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Diversity and distribution of butterflies in the open and close canopy forests of Cadaclan, San Fernando La union botanical garden of North Luzon, the Philippines

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Abstract

Butterflies were sampled in Cadaclan, San Fernando La Union Botanical Garden (LUBG) of North Luzon to provide information on species-level diversity trend and distribution of butterflies on the open and close canopy portion of the dipterocarp forest from 2012-2014 using field transect method Species accumulation curve shows that additional sampling is needed for the possible turnover of species. Butterfly abundance was higher in open canopy forest with a mean individual of 8.14 per 10 meters out of the 814 total individuals. The close canopy forest had only 4.57 mean individuals for the total of 457. Species level diversity was higher in open canopy forest (H' = 1.957) compared with the closed canopy forest (H' = 1.933). These results suggest that butterflies prefer open canopy forest or clearing for their plights. Butterfly spatial distribution was uneven in the dipterocarp forest of LUBG with only 6 species of aggregate assemblages and 98 species with random distribution.

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Introduction

Butterflies are very interesting subject of insects for study. Approximately 90% of butterfly species inhabit the tropics (Munyuli, 2010). Butterflies are taxonomically and ecologically well known (Mihoci *et al.,* 2011) and are regarded as good ecological indicators for other invertebrates. They also represent environmental quality changes and ecologically play important roles in agricultural landscapes (Munyuli, 2012). They are pollinators which ensure reproduction and survival of plants that are used by other organisms as source of food, reproductive areas and medicine; their presence reflects the absence of other organisms and changes in physico-chemical environment (Mohagan and Treadaway, 2010). Butterflies are also sociologically significant as they are morphologically and colorfully meaningful which has various effects to the culture to some groups of people. Economically, their pupae are sold to zoological gardens for hatching, their morphos are used for jewelry making and the adults are used for wedding release instead of dove to symbolize the socioeconomic metamorphosis of the newlyweds (Mohagan and Treadaway, 2010).

Despite butterfly diversity, ecological, behavioural or sociological and functional roles (e.g., pollination), they remain poorly studied in the tropics specifically in farmlands (Marchiori & Romanowski, 2006). Since butterflies provide significant ecological interactions with crops and native wild plant species in many ecosystems around the globe (Davis *et al.*, 2008), studies leading to their conservation is crucial in sustaining the productivity of agricultural and natural landscapes. Some of the key factors that influence diversity and distribution of species are geographic isolation, landscape features, altitude, and climate (Mihoci *et al.*, 2011). In mountain ecosystems, species distribution is determined by habitat and climate stability (Storch *et al.*, 2003). In the Philippines diversity been done by Baltazar (1991) to inventory the Philippine butterflies but not covering all areas in the country including North Luzon. In South Luzon, a survey of butterflies has been done in Mt. Makiling (Cayabyab, 1992) and Mt. Banahao (Lit, 2001). In Mindanao, several butterfly diversity studies were originated (Mohagan *et al.*, 2011; Mohagan and Treadaway, 2010). In North Luzon, La Union Botanical Garden (LUBG) is a montane garden park that once was a dense forest and now plants are domesticated for ecotourism use. It also features an agro-ecosystem on its vicinity. None of the studies mentioned above show the effects of microclimate in terms of canopy cover on butterfly diversity and abundance.

Hence, the influences of open and close canopy forests to butterfly existence are documented for the first time in La Union Botanical Garden (LUBG), San Fernando, and La Union, Philippines. Thus, this paper aimed to provide information on diversity and species abundance of butterflies in open and close canopy forests in LUBG.

Materials and methods

Description of Study Site, Entry Protocol and Sampling Stations

This study was conducted in the dipterocarp forest of LUBG with permission from the management of La Union Botanical Garden, Cadaclan, San Fernando, La Union (Fig 1). LUBG is a historic country style garden, located at 200-300 meters above sea level, and about 6.5 kilometers off the city of San Fernando. The total land area is 10 hectares with generally plain, rolling and gently sloping topography. Two study stations were identified: station 1 is the open canopy (Fig. 2.a) and close canopy forest (Fig.2.b).

Sampling Techniques

Transect line sampling

Transect line method of 1000 m at 100 m interval for both open and close canopy areas of LUBG were conducted. Each line transect data collection was done from 0900 to 1500 hours. All butterflies seen along the transect line were collected, counted and listed (Mohagan and Treadaway, 2010).

