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Species Diversity of Lepidoptera in Western Mindanao State University – Experimental Forest Area, *Zamboanga* City, Philippines

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ABSTRACT

Moths and butterflies belonging to Lepidoptera are considered biological indicators of human disturbances in tropical forests. This study aimed to determine the species diversity of Lepidoptera in Western Mindanao State University – Experimental Forest Area, Zamboanga City. Six sites were sampled for 126 person-hours. An opportunistic sampling method using sweep nets was employed. PAST software version 3.0 was used to determine biodiversity indices. Thirty-nine species consisting of 23 species of butterflies and 16 species of moth from eight families were recorded. The family Nymphalidae was dominant, most abundant, and had the highest species richness mainly due to its polyphagous nature. *Eurema hecabe tamiathis* was the most distributed and most abundant species (13.57%) which means that it can thrive in different types of habitats. *Idea electra* was the only Lepidoptera species categorized as vulnerable. Sampling site 4, a secondary dipterocarp forest, was the most diverse (H'=2.993), most abundant (30.00%), and with the highest species richness (S=23). The results showed that WMSU-EFA had a relatively moderate diversity (H'=2.2625) attributed to its diverse vegetation. There was no dominant species since the distribution in all sampling sites was even. Threat observed that can affect the Lepidoptera diversity of the sampling area was severe anthropogenic clearing.

Keywords: *Butterflies, Dipterocarp, Indicators, Moth, Nymphalidae.*

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INTRODUCTION

Species belonging to Lepidoptera live in interaction with many plant [1] and animal species [2]. Lepidoptera, which consists of moths and butterflies [3, 4], is a plant-feeder during its larval stage and nectar-feeder or fruit-feeder in its adult stage [3]. Both stages are almost highly dependent on vascular plants. This makes it an important herbivore and pollinator in the ecosystem [5]. Larval instars of butterflies and moths are with chewing type mouthparts [6, 7]. Also, Lepidoptera is considered a better biological indicator because of its sensitivity to environmental changes [8, 9]. It has over 157,424 known species worldwide [10] and with this number, it actually is the second largest order of Insecta, surpassed only by the beetles [11].

Nöske et al. [12] reported 282 species and 829 species of arctiid and geometrid moth species, respectively, in southern Ecuador. One hundred twenty-seven species in Kaya Muhaka, 56 species in Kaya Kinondo, and 77 butterfly species in Kaya Diani, all in Kaya forests in southern Kenya, were discovered by Lehmann and Kioko [13]. In the Atlantic Forest of Southeastern Brazil, Uehara-Prado et al. [14] recorded 70 butterfly species from six subfamilies of Nymphalidae (fruit-feeders) and concluded that forest fragmentation can affect fruit-feeding butterflies but not as severe that it can cause an obvious change on species diversity. In Asia, particularly Sabah, Borneo, a similar study, but on selective logging instead of forest fragmentation, was conducted by Dumbrell and Hill [15]. They sampled 58 species, also from Nymphalidae and concluded, based on ground-level data, that there is no

significant difference in species diversity between primary and selectively logged forests even though the primary forest is more diverse than the selectively logged one. In Poring Hill Dipterocarp Forest, also in Sabah, 1,169 macromoth species were documented by Abang and Karim [16] and found that the species diversity was very high due to a higher habitat diversity of their sampling area. Majumder et al. [17] recorded 59 butterfly species in Trishna Wildlife Sanctuary in northeast India and stated that butterflies under Nymphalidae are the dominant species in the said area. This is because they are active fliers and have polyphagous nature, enabling them to survive in different types of habitats. Kudavidanage et al. [18] reported 120 species of butterflies in Sri Lanka. As expected, tropical rainforests have very high species diversity [16]. However, research studies on Lepidoptera diversity in the tropical regions are still very few [19] regardless of all the related studies mentioned above.

