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Species Diversity of Lepidoptera in *Mimbilisan* Protected Landscape, *Misamis* Oriental, Philippines

Don Mark Guadalquiver[1*], Olga M. Nuñeza[1], Aimee Lynn Dupo[2]

[1] Department of Biological Sciences, College of Science and Mathematics and Premier Research Institute of Science and Mathematics, MSU-Iligan Institute of Technology, Iligan City, Philippines.
[2] Department of Biology and Museum of Natural History, University of the Philippines, Los Banos, Laguna, Philippines.

ABSTRACT

Mimbilisan Protected Landscape in Balingoan and Talisayan, Misamis Oriental is a critical watershed forest that provides valuable ecological services to its host municipalities and nearby communities. This study aimed to determine the species diversity and endemism of Lepidoptera in the area. The method used was opportunistic sampling using sweep nets for a total of 130 person-hours. Three sampling sites were established. Ninety-two species of Lepidoptera comprising 62 butterflies and 30 moths under 14 families and 76 genera were documented. The most abundant family observed was Nymphalidae (113 individuals, 28 species). The riparian area was found to host the most number of species and individuals (65 species and 161 individuals) due to its open canopy. High diversity was recorded in all three sampling sites (H'=3.173-3.846). Among the documented lepidopterans 22 were endemic butterflies of which five occurred exclusively in Mindanao. The presence of a high number of endemic species and the high level of diversity in Mimbilisan Protected Landscape indicated its importance as a habitat for lepidopterans and the need for continued conservation and management of the protected area.

Keywords: *Butterflies, Endemic, Moths, Nymphalidae, Riparian.*

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Corresponding author: Don Mark Guadalquiver
E-mail ✉ donmark.guadalquiver @ g.msuiit.edu.ph
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INTRODUCTION

Lepidoptera, which includes butterflies, moths, and skippers constitutes the second largest order in class Insecta with about 150,000 species in 135 families. [1, 2] In the adult stage, the large wings of Lepidoptera, which are covered with minute overlapping scales often produce distinctive color patterns. [2]

Lepidoptera forms an essential part of most terrestrial ecosystems. Both butterflies and moths are important pollinators of flowering plants since butterflies act as diurnal pollinators of flowers while moths are the major nocturnal pollinators. [1] They are also widely recognized as potential ecological indicators due to their sensitivity to any change in their habitats, atmosphere, local weather, and climate. [3] In addition, larvae and adults are major food sources for many other animals, including songbirds, bats, and other insects. [2]

For numerous taxa, species richness is much higher in the tropics than in temperate zone habitats. [4] As a tropical country, the Philippines exhibits abundant diversity of plants and animals and is even regarded as a megadiverse country yet is also a hotspot facing serious threats to biodiversity loss. [5] Habitat fragmentation, climate change, and agrochemical use threaten the lepidopteran fauna. [6] Several studies have been conducted to assess the status

of Lepidoptera, such as those in San Fernando La Union botanical garden, Northern Philippines, [7] Tandag, Surigao del Sur, [8] Mt. Timpoong and Mt. Hibok-Hibok, [9] and Mt. Hamiguitan, Davao Oriental, and Camiguin Island. [10] These studies have discovered a high species diversity of Lepidoptera indicating the need for habitat conservation and protection. Yet, many areas still await exploration especially in Mindanao, where many primary forests have been reduced for livelihood purposes. [10] One of the biologically unexplored areas in Mindanao is the Mimbilisan Protected Landscape in Misamis Oriental, which was declared as a protected landscape by reasons of its unique physical and biological significance. No records of Lepidoptera have been ever made despite its being a protected landscape and a critical watershed that provides valuable ecological services to its host municipalities and nearby communities. Thus, this study was conducted to assess the species diversity and endemism of Lepidoptera in Mimbilisan Protected Landscape.

MATERIALS AND METHODS

Study area

The study was conducted in Mimbilisan Protected Landscape (MPS) (Figure 1) located at 08° 56.928" N; 124° 51.914" E in the municipalities of Balingoan and Talisayan, Misamis Oriental in Northern Mindanao, Philippines. The protected landscape, consisting of 66 hectares, has an extensive forest and a maximum elevation of 535 meters above sea level (masl). The area is characterized by hills and low-lying mountains forming a gorge-like shape with Mindocdocan Creek at its base. The adjacent moderately steep slopes permit agricultural activity.

