A continued baseline assessment of fruit-feeding Nymphalid butterfly abundance and diversity between habitats at Firestone Center for Restoration Ecology in Costa Rica

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Introduction

Nymphalid butterflies are a diverse tropical group that has shown promise as an 'indicator species' of habitat health. This classification correlates to their sensitivity to both climatic and ecological disturbance due to a relatively short life cycle and host-plant reliance (DeVries 1987). For the past two years, changes in the number of fruit-feeding Nymphalid butterfly individuals and species have been recorded at the Firestone Center for Restoration Ecology, in southwestern Costa Rica (Haber 2005 & 2006). Originally lowland rainforest, the land was converted to a cattle farm in the 1950's and 1960's, and since 1993, has been the subject of restoration and sustainable forestry efforts. The center is now covered primarily by secondary tropical moist forest along with smaller patches of bamboo and pastureland and a few relatively mature riparian zones.

During the summer of 2007, total Nymphalid butterfly abundance and species richness was compared between specimens caught in butterfly traps placed in the upper and lower stories of the riparian forest, secondary forest, bamboo forest, and pastureland located within the reserve. This data was then used to analyze the effect of anthropological alterations to a habitat, such as destruction of original vegetation and the introduction of alien species, on butterfly populations. An analysis of abundance and species richness in these areas was also expected to aid in determining what characteristics of a habitat, i.e. the presence of water or tree density, significantly predict butterfly visitation. It was hypothesized that both the height at which a trap is placed and its location would have a significant effect on abundance and species richness.

Methods

Data collection

Butterflies were trapped and released for six weeks between June and July 2007 at the Firestone Reserve. Traps were set up at four sites, with a site in four distinct habitats on the reserve: riparian forest, recovering pastureland, bamboo forest, and secondary forest. The traps were constructed according to the Tropical Ecology, Assessment, and Monitoring (TEAM) Initiative butterfly monitoring protocol produced by the Center for Applied Biodiversity Science at Conservation International. Three sets of traps were hung at each site. One set of traps consisted of an upper trap and a lower trap attached below the upper trap by a rope at least 10m in length. The rope between the traps was adjusted in length so that the upper trap was raised as high as possible into the tree supporting the set of traps, and the lower trap was hung with the trap entrance approximately 1.5m above the ground. At the pasture site, no upper traps were constructed because there were no trees in the habitat that were tall enough to hang the upper story of traps. Traps were baited with local, in season, rotting fruit that was replaced approximately every three days for all traps. For the six week that data was collected, all traps were checked once a day, six days a week. At each trap, butterflies were identified using Philip J. DeVries guide to *The Butterflies of Costa Rica* (1987). During collections, the number of captured butterflies of each species was recorded, and then the butterflies were released. The number of individuals of each species observed over the six weeks of collections was totaled. This information was then used to analyze Nymphalid butterfly abundance and species richness between the four habitats, and the effect of trap height.

Analysis of experimental design

The two independent fixed factors analyzed for their effect on abundance and richness was habitat and trap height. Although technically nested because they were in the exact same location, the upper and lower traps were analyzed as independent sites.

The two dependent variables analyzed were total butterfly abundance and total species richness. It was necessary to examine both variables because when analyzed alone, abundance and total species richness can provide misleading information on differences in butterfly visitation observed between habitats and trap heights. While abundance data was necessary to analyze whether butterflies were visiting a habitat, a high number of individuals counted could be due to the high occurrence of one species. On the other hand, more species could be observed in one habitat, but with low overall visitation.

It was necessary to use the total butterfly abundance and total species richness because of pseudoreplication. Since the traps were never moved during the data collection, butterfly abundances and species richness observed each day were dependent on these locations. Consequently, it was unnecessary to check the butterfly traps everyday during the six weeks of collections. Future extensions of this research might check traps less frequently and instead set up more traps, or move the traps around their respective habitats.

Another consideration that had to be taken into account when analyzing this data was that the captured butterflies were not tagged before they were released. Therefore, it was not possible to determine if one butterfly had already visited the same trap. Using the total richness I was able to correct for this unknown, but repeated visitation could have affected the total abundances observed for the different traps. Also, it's possible that the increased visitation at one height had a confounding effect on the visitation of the other trap height in the same set.

Data analysis

Separate two-way ANOVAs were used to analyze the effects of habitat and trap height on butterfly abundance and species richness. Both independent variables, habitat and trap height, were treated as discrete fixed effects. The dependent variables, butterfly abundance and species richness, which were analyzed in separate two-way ANOVAs, were treated as continuous data.

When abundance was used as the dependent variable, there was a significant interaction effect between trap height and trap location ($F=7.101$ $df=2,14$ $p=0.007$). The total abundance data between the upper and lower traps was split and two independent one-way ANOVAs were run to analyze the effects of the different habitat locations. No significant interaction effect was observed between trap height and trap location when species richness was analyzed as the dependent variable ($F=0.564$ $df=2,14$ $p=0.582$). For all ANOVA tests that were conducted, Tukey HSD test were run to analyze significant differences between the habitats.