The Philippines, a tropical country, is also home to a diverse group of Lepidoptera. However, there are only a few biological records on Lepidoptera in Mindanao, which is the second largest island in the country [20]. Among these studies in Mindanao are those conducted in Mt. Hamiguitan, Davao Oriental [21], Bega Watershed, Agusan del Sur [20], Tandag, Surigao del Sur [22], and Mt. Timpoong and Mt. Hibok-hibok, Camiguin Island [23]. Despite these records, no lepidopteran study was conducted in Western Mindanao State University - Experimental Forest Area, the present study area.

METHODOLOGY

Study Area

Sampling was conducted in the experimental forest area of Western Mindanao State University located in Upper La Paz, Zamboanga City (Fig. 1). This is located in the southwestern part of Mindanao Island and is 26 kilometers away from the city proper. The land area of the forest is a total of 1277 hectares. The lowest point is about 600 meters above sea level (masl), located in the southwest, and the highest point is in the northern part at 1200 masl. The area is covered with diverse vegetation. The dominant tree species found are predominantly dipterocarps. There are also abundant non-tree species like rattan, vines, orchids, ground grasses, ferns, etc.

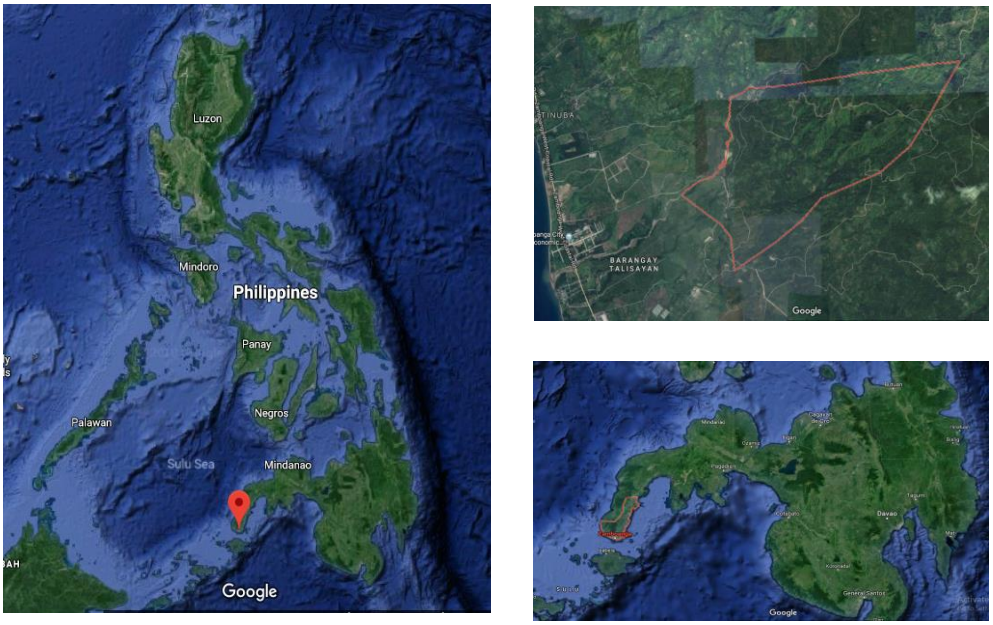

Figure 1. Map of the Philippines showing the location of Upper La Paz, Zamboanga City [24].

Sampling Sites

Site 1 at 7°02'46.0''N, 122°01'05.1''E is an agroecosystem area with an elevation of 875 masl and a moderately rugged slope. The emergent tree is white lauan (*Shorea contorta*), standing 25m with a DBH of 40cm. A small