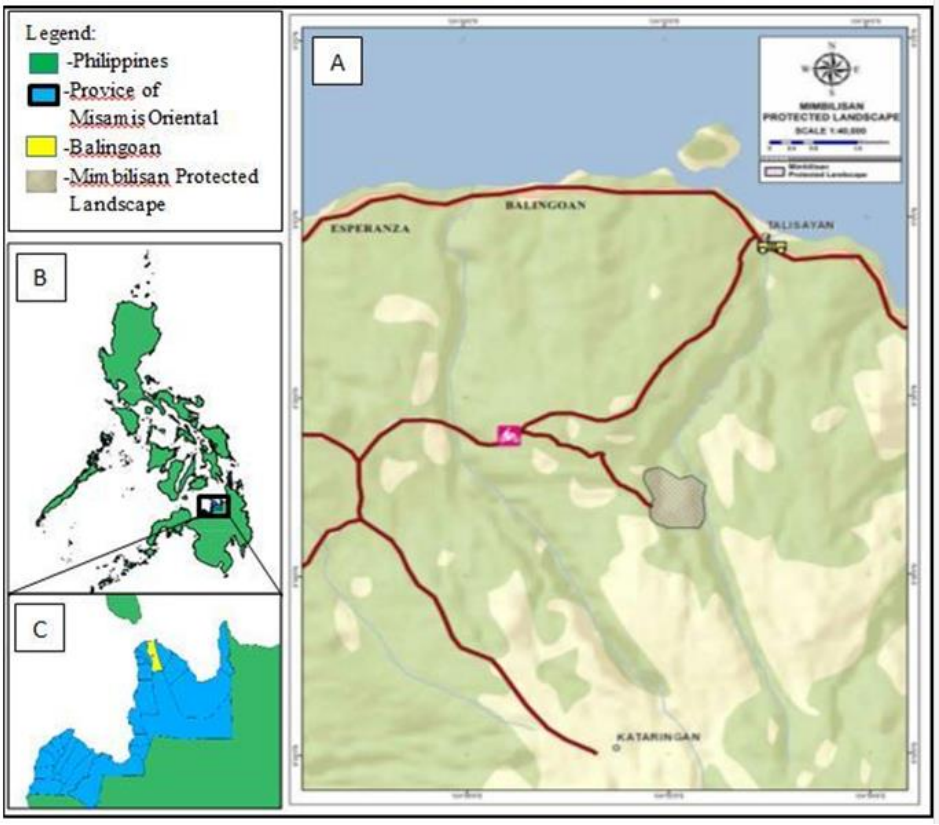

Figure 1. The location of Mimbilisan Protected Landscape (A) [11] shown in the map of the Philippines (B), province of Misamis Oriental, and the municipality of Balingoan (C) (Field GIS, 2017).

Sampling Sites

Three sampling sites were established. The first site (8.56820°N, 124.52042°E) is a mixed dipterocarp forest with secondary growth vegetation and mountainous slopes. The canopy cover is mostly composed of red lauan (*Shorea negrosensis*), white lauan (*Shorea contorta*), narra (*Pterocarpus indicus*), mahogany (*Swietenia mahogani*), "dao" (*Dracontomelon dao*), "tobog" (*Artocarpus sericarpus*), and "kaya kaya" (*Ficus-gul*). There also are epiphytes such as arboreal ferns and canopy vines. The rattan (*Calamus sp.*),

"mantawasi" (*Costus igneus*), and "pugahan" (*Caryota mitis*) composed the understory while a variety of plants like "dalily" (*Schismatoglottis calyptrata*) and ferns serve as ground cover. The distance to anthropogenic clearing is 450 meters. There are no on-site disturbances aside from trails used by locals to access the river.

The second site (8.9487°N, 124.8688°E) is located across the creek or the left side of the landscape, which is composed of mixed dipterocarp forest and the adjacent area dominated by coconuts (*Cocos nucifera*), cogon grass, ferns, and sedges. The area has secondary vegetation and mountainous slope. The forested area's emergent tree is white lauan (*Shorea* sp.). Canopy trees include red lauan (*Shorea negrosensis*), white lauan (*Shorea contorta*), "tanguile" (*Shorea polysperma*), "lagaklak" (*Dipterocarpus valida*), and "salin-ubod" (*Ficus benjamina*). Understory plants in the area include "barobo" (*Diplodiscus paniculatus*), "rattan" (Family Arecaceae), *Daemonorops chrysolepis*, *Calamus caryota,* and *Calamus mitis.* "Dalili" (*Schismatoglottis calyptrata* dominates is the ground cover plant. A small stream that eventually unites with the river flows by the forested area. There are no on-site disturbances aside from the trails. The distance to anthropogenic clearing is 1 km.

Site 3 is a riparian area that separates the two sampling sites and is located between the coordinates of 08°56.574' North; 124°52.059' East to 08°56.924' North; 124°52.062' East. The most common canopy taxa are *Dracontomelon dao*, *Bosscheria minahassae*, and "barobo" (*Diplodiscus paniculatus*). The emergent tree is "magkuno" (*Xanthostemon verdugonianus*). Understory plants include bamboo, "salin-ubod" (*Ficus benjamina*), "hanopol" (*Poikilospermum suaveolens*), *Clerodendrum paniculatum*, *Alocasia princeps, Aglaonema nitidum*, "gabi", *Pandanusyvanii,* and *Cheilocostus speciosus.* An open canopy characterized most of the area. Exposed boulders (due to the dry river) covered with moss are also abundant. There is a distance of 800 meters from the anthropogenic clearing.

