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Lepidopteron Species Diversity in the Experimental Forest of Western Mindanao State University, Zamboanga City

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ABSTRACT

Butterflies and moths, classified under the order Lepidoptera, are widely recognized as bioindicators of ecological changes in tropical forest ecosystems. This study aimed to assess the species diversity of Lepidoptera in the Western Mindanao State University Experimental Forest Area (WMSU-EFA) in Zamboanga City. Sampling was conducted at six separate locations over 126 person-hours, using an opportunistic sweep-netting technique. Biodiversity parameters were analyzed using PAST software version 3.0. A total of 39 species were identified, comprising 23 butterfly species and 16 moth species in eight families. The family Nymphalidae exhibited the highest number and abundance of species, probably due to its adaptability to different host plants. *Eurema hecabe tamiathis* emerged as the most frequently observed species (13.57%), indicating its ability to thrive in diverse environments. The only species that was vulnerable seemed to be *Idea electra*. Among all sites, the secondary dipterocarp forest (site 4) showed the highest species diversity (H' = 2.993), richness (S = 23), and population abundance (30.00%). The overall diversity index (H' = 2.2625) indicated moderate species diversity, likely supported by a variety of vegetation types. Species were evenly distributed throughout the study area, with no single dominant species. However, ongoing habitat disturbances, particularly deforestation and human land-use activities, pose potential risks to Lepidoptera populations in the area.

Keywords: Dipterocarp, Butterflies, Moth, Nymphalidae, Indicators

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Introduction

Lepidoptera species interact with a wide range of plant and animal species [1, 2] throughout their life cycle. This order, which includes moths and butterflies, primarily feeds on plant material during the larval stage [3, 4], while adult individuals consume nectar or fruit juices. Their strong dependence on vascular plants makes them key herbivores and pollinators within ecosystems [5], the larvae of butterflies possess chewing-type mouthparts [6, 7], which aid in feeding on plant tissues, as well as the larvae of moths. Furthermore, Lepidoptera serve as effective biological indicators due to their heightened sensitivity to environmental disturbances [8, 9]. With more than 157,424 documented species worldwide [10], this order represents one of the most diverse insect groups, second only to Coleoptera (beetles) in species richness [11].

Previous research has documented the diversity of Lepidoptera in various regions. For instance, studies in southern Ecuador identified 282 arctiid and 829 geometrid moth species [12]. In Kenya's Kaya forests, butterfly surveys recorded 127 species in Kaya Muhaka, 56 species in Kaya Kinondo, and 77 species in Kaya Diani [13, 14]. In the Atlantic Forest of Southeastern Brazil, fruit-feeding butterflies from 6 subfamilies of Nymphalidae were

examined, revealing that while habitat fragmentation influences butterfly populations, it does not drastically reduce species diversity. In Borneo, studies assessing butterfly diversity in both primary and selectively logged forests revealed no substantial variations between the two, though primary forests exhibited greater overall diversity [15]. Additionally, a study conducted in Sabah's Poring Hill Dipterocarp forest documented 1,169 Macro-moth species, emphasizing the impact of habitat diversity on species richness. Similar studies in South Asia have also identified Nymphalidae butterflies as the dominant species due to their adaptability and strong flight capabilities [16]. For example, research in India's Trishna Wildlife Sanctuary reported 59 butterfly species [17, 18], while surveys in Sri Lanka recorded 120 species. Given their rich ecosystems, tropical rainforests naturally sustain a vast diversity of Lepidoptera [19]. However, despite these findings, research on Lepidoptera diversity in tropical regions remains relatively scarce, highlighting the need for further studies.