sandy stream is present. Rattan of family Rhamnaceae and "nito" (*Lygodium circinnatum*) as well as mosses and canopy vines like "palo verde" (*Parkinsonia aculeata*), were observed. The grasses were highly dense which were composed of carabao grass (*Bouteloua dactyloides*), starflower (*Hypoxis hemerocallidea*), tiger grass (*Thysanolaena latifolia*), guinea grass (*Megathyrsus maximus*), and some ferns. Vegetation along the stream consisted of giant fern (*Angiopteris evecta*), Bengal arum (*Typhonium trilobatum*), "gabi-gabi" (*Jussiaea inclinata*), and "dilang-aso" (*Pseudelephantopus spicatus*). The ground was covered with approximately 10cm of leaf litter and 5cm of porous humus. The area had a clay type of soil which indicates soil erosion. Fallen logs and branches and even sedimentary and metamorphic exposed rocks were observed. Cultivation of pineapple (*Ananas comosus*), durian (*Durio zibethinus*), banana (*Musa* sp.), and lime (*Citrofortunella microcarpa*) was common in this site.

Site 2 at 7°01'47.3''N, 122°00'19.4''E is also an agroecosystem area with an elevation of 645 masl with a rolling slope facing east. Coconut (*Cocos nucifera*) was abundant in the site. There were no canopy epiphytes and vines. Understory plants are composed of palo verde, "gabi" (*Colocasia esculenta*), and cacao (*Gliricidia sepium*). Vegetation is composed of "dilang-aso", water primrose (*Ludwigia adscendens*), "makahiya" (*Mimosa pudica*), "hagonoy" (*Chromolaena odorata*), giant fern, garlic (*Allium sativum*), carabao grass and some ferns. Aside from coconuts, there were also papaya (*Carica papaya*), jackfruit (*Artocarpus heterophyllus*), and bananas. The area has a clay loam type of soil. Moss, fallen logs, exposed rocks, leaf litter, and humus were absent. An intermittent stream is present 100m away from the site.

Site 3, 7°02'46.7''N, 122°00'58.0''E, is a secondary dipterocarp forest with an elevation of 990 masl. It has a rugged slope and a flowing stream. Canopy trees have lichens and canopy vines like the love vines (*Cassytha filiformis*) on their trunks. The understory plants composed of silver fern (*Pityrogramma calomelanos*), "dilang-aso", water primrose, and fishtail palm (*Caryota mitis*). There was also pandan (*Pandanus sp.*), which was common, and rarely bananas were observed. The ground was covered with few carabao grass and mosses. There were also sedimentary rocks. The area has a porous and moist loamy type soil covered with approximately 10cm of humus and 20cm of leaf litter.

Site 4 at 7°01'48.0''N, 122°00'13.5''E is a secondary dipterocarp forest at an elevation of 645 masl, with rugged sloping terrain, and a flowing intermittent stream. The emergent tree was lanceleaf buttonwood (*Conocarpus lancifolius*) standing 18m with a DBH of 40cm. Canopy trees were dominated by "nibung" palm (*Oncosperma tigillarium*) and fishtail palm with a height of 8m. Orchids and canopy vines like Chinese skullcap (*Scutellaria baicalensis*) were present on the trunks of the canopy trees. Understory plants were composed of ferns like "nito", taro (*Alocasia sp.*), "dilang-aso," "bamban" (*Donax canniformis*), oakleaf fern (*Drynaria quercifolia*), rattan vines, bamboo, "hagithit", and "palmay". Bananas were also present. No grass was present and mosses were rarely observed. Exposed sedimentary rocks and fallen branches can also be seen. The soil was of a porous loamy type covered with approximately 10cm of leaf litter and thick humus. Tree nursery can be found in the site and anthropogenic clearing was present 25m away.

Site 5 at 7°03'20.0''N 122°00'04.0''E is a forest fragment and a highly disturbed dipterocarp forest due to logging for road construction. It has an elevation of 1019m, a rolling slope and a clear, flowing stream with a small waterfall. The emergent tree was almon tree (*Shorea almon*) with a height of 20m and a DBH of 10cm. The vegetation composed of moderately to highly dense dipterocarps. The underbrush composed of dipterocarp wildlings and carabao grass. The understory also included palo verde (*Parkinsonia aculeata.*), guinea grass and "camariang gubat" (*Kibatalia macgregorii*). Mosses, a few weeping figs (*Ficus sp.*), and rattan vines were also present, as well as fallen branches and twigs. The site had a porous, sandy, and loamy type of soil covered with approximately 10cm of leaf litter and humus. Anthropogenic clearing can be observed approximately 10m from the site.