Collection, Processing, and Identification of Samples

Samples were collected by opportunistic sampling using sweep nets, a method used by recent Lepidopteran studies such as those by Nuñeza *et al*. [12] and Mangaoang *et al*. [13] Sampling was conducted for 10 field days on July 17-21 and July 23-28, 2017 at 800 hours-1600 hours for a total of 130 person-hours. A maximum of three voucher specimens was taken per species that were not readily identified in the field, while the rest were released after identification or when they were readily identifiable even when they were flying. The collected samples were placed in a glassine paper and in clear plastic containers with naphthalene balls to avoid insect infestation. Photographs of each species were taken for documentation. Identification and subsequent determination of endemism were made through the use of the website Philippine Lepidoptera. Identification of the moths was verified by the third author.

Statistical analysis

Paleontological Statistics (PAST) software package ver.3.17 was used to determine biodiversity indices such as species richness, abundance, Shannon-Weiner index, evenness, and dominance.

RESULTS AND DISCUSSION

Species Composition

Ninety-two species of Lepidoptera with 291 individuals were collected comprising 62 species of butterflies and 30 species of moths representing 14 families and 76 genera. The number of butterfly species in Mimbilisan Protected landscape was lower than those at Mt. Hamiguitan, [10] Mt. Timpoong, Camiguin Island, [9] Key Biodiversity Areas (KBAs) of Mindanao, [14] Tandag, Surigao del Sur, [8] La Union Botanical Garden (LUBG) of Northern Luzon, [7] and Namdapha Tiger Reserve, India. [3] The species richness of moths in Sunderban Biosphere Reserve, India, and Motuban forest Croatia was also higher than the species richness in Mimbilisan Protected Landscape. [15, 16] This may be due to the differences in employed sampling techniques, duration of sampling, and a much larger study area (except the study in La Union Botanical Garden, Northern Luzon) with richer and more varied vegetation types.

On the other hand, Mimbilisan's butterfly species richness was significantly higher than those at Caraga, Davao Oriental, [13] Bega Watershed, Agusan del Sur, [12] Olib and Scedro Islands, Croatia, [17] Mt. Hibok-Hibok, Camiguin Island, [9], Jhagadia, India, [18] Lipa City, Batangas, [7] Gibraltar, [19] and Bulusukan, Bataan, Philippines. [20] The moth species richness was also

higher than those in Olib and Scedro Islands, Croatia [17] and in Bega Watershed. [12] These studies mostly employed opportunistic sampling collection (except Toledo and Mohagan [9]) and the sampling was done over a short period of time involving only days or weeks (except Kumar [18]); thus the study samples were more similar in nature. The area of Mimbilisan is also quite small but has shown to host a rich number of lepidopteran species. This could mean that Mimbilisan Protected Landscape is a preferred habitat for a number of lepidopterans and is able to sustain their needs. The high species richness was observed to be due to the lack of disturbance in the area accorded by its protected status, the type of vegetation, and the availability of larval host plants, which also agrees with the finding of Rajagopal et al. [21]

Table 1 shows the list of lepidopteran species with their occurrence in each site. Most of the specimens were collected and observed in the riparian area (site 3) where 65 species and 161 individuals were recorded. On the other hand, nearly the same number of species was recorded in both forest sites (33 species and 67 individuals in forest site 1 and 31 species and 63 individuals in forest site 2), with forest site 1 having slightly higher species richness than the other.

The result is similar to the previous findings of Nuñeza *et al*. [12] at Bega Watershed, Agusan del Sur and Fitzherbert *et al*. [22] at Katavi National Park, western Tanzania wherein open riverine habitats have the most number of species and individuals. This also coincides with Vu and Quang Vu's [23] observation

Table 1. Species composition, distribution, and relative abundance of Lepidoptera in Mimbilisan Protected Landscape.

