Comparing butterfly diversity in different tropical habitats

Allison Stoiser

Corresponding emails: astoise@g.clemson.edu & info@sustainableamazon.org

Abstract

Butterflies serve as indicator species of habitat health and type, with disturbance introducing more common and generalist species to an area, possibly making diversity indices unreliable in displaying effects of disturbed or agricultural practices on butterfly diversity. The region of Madre de Dios, located in southwestern Peru, has the highest butterfly diversity in the world, and faces increasing threats of habitat destruction due to monoculture and mining operations. Therefore, I compared community compositions of butterflies in an aguajal, terra firme forest, and an agroforestry system in Madre de Dios to see just how different the communities are as a baseline and compare their diversity indices. Through transects carried out in July 2018, I found that the most disturbed habitat, the agroforestry system, did have the highest diversity index and butterfly abundance, but the aguajal had the most unique butterfly fauna. This study shows that in tropical forests, habitat differences do lead to different butterfly species compositions and in order to conserve butterfly diversity, different habitats should be protected, even those that seem to have the lowest diversity indices.

Introduction

Butterflies, with their sensitivity to climate change, habitat fragmentation, and agricultural activities, serve as indicator species of habitat health and type (Van Swaay et al., 2015). In addition to this, they are integral members of the communities they inhabit, simultaneously acting as a consumer of plants and valuable food source for many other organisms. Their presence or absence reflect host plant presence as well, making them indicators of habitat type (Bonebrake et al., 2010). While some butterflies are generalists and their larvae feed on any plant species within a family, others require specific species of plants and the loss of a single species of plant, their host plant, can result in local extinctions of dependent butterflies. Because of this, even within a given habitat, butterfly populations vary between microsites with slight differences in vegetation, soil, and light penetration, and in the tropics this level of specialization reaches its height (Sparrow et al., 1994). While studies have suggested butterfly diversity in the tropics results from a mosaic of microhabitats (Sparrow et al., 1994), not all habitat types have been studied in depth. Additionally, habitats that are facing disturbances and threats are important to investigate further as these habitats might already be showing differences in butterfly diversity.

In particular, habitat disturbance can introduce more common and generalist species to an area, possibly making diversity indices unreliable in displaying effects of disturbed sites or agricultural practices on butterfly diversity (Ghazoul,

2002). Sun-loving butterflies, for example, may replace the losses of forest species in degraded habitats (Bonebrake et al., 2010). Contrasting to that, Ghazoul (2002) found that disturbance did in fact lower butterfly diversity in a tropical dry forest in Thailand. However, Larsen (2008) found that no known butterflies have gone extinct over the past 150 years in West Africa despite a loss of 80% of all forest cover, making the exact effect that habitat transformation has on butterflies not straightforward to understand.

One habitat that is facing increasing threats of deforestation are aguajals, how local riparian forests are called. The unsustainable felling of aguaje palms for fruit is one example of a stressor on this system, and the butterfly communities living within these habitats face the threat of this habitat's destruction. Another important and increasing habitat type that is understudied are agroforestry operations. These are promising economic ventures that focus on planting valuable timber and crop species together to create an agroforestry plot where wildlife can still thrive. Agroforestry systems are not threatened like aguajals, but are thought to be better for the future of biodiversity in tropical forests than mass plantation systems due to the presence of more native plants and a high plant diversity within the plot. Therefore, it is important to study the butterfly communities that live within them. If they do not differ greatly from those that live in the forest, then it is possible that agroforestry can be a vital way to preserve tropical invertebrate communities.

The region of Madre de Dios, located in southwestern Peru, has the highest butterfly diversity in the world, and faces increasing threats of deforestation and conversion of forest to unsustainable agriculture and mining operations. The highly heterogeneous and specialized Lepidoptera fauna make the region especially interesting to compare butterfly community compositions. Therefore, I conducted a study comparing butterfly communities in aguajal, terra firme forest, and a young agroforestry plot bordering forest at Finca Las Piedras, a site located in the department, to increase our knowledge of butterfly communities within these habitats. I hypothesized that the community compositions would be significantly unique from one another.

Methods

Habitats surveyed

The field site of the Alliance for a sustainable Amazon (ASA), Finca Las Piedras (S 12°13.570'; W 069°06.850'), is a 54-hectare property two kilometers from the Interoceanic Highway. The property exists of disturbed terra firme forest, a young agroforesty plot, and degraded land. An aguajal is located next to the property.

Aguajals are riparian forests with aguaje palms (*Mauritia flexuosa*), as the dominant species present. In the terra firme forest, Brazil nuts (*Bertholletia excelsa*) are the dominant species, with many representatives from the plant families Araceae, Aracaceae, and Marantaceae. The young agroforestry plot (ca. two years old) borders the terra firme forest and features *Inga edulis*, cacao, and other valuable timber and food tree species. Surrounding the property are papaya and watermelon farms as well as a belt of forest used as Brazil nut concessions.