Collection and Preservation

The collections were done from January to December of 2012-2014.There were only 3-5 individuals of butterflies collected while duplicates were released in the wild (Mohagan and Treadaway, 2010). Individual butterflies were immobilized in a jar with ethyl acetate prior to placing them in a paper triangle. Moth balls are added to the butterflies in the storage box to prevent molds and ants attack.

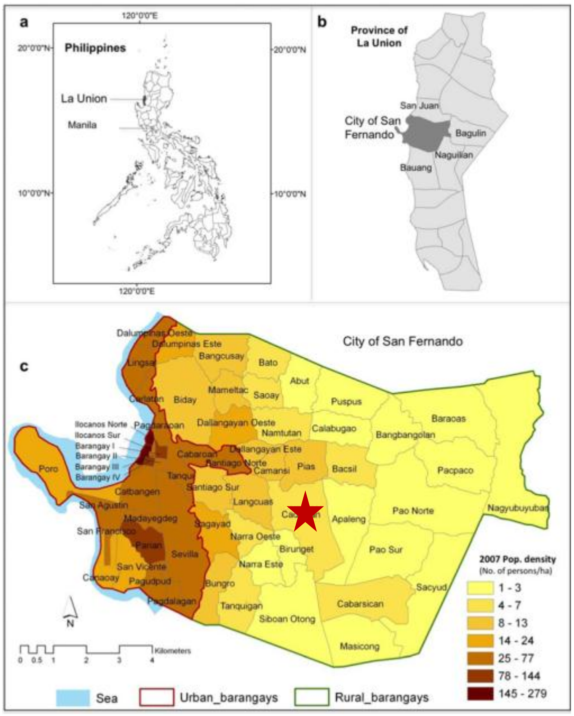

Fig. 1. Location of the study site indicated by a red star. (Estoque *et al.*, 2012).

Fig. 2. Portion of the open canopy (a) and close canopy (b) in La Union Botanical Garden.

Classification and Identification

The butterfly classification and identification sought the assistance of Alma B. Mohagan of Central Mindanao University and the use of references like books, journals, and photographs of previously identified specimens. Examples of these are *Butterflies of the World,* Revised Checklist of Butterflies of the Philippine Islands by Treadaway and Schroeder (2012) and *An Inventory of Philippine Insects: Order Lepidoptera* by Baltazar (1991).

Diversity and Distribution Assessment

Shannon-Weiner diversity index and abundance as well as spatial distributions of butterflies were determined using Bio Pro software version 2.0.

Determination of Ecological Parameters

Temperature readings were taken thrice every sampling time at 900 and 1500 hours. The light penetration is determined by the availability of light throughout sampling hours and sunflect intervals were noted in the close canopy forest. Vegetation types were considered and also elevation was determined using altimeter.

Results and discussion

Diversity of butterflies at LUBG

Species accumulation curve (Fig. 3) showed that sampling requirement was met. A total of 104 species of butterflies were recorded. The open and close canopy forests had 100 species each in the dipterocarp forest of LUBG (Table 1). Out of the total 1,278 individuals sampled, abundance was higher in open canopy with 807 individuals than in close canopy forest with 471 individuals. The uneven species richness was probably due to the differences in temperature (open 24-36 °Ċ) and (close 16-24 °Ċ) and varied food plants present in open canopy as compared to close canopy. A canopy that affects light penetration is needed for the growth of food plants of most butterflies (Emmel and Emmel, 2005). Butterflies are cold blooded insects that prefer sunny areas to warm up and move around (BRE, 2014) and their diversity depend on the abundance of their food plants and larval host plants.

