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Butterfly Species Diversity and Habitat Heterogeneity across Altitudinal Gradients of Mt. Banahaw de Majayjay, Philippines

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ABSTRACT

Butterfly diversity and associated flora were assessed in three different types of habitats in Mt. Banahaw de Majayjay, Philippines in order to determine the mountain's ecological state. Butterfly census techniques include trapping and net sweeping along a modified transect line (1000m) in three habitat types. Separately, trees and undergrowth host plants were surveyed from the five 10-m² plot established alternately at every 200-m interval along the same transect and from the four 1-m² quadrat established within each plot. A total of 81 butterfly species and subspecies were recorded including one new migrant species. Butterfly and host plant species diversity was highest in agroforestry (H' = 3.60 and 2.78) while lowest in dipterocarp forest (H'=2.36 and 1.75). These patterns were significantly related to shifts in dispersal pattern and structure of vegetation, particularly host plants, temperature and slope of habitats, as determined by the canonical correspondence analysis (CCA) using the same environmental variables. Bivariate analysis showed that the mean elevation negatively affects the wet season butterfly species richness and diversity.

Keywords: butterfly, community, diversity, habitat, heterogeneity

INTRODUCTION

Butterfly fauna is closely associated with their host plants for their entire life cycle (Wilson *et al.* 1997). The ecosystem could be assessed through the diversity and abundance of butterflies in a given area. Many authors attested that their sensitivity to light levels of disturbance, interdependency with host plants (Danielsen *et. al* 2004), and their specificity to a single species or family of host plants (a condition known as oligophagy) (Dennis 1997) or to a specific habitat (disconcordant) (Mohagan *et.al* 2009) were characteristics of useful indicator for species habitat disturbance.

Studies on butterflies leading to their protection and conservation are very scanty and their ecological importance is sometimes overlooked as well. Based on a key informant interview (KII) done by the Protected Area Management Board, the lack of knowledge of Majayjay local communities on butterfly fauna and their host plants has resulted to lack of biological monitoring of the butterfly and of other insects that locals considered as pests. Agricultural conversion of flanks of Mt. Banahaw and the harmful farm practices have continuously decimated the butterfly fauna (Gascon 2002 & Agudilla 2011). Most biological explorations were confined in Mt. Banahaw de Lucban such as the work of Lit Jr. (1998), Gascon (2002), Gascon *et al*. (2006), and Agudilla 2011) to name a few but almost lacking for butterfly studies, specifically in Mt. Banahaw de Majayjay. Recent study on butterfly recorded 76 butterfly species in Mt. Banahaw de Lucban (Gascon *et al*. 2006) including an endangered species, *Troides rhadamantus*. Mt. Banahaw de Majayjay has been considered as threatened like Mt. Banahaw de Lucban which needs to be explored for its protection and conservation. Integral part of this study provides baseline information on the abundance, richness, and diversity of butterfly fauna in Mt. Banahaw de Majayjay as additional indicators of the present ecological state of the mountain; to analyze effects of environmental factors significantly affecting the butterfly fauna; and to recommend conservation measures for the species and their habitats.

METHODOLOGY

Study Area

The study site is situated in Mt. Banahaw de Majayjay, is part of Mt. Banahaw–San Cristobal Protected Landscape complex under the municipal jurisdiction of Majayjay, Laguna, Philippines and is located at 14^0 08' north latitude and 121^0 28' east longitude. It has Climatic Type III; characterized by two seasons that are not very pronounced – relatively dry during November to April and wet during the rest of the years (DENR 2010). Surveys of butterflies were conducted for six months from September 2011 to May 2012. The three habitat types across altitudinal gradients were considered for sampling such as agroforestry, riparian habitat, and dipterocarp forest. One transect line (1000 m) divided into five sampling points (200–m interval) was established along the existing trails at each habitat type for butterfly assessment. Moreover, five 10-m² plots were established alternately at every 200-m interval along the same transect for host tree sampling, while four 1-m² quadrats within each plot served for sampling of undergrowth host plants.