Site 6 at 7°02'48.9''N 122°00'52.9''E is also a forest fragment and a highly disturbed dipterocarp forest due to a human settlement nearby. It is generally exposed to sunlight with an elevation of 842m, flat to rugged slope, and a lateral stagnant clear creek. The canopy was the tan-

bark oak (*Lithocarpus* sp.) with a height of 30m and a DBH of 15cm. Lichens and mosses were present but vines were absent. Carabao grass, some ferns including giant fern, "lipang-aso" (*Urtica dioica*), and *Colocasia esculenta* were observed. The site had a clay loamy type of soil covered with approximately 10cm of leaf litter and humus, as well as a few exposed metamorphic rocks.

Collection, Identification, and Pr cessing of Samples

The opportunistic sampling method was employed for seven field days and 126 person-hours in six sampling sites. Samples were captured using sweep netting and were put in a glassine paper. Only two to three voucher specimens were taken, the rest were released back to the habitat. Glassine papers containing the voucher specimens were enclosed in a plastic container with mothballs to prevent other insects from penetrating the specimens. For the moths, only the diurnal ones were captured. Photo documentation in the field was done. Initial identification was done using the Philippine Lepidoptera website and verified by Dr. Jade Aster T. Badon of Silliman University and a member of Philippine Lepidoptera Inc. while moth identification was verified by Dr. Leana Lahom Cristobal, founder of Philippine Lepidoptera Inc. and a member of Asian Lepidoptera Conservation.

Statistical Analysis

Paleontological Statistics Software Package (PAST) version 3.0 was used in calculating the biodiversity indices.

RESULTS AND DISCUSSION

Thirty-nine species of Lepidoptera were recorded in six sampling sites in WMSU-EFA, Zamboanga City, Philippines. This record is higher than the ones recorded in Central Kalimantan, Indonesia [25] and Bega Watershed, Agusan del Sur [20]. The high species richness was observed to be due to the rich plant composition of the sampling area, which is mostly dipterocarp forest. However, the results were lower than the Lepidoptera composition on Dinagat Island [26], Mt. Hamiguitan [21], Mt. Kitanglad, Mt. Apo, Mt. Musuan, and Mt. Timpoong [27]. This was observed to be due to the difference in the sampling techniques employed. The studies mentioned used insect traps which can capture more individuals and more species but only sweep netting was employed in the present study.

Out of the 39 species, 23 are butterflies belonging to four families and 20 genera (Table 1). Fifteen species are from family Nymphalidae, three from Lycaenidae, four from Pieridae, and one from Papilionidae. Nymphalidae was the dominant family, most abundant, and had the highest species richness. The same results were obtained by Marchiori & Romanowski [28]. Nymphalids are always dominant in tropical regions because of their polyphagous nature which enables them to survive in different habitats [29]. Family Nymphalidae also has many active flying butterflies that search for food in large areas [30].

Table 1. Species richness and relative abundance (in parenthesis) of butterflies in WMSU-EFA.

Species Name	Agroecosystem		Secondary Forest		Forest Fragment		Total
	Site 1 (875 masl)	Site 2 (645 masl)	Site 3 (990 masl)	Site 4 (645 masl)	Site 5 (1 019 masl)	Site 6 (842 masl)	
Family Lycaenidae							
Celarchus archagathos archagathos (Fruhstorfer, 1910)	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	1 (0.72)	2 (1.44)
Jamides sp.	1 (0.72)	0 (0)	1 (0.72)	0 (0)	0 (0)	0 (0)	2 (1.44)
Prosotas sp.	4 (2.90)	0 (0)	0 (0)	1 (0.72)	0 (0)	2 (1.44)	7 (5.07)
Family Nymphalidae							
Cethosia luzonica magindanaica (Semper, 1888)	3 (2.17)	1 (0.72)	0 (0)	1 (0.72)	0 (0)	0 (0)	5 (3.62)
Euploea mulciber mindanensis (Staudinger, 1885)	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	1 (0.72)

