

Faunistic Study on Butterflies in the Lowland Forests of Central Surigao del Sur, Philippines

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ABSTRACT

The province of Surigao del Sur is among the areas in the Philippines with limited wildlife studies, especially on lepidopteran fauna. Thus, this study was conducted to evaluate the butterfly congregation and diversity in Gamut and Mat-e, areas which are underexplored for lepidopteran surveys. It also aimed to assess the conservation and ecological status of the species. Sweep netting for a total of 196 person-hours was carried out to document the species. The results revealed a total of 29 species belonging to four families. Among the families, Nymphalidae was the most represented, comprising 48% of the total richness. The species *Gandaca harina mindanaensis* and *Junonia hedonia ida* were the most dominant in both sites representing 12% (each) of the total population. Species richness and diversity (H') were relatively higher in Mat-e ($n=22$; $H'=1.22$) than in Gamut ($n=15$; $H'=1.00$). The total endemism was 31%, but higher endemism was observed in Mat-e (36%) compared with Gamut (20%). The noteworthy findings are the listing of the nationally and globally assessed as rare species (*Acroptalmia leto ochine* and *Jamides celeno*), but were locally assessed as common in Mat-e. One recorded butterfly (*Atrophaneura semperi aptonia*) was assessed to be a threatened species. Based on the results, the two habitats showed a poor representation of butterfly assemblage, however, these results are highly affected by the limitations of the observation. Thus, it is recommended that an intensive study on butterflies in the area should be considered.

Keywords: Composition, diversity, endemism, richness, Lepidoptera

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INTRODUCTION

Butterflies form an essential part of the ecosystem with its ecological role as a significant pollinator of various terrestrial ecosystems (Myers *et al.*, 2000; Guadalquiver *et al.*, 2019). They also served as an environmental indicator due to its sensitivity to the changes in its habitat, local weather, and climate (Kyerematen *et al.*, 2018). Most importantly, they served as one of the food web foundations as their larval form is the primary food of various organisms in the higher trophic level (Ferrante *et al.*, 2014; James, 2017). Taxonomically, these organisms are considered a well-studied taxon compared with other insect groups due to their visual appeal that attracts the different hobbyists and researchers (New, 1997; Thomas, 2005; Chowdhury *et al.*, 2017). Thus, leading to the

identification of approximately 28,000 species across the globe (Tiple, 2011; Khan *et al.*, 2015). Of these, 90% are reported to inhabit the tropics (Boriani *et al.*, 2005; Bonebrake *et al.*, 2010; Munyuli, 2013).

The Philippines is a tropical country and is globally recognised as megadiverse because of its high accounts of the flora and faunal species with a high percentage of endemism (Heaney *et al.*, 1999). Relative to this, one major component of its insect diversity is represented by butterflies comprising 8% of the total known extant insect species in the country (de Jong & Treadway, 1993; Nacua *et al.*, 2019; Foundation for the Philippine Environment, 2020). Further efforts on documenting the species are also evident, which leads to the documentation of new species and sub-

species (Treadaway, 1995; Mohagan & Treadaway, 2010; Treadaway, 2012). Simultaneously, some studies focused on evaluating its ecology (Nacua *et al.*, 2015; Mohagan *et al.*, 2018) and conservation prioritisation (Danielsen & Treadaway, 2004).

However, despite this acquired attention and scientific efforts, studies on butterfly fauna are still poorly known. Scientists suggest there are still several places yet to be explored (Guadalquiver *et al.*, 2019) and require further documentation for butterflies, especially in the Philippines. The country itself is considered one of the biodiversity hotspots (Ong, 2002). A territory with a high level of threats in various aspects and negatively impacts the vast diversity of wildlife in the area (Conservation International, 2020). On the other hand, conducting biodiversity profiling is an essential endeavor, for it serves as a foundation for any eventual conservation efforts. It serves as a guideline to what appropriate measures should be considered depending on the data presented. Above all, it aids as an instrument in understanding further the ecology of the organisms in local and global perspectives (Ehrlich & Hanski 2004; Pyke & Ehrlich, 2010).