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To determine the characteristics of the three habitats' elevation, slope, and temperature were measured at each sampling point using GPSMap 60CSX and WS-9160U-IT digital thermometer, respectively. The averages of elevation, slope, and temperature based on the five sampling points, respectively, were 627.17 masl, 13%, and 31.5°C (agroforestry), 547.33 masl, 18.5%, and 29.4°C (riparian), and 801.78 masl, 30.17%, and 25.5°C (dipterocarp) (Table 1).

Table 1. Average temperature at each habitat type

Habitat Type	Average Temperature (°C)
Agroforestry	31.50
Riparian	29.42
Dipterocarp	25.50

Survey and Collection of Butterfly and Host Plant Species

A pictorial guide for the Philippine butterflies was used as guide in the identification of butterflies encountered during survey periods, while the voucher specimens deposited in the National Crop Protection Cluster (NCPC) were used to compare unidentified collected butterflies from Mt. Banahaw de Majayjay. Butterfly voucher specimens were prepared to be deposited in the Museum of Natural History at the University of the Philippines Los Baños.

Butterflies were surveyed for six months from 8:00 AM to 4:00 PM using different methods that include trapping (Turner *et al.*, 2003), netting, and transect walk method (De Vries 1987; Upton 1991) with modification. Five feeding traps baited with mashed overripe and rotten fruits of bananas were set at each habitat with the base at one meter above the ground. These were tended for a total of 12 days, making a total of 180 trapping days. Four persons carried out sweep netting at low bushes to hunt crepuscular and resting butterflies at each habitat for a total of 12 days; making a total of 144 sweeping days. Transect walk method with modification was carried out in three transect lines representing the three habitat types. Each transect was traversed twice during each day of the survey period for a total of 12 days making a total of 72 transect walks. Modification of the transect walk method includes counting of butterflies flying 2-m high along the track and within 5-m on both sides of transect. This was made in order to establish a good baseline data of butterfly fauna in Mt. Banahaw de Majayjay.

For vegetation survey, an expert in plant identification from UPLB provided on-site assistance in the identification of host plants. No herbarium specimens of host plants were collected since all plants have been identified on-site.

Data Analysis

Diversities of butterfly and host plants by habitat type were assessed using the following biodiversity indices: abundance (N), species richness (S), Berger-Parker Index (1/d), Simpson index (D), Shannon-Weiner Diversity Index (H'), and Margalef Index (Dmg). Abundance and species richness were computed based on the number of individuals and species respectively. Variations in abundance of butterflies during wet and dry seasons at each habitat type were statistically compared using t-test following the formula given by Magurran (1988).

In order to determine which among the aforementioned biodiversity indices contributed significantly to the butterfly diversity, bivariate analyses were carried out to assess the correlations between host plant and butterfly diversities, and butterfly diversity and attributes of physical environment (mean elevation (Elev), slope (Mean SL), and temperature (Mean Temp)) using SPSS 16.

To determine the similarity of butterfly species composition at each sampling point similarity index was obtained from the Bray -Curtis Cluster Analysis generated using Biodiversity Professional Beta 1. Canonical correspondence analysis (CCA) was generated using CANOCO 4.5 (ter Braack 1989) for multivariate analyses (ter Braak 1985) among butterfly-environment associations.

Limitations of the Study

The methods employed in the study limited the sampling of butterflies to low-flyers (species flying <2 meters high). Sampling bias may have slight implication to the understanding of the whole diversity and dynamics of the butterfly fauna in Mt. Banahaw de Majayjay. However, results of the study positively contribute to the development of long-term management and monitoring of ecological state of ecosystems alike.

RESULTS AND DISCUSSION

Butterfly Species Composition

Overall, 81 butterfly species were recorded and identified in Mt. Banahaw de Majayjay, belonging to 75 genera in six families of the Superfamily Papilionoidea and six genera in the solitary family Hesperiidae of Superfamily Hesperioidea (Table 2).