Faunis phaon leucis (Felder & Felder, 1861)	3 (2.17)	0 (0)	3 (2.17)	2 (1.44)	4 (2.90)	4 (2.90)	16 (11.59)
Idea electra electra (Semper, 1878)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	0 (0)	1 (0.72)
Ideopsis gaura glaphyra (Moore, 1883)	1 (0.72)	0 (0)	2 (1.44)	0 (0)	0 (0)	0 (0)	3 (2.17)

Table 1. Species richness and relative abundance (in parenthesis) of butterflies in WMSU-EFA. (cont.)

Species Name	**Agroecosystem**		**Secondary Forest**		**Forest Fragment**		**Total**
	Site 1 (875 masl)	**Site 2 (645 masl)**	**Site 3 (990 masl)**	**Site 4 (645 masl)**	**Site 5 (1 019 masl)**	**Site 6 (842 masl)**	
Junonia hedonia ida (Cramer, 1775)	1 (0.72)	0 (0)	0 (0)	3 (2.17)	0 (0)	5 (3.62)	9 (6.52)
Mycalesis ita imeldae (Aoki & Uemura, 1982)	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	1 (0.72)
Mycalesis sp.	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.72)	1 (0.72)
Parantica luzonensis luzonensis (C. & R. Felder, 1863)	2 (1.44)	0 (0)	0 (0)	2 (1.44)	0 (0)	0 (0)	4 (2.90)
Ragadia melindena melindena (C. & R. Felder, 1863)	1 (0.72)	0 (0)	0 (0)	2 (1.44)	0 (0)	0 (0)	3 (2.17)
Symbrenthia lilaea semperi (Moore, 1899)	0 (0)	1 (0.72)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.72)
Tanaecia leucotaenia leucotaenia (Semper, 1878)	0 (0)	0 (0)	1 (0.72)	3 (2.17)	0 (0)	0 (0)	4 (2.90)
Ypthima sempera chaboras (Fruhstorfer, 1911)	3 (2.17)	3 (2.17)	0 (0)	2 (1.44)	0 (0)	0 (0)	8 (5.80)
Ypthima stellera stellera (Eschscholtz, 1821)	0 (0)	3 (2.17)	0 (0)	4 (2.90)	1 (0.72)	0 (0)	8 (5.80)
Family Papilionidae							
Papilio antonio antonio (Hewitson, 1875)	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	1 (0.72)
Family Pieridae							
Delias diaphana diaphana (Semper, 1878)	1 (0.72)	2 (1.44)	0 (0)	0 (0)	2 (1.44)	0 (0)	5 (3.62)
Eurema hecabe tamiathis (Fruhstorfer, 1910)	1 (0.72)	6 (4.35)	2 (1.44)	5 (3.62)	3 (2.17)	2 (1.44)	19 (13.77)
Eurema sarilata sarilata (Semper, 1891)	0 (0)	2 (1.44)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1.44)
Pareronia boebera boebera (Eschscholtz, 1821)	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	1 (0.72)
Total Number of Individuals	21	18	10	30	15	15	**104**
Total Number of Species	11	7	6	15	5	6	**23**

For the moth species, 16 species belong to four families and six subfamilies (Table 2). Nine species are from family Erebidae, five from Crambidae, and one species each for families Zygaenidae and Geometridae.

Of the 39 species of Lepidoptera, the most dominant was the butterfly *Eurema hecabe tamiathis* with 19 individuals. The study of Bora et al. [29] also had *Eurema hecabe* as the most dominant species. *Eurema hecabe* is a generalist species which means that it can thrive in many kinds of habitats [31].