The Philippines, known for its tropical climate, hosts a rich diversity of Lepidoptera. However, biological records of Lepidoptera in Mindanao—the country's second-largest island—remain limited [20]. Previous studies on Mindanao's Lepidoptera have focused on areas such as Mt. Hamiguitan in Davao Oriental [21], Bega Watershed in Agusan Del Sur [20], Tandag in Surigao Del Sur [22], and Mt. Timpoong and Mt. Hibok-Hibok on Camiguin Island [23]. These documented studies being said, no research on Lepidoptera has been conducted in our research area, which serves as the present study site, which is in the experimental forest area of Western Mindanao State University. This research aimed to assess the diversity of Lepidoptera species within the experimental forest area of Western Mindanao State University (WMSU-EFA) in Zamboanga City.

Materials and Methods

The area of study

Sampling took place at the Western Mindanao State University's Experimental Forest Area **(Figure 1)**. This site is positioned in the southwest of Mindanao Island, around 26 kilometers from the center of Zamboanga City. The forest covers an area of 1,277 hectares. The lowest part of the area is approximately six hundred meters above sea level (masl) in the southwest, while the highest point reaches up to 1,200 masl in the northern region. The site features a variety of plant life, with dipterocarps being the most prevalent tree species. In addition to trees, the forest is home to a rich variety of non-tree species such as rattan, vines, orchids, grasses, and ferns.

a) b) c)

Figure 1. Map of the study area in the Philippines [24].

Sites of sampling

The first site's sampling location, positioned at 7°02'46.0'' N, 122°01'05.1'' E, lies within an agroecosystem at an altitude of 875 meters above sea level (masl). The terrain is moderately rugged. The primary emergent tree

species is white lauan, which reaches a height of 25 meters and has a diameter of 40 cm at breast height. A little sandy stream runs through the area. Plant life includes rattan species from the Rhamnaceae family, "nito" (*Lygodium circinnatum*), and various mosses, along with vines such as "palo verde". The ground layer is densely covered with grasses like carabao grass, starflower, tiger grass, guinea grass, and certain ferns. Along the stream, you can find giant fern, Bengal arum, "gabi-gabi", and "dilang-aso". The forest floor is covered in about 10 cm of leaf litter and 5 cm of porous humus. That soil is clay-based, suggesting some level of erosion. Additionally, fallen logs, branches, and exposed sedimentary and metamorphic rocks are visible. Agricultural activities in the area include the cultivation of pineapple, durian, bananas, and lime.

The second site, located at 7°01'47.3'' N, 122°00'19.4'' E, is also a specific type of ecosystem that is modified or managed for agricultural purposes, situated at 645 meters above sea level (masl) on a gently sloping eastward-facing terrain. Coconut palms (Cocos nucifera) are abundant here, with no noticeable presence of canopy epiphytes or vines. The understory consists of species like palo verde, "gabi", and cacao. Other common plants include "dilang-aso," water primrose, "makahiya", "agony", giant fern, garlic, carabao grass, and some ferns. Aside from coconut, crops such as papaya, jackfruit, and bananas can also be found. The soil in this area is clay loam, and no moss, fallen logs, or exposed rocks are found here. An intermittent stream was located about 100 meters from the site.

The third site, located at 7°02'46.7'' N, 122°00'58.0'' E, is a secondary dipterocarp forest situated at the height of 990 meters above sea level (masl). It features a flowing stream and a steep slope. The canopy trees host various lichens, with canopy vines such as love vines growing on their trunks. Understory plants include silver fern, "dilang-aso," water primrose, and fishtail palm. Pandan is abundant, and bananas are rarely observed. The forest floor is covered with mosses and sparse carabao grass, along with exposed sedimentary rocks. The soil is a loamy, porous type that retains moisture, with approximately 10 cm of humus and 20 cm of leaf litter on the surface.