Taxon	Sampling Sites			Total	RA(%)
	Mixed Dipterocarp Forest (S1)	Mixed Dipterocarp Forest and agroeco-system (S2)	Riparian Area (S3)		
BUTTERFLIES					
I. Hesperidae					
1. *Ancistroides nigrita fumatus* Mabille 1876	1	5	1	7	2.41
2. *Choaspes adhara boreus* de Jong & Treadaway 1993	0	0	1	1	0.34
3. *Halpe luteisquama* * Mabille 1876	0	0	1	1	0.34
4. *Tagiades japetus titus* Plötz 1884	0	1	0	1	0.34
5. *Tagiades trebellius martinus* Plötz 1884	1	0	2	3	1.03
II. Lycaenidae					
6. *Allotinus fallax eryximachus* Fruhstorfer 1913	0	0	2	2	0.69
7. *Arhopala theba* * Hewitson 1863	0	4	0	4	1.37
8. *Caleta argola argola* Hewitson 1876	0	1	0	1	0.34
9. *Cheritra orpheus orphnine* * Cowan 1967	2	1	8	11	3.78
10. *Curetis nesophila* Felder 1862	0	0	1	1	0.34
11. *Drupadia niasica florens* Cowan 1974	0	2	1	3	1.03
12. *Ionolyce helicon merguiana* Moore 1884	0	0	1	1	0.34
13. *Jamides celeno lydanus* Fruhstorfer 1910	3	3	10	16	5.5
14. *Jamides espada sabatus* Fruhstorfer 1915	0	0	2	2	0.68
15. *Jamides* sp.	3	2	9	14	4.81
16. *Nacaduba limbura* * Fruhstorfer 1916	0	1	0	1	0.34
17. *Tajuria jalajala* * C. & R. Felder, 1862	0	1	1	2	0.69
III. Nymphalidae					
18. *Acrophtalmia leto ochine* * Semper 1887	0	1	1	2	0.69
19. *Amathusia phidippus pollicaris* Butler 1870	0	0	1	1	0.34
20. *Cethosia luzonica magindanaica* ** Semper 1888	0	0	1	1	0.34
21. *Cupha arias arias* C.& R. Felder 1867	0	0	1	1	0.34
22. *Cyrestis maenalis maenalis* Erichson 1834	0	0	1	1	0.34
23. *Danaus melanippus edmondii* Lesson 1837	0	1	3	4	1.37
24. *Dichorragia nesimachus peisistratus* Fruhstorfer 1913	1	0	0	1	0.34
25. *Euploea mulciber mindanensis* Staudinger 1885	1	0	0	1	0.34

Continuation of Table 1. Species composition, distribution, and relative abundance of Lepidoptera in Mimbilisan Protected Landscape.

26. *Faunis phaon leucis* * Felder & Felder, 1861	10	5	0	15	5.15
27. *Hypolimnas anomala anomala* Wallace 1869	0	1	2	3	1.03
28. *Hypolimnas bolina philippensis* Butler 1874	0	0	4	4	1.37
29. *Ideopsis juventa manillana* Moore 1883	3	3	1	7	2.41
30. *Junonia hedonia ida* Cramer 1775	0	0	7	7	2.41
31. *Lexias panopus boholensis* Okano & Okano, 1988	1	1	0	2	0.69
32. *Melanitis atrax lucillus* * Fruhstorfer 1908	1	1	1	3	1.03
33. *Moduza pintuyana pintuyana* * Semper 1878	0	0	1	1	0.34
34. *Mycalesis* sp.*	0	1	0	1	0.34
35. *Neptis cyra vibusa* * Semper 1889	6	6	5	17	5.84
36. *Polyura athamas acuta* Rothschild 1899	0	0	6	6	2.06
37. *Ptychandra leucogyne* Felder & Felder 1867	3	2	1	6	2.06
38. *Ragadia melindena melindena* * Felder & Felder 1863	0	0	3	3	1.03
39. *Rhinopalpa polynice stratonice* C. & R. Felder 1867	0	0	7	7	2.41
40. *Symbrenthia hippoclus galepsus* Fruhstorfer 1908	0	0	1	1	0.34
41. *Tacola magindana magindana* * Semper 1878	0	0	1	1	0.34
42. *Tanaecia leucotaenia aquamarina* ** Fruhstorfer 1912	0	1	0	1	0.34
43. *Tarattia cosmia cosmia* * Semper 1878	4	5	4	13	4.47
44. *Ypthima sempera chaboras* * Fruhstorfer 1911	2	0	0	2	0.69
45. *Zeuxidia sibulana sibulana* ** Honrath 1884	0	0	1	1	0.34
IV. Papilionidae					
46. Achillides palinurus daedalus C.& R. Felder 1861	0	0	1	1	0.34
47. *Lamproptera meges decius* C.& R. Felder 1862	0	0	6	6	2.06
48. *Graphium agamemnon agamemnon* Linnaeus 1758	0	0	3	3	1.03
49. *Graphium sarpedon colus* Fruhstorfer 1907	0	0	2	2	0.69
50. *Menelaides deiphobus rumanzovia* Eschscholtz 1821	0	1	3	4	1.37
51. Menelaides helenus hystaspes C.& R. Felder 1862	0	0	4	4	1.37
52. *Menelaides polytes ledebouria* Eschscholtz 1821	0	0	3	3	1.03
V. Pieridae					
53. *Appias nero domitia* C.& R. Felder 1862	0	0	1	1	0.34
54. *Cepora aspasia orantia* Fruhstorfer 1910	0	0	1	1	0.34
55. *Delias henningia ochreopicta* Butler 1869	1	0	0	1	0.34

Continuation of Table 1. Species composition, distribution, and relative abundance of Lepidoptera in Mimbilisan Protected Landscape.