The results of this study showed that butterfly and moth species are highly abundant in sampling site 4, which is a secondary dipterocarp forest. The same results can be observed in the study of Ramirez and Mohagan [22] in Tandag, Surigao del Sur. Jew et al. [32] reported that species richness and abundance highly depend on the heterogeneity of a habitat. The abundance in site 4 was observed to be due to the

higher vegetation diversity present in the site. The site with the least abundance was sampling site 6, a forest fragment and a highly disturbed dipterocarp forest. The same results were recorded in the study of Nuñeza et al. [20] in Bega Watershed, Agusan del Sur. According to Leksono et al. [33], overall abundance and species richness decline with increasing site disturbance.

Sampling site 3, which is a secondary dipterocarp forest, had the most number of species. The study of Ramirez and Mohagan [22] in Tandag, Surigao del Sur also had the highest species richness in the dipterocarp forest. This site was moderately disturbed and according to Vu & Vu [34], slightly disturbed areas give rise to more diverse plants. This is a very positive effect because when there is higher plant diversity in the area, more Lepidoptera species will thrive [35]. The second species-rich site is sampling site 1, an agroecosystem site, similar to the study of Toledo & Mohagan [23] in Mt. Timpoong, Camiguin Island. This site is near a secondary forest or a less disturbed area, which is usually a site with higher species richness [36]. This difference in species composition indicates the presence of an edge effect. A study by Chacoff and Aizen [37] in Argentina showed that forest edges have higher morphospecies number than in plantations or agroecosystems. The proximity of the forests to the agroecosystem site can cause the mixing of species pool [38]. Therefore, it can influence the species composition of the agroecosystem site [39].

Table 2. Species richness and relative abundance (in parenthesis) of moth species in WMSU-EFA.

Species Name	Agroecosystem		Secondary Forest		Forest Fragment		Total
	Site 1 (875 masl)	Site 2 (645 masl)	Site 3 (990 masl)	Site 4 (645 masl)	Site 5 (1019 masl)	Site 6 (842 masl)	
Family Crambidae							
Cnaphalocrocis sp.	0 (0)	2 (1.44)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1.44)
Conogethes sp.	2 (1.44)	2 (1.44)	0 (0)	0 (0)	0 (0)	1 (0.72)	5 (3.62)
Nevrina procopia (Stoll, 1781)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	0 (0)	1 (0.72)
Unidentified Pyraustinae	0 (0)	1 (0.72)	0 (0)	1 (0.72)	0 (0)	0 (0)	2 (1.44)
Unidentified Spilomelinae	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	1 (0.72)
Family Erebidae							
Chalciope mygdon (Cramer, 1777)	1 (0.72)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.72)
Mocis frugalis (Fabricius, 1775)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	0 (0)	1 (0.72)
Mocis undata (Fabricius, 1775)	1 (0.72)	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	2 (1.44)
Nyctemera adversata (Schaller, 1788)	0 (0)	0 (0)	0 (0)	2 (1.44)	0 (0)	0 (0)	2 (1.44)
Nyctemera coleta (Stoll, 1781)	0 (0)	1 (0.72)	0 (0)	2 (1.44)	0 (0)	0 (0)	3 (2.17)
Nyctemera contrasta contrasta	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	1 (0.72)
Unidentified Arctiinae	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	0 (0)	1 (0.72)
Unidentified Arctiinae	2 (1.44)	4 (2.90)	0 (0)	0 (0)	0 (0)	1 (0.72)	7 (5.07)
Unidentified Lisothiini	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.72)	0 (0)	1 (0.72)
Family Geometridae							
Eumelea sp.	0 (0)	0 (0)	0 (0)	2 (1.44)	0 (0)	1 (0.72)	3 (2.17)

Table 2. Species richness and relative abundance (in parenthesis) of moth species in WMSU-EFA. (cont.)