The fourth site is located at 7°01'48.0'' N, 122°00'13.5'' E, site 4 is a secondary dipterocarp forest at a height of 645 masl, with rugged terrain and an intermittent stream. The primary emergent tree in this area is lance-leaf buttonwood, which reaches 18 meters in height and has a DBH of 40 cm. Canopy trees are predominantly "nibung" palm and fishtail palm, both reaching around 8 meters in height. Orchids and vines such as *Chinese skullcap* are common on tree trunks. The understory is made up of ferns like "nito," taro, "dilang-aso," bamboo, "bamban" (*Donax canniformis*), and other plants including rattan and "hagithit." Bananas are present, but grasses and mosses are rare. The soil is a loamy type, porous, covered by approximately 10 cm of Thick humus and leaf litter. The site also has a tree nursery, and human-caused clearing is found about 25 meters away.

The fifth site is located at 7°03'20.0'' N, 122°00'04.0'' E, this site is a forest in a heavily disturbed dipterocarp forest, impacted by logging activities for the construction of the road. It lies at the height of 1019 masl on a gently sloping terrain with a clear stream and a tiny waterfall. The almond tree (*Shorea almon*), standing at 20 meters with a DBH of 10 cm is the emergent tree. The vegetation is primarily made up of moderately to densely distributed dipterocarps, consisting of carabao grass and dipterocarp wildlings. Other understory plants include palo verde, guinea grass, and "camariang gubat" Mosses, a few weeping figs, and rattan vines can also be found, along with fallen twigs and branches. The soil is a mix of sandy and loamy types, covered with around 10 cm of humus and leaf litter. The anthropogenic clearing is observable from approximately 10 meters.

The sixth and last site is situated at 7°02'48.9'' N, 122°00'52.9'' E, site 6 is another forest fragment, highly disturbed by a nearby human settlement. The area is largely exposed to sunlight, at an elevation of 842 masl, with a flat to rugged slope and a stagnant creek. The canopy is dominated by tan-bark oak, which grows to about 30 meters tall with a DBH of 15 cm. Lichens and mosses are present on the trees, but no vines are observed in the canopy. The understory includes carabao grass, ferns like a giant fern, "lipang-aso", and *Colocasia esculenta*. The soil is clay loam, covered with roughly 10 cm of humus and leaf litter, along with a few exposed metamorphic rocks.

Sample collection, identification, and handling

The study used an opportunistic sampling technique over seven field days, totaling 126 person-hours, across six different locations. Specimens were collected using sweep nets and placed on glassine paper. Only a few specimens, typically two to three, were retained as vouchers, while the majority were carefully released back into the environment. The voucher specimens were wrapped in glassine paper and stored in a container protected from being contaminated by other insects.

Only daytime-active moths were collected for this study. Field documentation was carried out through photography. Species identification was initially conducted using the Philippine Lepidoptera website and later confirmed by Dr. Jade Aster T. Badon from Silliman University, a member of the Philippine Lepidoptera Inc. Moth identifications were further reviewed by Dr. Leana Lahom Cristobal, the founder of Philippine Lepidoptera Inc.

Statistical procedures

Biodiversity indices were computed using version 3.0 of the Paleontological Statistics Software Package (PAST).

Results and Discussion

A total of 39 Lepidoptera species were documented across 6 sampling sites in Zamboanga City, Philippines. This number surpasses the records from Central Kalimantan, Indonesia [25]. The notable species diversity in this area can be attributed to the varied plant life, primarily dominated by dipterocarp forests. However, the species count is lower compared to reports from Dinagat Island [26], Mountain Hamiguitan [21], and several other mountainous regions including Mountain Kitanglad, Mountain Apo, Mountain Musuan, and Mountain Timpoong [27]. This disparity is likely due to differences in sampling methods, as previous studies employed insect traps, which tend to capture a greater number and variety of species, while this study relied solely on sweep netting.