Surigao del Sur is among Mindanao territories reported to possess a high percentage of forest cover still. However, recent reports revealed that the place has the highest forest cover loss rate than any provinces in the Philippines (Fallarcuna & Perez, 2016), an ecological dilemma attributed to timber harvesting and mining (Forest Management Bureau, 2003). Regarding lepidopteran diversity, the area was observed to have limited and scarce information that can be retrieved for scientific and local usage. For this reason, the study was conducted to address this ecological loophole and provide baseline information on butterflies in the underexplored areas. The study specifically aimed to evaluate the composition and richness of butterflies in Tago and Cagwait. It also aimed to assess the status of the organisms in the area.

MATERIALS AND METHODS

Study Site and Habitat Description

The first study site was located in the lowland forest of Gamut, Tago, Surigao del Sur (Figure 1(a)), situated at 9.011389 North and 126.169943 East. The area has two distinct vegetations, the secondary mixed dipterocarp forest and the agroecosystem, with the latter as the dominant

vegetation. The distance of the site to the nearest human settlement was approximately 100 meters from the starting point. The dominant plants in the agroecosystem were *Cocos nucifera* and *Paspalum conjugatum* while in the secondary mixed dipterocarp forest, there were mixtures of secondary and old-growth dipterocarp tree species and shrubs. The canopy cover in the agroecosystem was around 20% to 50%, starting from the lower up to the upper portion of the area whereas in the secondary mixed dipterocarp, canopy cover ranges from 40% to 80%. The terrain slope was light to moderate at an angle of 10 to 30 degrees, wherein the higher slopes were observed in the upper secondary mixed dipterocarp forest. Leaf litter was low to moderate. Fallen logs were seldomly seen. The streams expanded from the agroecosystem up to the upper secondary mixed dipterocarp forest with varying wide along the way. The water current and level upon the conduct were relatively low. During the fieldwork, the weather was sunny with the temperature ranged from 27 to 28 °C.

The second study site was located in the lowland forest of Mat-e, Cagwait, Surigao del Sur (Figure 1(b)), situated at 8.884153 North and 126.2295071 East. The area has a characteristic of agroecosystem in the lower part and secondary mixed dipterocarp vegetation in the upper part. But the latter serves as the most dominant type. The nearest human settlements from the starting point were approximately 500 meters. The dominant plant structures in the agroecosystem were composites of *C. nucifera*, fruit trees, and various grasses and weeds. In the secondary mixed dipterocarp forest, the dominant plants were old-growth dipterocarp trees, shrubs, and epiphytes. The canopy cover for the agroecosystem was 20 to 50%, while the canopy cover for the secondary mixed dipterocarp forest ranges from 50 to 80%. The terrain slope was generally light to moderate at an angle of 20 to 40°. But other portions were observed to have a slope angle of 50 to 60°. Leaf litter was few to none in the agroecosystem was observed to be moderate in the second vegetation. Fallen logs were observed only in the secondary mixed dipterocarp forest. Water bodies like streams were also observed. It has a stretch that runs from the agroecosystem up to the secondary mixed dipterocarp forest. The stream width, water level, and current were relatively wider, higher, and stronger than the first site except for some parts. The weather during the study was generally sunny with the temperature ranged from 26 to 27 °C.



Figure 1. Portion of the sampled habitat in Gamut (a) and Mat-e (b)

Sampling Design, Data Collection and Identification

A 1000-meter transect line that laid along the primary stream was established. The transect was a contiguous line that passed through two distinct habitats, agroecosystem and secondary mixed dipterocarp forest, accordingly. As for the site in Gamut, out of the 1000 m transect, 700 m of the transect falls in the agroecosystem, while the remaining 300 distance falls in the secondary mixed dipterocarp forest. Meanwhile the transect in Mat-e, only the first 400 m of the transect falls in the agroecosystem habitat, while the rest of the 600 m lies in the secondary mixed dipterocarp forest. Along this transect, sweep netting for 98 person-hours per study site was performed to capture and document the species. The fieldwork was carried out during July 7-8, and August 4 in the year 2018. On the other hand, the fieldworks in Gamut were conducted on February 10, May 12, 30-31, 2018. The sampling effort allotted were 21, 49, 14, and 14 person-hours per day, respectively. The 98 sampling hours in Mat-e were the accumulated sampling efforts from the two sampling periods with 35 sampling hours allotment in the first visit, which covers two days, and 28 hours in the last visit.