Species Name	Agroecosystem		Secondary Forest		Forest Fragment		Total
	Site 1 (875 masl)	Site 2 (645 masl)	Site 3 (990 masl)	Site 4 (645 masl)	Site 5 (1019 masl)	Site 6 (842 masl)	
Family Zygaenidae							
Eucorma mindanaoensis (Kishida, 1996)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.72)	1 (0.72)
Total Number of Individuals	6	10	2	10	2	4	**34**
Total Number of Species	4	5	2	7	2	4	**16**

Table 3 shows the presence and absence of Lepidoptera species in six sampling sites. The most species-rich site was sampling site 4, the secondary dipterocarp forest, where *Eurema hecabe tamiathis*, *Faunis phaon leucis,* and *Tanaecia leucotaenia leucotaenia* were found. Species found in forest fragments, sites 5 and 6, are *Faunis phaon leucis* and *Eurema hecabe tamiathis*, which means that these species can survive in highly disturbed areas even though the vegetation is slowly changing. The species that are found in agroecosystems sites (site 1 and site 2) are *Cethosia luzonica magindanaica*, *Ypthima sempera chaboras*, *Delias diaphana diaphana*, *Eurema hecabe tamiathis,* and an unidentified Arctiinae. The distribution of these species highly depends on food availability, food variation, and light preferences [20, 40]. Of all the species recorded in this study, only *Eurema hecabe tamiathis* can be found in all sites. Aside from this species' generalist nature, it also prefers places near roads and most of the sampling sites in this study are near roads [31]. There were nine Philippine endemic species recorded in this study, namely: *Celarchus archagathos archagathos, Delias diaphana diaphana, Eurema sarilata sarilata, Idea electra electra, Nyctemera contrast contrasta, Pareronia boebera boebera, Ragadia melindena melindena, Ypthima sempera chaboras,* and *Ypthima stellera stellera.* Four Mindanao endemic species were recorded, namely *Cethosia luzonica magindanaica, Ideopsis gaura glaphyra,* and *Mycalesis ita imeldae.* Overall endemism is 33%.

The butterfly *Idea electra* is a threatened species and red-listed as vulnerable by the IUCN [41]. It was found only in sampling site 3, a secondary forest. The rest of the species have not yet been evaluated by the IUCN.

Table 3. Presence and absence of butterflies and moths in WMSU-EFA.

Species Name	Agroecosystem		Secondary Forest		Forest Fragment	
	Site 1 (875 masl)	Site 2 (645 masl)	Site 3 (990 masl)	Site 4 (645 masl)	Site 5 (1019 masl)	Site 6 (842 masl)
BUTTERFLIES						
Family Lycaenidae						
*Celarchus archagathos archagathos**				■		■
Jamides sp.	■		■			
Prosotas sp.	■			■		■
Family Nymphalidae						
*Cethosia luzonica magindanaica***	■	■		■		

Table 3. Presence and absence of butterflies and moths in WMSU-EFA. (cont.)

Species Name	Agroecosystem		Secondary Forest		Forest Fragment	
	Site 1 (875 masl)	Site 2 (645 masl)	Site 3 (990 masl)	Site 4 (645 masl)	Site 5 (1019 masl)	Site 6 (842 masl)
Euploea mulciber mindanensis				■		
Faunis phaon leucis	■		■	■	■	■
*Idea electra electra**					■	
*Ideopsis gaura glaphyra***	■		■			
Junonia hedonia ida	■			■		■
*Mycalesis ita imeldae***				■		
Mycalesis sp.						■
Parantica luzonensis luzonensis	■			■		
*Ragadia melindena melindena**	■			■		
Symbrenthia lilaea semperi		■				
Tanaecia leucotaenia leucotaenia			■	■		