Data collection

Three 250-meter transects were created at Finca Las Piedras to sample butterfly diversity in different habitats, including aguajal, terra firme forest, and an agroforestry edge, using a GPS. Each transect was at least 250 meters away from the others, with the aguajal transect being at

least 600 meters from any other transect. Transects followed established trails and were carried out on warm days without rain where the temperature was above 20°C. Transects began, at earliest, at 10:00AM and were concluded by 4:00PM. Each transect was completed nine times. I walked along the path at a slow pace with an aerial net and attempted to capture all butterflies that occurred within three meters to the front, left and right of the path. Any butterflies beyond that range were not counted. Butterflies identifiable upon capture were released and the rest were collected to be identified later, with only captured butterflies counted in the study. At the end of the transect, I recorded the ending time and returned to Finca Las Piedras to photograph and add specimens to its collection to be identified to species if possible using Garwood et al. (2009), or to morphospecies if not possible. All data was collected in July 2018.

I analyzed data using R, including calculating Shannon-Weaver diversity indices. I created a cluster diagram using the Bray-Curtis similarity and single-linkage methods. I performed an ANOVA test to determine if abundances were significantly different among the habitats. All assumptions to perform these tests were met.

Results

The number of species (including morphospecies) recorded in the aguajal, agroforestry system, and terra firme forest were 22, 43, and 31 respectively, to come to a total of 86 species recorded at Finca Las Piedras during July 2018. The Shannon-Weaver diversity indices of the habitats in the same order were 2.43, 3.49, and 2.74.

A cluster diagram shows the relationship between community compositions in the aguajal, agroforestry system, and terra firme forest with the aguajal being most different from the other two habitats (Fig. 1). In addition, an ANOVA revealed that the communities were not significantly different regarding butterfly abundance ($df = 2$, $F = 2.93$, $p = 0.073$).

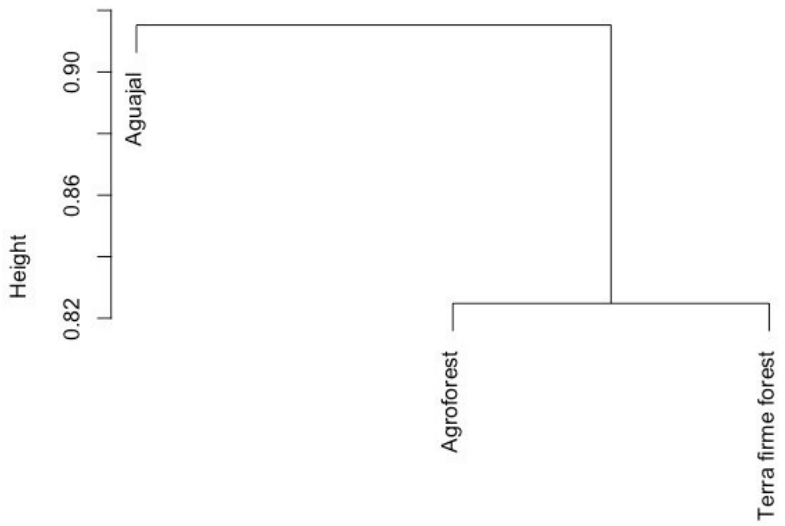

Figure 1: Cluster diagram showing differences between butterfly species compositions of the three habitats (aguajal, agroforest and terra firme forest) at Finca Las Piedras using Bray-Curtis and single-linkage methods.

Discussion

In this study, I investigated the butterfly communities of three different habitats, aguajal, agroforest and terra firme forest at Finca Las Piedras. I found that the most abundant and diverse butterfly community existed in the agroforestry plot, while the aguajal featured the most unique community with the least abundance and diversity. I recorded 43 species and morphospecies during the month of July in the agroforestry plot. This location also had the most individuals, at 73 individuals caught over the course of 9 transects. The aguajal had the least diversity and abundance, but was the most unique habitat of the three as the cluster analysis revealed. Several unique Satyrinae and Riodinidae were abundant and collected in this habitat that were not found in the other two sites.

The high abundance and species richness of the agroforestry system could possibly be due to edge effect, as explained in Ghazoul's (2002) study. Also, during the month of July, asteraceous flowers were in bloom along the trail, attracting many Hesperiidae, Riodinidae, and Nymphalidae that may otherwise have not been present on the transect. However, overall community composition of the agroforestry plot was still quite similar to the secondary terra firme forest, showing that even though it was a more disturbed system, it still can feature viable and diverse butterfly communities.

Differences in butterfly abundance across the habitats were not significant, but only just so. Over nine transects, 28 more butterflies were caught in the food forest than the aguajal. This could possibly be due to the difficulty of capturing butterflies in open versus closed habitats, but also may just show that the sunnier agroforestry plot attracts more, and often cosmopolitan and disturbance-tolerant, butterflies.

Overall, my study showed that butterfly communities are different among different tropical habitats, with the aguajal having the most unique species composition. The agroforestry system still held high butterfly diversity and was similar to the terra firme forest, as well, showing that butterflies are still able to utilize this type of habitat. However, the agroforest may have had more disturbance-tolerant or sun-loving species making up its community composition, such as *Heliconius sara* and *Dryas iulia*.

Future studies should continue with the methodology outlined in this paper to survey butterfly communities throughout the entire year, as this study was restricted to one month of the dry season. More transects should be created in all three habitats as well, so habitats can be represented by more than one 250-meter line. In addition, analyzing the butterfly species present in each community could lead to interesting findings, in case certain habitats are more conducive to different family diversity.

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