The improvised sweep nets made of silk cloth with a diameter of 50 to 60 centimeters were used. The collected individuals were placed in a folded glassine paper for further taxonomic analysis. Initial identification was carried out by comparing the samples to the existing photographic guides and keys from published monographs and articles (Treadaway, 1995; Ramirez & Mohagan, 2012). Afterward, the initial identification, characteristic notes, and pictures were sent to the expert for verification. The samples were then subjected to final preservation and it was pinned for museum display and educational purposes.

Data Analyses and Status Assessment

The Biodiversity Professional 2.0 software was used to determine the Diversity Indices. As for the local rarity assessments, the established criteria by Mohagan and Treadaway (2010) was used and followed. However, modifications were made, and the "Very Rare" category was not adopted. The species were just assessed as either Rare (1-5 individuals), Common (6-10), or Very Common (11 plus). The adjustments were made as to the concern on the parity of the sampling effort. The

assessment tool was derived from a more robust study, while the current study encountered various hindrances that limits the data collection. Hence, in order to address the possibility of being too subjective in giving the status, modifications were made. As to the National Assessment, the report in the papers of Treadaway (1995), Mohagan and Treadaway (2010), Mohagan *et al.* (2011), and Ramirez and Mohagan (2012) were used as references. The global status was based on the International Union and Conservation for Nature (IUCN, 2020) web page. The species endemism was aligned to the online database established by Badon *et al.* (2013).

RESULTS AND DISCUSSION

Species Composition and Abundance

A total of 159 individuals of butterflies were captured in the two habitats. Of these, 103 and 56 individuals were captured from Mat-e and Gamut, respectively. The totality of captures was considered low with respect to the number of sampling hours exerted which sums-up to 98 man-hours per site. However, it should be noted that these captures do not exactly equates to the totality of butterfly abundance in the area, since the value only represents the captured individuals, and it excludes the uncaptured one. During the study, more individuals of butterflies were actually observed; however, most of those butterflies were not caught due to various limitations such as the availability of butterfly nets for capturing high and fast flying butterfly species. Meanwhile, of these captured individuals, 29 species were identified to belong to 19 genera and four families. Among the families, Nymphalidae was the most represented group with a total of 14 documented species from the two sites. This is followed by Papilionidae and Pieridae having six representative species, while the least represented group was Lycaenidae with only three documented species (Figure 2). When it comes to per habitat perspective, the same butterfly composition trend was observed for both localities wherein nymphalids were the well-documented butterfly group. The result conforms with the findings of Mohagan and Treadaway (2010) at Mt. Hamiguitan, Gestiada *et al.* (2014) at Mt. Banahaw, and Nacua *et al.* (2015) at the La Union Botanical Garden, Philippines. The same observation was also noted from the studies conducted in the tropical forests of Vietnam (Vu & Quang-Vu, 2011), Indonesia (Koneri & Saroyo, 2017) and Ecuador (Castro & Espinosa, 2015) wherein