*Ypthima sempera chaboras**	■	■		■		
*Ypthima stellera stellera**		■		■	■	
Family Papilionidae						
Papilio antonio antonio				■		
Family Pieridae						
*Delias diaphana diaphana**	■	■			■	
Eurema hecabe tamiathis	■	■	■	■	■	■
*Eurema sarilata sarilata**		■				
*Pareronia boebera boebera**				■		
MOTHS						
Family Crambidae						
Cnaphalocrocis sp.		■				
Conogethes sp.	■	■				■
Nevrina procopia			■	■		
Unidentified Pyraustinae		■		■		
Unidentified Spilomelinae						
Family Erebidae						
Chalciope mygdon	■					
Mocis frugalis			■			
Mocis undata	■				■	
Nyctemera adversata				■		
Nyctemera coleta		■		■		
*Nyctemera contrasta contrasta**				■		
Unidentified Arctiinae				■		

Table 3. Presence and absence of butterflies and moths in WMSU-EFA. (cont.)

Species Name	Agroecosystem		Secondary Forest		Forest Fragment	
	Site 1 (875 masl)	Site 2 (645 masl)	Site 3 (990 masl)	Site 4 (645 masl)	Site 5 (1019 masl)	Site 6 (842 masl)
Unidentified Arctiinae	■	■				■
Unidentified Lisothiini					■	
Family Geometridae						
Eumelea sp.				■		■
Family Zygaenidae						
Eucorma mindanaoensis						■

■ - Presence, □ - Absence, *Philippine endemic, **Mindanao endemic,

Table 4 shows the biodiversity indices of Lepidoptera species in this study. The average Shannon-Wiener Diversity Index of all six sampling sites was 2.2625, which means that WMSU-EFA has moderate diversity [42]. Sampling site 3, a secondary dipterocarp forest, was the most diverse site (H'=2.993). This is because of its diverse vegetation, presence of water, and slight light exposure [35]. This site was near a primary forest and since secondary forests can also support species from primary forests, some species shown in site 3 of this study may have also come from the primary forest [43]. The second most diverse site was sampling site 1, an agroecosystem site (H'=2.57). According to Tscharntke et al. [39], the proximity of forests and agroecosystem areas has a strong influence on the diversity of the agroecosystem areas. The site with the lowest species diversity was site 5, a forest

fragment and a highly disturbed dipterocarp forest (H'=1.633). It was near an anthropogenic clearing. According to Irwin et al. [44], disturbances, especially severe ones like deforestation, typically decrease species diversity, including native or endemic ones. Distribution was even in all sampling sites indicating that there was no dominant species.

Table 4. Biodiversity indices of lepidoptera in WMSU-EFA.

Species Name	Agroecosystem		Secondary Forest		Forest Fragment		Average
	Site 1 (875 masl)	Site 2 (645 masl)	Site 3 (990 masl)	Site 4 (645 masl)	Site 5 (1019 masl)	Site 6 (842 masl)	
Taxa	15	12	8	23	6	10	12.3
Individual	27	28	12	42	12	19	23.3
Shannon	2.57	2.317	1.979	2.993	1.633	2.083	2.2625
Evenness	0.8712	0.8452	0.9046	0.8672	0.8529	0.803	0.8574

CONCLUSION

This study has recorded 39 Lepidoptera species consisting of 23 butterflies and 16 moth species. Endemism is at 33% with nine Philippine endemic and three Mindanao endemic species. *Idea electra*, a Philippine endemic butterfly species, was the only recorded threatened species and red-listed as vulnerable by the IUCN. The study area, WMSU-EFA, has moderate diversity (H'=2.2625) which is attributed to a variety of food sources and the diverse vegetation of the sampling area. Family Nymphalidae was the dominant, most abundant, and most species-rich family. This is highly due to its polyphagous and active flying nature. *Eurema hecabe tamiathis* was the most distributed species. Sampling site 4, a secondary forest, was the most diverse site (H'=2.993), most abundant (30.00%), and with the highest species richness (S=23) mainly because it was composed of diverse vegetation and enough light exposure. The severe anthropogenic clearing was the observed threat that is most likely to affect the diversity of Lepidoptera in the area.

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Conflict of Interest

The authors declare no conflict of interest.

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