56. *Eurema alitha alitha* Felder & Felder 1862	0	1	0	1	0.34
57. *Eurema blanda vallivolans* Butler 1863	0	0	3	3	1.03
58. *Eurema hecabe tamiathis* Fruhstorfer 1910	1	4	4	9	3.09
59. *Eurema sarilata sarilata* * Semper 1891	0	0	1	1	0.34
60. *Gandaca harina* Horsfield 1829	1	3	2	6	2.06
61. *Pareronia boebera trinobantes* ** Fruhstorfer, 1911	4	2	3	9	3.09
VI. Riodinidae					
62. *Abisara mindanaensis mindanaensis* ** Semper 1892	0	0	1	1	0.34
MOTHS					
VII. Callidulidae					
63. *Callidula sumatrensis* Pagenstecher 1887	3	0	0	3	1.03
64. *Tetragonus catamitus* Geyer 1832	1	0	0	1	0.34
VIII. Crambidae					
65. *Nevrina procopia* Stoll 1781	0	0	1	1	0.34
66. *Marasmia patnalis* Bradley 1981	0	0	1	1	0.34
67. Unidentified *Crambidae*	0	0	1	1	0.34
IX. Erebidae					
68. *Agape* sp.	1	0	0	1	0.34
69. *Barsine* sp.	0	0	2	2	0.69
70. *Diduga* sp.	0	0	1	1	0.34
71. *Erebus macrops* Linnaeus 1768	0	0	1	1	0.34
72. *Hulodes caranea* Cramer 1782	1	0	0	1	0.34
73. *Ischyja* sp.	1	0	0	1	0.34
74. *Nyctemera baulus integra* Walker 1866	1	0	0	1	0.34
75. *Nyctemera coleta* Cramer 1781	1	0	0	1	0.34
76. *Phyllodes verhuelli* Vollenhoven 1858	0	0	1	1	0.34
77. Unidentified *Eribidae: Arctiinae*	0	0	1	1	0.34
78. Unidentified *Eribidae:Arctiinae: Syntomini*	3	0	0	3	1.03
79. Unidentified *Erebidae: Herminiinae*	1	0	0	1	0.34
80. Unidentified *Erebidae: Lymantriinae*	1	0	0	1	0.34

Continuation of Table 1. Species composition, distribution, and relative abundance of Lepidoptera in Mimbilisan Protected Landscape.

X.Geometridae					
81. *Alex palparia* Walker 1861	0	0	1	1	0.34
82. *Bytharia uniformis* Swinhoe 1902	0	0	1	1	0.34
83. *Comibaena* sp.	1	0	0	1	0.34
84. *Eumelea rosalia* Stoll 1781	0	1	0	1	0.34
85. *Hyposidra leucomela* Walker 1866	0	1	3	4	1.37
86. *Pareumelea hortensiata* Guenée 1857	1	0	0	1	0.34
87. *Petelia* sp.	0	0	1	1	0.34
88. *Tanaorhinus viridiluteata* Walker 1861	1	0	0	1	0.34
XI. Noctuidae					
89. Unidentified *Noctuidae*	0	0	1	1	0.34
XII. Nolidae					
90. *Westermannia* sp.	0	0	1	1	0.34
XIII. Uraniidae					
91. *Lyssa zampa* Butler 1869	1	0	5	6	2.06
XIV. Zygaenidae					
92. *Chalcosia nyctemeroides* Semper 1898	1	0	1	2	0.69
Total number of individuals	**67**	**63**	**161**	**291**	
Total number of species	**33**	**30**	**65**	**92**	
Philippine endemic	**6**	**13**	**13**	**17**	
Mindanao endemic	**2**	**2**	**3**	**5**	
Total number of endemics	**8**	**15**	**16**	**22**	

Legend: RA-Relative abundance
*Philippine Endemic
**Mindanao Endemic

That the proportion of common species tends to increase from the natural forest to the streamside. Accordingly, the distribution and abundance of each species can be determined by the combination of many physical and abiotic variables required for the survival and reproduction of their individuals. [24] The characteristic of the riparian area is its open canopy where sunlight can easily penetrate. According to Nacua *et al*., [7] high abundance and richness of the butterflies can be seen in open canopies as light penetrates the area for plant growth and allows a variety of food plants, enabling butterflies to thrive. Being cold-blooded insects, butterflies also prefer sunlit areas as this allow them to optimize their physiological processes and warm their muscles to enable themselves to fly. [25] Day-flying moths are also said to be abundant in sunny areas while nocturnal moths prefer more open habitat conditions. [26]

Visitation of mud puddles and patches of moist soil, a phenomenon called puddling, is also common among many lepidopterans. [27] Thus, the stream provides many puddling areas for the species in which they obtain salts and minerals needed for reproduction. [28, 29] This had been observed several times in the area especially with members of family Pieridae. Persistence of the dryness of the stream, observed during sampling despite the wet season, might

be detrimental to the lepidopterans. As Fitzherbert *et al*. [22] reported, the protection of water sources is important as water sources provide important conservation service for invertebrates including lepidopterans.