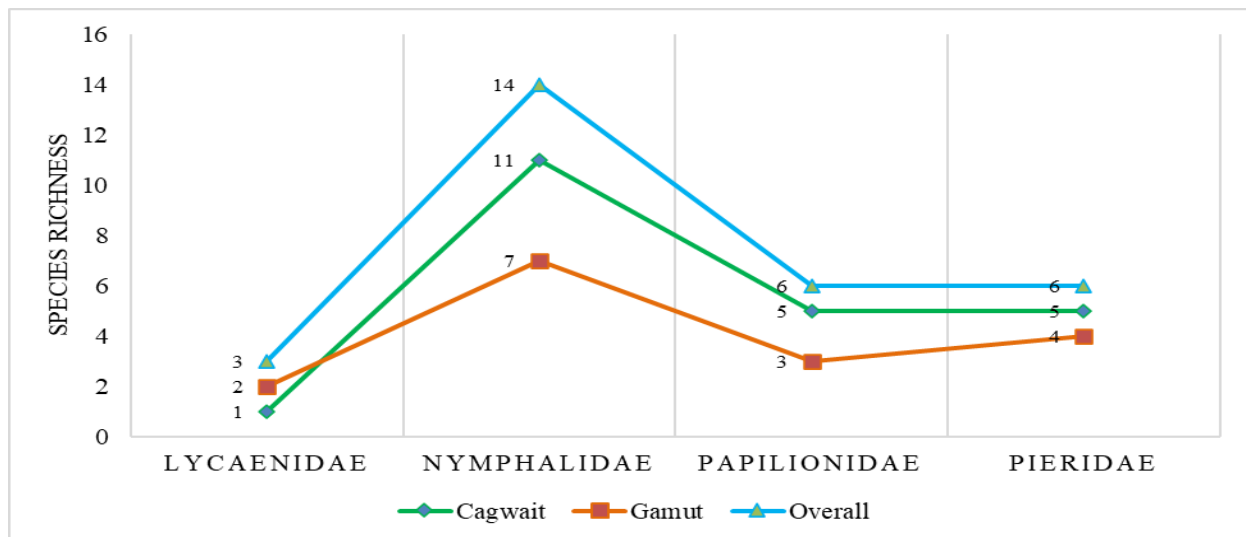


Figure 2. The trend of butterfly species assemblage in two habitats and collated species richness patterns grouped into families

nymphalids are the ones that dominate the area.

The high richness of the nymphalids is attributed to three main factors. First, as to the taxonomic groupings, the family is the largest butterfly group with over 6,000 known species across the globe (Zarikian & Kalashian, 2016). Thus, suggesting a higher diversity and wide distribution, especially in the tropics where the group is widely distributed. With this, considering that an approximate 90% of the butterfly species are found in the tropical regions (Bonebrake *et al.*, 2010; Munyuli, 2013), and giving the fact that the study site is a tropical forest, the narrative on nymphalids high global diversity and wide distribution could be plausible support. The observation is agreed by various studies (Guadalquiver *et al.*, 2019; Koneri *et al.*, 2019; Sebua & Nuñez, 2020) wherein nymphalids are the documented dominant group in most habitats. Secondly, relative to foraging behavior, nymphalids are considered voracious eaters that feed on various types of plants, especially at their larval stage; thus, making them more adaptive to different habitats (Qureshi & Bhagat, 2015). A concept that also relates to why the butterfly congregation pattern for both localities is the same, even though the plant assemblage is somehow different. Lastly, this result could be attributed to the presence of the host plants of nymphalids. Based on the visual assessments performed in both areas, the habitat in Mat-e was noted to have more plants that bear flowers during the fieldwork. The idea agrees with the report of Junior and Diniz (2015) that habitat structure and plants phenology

are important ecological supporting factors for Nymphalidae, especially in temporal perspective.

Lycaenidae is reported to be the second-largest butterfly group with an estimated extant species of 5,000 (Badon *et al.*, 2013). However, despite these numbers, the group is less represented in this study. The result aligns with the findings of Sundufu and Dumbuya (2008), Nacua (2016), Koneri *et al.* (2019), , with studies conducted from the tropical forests of Africa, Philippines and Indonesia, accordingly. However, the overall generalization on this faunistic observation could not be fully drawn due to limited sample size and effort as compared with other rigorous studies that lasted for months and even years like the studies of Ballentes *et al.* (2006), Mohagan and Treadway (2010), Mohagan *et al.* (2011), and Ansari *et al.* (2015). Nevertheless, noteworthy reasons are worth elucidating. The lycaenids are reported to be more sensitive, especially on habitat alteration, for changes in the habitat affect its composition (New, 1993). It was noted that portions of the sampled area were altered ecosystems; thus, possibly suggests the composition of the lycaenids has been affected because of the changes in the site’s topography.

Out of the 29 species recorded, only three species were noted as common in both habitats (Table 1). These species include one nymphalid (*Junonia hedonia ida*) and two pierids (*Eurema blanda vallivolans* and *Gandaca harina mindanaensis*). The high abundance of these species, specifically the butterfly *J. hedonia ida*

Table 1. Butterfly species rarity, conservation, and endemism assessment. The following legends are the following: NE: Non-Endemic, ME: Mindanao Endemic, PE: Philippine Endemic. Species name with asterisk at the upper right is assessed as threatened species