Similarity Index of <40% indicates very low similarity of butterfly composition in Mt. Banahaw de Majayjay across habitat types. Dendogram of cluster analysis (Figure 1) on the basis of similarity of butterfly species composition at each habitat type had shown four clusters of unique habitat types. Two sampling points, Rivers 2 and 4, in the riparian habitat were ecologically similar with >55% similarity index. These are clustered together with Rivers 1, 3 and 5 and Dip 3 with low similarity index of <50% and comprised the first cluster. Dip 1, Dip 2 and Dip 5 in the dipterocarp habitat comprised the second cluster of habitat on the basis of butterfly species composition with similarity index of >50%. All sampling points in the agroforestry habitat comprised the third cluster with similarity index of >50%. Dip 4 is the fourth cluster as a very unique habitat with similarity index of <40%. The Dendrogram produced in the clustering of habitats in this study did not follow the original classification of habitats.

Table 2. The species composition, abundance, distribution, and local status of butterflies in Mt. Banahaw de Majayjay

Sp. No.	Taxonomic Identification	Number of Encounters				Sp. No.	Taxonomic Identification	Number of Encounters			
		Riparian	Agroforestry	Dipterocarp	Total			Riparian	Agroforestry	Dipterocarp	Total
A. Danaidae						**D. Nymphalidae**					
1	*Danaus (Salatura) melanippus edmondii*	8	49	2	**59**	20	*Athyma gutama gutama*	0	7	0	**7**
2	*Euphloea mulciber dufresne*	8	1	0	**9**	21	*Athyma kasa*	1	8	0	**9**
3	*Ideopsis juventa manillana*	0	10	0	**10**	22	*Cethosia biblis insularis*	0	1	0	**1**
4	*Parantica luzonensis luzonensis*	3	9	0	**12**	23	*Cyrestis maenalis maenalis*	13	7	0	**20**
5	*Parantica vitrina vitrina*	2	24	0	**26**	24	*Doleshallia bisatilde philippinensis*	6	18	4	**28**
6	*Tirumala limniaceae orestilla*	1	19	2	**22**	25	*Hypolimnas bolina philippinensis*	13	20	4	**37**
B. Hesperiidae						26	*Junonia almanac almana*	9	3	1	**13**
7	*Cephrenes chrysozona chrysozona*	0	4	0	**4**	27	*Junonia atlites atlites*	1	5	0	**6**
8	*Notocrypta paralysos volux*	0	5	0	**5**	28	*Junonia hedonia ida*	28	32	0	**60**
9	*Parnara naso bada*	0	4	0	**4**	29	*Lasippa illigera illigera*	2	23	0	**25**
10	*Tagiades japetus titus*	0	3	0	**3**	30	*Lexias satrapes satrapes*	0	0	3	**3**
11	*Tagiades trebellius martinus*	0	3	0	**3**	31	*Moduza urdaneta urdaneta*	0	1	0	**1**
12	*Hesperiidae sp. 1*	0	10	0	**10**	32	*Pantoporia cyrilla cyrilla*	1	0	0	**1**
13	*Hesperiidae sp. 2*	0	13	0	**13**	33	*Pantoporia dama dama*	2	0	0	**2**
14	*Xanthoneura telesinus*	0	4	0	**4**	34	*Phalanta phalanta phalanta*	3	0	0	**3**
C. Lycaenidae						35	*Parthenos sylvia philippensis*	0	2	0	**2**
15	*Jamides philatus osias*	18	63	17	**98**	36	*Rhinopalpa polynice stratonice*	1	0	0	**1**
16	*Jamides schatzi nakamotoi*	8	40	28	**76**	37	*Symbrenthia hippoclus galepsus*	0	2	0	**2**
17	*Logania sp.*	0	1	0	**1**	38	*Tanaecia calliphorus calliphorus*	5	3	13	**21**
18	*Prosotas dubiosa lumpura*	0	1	0	**1**	39	*Vindula dejone dejone*	5	0	0	**5**
19	*Lycaenidae sp. 1*	0	12	0	**12**						
Subtotal		**48**	**275**	**49**	**372**			**90**	**132**	**25**	**247**