Results

Habitat had a significant effect on butterfly abundance in both the lower traps (Figure 1; F=10.634 df=3,8 p=0.004), and the upper traps (Figure 1; F=6.512 df=2,6 p=0.031). The lower riparian forest traps had a significantly lower abundance than any of the other habitats (Tukey HSD; bamboo, p=0.025, pasture, p=0.032; secondary forest, p=0.003). The observed abundances for the lower traps in the recovering pastureland, secondary forest, and bamboo forest were not significantly different from each other. For the upper traps, the riparian forest butterfly abundance was only significantly lower than the secondary forest abundance (Tukey HSD; p=0.028). Unlike the lower traps, the upper bamboo forest trap abundance was not significantly different from the riparian forest abundance (Tukey HSD; p=0.461); similarly to the lower traps, the bamboo site abundance was not significantly different that the observed secondary forest abundance (Tukey HSD; p=0.133).

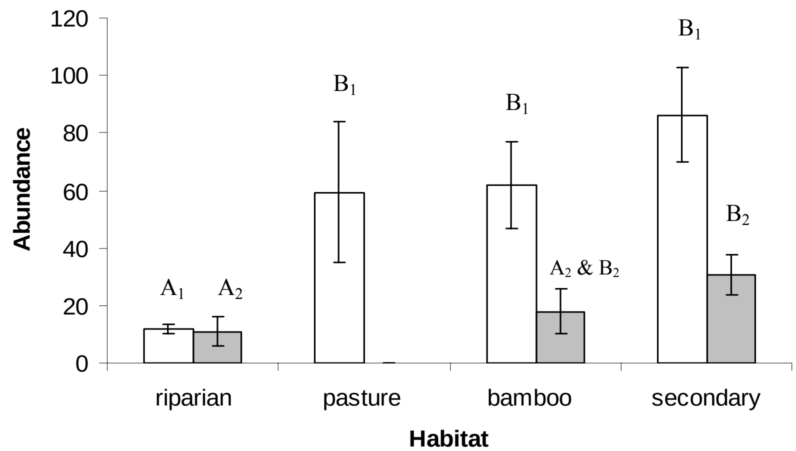

Figure 1. Effect of habitat and trap height on Nymphalid butterfly abundance (Mean±SE; n=3) □=lower trap, ■= upper trap.

Species richness for the different trap heights was not significantly different (Figure 2; F=0.801 df=1 p=0.386), but habitat did have a significant effect (Figure 2; F=24.770 df=3 p<0.001). Again, the riparian forest had significantly lower counts than any of the other habitats (Tukey HSD; bamboo, p=0.020, pasture, p<0.001; secondary forest, p<0.001). The greatest species richness was observed at the pasture site and in the secondary forest, and between these two sites, species richness was not significantly different (Tukey HSD; p=0.582). The bamboo forest species richness was significantly lower than what was observed for both the secondary forest (Tukey HSD; p=0.006), and the pasture site (Tukey HSD; p=0.002).

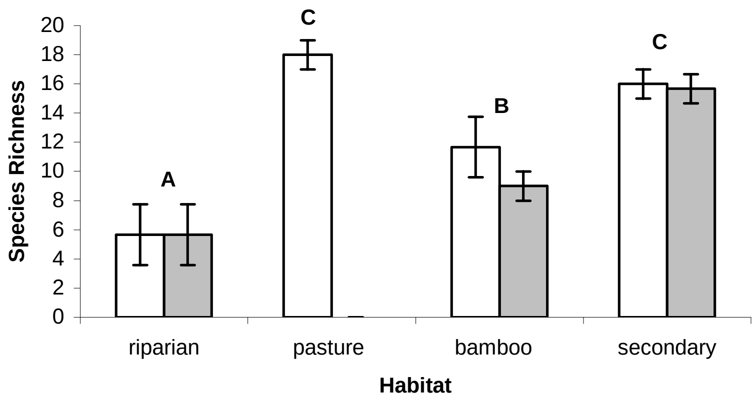

Figure 2. Effect of habitat and trap height on Nymphalid butterfly species richness (Mean±SE; n=3) □=lower trap, ■= upper trap.

Discussion

The results suggest that currently, butterfly abundance is independent of the effects of past anthropological alterations to the Firestone Reserve ecosystem. In general, butterflies appeared to show no preference for secondary forest, characterized by increased shrubbery and older growth, over areas dominated by a nonnative species, bamboo, or more open grassy areas. The least disturbed habitat analyzed, the riparian forest, was visited by the lowest number of butterflies. The riparian traps were in close proximity to bodies of stagnant water, which are often breeding grounds for insects that may have been competing for food sources with the butterflies.

Species richness was also the lowest in the riparian forest, which may suggest that many Nymphalid host plants do not grow in these areas. The second highest species richness was observed in the bamboo forest, which did not have the diversity of vegetation observed in the riparian forest. Greater species richness in the bamboo forest suggests that the types of plant species present are more important in maintaining butterfly diversity than the number of plants plant species. Bamboo appeared to support a greater number of species than the variety of vegetation observed in the riparian forest. The secondary forest and recovering pastureland had the greatest number of species collected. Despite being characterized by very different concentrations of low shrubbery, there was no significant difference in the number of species observed between these two habitats. Again, it is possible plant density was less influential than the plant species present, and that key host plant species were present in both habitats. In general, the observed species richness did not support the hypothesis that the least disturbed habitats would have the greatest number of species.

The separation of the lower and upper traps did not change any of the general trends observed in the Nymphalid butterfly abundance and species richness between the four habitats. As the forest in the reserve matures, it may be possible to increase the separation between the upper and lower story traps. Different trends may be observed when the difference in trap height is increased.

Future extensions of this experiment could sample less days but increase the number of traps at each type of habitat. Also, it would be beneficial to record whether butterflies were visiting a particular plant species in each area or a wide variety of plants, since these results did not suggest any conclusive trends.

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