families (Acrididae and Romaleidae). The high amount of individuals (especially Acrididae) in the Plot A may be related with soil quality parameters, because Plot A has a higher organic matter concentration and better nutritional content in general terms (data not shown). However, a more detailed study need to take place because in Kenia, the Orthoptera abundance was positively correlated with manganese quantity, but negatively correlated with Nitrogen and Carbon (Ayuke *et al.*, 2009).

Table 3. Total Abundance of Orthoptera by plots and rainy periods

	PA					PB				
	Acrid	Gryll	Romal	Stenope	NonID	Acrid	Gryll	Romal	Stenope	NonID
April	397	54	139	0	0	98	20	17	0	3
July	7	13	0	0	3	0	8	3	0	14
September	27	39	5	4	0	8	28	1	1	6

Acrid=Acrididae, Gryll=Gryllidae, Romal=Romaleidae, Stenope=Stenopelmatidae, NonID= Not Identified

Conclusions

- The richness and abundance of Orthoptera are higher in the month with the highest precipitation regime in both soil conditions (Alluvial and Colluvial), therefore April must be considered as the best month for Orthoptera sampling.
- The most representative families in this study are: Acrididae, Gryllidae y Romaneidae. Acrididae presented the most importantn variations both for precipitation and soil conditions, as a potential indicator for biological studies.

Field study permit

The data collection for this article was posible under the General Agreement for Genetic Resources Access provided to the Program: "Ecosystems, Biodiversity and Species-conservation, Invertebrates and their interactions, with code: MAE-DNB-CM-2018-0087, within the ReFIIBiC project. This program is cooordinated by Universidad Estatal Amazónica.

References

Ayuke, F. O. *et al.* (2009) 'Macrofauna diversity and abundance across different land use systems in Embu, Kenia', *Tropical and Subtropical Agroecosystems*, 11, pp. 371–384.

Barrientos-Lozano, L. (2004) 'Orthoptera', in Llorente Bousquets, J. et al. (eds) *Biodiversidad, taxonomía y biogeografía de Artrópodos de México: Hacia una síntesis de su conocimiento*. Mexico D.F.: UNAM, pp. 603–625.

Chown, S. L. and Terblanche, J. S. (2006) 'NIH Public Access', in Simpson, S. J. (ed.) *Advances in Insect Physiology*. Science Direct, pp. 50–152. doi: 10.1016/S0065-2806(06)33002-0.Physiological.

Hlongwane, Z. T. (2018) *Use of ground-dwelling arthropods as bioindicators of ecological condition in grassland and forest vegetation at eThekwini Municipality in KwaZulu- Natal*. University of KwaZulu-Natal.

Jiang, M. *et al.* (2015) 'Diversity and Abundance of Soil Animals as Influenced by Long-Term Fertilization in Grey Desert Soil, China', *Sustainability*, 7, pp. 10837–10853. doi: 10.3390/su70810837.

Kuruvila, M. E., Mohan, S. and Jacob, S. (2019) 'Effect of Seasonal Variations in Grasshopper Diversity at Selected High and Low Range Areas', *International Journal of Advanced Scientific Research and Management*, 4(2), pp. 239–242.

Llucià Pomares, D. (2002) *Revisión de los ortópteros (Insecta : Orthoptera) de Cataluña (España)*. Edited by S. entomológica A. (SEA). Zaragoza: Gorfi, S.A.

Luna, J. M. (2005) 'Técnicas de colecta y preservación de insectos', *Boletín Sociedad Entomológica*

Aragonesa, 37(2005), pp. 380–408. Available at: https://www.sciencedirect.com/bookseries/advances-in-insect-physiology/vol/33/suppl/C.

Martínez, G. and Zerbino, S. (2008) *Saltamontes y langostas en las praderas uruguayas.*, *Sitio Argentino de Producción Animal*. Available at: http://www.produccion-animal.com.ar/produccion_y_manejo_pasturas/pasturas_combate_de_plagas_y_malezas/102-langostas.pdf.

Morales, M. (2019) 'Scientific Graphing Functions for Factorial Designs Author'.
Moyano, L. (2014) *Estudio y seguimiento de la fauna de Orthoptera de un entorno natural sometido a un programa de restauración ecológica en el sur de la Península Ibérica*. Universidad de Córdova.

Oksanen, A. J. *et al.* (2019) 'Community Ecology Package', pp. 1–21.

Ríos Guayasamín, P. (2018) *Restauración forestal e identificación de indicadores biológicos conexos en la Amazonía Ecuatoriana (ReFIIBiC)*. Puyo, MAE- DNB-CM-2018-0087.

Ríos Guayasamín, P., Muñoz Rengifo, J. and Smith, S. M. (2018) 'Soil invertebrates in the Tropics: a bibliographical revision', in Alemán, R. et al. (eds) *III Congreso internacional de agroecología: 'Comunidades en armonía con la naturaleza' - I Congreso Iberoamericano de agricultura sostenible*. Puyo: Universidad Estatal Amazónica - Reima, pp. 270–290.

Rohyani, I. and Ahyadi, H. (2017) 'Diversity and abundance of soil insects at Jeruk Manis Protected Forest in East Lombok (Indonesia) using several trapping methods', *Biodiversitas*, 18(2), pp. 809–812. doi: 10.13057/biodiv/d180253.

Triplehorn, C. and Johnson, N. F. (2005) *to the Studyof Insects Seventh Edition*.

UEA (2019) *CENTRO DE INVESTIGACIÓN, POSGRADO Y CONSERVACIÓN AMAZÓNICA*, *CENTRO DE INVESTIGACIÓN, POSGRADO Y CONSERVACIÓN AMAZÓNICA*. Available at: https://www.uea.edu.ec/?page_id=2376.

Westerduijn, R. and Cadena-Castañeda, O. J. (2014) *Common Orthoptera from Pastaza, Ecuador*. Bogotá. Available at: https://fieldguides.fieldmuseum.org/sites/default/files/rapid-color-guides-pdfs/634_0.pdf.

Wobbrock, J. O. *et al.* (2011) 'The Aligned Rank Transform for Nonparametric Factorial Analyses Using Only A NOVA Procedures', in *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '11).* Vancouver, British Columbia: New York: ACM Press, pp. 143–146.

Zumbado, M. and Azofeifa, D. (2018) *de importancia agrícola*. Edited by M. Zumbado Arrieta and D. Azofeifa Jimenez. Heredia: Programa Nacional de Agricultura Orgánica (PNAO).