Among the 39 species recorded, 23 are butterflies belonging to 4 families and twenty genera **(Tables 1 and 2)**. The family Nymphalidae was the most represented, with 15 species, followed by three species from Lycaenidae, four from Pieridae, and one from Papilionidae. Nymphalidae emerged as the dominant family in both abundance and species richness, consistent with the findings of a study [28]. This dominance is typical of tropical regions, where Nymphalids thrive due to their generalist feeding behavior, which allows them to inhabit a variety of environments [29]. Additionally, many Nymphalid butterflies are highly mobile, enabling them to cover extensive areas in search of food [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 (1019 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 2. 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 (1019 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

In this study, 16 moth species were identified, belonging to 4 families and 6 sub-families **(Tables 3 and 4)**. Nine species came from the Erebidae family, five from Crambidae, and 1 species each from the Zygaenidae and Geometridae families.

Among the 39 Lepidoptera species recorded, *Eurema hecabe tamiathis* emerged as the most abundant, with 19 individuals. Similarly, *Eurema hecabe* was also the dominant species in the study by Bora *et al*. [29]. This butterfly is a general species, capable of thriving in a variety of places [31].

The findings of this study indicate that both butterflies and moths are particularly abundant at site 4, a secondary dipterocarp forest. This aligns with the observations made by Ramirez and Mohagan [22] in Tandag, Surigao del Sur. According to Jew *et al*. [32], the richness and abundance of species are closely tied to habitat heterogeneity. The high abundance at site 4 can be attributed to the rich diversity of vegetation present in that area. On the other hand, site 6, a disturbed dipterocarp forest and a forest fragment showed the least abundance. This trend was also observed in the study by Nuñeza *et al*. [20] in Bega Watershed, Agusan del Sur. Leksono *et al*. [33] noted that as disturbance levels increase in a site, both abundance and species richness tend to decrease.

Sampling site 3, a secondary dipterocarp forest, recorded the highest species diversity. This matches the findings of Ramirez and Mohagan [22], who observed the greatest species richness in dipterocarp forests in Tandag, Surigao del Sur. This site was moderately disturbed, and as Vu and Vu [34] suggested, slightly disturbed areas often lead to greater plant diversity. This, in turn, positively impacts the diversity of Lepidoptera species, as more plant species create a suitable environment for them to thrive [35].

The 2nd richest site in terms of species was site 1. This mirrors the results found by Toledo and Mohagan [23] in Mountain Timpoong, Camiguin Island, where species richness was higher in areas near secondary forests or less disturbed habitats [36]. The variation in species composition between these sites indicates the presence of an edge effect. Chacoff and Aizen [37] observed in Argentina that forest edges often exhibit higher numbers of morphospecies compared to plantations or agroecosystems. The proximity of forests to the agroecosystem at site 1 likely facilitated the combining of species pools [38], influencing the species composition in this agroecosystem site [39].

Table 3. 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 4. 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**

Tables 5-7 present the occurrence of Lepidoptera species across six different sampling sites. The site with the highest species diversity was site 4, the secondary dipterocarp forest, where species such as *Eurema hecabe tamiathis*, *Faunis phaon leucis*, and *Tanaecia leucotaenia leucotaenia* were recorded. In contrast, species found in the forest fragments at sites 5 and 6—Faunis phaon leucis and *Eurema hecabe tamiathis*—indicate that the species can persist in highly disturbed places, even as vegetation is gradually changing. Sites 1 and 2, the agroecosystem areas, hosted species such as *Cethosia luzonica magindanaica*, *Ypthima sempera chaboras, Delias diaphana diaphana*, *Eurema hecabe tamiathis*, and an unidentified Arctiinae. The distribution of these species is largely influenced by factors such as food variation, availability, and light preferences [20, 40]. Notably, *Eurema hecabe tamiathis* was the only species present in all sampling sites, likely due to its generalist nature and preference for areas near roads, many of which were located close to roadways [31].

Table 5. 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 6. 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 7. 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,

The study also identified 9 Philippine endemic species, including *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*. Additionally, four species endemic to Mindanao were recorded: *Cethosia luzonica magindanaica*, *Ideopsis gaura glaphyra*, and *Mycalesis ita imeldae*. This brings the overall endemism to 33%.