Table 2. The species composition, abundance, distribution, and local status of butterflies in Mt. Banahaw de Majayjay *(continued)*

Sp. No.	Taxonomic Identification	Number of Encounters Riparian	Agroforestry	Dipterocarp	Total	Sp. No.	Taxonomic Identification	Number of Encounters Riparian	Agroforestry	Dipterocarp	Total
E. Papilionidae						**F. Pieridae**					
40	*Atrophaneura semperi semperi*	1	0	0	**1**	62	*Eurema alitha jalendra*	3	37	2	**42**
41	*Chilasa clytia palephates*	1	0	0	**1**	63	*Eurema hecabe*	11	58	2	**71**
42	*Graphium agamemnon agamemnon*	51	27	4	**82**	64	*Eurema sarilata aquilo*	6	25	1	**32**
43	*Graphium agamemnon agamemnon*	2	0	0	**2**	65	*Hebomoia glau-cippe philippensis*	4	14	0	**18**
44	*Graphium sarpedon sarpedon*	26	11	1	**38**	66	*Leptosia nina georgi*	21	0	4	**25**
45	*Lamproptera meges decius*	1	8	0	**9**	67	*Pareronia boebera boebera*	0	1	0	**1**
46	*Papilio alphenor ledebouria*	75	28	16	**119**	**G. Satyridae**					
47	*Papilio daedalus daedalus*	15	4	2	**21**	68	*Acrophtalmia artemis artemis*	50	15	13	**78**
48	*Papilio demoleus libanius*	0	2	0	**2**	69	*Amathusia phidip-pus pollicaris*	3	0	0	**3**
49	*Papilio hystaspes*	12	8	0	**20**	70	*Faunis phaon phaon*	25	1	5	**31**
50	*Pachliopta kotzebuea kotzebuea*	9	0	0	**9**	71	*Lethe chandica*	3	0	0	**3**
51	*Papilio lowi*	0	3	0	**3**	72	*Mycalesis igoleta igoleta*	4	1	5	**10**
52	*Papilio rumanzovia*	11	9	1	**21**	73	*Mycalesis ita ita*	24	108	12	**144**
53	*Troides magellanus magellanus*	0	2	0	**2**	74	*Melanitis leda leda*	20	14	9	**43**
54	*Troides rhadamantus*	5	16	1	**22**	75	*Mycalesis minues philippina*	1	14	0	**15**
F. Pieridae						76	*Mycalesis tagala tagala*	6	3	30	**39**
55	*Appias albina semperi*	0	3	0	**3**	77	*Ptychandra leucogyne*	1	1	0	**2**
56	*Appias olferna peducaea*	0	10	0	**10**	78	*Ptycandra lorquinii lorquinii*	1	0	0	**1**
57	*Cepora iudith olga*	4	0	0	**4**	79	*Ragadia luzonia luzonia*	61	18	113	**192**
58	*Catopsilia pomona pomona*	3	4	0	**7**	80	*Ypthima sempera sempera*	0	21	0	**21**
59	*Catopsilla pyranthe pyranthe*	1	2	0	**3**	81	*Zethera pimplea*	12	2	0	14
60	*Delias henningia henningia*	0	12	0	**12**						
61	*Delias hyparete luzonensis*	0	0	1	**1**						
Subtotal		**217**	**149**	**26**	**392**		**Subtotal**	**256**	**333**	**196**	**785**
							Grand Total				**1796**