The two other sampling sites were the forested areas at the left and right side of the Mindocdocan creek. The first forested site was a mixed dipterocarp forest with secondary vegetation, which was the first to be encountered upon entrance to the area. The second site was a mixed dipterocarp forest with secondary vegetation but it included an adjacent agroecosystem, which was an open canopy area, densely occupied by coconut trees, ferns, sedges, and cogon grass. There was also a small stream, eventually connected to the river in the riparian area. Both these sites had a lower number of species and individuals than the riparian area because of the less sunlight that penetrates the area. However, they also host species that are habitat-specific and restricted to dark canopy areas such as those of the subfamily Morphinae. In addition, there also was difficulty in sampling the area because of the steep slopes that limited sampling activity to a few plain areas or to the trails that run through the forest. When comparing the two forested areas, sampling site 1, forested area, had a moderately higher number of species and individuals than site 2, forested area, although the species' richness and abundance would have favored site 2 because of the more varied habitat and the presence of open canopy and water supply. [7, 20, 29] This may be due to difficulty in the access of site 2 and limited time thus leading to a lower sampling effort. In contrast, the easy access to site 1 being the passageway to other sites facilitated sampling and led to a greater sampling effort.

Among the different documented species, the most abundant was *Neptis cyra vibusa,* commonly called as 'sailer' accounting to 17 individuals or 5.84% of the total individuals of Lepidoptera collected. This species is a Philippine-endemic [30] and was collected from all sampling sites. This can mean that this butterfly thrives well in the area. Another very abundant butterfly in the area was the Common Cerulean or *Jamides celeno lydanus* with a relative abundance of 5.5%. It was mostly seen in the riparian area but it was also observed in the forested sites. *Faunis phaon leucis* was also very abundant in the area with 5.15% relative abundance. This species is a weak flyer that can only be seen in the forested area flying low on the ground or over "dalily" (*Schismatoglottis calyptrata*) plants as it prefers the dark understory of the forest. This species can be found only in Mindanao and Basilan Islands. [30]

Figure 2 shows that the butterflies are represented by six families: Hesperidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, and Riodinidae. Nymphalidae had the most number of species and individuals (28 and 113, respectively) while Riodinidae had the least with only a single species and individual. Similar results were obtained in the studies of Mangaoang *et al*., [13] Ramirez Restrepo *et al*., [24] Nidup *et al*., [31] and Toledo and Mohagan [9] wherein Nymphalidae dominated. Nymphalidae is the largest family of butterflies in the world with over 6,000 species; [32] so, this explains its dominance in the area. Aside from that, Nymphalid butterflies can feed on different types of food, which makes them able to live in all types of habitats, as observed in the study of Padhye et al. [33] Thus, the members of the Nymphalidae family dominate especially in the tropical areas. [34]. However, only three species of Riodinidae occur in Mindanao and are usually confined in higher elevation, [30] but in this study, only a single species was recorded.

The collected diurnal moths were from eight families: Callidulidae, Crambidae, Eribidae, Geometridae, Noctuidae, Nolidae, Uranidae, and Zygaenidae. Among these families, Eribidae, Geometridae, Noctuidae, and Uranidae are the ones documented in Olib and Scedro Islands, Croatia, [17] Biñan City, Laguna, [35] Northeast of Mt. Malindang range, [36] Mt. Balatukan, [37] and at Bega Watershed. [12] Most of the species were from the family Erebidae (13 species and 16 individuals). The dominance of Erebidae can be attributed to its large diversity, which is abundantly found in diverse habitats. It is the largest family of moths, worldwide, which contains 24,569 species belonging to 18 subfamilies. [16]

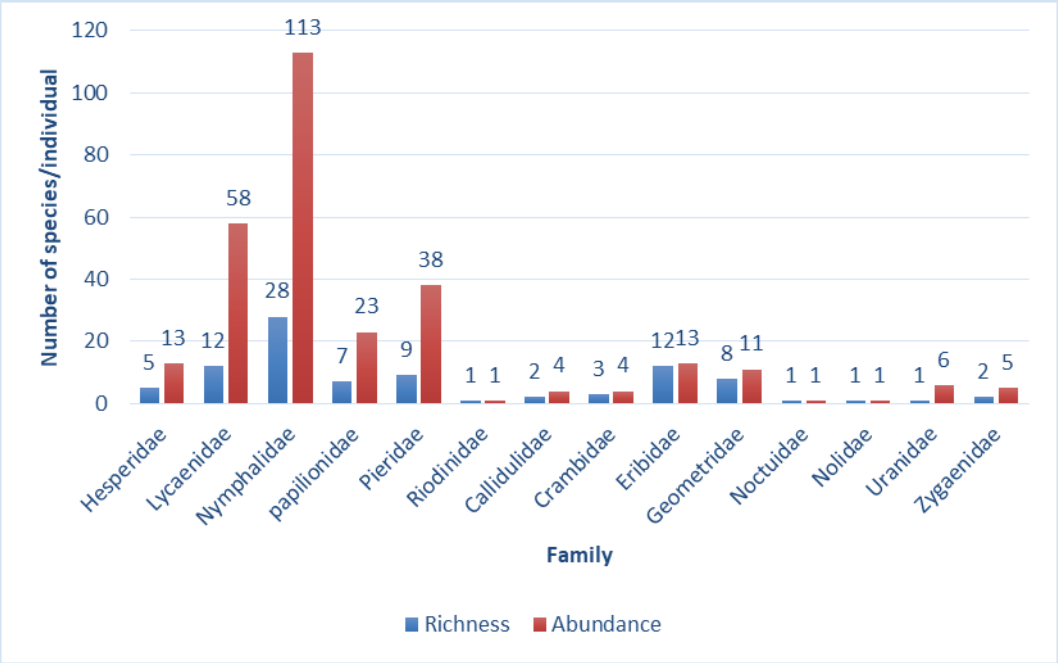

Figure 2. Species richness and abundance in different families.