Among the species recorded, Idea electra is considered vulnerable and is listed as a threatened species by the IUCN [41]. It was only found at site 3. The IUCN has not yet evaluated the status of the other species. The overall average Shannon-Wiener Diversity Index across all 6 sampling sites was 2.2625, indicating moderate diversity within the WMSU-EFA area [42]. Site three had the highest diversity (H' = 2.993), which can be attributed to its varied vegetation, water presence, and moderate light exposure [35]. Some species recorded at this site may have originated from the nearby primary forest [43]. Site 1, an agroecosystem site, was the second most diverse (H' = 2.57). The proximity of forests to agroecosystems has been shown to significantly influence diversity in agroecosystem areas [39]. On the other hand, site five had the lowest diversity (H' = 1.633). Located near an anthropogenic clearing, this site's low diversity is likely due to the effects of disturbance. Research by Irwin *et al*. [44] suggests that disturbances such as deforestation often lead to a decrease in species diversity, including endemic species. Species distribution was relatively even across all sampling sites, suggesting no dominant species in the area **(Table 8)**.

Table 8. 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 documented 39 species of Lepidoptera, including twenty-three butterfly species and sixteen moth species. Endemism was observed at a rate of 33%, with nine species endemic to the Philippines and three to Mindanao. The only threatened species found was *Idea electra*, a Philippine endemic butterfly, which is listed as vulnerable by the IUCN. The WMSU-EFA area showed moderate biodiversity (H'=2.2625), largely due to the availability of various food sources and the rich plant diversity. The Nymphalidae family was the most dominant, abundant, and species-rich, largely because of its polyphagous nature and active flight patterns. *Eurema hecabe tamiathis* was the most widely distributed species across the sites. Site 4, stood out as the most diverse (H' = 2.993), abundant (30.00%), and species-rich (S = 23), primarily due to its diverse vegetation and sufficient light

exposure. The most significant threat to Lepidoptera diversity in the area appeared to be the intense anthropogenic clearing.

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References

1. Cabrido C, Demayo CG. Antimicrobial and cellular metabolic effects of the ethanolic extract of the dallas red variety of Lantana camara. Pharmacophores. 2018;9(1):10-8.
2. Zeghti S, Bouras A, Kherbouche Y, Sekour M. Assessment of the diversity of Lepidoptera and the importance of useful and harmful species in palm groves (Algeria). World J Environ Biosci. 2019;8(1):11-20.
3. Regier JC, Zwick A, Cummings MP, Kawahara AY, Cho S, Weller S, et al. Toward reconstructing the evolution of advanced moths and butterflies (Lepidoptera: Ditrysia): an initial molecular study. BMC Evol Biol. 2009;9(1):280.
4. Saad A, Bounaceur F. Diversity of Lepidoptera (Rhopalocera) in natural and modified habitats of Bousaâda, Algeria. World J Environ Biosci. 2018;7(1):79-83.
5. Krenn HW. Feeding mechanisms of adult Lepidoptera: structure, function, and evolution of the mouthparts. Ann Rev Entomol. 2010;55:307-27.
6. Khyade VB. The importance of nature (length) of proboscis in hesperiidae butterflies. World J Environ Biosci. 2019;8(2):1-10.
7. Choudhary NKN, Mallya R. Phytochemical investigation and antibacterial activity of a medicinal plant. Int J Pharm Phytopharmacol Res. 2019;9(4):53-8.
8. Thomas JA. Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. Philos Trans R Soc B Biol Sci. 2005;360(1454):339-57.
9. Bonebrake TC, Ponisio LC, Boggs CL, Ehrlich PR. More than just indicators: a review of tropical butterfly ecology and conservation. Biol Conserv. 2010;143(8):1831-41.
10. van Nieukerken EJ, Kaila L, Kitching IJ, Kristensen NP, Lees DC, Minet J, et al. Order Lepidoptera Linnaeus, 1758. In: Zhang ZQ, ed. Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness. Zootaxa. 2011;3148(1):212-21.
11. Wahlberg N, Wheat CW, Peña C. Timing and patterns in the taxonomic diversification of Lepidoptera (butterflies and moths). PLOS one. 2013;8(11):e80875. Available from: https://www.ncbi.nlm.nih.gov/pmc/article s/PMC3839996/
12. Nöske NM, Hilt N, Werner FA, Brehm G, Fiedler K, Sipman HJ, et al. Disturbance effects on diversity of epiphytes and moths in a montane forest in Ecuador. Basic Appl Ecol. 2008;9(1):4-12.
13. Lehmann I, Kioko E. Lepidoptera diversity, floristic composition and structure of three Kaya forests on the south coast of Kenya. J East Afr Nat Hist. 2005;94(1):121-63.
14. Uehara-Prado M, Brown Jr KS, Freitas AV. Species richness, composition and abundance of fruit-feeding butterflies in the Brazilian Atlantic Forest: comparison between a fragmented and a continuous landscape. Glob Ecol Biogeogr. 2007;16(1):43-54.
15. Dumbrell AJ, Hill JK. Impacts of selective logging on canopy and ground assemblages of tropical forest butterflies: implications for sampling. Biol Conserv. 2005;125(1):123-31.
16. Abang F, Karim C. Diversity of macromoths (Lepidoptera: Heterocera) in the Poring Hill dipterocarp forest, Sabah, Borneo. J Asia Pac Entomol. 2005;8(1):69-79.
17. Majumder J, Lodh R, Agarwala BK. Butterfly species richness and diversity in the Trishna Wild-life Sanctuary in South Asia. J Insect Sci. 2013;13(1):79. doi:10.1673/031.013.7901