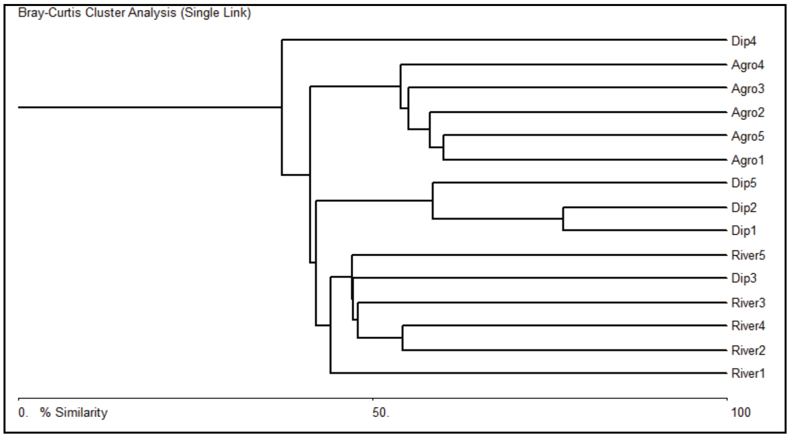

Figure 1. Dendogram of cluster analysis of butterfly species composition.

A pair of *Troides rhadamantus* L., an endangered species listed under Appendix II of CITES, was observed mating while on flight along the riparian habitat. A few individuals of *T. rhadamantus* were also observed nectaring *Lantana* sp. and *Leea* sp. in the agroforestry habitat. This species was also recorded by Gascon *et al.* (2006) in Mt. Banahaw de Lucban. The ecological status of *T. rhadamantus* may be attributed to the subsequent loss of its larval food plant, the *Aristolochia* sp., after land conversion. *Aristolochia* sp. is a vine commonly occurring in both lowlands and uplands which are easily affected by land use change. Harmful farm practices in Mt. Banahaw de Majayjay continuously threaten the survival of both *T. rhadamantus* and *Aristolochia* sp. Larvae of *T. rhadamantus* are voracious feeders which consume both leaves and stems of *Aristolochia*. Their behavior can be a good subject of research to come up with appropriate conservation measures for this endangered species.

Papilio lowi Druce of Palawan origin (also found in Borneo) was noted as a new record in Mt. Banahaw de Majayjay. The discovery of this butterfly species implies the presence of other species, possibly the "migrant" ones despite habitat disturbances. It further indicates that *P. lowi* can exist in less disturbed areas provided that their host plants are present. The occurrence of *P. lowi* in the present study site may be due to the presence of some butterfly gardens in the neighboring towns within Laguna.

Breeding, trading and transport of live stocks of butterfly, although with high socio-economic potential and have been one of the lucrative business enterprises in the country must be regulated and monitored by the Department of Environment and Natural Resources (DENR). If properly monitored, butterfly farming could be a good endeavor leading to *ex situ* conservation; otherwise, the business will just threaten more the butterfly fauna.

Rules and regulations for the protection and conservation of wildlife must be strictly implemented by the DENR. Butterfly breeders must comply with all the requirements stated in the DENR Administrative Order No. 2002-19 prior to the establishment of butterfly garden facility. They are obliged to release 10% of the total production of captive-bred endemic butterfly species to the specific area where the species were collected. On the other hand, illegal breeders and sub-breeders of butterflies must be sanctioned and penalized accordingly based on RA 9147.

However, the occurrence of *P. lowi* in the Philippines and Borneo may indicate that these countries have some degree of similarity in terms of vegetation and environmental conditions favorable for the species. The degree of similarity between these countries in terms of flora and fauna could be supported by the theory of land bridge connectivity (Cayabyab 2000). The current distribution of *P. lowi* could be explained by the dispersal capacity of the species (Mc Intire *et al* 2007). *P. lowi* belongs to a group of swallowtails under *Papilionidae* with high capacity for long distance migration due to its large expanded wings and large bodies.