Endemism and Conservation status

Figure 3 shows the number of endemic lepidopterans according to the sampling site. Among the 62 collected species of butterflies, 17 or 27.42% were Philippine endemic as follows: *Acrophtalmia leto ochine, Arhopala theba, Cheritra orpheus orphnine, Eurema sarilata sarilata, Faunis phaon leucis, Halpe luteisquama, Melanitis atrax lucillu, Moduza pintuyana pintuyana, Mycalesis* sp. *Nacaduba limbura, Neptis cyra vibusa, Ptychandra leucogyne, Ragadia melindena melindena, Tacola magindana magindana, Tajuria jalajala, Tarattia cosmia cosmia, and Ypthima sempera chaboras.* Moreover, five or 8.06% were endemic to the island of Mindanao as follows: *Abisara mindanaensis mindanaensis, Cethosia luzonica magindanaica, Pareronia boebera trinobantes, Tanaecia leucotaenia aquamarina,* and *Zeuxidia sibulana sibulana*. Of these endemic species, eight occurred in the forested site 1, 15 occurred in the forested area 2, and 16 were documented in the riparian site. On the other hand, no species of moth in Mimbilisan was endemic in the country.

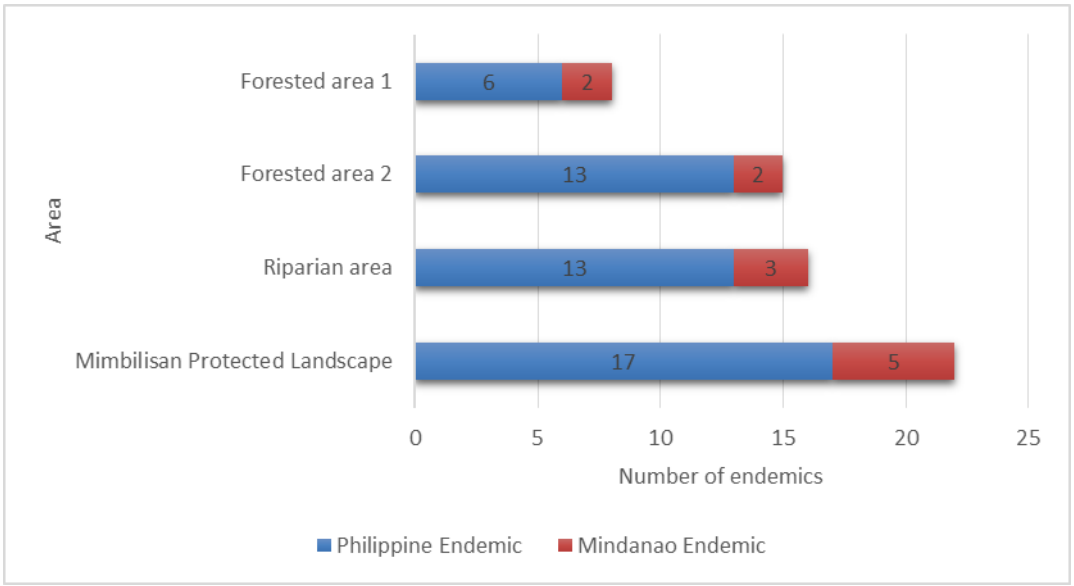

Figure 3. The number of endemic species of Lepidoptera according to sampling station in Mimbilisan Protected Landscape.

Overall, 18.47% or 17 species of lepidopterans in Mimbilisan Protected Landscape were Philippine-endemic while 5.43% or 5 species were Mindanao-endemic. This brings to total endemism of 24.73% (22 of 93 species), which is higher compared to Mt. Timpoong (18 endemics), Mt Hibok-Hibok (8 endemics), [9] Mt. Balatukan (15 endemics), [37] Tandag, Surigao del Sur (18 endemics), [8] and Mt. Kalatungan (17 endemics). [37] This shows that Mimbilisan Protected Landscape is a favorable habitat for these endemic species. This could be because of the lack of disturbance in the area [38] accorded by its being a protected landscape. As reported by Bae and Park [39] and Saloma, [38] endemic species prefer the least disturbed areas such as mountainous areas especially those with little urbanization and extensive forest watersheds. Owing to the fact that they are restricted to a small geographical range, endemic species are particularly rare and vulnerable to threats of extinction. [40] The presence of endemic species in Mt. Mimbilisan shows the importance of the protection and conservation of the area as it sustains species that exist only in the Philippines and even in Mindanao. However, No species of Lepidoptera is listed as threatened according to the IUCN Red List of Threatened species. [41]