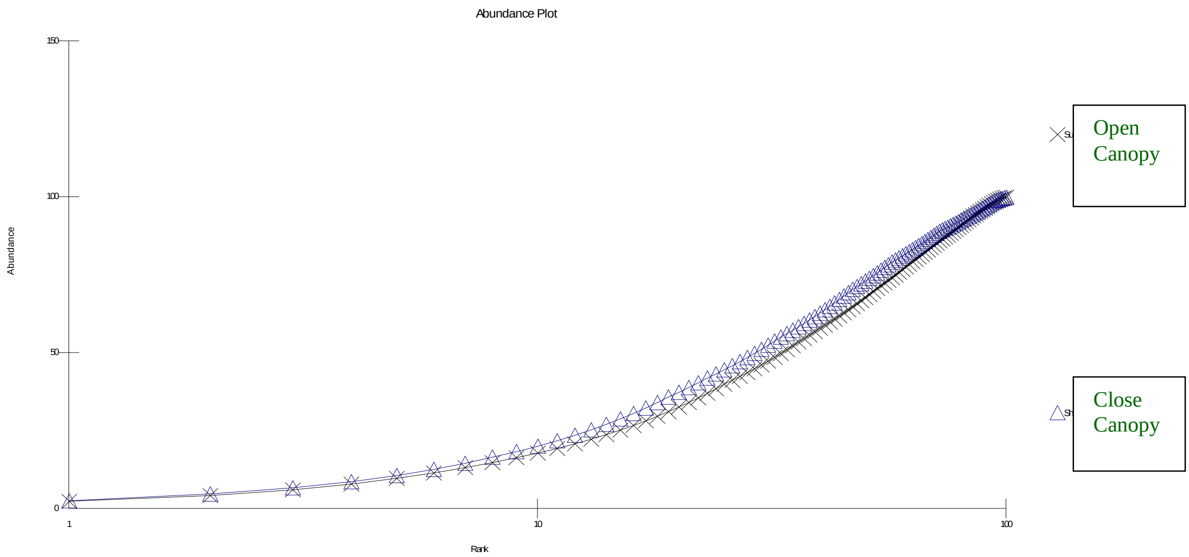

Fig. 3. Species accumulation curve for butterflies of open and close canopy forests of LUBG.

Richness trend of butterflies using Shannon-Weiner index (Fig. 4 & Table 1) showed that species diversity level was higher in open canopy (H'=1.957) than in close canopy (H'=1.9333). Butterfly diversity using Kruger (2005) scale showed fair level between open and close canopy forests. It falls to 1.5-3.0. Habitat may also have fair diversity due to the availability of nectar, host plants and native plants to attract variety of butterflies and caterpillars to feed on (Mohagan and Treadaway, 2010). The LUBG is a modified habitat due anthropogenic development for ecotourism. It was once a dense forest that was subsequently cleared for landscaping. The fragmentation and degradation of forest and the decreased of original plant diversity, proportion of native plants and vegetation complexity (McDonnell *et al.*, 1990) affects diversity of butterflies, consequently, its fair level is a response to the destruction and deterioration of their habitats.

This study also demonstrated that the contributing factor that might affect species richness is the availability of food plants in the montane forest which is true to the study of Toledo and Mohagan (2011) wherein Mt. Timpoong dipterocarp forest *Medenilla* sp. are plenty and fruit trees that serve as food plant of some frugivorous butterfly species. According to the study of Ferrer-Paris *et al.* (2013) there is a significant and strong correlation between host plant diversity and butterfly species richness and that most butterflies use angiosperms for food plant.

Ramirez and Mohagan (2012) and Billones (2012) collected lower number of species in the dipterocarp forest having 89 and 66 species respectively only as compared to the present study (104 species). Dipterocarp forest in both studies are rich in trees, fruits and water sourcewhich meet the potential needs of butterflies. According to Mohagan *et al.* (2011) butterflies species richness have the tendency to become richer in forest habitats than in highly disturbed areas. This implies that vegetation type also affects species richness and anthropogenic disturbances are detrimental to conservation of butterflies (Stefanescu *et al.*, 2004). According to the study of Stefanescu *et al.* (2010) both climatic and anthropogenic factors play an important role in determining butterfly species richness which supports the present study.

Shannon Wiener index showed high level in LUBG (H'1.94) than in Mt. Malambo 2 (H'=0.88) in Bukidnon. This was attributed to the differences in the sampling effort and weather conditions during sampling. This result was similar to the study of Ramirez and Mohagan (2012) in Brgy. Maitum, Surigao del Sur and Billones (2012) in Mt. Kitanglad in which agro ecosystem has low level of diversity with (H'= 1.369) and (H'= 1.22), respectively, as was compared to dipterocarp forest. This result of the study implies that most butterfly species prefer to live in forested area such as dipterocarp forest with sunlight penetration than in close canopy and there is dependence of butterflies to biotic and abiotic factors present or available in the area which is poorly understood yet.

Table 1. Diversity of butterflies in Open and Close Canopy forests in LUBG.