Conservation Status of Butterfly Species

Commonness and rarity of butterfly species were classified according to Treadaway's Checklist (1995) in which very rare species have 1–3 occurrence, rare species have 4–10 occurrence, common species have 11-20 occurrence, and very common species have 21 and above occurrence in which occurrence was based on the number of encounter of the species, spread across time and space, for a total of 180 trapping days, 144 sweeping days and 72 transect walks after the 6-month survey period. Complete taxonomic list of butterflies sampled at each habitat type and local status is presented in Table 2**.**

At community level, there were a total of 27 very rare, 17 rare, 10 common and 27 very common butterfly species in Mt. Banahaw de Majayjay. Most abundant of the very common species were *Ragadia luzonia luzonia, Mycalesis ita ita* and *Papilio alphenor ledebouria* which occur in all habitat types, hence, regarded as concordant species (species that can exist in a wide range of habitat) (Mohagan *et. al* 2010). Among the very rare species was *Lexias satrapes satrapes* C. & R. Felder which is found in the dipterocarp forest. Mohagan *et. al* (2010) also recorded two *Lexias* sp. in the dipterocarp and pygmy forest of Mt. Hamiguitan. Therefore, *L. satrapes satrapes* can be considered as forest-restricted species.

Species Abundance, Richness, and Diversity

There was a very high species diversity (H' = 3.93) of butterfly at community level. The agroforestry area had the most abundant and high species richness (889 individuals and 67 species), and the most diverse habitat (H'=3.63). *Mycalesis ita ita* C. & R. Felder which is dependent on Poaceae species for their food at larval stage was the most abundant species in agroforestry habitat. The riparian habitat ranked second with 611 individuals and 56 species of butterflies and with diversity index of H'=3.34. The dipterocarp forest had the least abundance and species richness and the least diverse habitat (296 individuals, 28 species, and H'=2.36, respectively). Ragadia luzonia luzonia C. & R. which is dependent on Sellaginela plana at larval stage was the most abundant butterfly species in the dipterocarp habitat.

Regarding the host plants, 30 plant species (Table 3) were identified as host plants of butterfly fauna with diversity index of H'=3.14 at community level and a very low to low diversity at habitat level (Table 4). Among the common species of host plants were Selaginella plana (Desv. ex Poir.) Heiron, Lantana camara L., Rubus sp., Melastoma malabathricum L., Citrus maxima (Burm.) Merr., Oplismenus compositus (L.) P. Beauv., Strongylodon macrobotrys A. Gray, Asclepias currasavica L., Cassia alata, and Sambucus javanica Reinw. ex. Bl.

Table 3. Host plants of butterflies documented in Mt. Banahaw de Majayjay September 2011-May 2012 (Baltazar 1991, Cayabyab 2000, Agudilla 2011 and Database of Host Plants of the World's Lepidoptera)

Family Name	Scientific Name	Common Name
	Adult and Larval Host plants	
Acanthaceae	*Justicia gendarussa* Burm. f.	Justicia
Acanthaceae	*Pseuderanthemum atropurpureum**	
Annonaceae	*Uvaria rufa* Blume	Uvaria
Apocynaceae	*Asclepias curassavica* L.*	
Asteraceae	*Elephantopus tomentosus* L.*	
Asteraceae	*Ageratum conyzoides* L. *	
Convolvulaceae	*Ipomea batatas* (L.) Lamk.	Sweet potato
Fabaceae	*Cassia alata*	Bayabas-bayabasan
Fabaceae	*Strongylodon macrobotrys* A. Gray	Jade vine
Caprifoliaceae	*Sambucus javanica**	Sauco
Loranthaceae	*Loranthus philippinensis*	
Melastomataceae	*Melastoma malabathricum*	Malatungau
Moraceae	*Artocarpus heterophyllus* Lamk.	Nangka
Moraceae	*Ficus ulmifolia* Lam.	Upli
Musaceae	*Musa sp*	Abaca
Passifloraceae	*Passiflora* sp.	
Poaceae	*Oplismenus compositus*	Kuraurau
Rosaceae	*Rubus* sp.	Wild strawberry
Rubiaceae	*Mussaenda philippica* A. Rich	Kahoy dalaga
Rutaceae	*Citrus maxima* (Burm.) Merr.	Lukban
Selaginellaceae	*Selaginella plana* Hieron	Kamariang gubat
Urticaceae	*Poikilospermum suaveolens* (Blume) Merr.	Hanopol
Verbenaceae	*Lantana camara* L.*	Coronitas
Verbenaceae	*Stachytarpheta jamaicensis* (L.) Vahl*	Kandi-kandilaan lunti

The decreasing trend of butterfly species richness and diversity in Mt. Banahaw de Majayjay from lower (agroforestry habitat) to the higher elevations (dipterocarp forest) and gradients was consistent with the results of separate studies (Toledo *et. al* 2011 and Mohagan *et. al* 2010). They ascertained that the drastic variation in species composition of vegetation is brought about by the changes in temperature (Table 4), humidity, rainfall and sunshine and the dispersal and growth patterns of vegetation (host plants) from lower elevation to higher elevations which significantly affect butterfly species composition, richness and diversity.