18. Kudavidanage EP, Wanger TC, De Alwis C, Sanjeewa S, Kotagama SW. Amphibian and butterfly diversity across a tropical land-use gradient in Srilanka; implications for conservation decision making. Anim Conserv. 2012;15(3):253-65.
19. Van Lien V, Yuan D. The differences of butterfly (Lepidoptera, Papilionoidea) communities in habitats with various degrees of disturbance and altitudes in tropical forests of Vietnam. Biodivers Conserv. 2003;12(6):1099-111.
20. Nuñeza KM, Nuñeza OM, Dupo AL. Species richness of Lepidoptera in Bega Watershed, Prosperidad, Agusan del Sur, Philippines. Bull Environ Pharmacol Life Sci. 2016;5(8):83-90.
21. Mohagan AB, Treadaway CG. Diversity and status of butterflies across vegetation types of Mt. Hamiguitan, Davao Oriental, Philippines. Asian J Biodivers. 2010;1(1):1-24.
22. Ramirez RK, Mohagan AB. Diversity and status of butterflies in Maitum Village, Tandag, Surigao del Sur, Philippines. Asian J Biodivers. 2012;3(1):74-112.
23. Toledo JM, Mohagan AB. Diversity and status of butterflies in Mt. Timpoong and Mt. Hibok-hibok, Camiguin Island, Philippines. JPAIR Multidiscip J. 2011;6(1):103-16.
24. Google Maps. Philippines. [Image on internet]. 2019 [updated 2019; cited April 9, 2019. Available from: https://www.google.com/maps/@12.0609 728,121.8550578,1660577m/data=!3m1!1e3
25. Houlihan PR, Harrison ME, Cheyne SM. Impacts of forest gaps on butterfly diversity in a Bornean peat-swamp forest. J Asia Pac Entomol. 2013;16(1):67-73.
26. Mohagan AB, Mohagan DP, Libor R. Diversity and status of butterflies in Dinagat Island, Philippines. SDSSU Multidiscip Res J. 2013;1(1):34-40.
27. Mohagan DP, Tambuli AE, Mohagan AB. Diversity of butterflies in the selected key biodiversity areas of Mindanao, Philippines. Asian J Biodivers. 2013;2(1):121-48.
28. Marchiori MO, Romanowski HP. Species composition and diel variation of a butterfly taxocene (Lepidoptera, Papilionoidea and Hesperioidea) in a restinga forest at Itapuã State Park, Rio Grande do Sul, Brazil. Rev Bras Zool. 2006;23(2):443-54.
29. Bora A, Meitei LR, Deb M. Butterfly species richness and diversity in experimental botanic garden, botanical survey of India, ERC, Umiam, Meghalaya, India. J Entomol Zool Stud. 2014;2(5):212-7.
30. Eswaran R, Pramod P. Structure of butterfly community of Anaikatty hills, Western Ghats. Zoos'Print J. 2005;20(8):1939-42.