Index	Open Canopy	Close Canopy
Shannon H' Log Base 10.	1.957	1.933
Shannon Hmax Log Base 10.	2	2
Shannon J'	0.979	0.967

The spatial distribution of butterflies showed that there were only 5.67% or 6 species which has aggregate assemblages. The 98 species were of random distribution (Table 2). The following butterflies have aggregate assemblages: ***Zizinia otis oriens (Butler), Hypolimnas bolina, Ideopsis juventa, Parthenos sylvia, Leptosia nina*** and ***Abisara echerius laura***. These butterflies feed on herbs growing on the cleared areas of the forest. Thus requires sunlight penetration or an open canopy as these butterflies are sun lovers and are mostly found in the disturbed habitats. This suggests that some part of the LUBG has some level of anthropogenic disturbance. This observation is consistent to the history of the place which was once a dense forest but such landscape is modified for ecotourism with introduction of domesticated plants for aesthetic value. This result is consistent to Mohagan and Treadaway (2010) and Reeder *et al.* (2012) in which anthropogenic butterflies are abundant in the agro ecosystem than in higher elevation with less human activities or disturbances. The rare and endemic species of butterflies in LUBG were found in the close canopy with cooler temperature. Rodriguez *et al.* (2014) demonstrated that microclimate affects species diversity and variability. In the present study, common butterfly species are distributed in warmer open canopy and rare and endemic in the close canopy forest of LUBG.

Table 2. Species distribution of Butterflies.

Species	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
1. *Cephrenes ocale chrysozona*	24.50	6.50	3.769	1	0.049	Random
2. *Arhopala myrzala myrzala* Hewitson	8.00	6.00	1.333	1	0.247	Random
3. *Cheritra orpheus orpheus* C & R felder	0.50	2.50	0.200	1	0.659	Random
4. *Chilades mindora* (Felder & Felder)	4.50	3.50	1.286	1	0.256	Random
5. *Curetis tagalica tagalica* (C & R Felder)	2.00	5.00	0.400	1	0.535	Random
6. *Drupadia rapendra resulata*	4.50	6.50	0.692	1	0.590	Random
7. *Hypolycaena erylus tmolus* C.&R. Felder	2.00	4.00	0.500	1	0.513	Random
8. *Hypothecla astyla astyla* C & R Felder	2.00	5.00	0.400	1	0.535	Random
9. *Jamides alecto manillana* Toxopeus	2.00	4.00	0.500	1	0.513	Random
10. *Jamides celeno lydanius* (Cramer)	0.50	9.50	0.053	1	0.814	Random
11. *Jamides cyta koenigswarteri*	0.50	4.50	0.111	1	0.738	Random
12. *Rapala manea philippensis* Fruhstorfer	18.00	11.00	1.636	1	0.198	Random
13. *Spindasis syama negrita* C. Felder	18.00	12.00	1.500	1	0.218	Random
14. *Zizina otis oreins* (Butler)	84.50	13.50	6.259	1	0.012	Aggregated
15. *Achilledes palinurus daedalus* Felder	8.00	4.00	2.000	1	0.153	Random
16. *Atrophaneura semperi semperi* (C& R Felder)	4.50	6.50	0.692	1	0.590	Random
17. *Arisbe eurypilus gordion* Tsukada & Nishiyama	4.50	3.50	1.286	1	0.256	Random
18. *Chilasa clytia paliphates* Westwood	4.50	3.50	1.286	1	0.256	Random
19. *Graphium agamemnon agamemnon* Linnaeus	4.50	4.50	1.000	1	0.319	Random
20. *Graphium sarperdon sarpedon* Linnaeus	12.50	4.50	2.778	1	0.091	Random