Table 4. Biodiversity indices of host plants species at each habitat type

Habitat Type	Species Abundance	Species Richness	Species Diversity
Agro-forestry	48	20	2.78
Riparian	13	7	1.54
Dipterocarp	17	7	1.75

Statistical Analysis

Results of t-test showed a very high seasonal diversity variation of butterflies ($p<0.01$) and established that butterflies were more abundant during dry season over wet season. At community level, an increase in butterfly diversity was noted when the season shifted from wet (November) to dry (March) (Figure 2). Several studies as to the seasonal preferences of butterfly species pointed out that in some part of the tropics having alternating wet and dry season, butterflies exhibited seasonal changes in abundance (Davis 1945). Some findings revealed that during the onset of wet season, most plant species produced new foliage due to the increased precipitation (Bates 1945); the reason why there are insects that increased in number during that time due to availability of their larval food plants. Yet, findings by Bierne (1955) suggested that warm, dry season was most beneficial for some insects than wet season. Study done by Pollard (1997) showed evidences of some butterfly species having high preferences in dry season over the wet season.

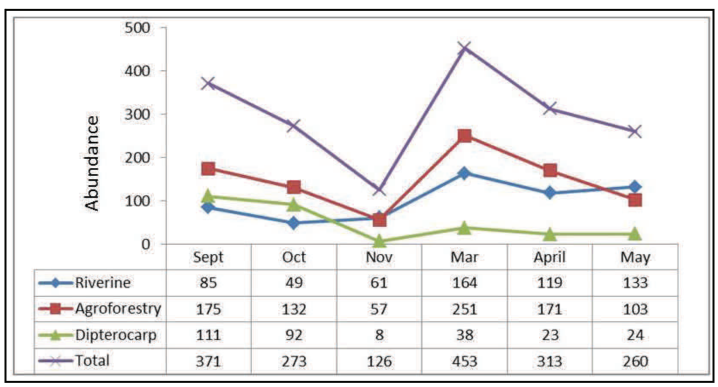

Figure 2. Variation in abundance of butterflies in Mt. Banahaw de Majayjay across habitat types, September 2011-May 2012.

Table 5. Interset correlations between the butterfly species composition on dry season and environmental variables

Axes	1	2	3	4	Total Inertia
Eigenvalues	**0.493**	**0.18**	0.086	0.043	2.221
Lengths of gradient	2.914	2.076	1.899	1.986	
Species-environment correlations	**0.948**	**0.889**	0.982	0.825	
Cumulative percentage variance					
of species data	22.2	30.3	34.2	36.1	
of species-environment relation	24.7	**33.3**	0	0	
Sum of all eigenvalues					2.221
Sum of all canonical eigenvalues					1.785
	Correlation Coefficients				
N	0.3559	-0.0299	0.0079	-0.4134	
S	0.6348*	-0.1936	-0.1853	-0.5971	
Nmax	-0.3835	-0.2776	-0.2076	-0.4217	
H’	0.7113*	-0.0501	-0.255	-0.4624	
Simpson	0.6054*	0.0578	-0.3544	-0.306	
Berger-P	0.8035*	0.1828	0.2228	-0.1241	
Dmg	0.6747*	-0.199	-0.2605	-0.5898	
E	0.626*	0.1009	-0.0404	-0.0287	
Mean Temp	0.7845*	0.0636	-0.3327	-0.4093	
Mean Elev	0.0847	-0.0521	0.8558	0.3084	
Mean SL	-0.6619*	-0.2937	0.269	0.0733	