31. Cleary DF, Boyle TJ, Setyawati T, Menken SB. The impact of logging on the abundance, species richness and community composition of butterfly guilds in Borneo. J Appl Entomol. 2005;129(1):52-9.
32. Jew EK, Loos J, Dougill AJ, Sallu SM, Benton TG. Butterfly communities in miombo woodland: biodiversity declines with increasing woodland utilisation. Biol Conserv. 2015;192:436-44.
33. Leksono AS, Nakagoshi N, Isagi Y. The effects of forest disturbances on flying insect assemblages in Trawas, east Java. Tropics. 2005;14(4):335-43.
34. Vu LV, Quang Vu C. Diversity pattern of butterfly communities (Lepidoptera, Papilionoidae) in different habitat types in a tropical rain forest of Southern Vietnam. ISRN Zool. 2011;2011(1):1-8.
35. Hawes J, da Silva Motta C, Overal WL, Barlow J, Gardner TA, Peres CA. Diversity and composition of Amazonian moths in primary, secondary and plantation forests. J Trop Ecol. 2009;25(3):281-300.
36. Tylianakis JM, Klein AM, Tscharntke T. Spatiotemporal variation in the diversity of Hymenoptera across a tropical habitat gradient. Ecology. 2005;86(12):3296-302.
37. Chacoff NP, Aizen MA. Edge effects on flower-visiting insects in grapefruit plantations bordering premontane subtropical forest. J Appl Ecol. 2006;43(1):18-27.
38. Axmacher JC, Tünte H, Schrumpf M, Müller-Hohenstein K, Lyaruu HV, Fiedler K. Diverging diversity patterns of vascular plants and geometrid moths during forest regeneration on Mt Kilimanjaro, Tanzania. J Biogeogr. 2004;31(6):895-904.
39. Tscharntke T, Sekercioglu CH, Dietsch TV, Sodhi NS, Hoehn P, Tylianakis JM. Landscape constraints on functional diversity of birds and insects in tropical agroecosystems. Ecology. 2008;89(4):944-51.
40. Kumar V, Reddy PV, Anal AK, Nath V. Outbreak of the looper, Perixera illepidaria (Lepidoptera: Geometridae) on litchi, Litchi chinensis (Sapindales: Sapindaceae)-a new pest record from India. Florida Entomol. 2014;97(1):22-9.
41. Lepidoptera Specialist Group 1996. Idea electra. The IUCN Red List of Threatened Species 1996: e.T10781A3215545. [cited 2019 April 22]. doi:10.2305/IUCN.UK.1996. RLTS.T10781A3215545.en

42. Odum EP. Fundamentals of ecology. Third ed. Philadelphia, USA: W.D. Saunders Corporation; 1971. 574 p.
43. Dent DH, Wright SJ. The future of tropical species in secondary forests: a quantitative review. Biol Conserv. 2009;142(12):2833-43.
44. Irwin MT, Wright PC, Birkinshaw C, Fisher BL, Gardner CJ, Glos J, et al. Patterns of species change in anthropogenically disturbed forests of Madagascar. Biol Conserv. 2010;143(10):2351-62.