Species	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
21. *Lamproptera megis decius* C&R Felder	0.50	3.50	0.143	1	0.707	Random
22. *Manelaides deiphobus rumanzovia*	0.50	5.50	0.091	1	0.761	Random
23. *Menelaides ledebouria polytes*	2.00	4.00	0.500	1	0.513	Random
24. *Menelaides helenus hystaspes*	0.50	3.50	0.143	1	0.707	Random
25. *Pachliopta kotzebuea asina* Tsukada and Nishiyama	0.50	5.50	0.091	1	0.761	Random
26. *Pachliopta phlegon strandi* Bryk	8.00	5.00	1.600	1	0.203	Random
27. *Papilio demoleus libanius* Frushtorfer	24.50	6.50	3.769	1	0.049	Random
28. *Papilio hipponous hipponous* C& R Felder	18.00	5.00	3.600	1	0.055	Random
29. *Troides magellanus* Felder	0.50	6.50	0.077	1	0.778	Random
30. *Troides rhadamantus* (Lucas)	2.00	6.00	0.333	1	0.571	Random
31. *Danaus chrysippus chrysippus* (Linnaeus)	12.50	4.50	2.778	1	0.091	Random
32. *Danaus melanippus edmondii* Lesson	8.00	6.00	1.333	1	0.247	Random
33. *Amathusia phidippus pollicaris* Butler	2.00	7.00	0.286	1	0.600	Random
34. *Tarattia gumata gumata* Moore	0.50	5.50	0.091	1	0.761	Random
35. *Athyma kasapara kasa*	0.50	5.50	0.091	1	0.761	Random
36. *Athyma saskia* Schroeder &Treadaway	2.00	4.00	0.500	1	0.513	Random
37. *Doleschalia bisaltide philippenses*	4.50	3.50	1.286	1	0.256	Random
38. *Cethosia biblis insularis* C & R Felder	2.00	5.00	0.400	1	0.535	Random
39.*Cethosia Luzonica Luzonica* C & R Felder	18.00	5.00	3.600	1	0.055	Random
40.*Charaxes amycus amicus* C& R Felder	8.00	5.00	1.600	1	0.203	Random
41.*Cirrochroa tyche tyche* C & R Felder	2.00	4.00	0.500	1	0.513	Random
42.*Cupha arias arias* C & R Felder	4.50	3.50	1.286	1	0.256	Random
43.*Cyrestis maenalis maenalis* Erichson	8.00	4.00	2.000	1	0.153	Random
44.*Euploea leucostictos leucostictos* (Gmelin)	18.00	7.00	2.571	1	0.104	Random
45. *Euploea mulciber dufresne* Godart	12.50	6.50	1.923	1	0.162	Random
46. *Euploea sylvester laetificia* Butler	12.50	4.50	2.778	1	0.091	Random
47.*Euploea tulliolus polita* Erichson	18.00	5.00	3.600	1	0.055	Random
48.*Hypolimnas anomala anomala* (Wallace)	32.00	8.00	4.000	1	0.043	Random
49.*Hypolimnas bolina philippensis* (Butler)	50.00	10.00	5.000	1	0.024	Aggregated
50.*Idea leuconoe leuconoe* Erichson	0.50	12.50	0.040	1	0.836	Random
51. *Ideopsis juventa luzonica* (Moore)	4.50	10.50	0.429	1	0.520	Random
52.*Ideopsis juventa manillana* (Moore)	50.00	7.00	7.143	1	0.007	Aggregated
53.*Junonia almana almana* (Linnaeus)	8.00	8.00	1.000	1	0.319	Random
54.*Junonia atlites atlites* (Linnaeus)	4.50	10.50	0.429	1	0.520	Random
55.*Junonia iphita horsfield* (Moore)	8.00	10.00	0.800	1	0.625	Random
56*Junonia orithya leucasia* Fruhstorfer	18.00	5.00	3.600	1	0.055	Random
57.*Kaniska canace benguetana* (Semper)	2.00	2.00	1.000	1	0.319	Random
58.*Libythea geoffroy bardas* Frushtorfer	0.50	3.50	0.143	1	0.707	Random
59.*Melanitis leda leda* Linnaues	4.50	6.50	0.692	1	0.590	Random
60.*Mycalesis bisaya samina* Frushtorfer	12.50	6.50	1.923	1	0.162	Random
61.*Mycalesis kashiwaii pula* Aoki and Uemura	0.50	7.50	0.067	1	0.792	Random
62.*Mycalesis mineus philippina* (Moore)	0.50	6.50	0.077	1	0.778	Random
63.*Mycalesis perseus caesonia* Wallgreen	2.00	6.00	0.333	1	0.571	Random
64.*Mycalesis tagala tagala* C & R Felder	0.50	6.50	0.077	1	0.778	Random
65.*Neptis sp.* Fabricius	4.50	2.50	1.800	1	0.176	Random
66.*Orsotriaena medus medus* Fabricius	0.50	3.50	0.143	1	0.707	Random
67.*Pantoporia dama dama* (Moore)	4.50	2.50	1.800	1	0.176	Random
68.*Parantica luzonensis luzonensis* C & R Felder	0.50	1.50	0.333	1	0.571	Random
69*Parantica vitrine vitrine* C & R Felder	2.00	2.00	1.000	1	0.319	Random
70.*Parthenos sylvia philippinensis* Frushtorfer	0.00	2.00	0.000	1	0.000	Aggregated
71.*Phalantha phalantha* (Drury)	2.00	4.00	0.500	1	0.513	Random
72..*Ptychandra lorquinii lorquini* C & R Felder	0.50	5.50	0.091	1	0.761	Random