Biodiversity Indices

Table 2 shows that all the three sites have moderate evenness with values nearer to one. [42] Station 2 has the highest evenness value followed by stations 1 and 3. This implies that station 2 has the most prevalent distribution of lepidopterans in the area. Evenness is said to have a positive effect on productivity by increasing the representation of each species. Moreover, it controls the variation of traits represented in a community thereby influencing the richness effect. [43, 44] Meanwhile, forested site 1 had the highest dominance index because of the presence of a dominant species, *Faunis faun leucis* (14.9%) that is due to the closed canopy environment of site 1, as the favored habitat of the said species.

Table 2. Biodiversity indices of Lepidoptera in Mimbilisan Protected Landscape.

	Site 1 (Mixed Dipterocarp Forest)	**Site 2** (Mixed Dipterocarp Forest and Agroecosystem)	**Site 3** (Riparian Area)
Taxa	33	30	65
Individuals	67	62	161
Dominance	0.05591	0.05099	0.0282
Shannon	3.199	3.173	3.846
Evenness	0.7423	0.7958	0.7202

Among the three sites, site 3 or the riparian area was the most diverse with a diversity value of 3.8462 indicating high diversity. According to Richardson, [44] Shannon-Wiener value of >3 represents high diversity, values lower than 1 represent low diversity, and values between 1 and 3 are implications of moderate diversity. The high diversity of the riparian area can be attributed to several factors. The open canopy in the area provided a good spot for lepidopterans to bask and warm themselves with much-needed sunlight for energizing their wings for flight. [20, 25] This makes it more appealing to lepidopterans than the area of natural forest where a close canopy provides little or minimal sunlight. Furthermore, Vu and Quang Vu [23] reported that environment along streams and wetlands attracts lepidopterans as it is especially diversified with vegetation, rock, sand, and water in which lepidopterans land to take the nutrients and water that they need hence supporting the diversity of the riparian area in this study. The study of Highland *et al*. [45] on moth diversity also showed that riparian forests are more stable and predictable communities for moths since these communities have less inter-annual variability. This makes the riparian area an important habitat for lepidopterans. Nonetheless, the two other sites are still considered as areas with high diversity (>3) having values of 3.199 and 3.173 for sites 1 and 2, respectively. Thus, the area of Mimbilisan Protected Landscape is an area with a high-diversity for lepidopteran fauna as a whole. This can be attributed to the land cover characteristics and availability of diverse plants and access to host plants in the area. [46] As observed, many common understory plants in the area such as "salinubod" (*Ficus benjamina*), "hanopol" (*Poikilospermum suaveolens)*, "pugahan" (*Caryota mitis-murag anahaw*), "narra" (*Pterocarpus indicus*), *Calamus* sp., and *Cheilocostus speciosus* are important larval food plants for lepidopterans. [47-49] Nectar plants were also present in the area such as the Pagoda flower or *Clerodendrum paniculatum,* the most notable nectar plant especially in the riparian area commonly visited

by papilios and lycaenids. *Lantana camara, Mimusa pudica, Stachytarpheta jamaicensis,* and *Strongylodon* sp. [49-51] were also abundant fruit-bearing taxa including *Artocarpus odoratissimus*, *Artocarpus heterophyllus*, *Lansium parasiticum,* and 'balingbing' (*Averrhoa carambola*), present in the area and can also serve as food sources. Thus, it can be seen that habitat heterogeneity plays a significant role in the diversity of Lepidoptera. Moreover, in the study of Padhye *et al*., [33], habitat-wise assessments showed that the maximum species diversity and high endemism could be found in undisturbed natural habitats such as evergreen forest, deciduous forest, and riparian habitats. The absence of disturbance in the area provides a stable habitat for diverse species to thrive. As the studies have suggested, butterfly species diversity generally increases with the increase in vegetation and declines in disturbance. [21, 22]

CONCLUSION

Mimbilisan Protected landscape is the home of at least 92 species and 291 individuals of lepidopterans with the riparian area hosting the most number of species and individuals. Nymphalidae is the most abundant and rich family with 113 individuals and 28 species and *Neptis cyra vibusa* (5.84%), a Philippine-endemic, is the most abundant species. 22 of the 62 butterflies are endemic wherein 17 are Philippine-endemics and five are Mindanao-endemics. Shannon-Wiener diversity index showed that all three sampling sites have a high diversity of Lepidoptera (H'=3.173-3.846), the riparian area being the most diverse, attributed to its undisturbed nature and presence of extensive vegetation cover of larval host plants and food plants. The presence of a high number of endemic species, which are mostly vulnerable to threats, and the high level of diversity in the area indicate the great importance of the area as habitat for lepidopterans.

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Conflict of Interest

The authors declare no conflict of interest in the conduct of this study.

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