Results of canonical correspondence analysis (CCA) of correlations between butterfly species occurring on dry season and environmental variables showed that two axes explained the total variations of 2.221. The species-variables correlations for the two axes are high having *r* values of 0.948 and 0.889 (Table 5). Variables with high correlation in butterfly species composition at each sampling point were: the biodiversity indices of host plants such as Shannon-Weiner Diversity Index (H’) (*r=0.7113*), Simpson’s Index (D) *(r=0.6054*), Berger-Parker Index (1/d) *(r=8035)*, Margalef Index (Dmg) *(r=0.6747)*, Evenness Index (E) *(r=0.626)* and attributes of physical environment such mean temperature (Mean Temp) *(r=0.7845)*, and mean slope (Mean SL) *(r=-0.6619).*

The bi-plot generated based on butterfly species composition and ecosystem variables (Figure 3) shows that butterfly species composition separates ecosystem types. Butterfly species compositions in Sampling Points 2 to 5 of the riparian habitat were clustered together, though Sampling Point 3 was a bit farther from Cluster 1. Sampling Points 6 to 10 (all belonging to the agroforestry habitat) were clustered together (Cluster 2). Sampling Points 11 to 15 of the dipterocarp habitat and Sampling Point 1 of the riparian habitat are clustered as another group (Cluster 3). The bi-plot indicates that butterfly species composition in the agroforestry habitat (Cluster 1) in axis 1 was highly significantly affected by host plants’ diversity and mean temperature. On the other hand, Clusters 1 and 3 in axis 2 were highly negatively affected by mean slope (Mean SL).

Mean elevation was another determinant factor negatively affecting (*r* = -0.5751) butterfly diversity during wet season as determined by the bivariate analysis. During heavy rains, butterflies can hardly fly on wet wings especially in high elevation areas (Mohagan *et al.* 2010). Present findings on species-temperature correlation, species-elevation, species-slope, and species-host plants correlations support the explanations why butterfly species preferred and abound in the agroforestry habitat having sunlit and open-spaced area than in the shaded and cool places of the dipterocarp forest.

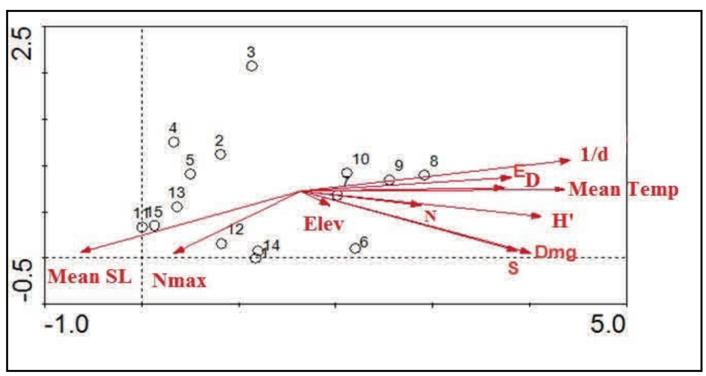

Figure 3. Bi-Plot of Butterfly Composition by Ecosystem and Variables.

CONCLUSION

The presence of 81 butterfly species, the discovery of new migrant species of *P. lowi*, and the presence of a dipterocarp forest-restricted species of *L. satrapes satrapes* indicate a less disturbed to a fair state of Mt. Banahaw de Majayjay. This is based on the high to very high species diversity indices of both the butterfly and host plant at community level. Some butterfly species like *P. lowi* may still increase in disturbed areas provided their host plants are naturally abundant or domesticated by humans. Butterfly richness and diversity in agroforestry were higher than those in dipterocarp forest due to the drastic changes in vegetation (host plants) patterns, structure and dispersal, and temperature between lower and higher elevational gradients. The endangerment and potential decimation of *T. rhadamantus* necessitate species conservation approach for the protection of butterfly fauna and restoration of Mt. Banahaw de Majayjay.

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