Species	Variance	Mean	Chi-sq	d.f.	Probability	Aggregation
73.*Rhinopalpa polynices tratonice* (C. & R. Felder)	18.00	5.00	3.600	1	0.055	Random
74.*Symbrenthia lilaea semperi* Moore	24.50	5.50	4.455	1	0.033	Random
75.*Tanaecia calliphorus calliphorus* (C.&R. Felder)	2.00	3.00	0.667	1	0.581	Random
76.*Tirumala hamata orientale* (Semper)	2.00	3.00	0.667	1	0.581	Random
77. *Vagrans sinha sinha* (Kollar)	2.00	4.00	0.500	1	0.513	Random
78. *Ypthima sempera sempera*	0.50	5.50	0.091	1	0.761	Random
79. *Zethera pimple pimplea*	2.00	4.00	0.500	1	0.513	Random
80. *Appias albino semperi* (Moore)	12.50	12.50	1.000	1	0.319	Random
81.*Appias lyncida andrea* (Eschscholtz)	8.00	10.00	0.800	1	0.625	Random
82.*Appias maria maria* (Semper)	4.50	8.50	0.529	1	0.526	Random
83.*Appias nero domitia* (C & R) Felder	8.00	10.00	0.800	1	0.625	Random
84.*Appias olferna peducaea* Fruhstorfer	32.00	10.00	3.200	1	0.070	Random
85.*Appias phoebe phoebe* (C&R Felder)	8.00	10.00	0.800	1	0.625	Random
86.*Catopsilia pomona pomona* Fabricius.	2.00	9.00	0.222	1	0.643	Random
87.*Catopsilia pyranthe pyranthe* (Linnaeus)	8.00	10.00	0.800	1	0.625	Random
88.*Catopsilia scylla asema* Staudinger	12.50	9.50	1.316	1	0.250	Random
89.*Catopsilia scylla cornelia* Fabricius	32.00	9.00	3.556	1	0.056	Random
90.*Cepora aspasia olga* (Stall) Eschscholtz	12.50	7.50	1.667	1	0.193	Random
91.*Cepora boisduvaliana boisduvaliana* C&R Felder	24.50	8.50	2.882	1	0.085	Random
92.*Cepora judith olga* (Eschscholtz)	8.00	10.00	0.800	1	0.625	Random
93.*Delias baracasa benguetana* Inomata	0.50	8.50	0.059	1	0.804	Random
94.*Delias georgina georgina* C & R Felder	0.50	8.50	0.059	1	0.804	Random
95.*Delias henningia henningia* Eschscholtz	0.50	9.50	0.053	1	0.814	Random
96.*Delias hyparete luzonensis* C & R Felder	8.00	10.00	0.800	1	0.625	Random
97.*Eurema alitha jalendra* Fruhstorfer	40.50	10.50	3.857	1	0.047	Random
98. *Eurema hecabe hecabe* (Linnaeus)	18.00	9.00	2.000	1	0.153	Random
99. *Eurema hecabe tamiathis*	0.50	9.50	0.053	1	0.814	Random
100.*Gandaca harina mindanensis* Fruhstorfer 1910	18.00	9.00	2.000	1	0.153	Random
101.*Leptosia nina georgi* Frushtorfer	32.00	6.00	5.333	1	0.020	Aggregated
102.*Pareronia boebera boebera*(Eschscholtz)	24.50	8.50	2.882	1	0.085	Random
103.*Pieris canidia canidia* (Sparman)	2.00	9.00	0.222	1	0.643	Random
104. *Abisara echerius laura* Frushtorfer	0.00	1.00	0.000	1	0.000	Aggregated

Conclusions and recommendation

Diversity of butterflies in the open and close canopy in the dipterocarp forest of Cadaclan, San Fernando La Union Botanical Garden of North Luzon, Philippines is of fair level. Higher species level diversity was observed in open canopy with H'=1.957 close canopy H'=1.9333. Distribution of butterflies in LUBG is uneven. Only 6 species were common and are aggregate in assemblages while the remaining 98 species were at random or scattered distribution. Forest canopy, water sources and light penetration affects butterfly diversity and status in LUBG.

It is suggested that the remnant butterflies and native host and food plants be protected to conserve biodiversity not just of butterflies but also of other organisms and more studies on the effects of the sizes of flower blooms, varieties of plants, vegetation complexity and native host plants to the diversity, species composition and distribution of butterflies in LUBG.

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