Taxon	Abundance		Total	Assessment Status			Endemism
	Gamut	Mat-e		Local	National	Global	
Lycaenidae							
<i>Jamides celeno</i>		6	6	common	rare	rare	NE
<i>Jamides</i> sp.	1		1	rare	-	-	-
<i>Jamides suidas suidas</i>	1		1	rare	-	-	NE
Nymphalidae							
<i>Acrophtalmia leto ochine</i>		8	8	common	rare	-	ME
<i>Cirrochroa tyche tyche</i>	1	1	2	rare	common	-	NE
<i>Euploea mulciber mindanensis</i>	1		1	rare	common	-	NE
<i>Faunis phaon leucis</i>		2	2	rare	common	-	PE
<i>Faunis</i> sp.		1	1	rare	-	-	-
<i>Hypolimnas anomala</i>	1		1	rare	common	common	NE
<i>Junonia almana</i>		10	10	common	common	common	NE
<i>Junonia hedonia ida</i>	10	9	19	common	common	common	NE
<i>Mycalesis mineus philippinensis</i>		3	3	rare	common	rare	NE
<i>Neptis cymela niletus</i>		9	9	common	common	-	PE
<i>Neptis mindorana pseudosoma</i>	1		1	rare	common	-	PE
<i>Vindula dejone dejone</i>		5	5	rare	common	-	NE
<i>Ypthima sempera chaboras</i>	12	2	14	common	common	common	PE
<i>Ypthima stelleria stelleria</i>	4	6	10	common	common	-	PE
Papilionidae							
<i>Arisbe stratoctes stratoctes</i>	1	4	5	rare	-	-	NE
<i>Atrophaneura semperi aptonia*</i>		1	1	rare	rare	rare	PE
<i>Graphium agamemnon</i>		2	2	rare	common	-	NE
<i>Menelaides deiphobus rumanzovia</i>	2	2	4	rare	common	-	NE
<i>Menelaides polytes ledebouria</i>	2		2	rare	common	-	NE
<i>Pachliopta mariae mariae</i>		5	5	rare	common	-	PE
Pieridae							
<i>Catopsilia pyranthe pyranthe</i>	2		2	rare	common	common	NE
<i>Catopsilia scylla asema</i>		3	3	rare	common	common	NE
<i>Catopsilia</i> sp.		6	6	common	-	-	-
<i>Eurema alitha alitha</i>		1	1	rare	common	common	ME
<i>Eurema blanda vallivolans</i>	9	7	16	common	common	common	NE
<i>Gandaca harina mindanaensis</i>	9	10	19	common	common	-	NE
Total	56	103	159				

conforms with the report by Mohagan *et al.* (2011) and Ramirez and Mohagan (2012). The species is reported to inhabit the tropical lowland forest and tend to be more abundant in any area. It is also considered a common species throughout the Philippine islands with a wide geographic distribution that extends from northern to southern Philippines (Badon *et al.*, 2013).

Species Richness and Diversity

Among the 29 butterfly species recorded, 22 species were observed in Mat-e, while 15 species were noted in Gamut. Comparatively, Mat-e showed to be more species-rich as compared to the latter. The diversity indices were also relatively higher in Mat-e ($H'=1.22$; $J'=0.91$) than Gamut ($H'=1.00$; $J'=0.83$). The evenness shows how evenly distributed the population of the species is in a particular community. On the other hand, the equitability gives the highest probable diversity value obtained from a given data set. The concept suggests that if J' (species evenness) is closer to the value of 1, the maximum number, the more diverse the community is. The same concept is applied if the H' is more relative to the value of H_{max} (Table 2).

The higher diversity index observed in Mat-e compared with Gamut is attributed to the anthropogenic activities and the characteristic of the habitat itself where the transect is mostly located. As mentioned, the transect established in Gamut was predominantly laid along the agroecosystem with much exposure to human activities due to its nearness to human settlements. Meanwhile, the site in Mat-e was mostly located in the secondary mixed dipterocarp forest. Reports suggest that human activities have a significant negative impact towards butterfly diversity (White & Kerr, 2007; Gallou *et al.*, 2017) because it leads to a natural habitat loss, which is mostly a manifestation of agricultural practices (Mckinney, 2002; Stefanescu *et al.*, 2004; Bergerot *et al.*, 2011; Habel *et al.*, 2016; Thomas, 2016). Thus, altering the plant community's composition, especially the availability of nectar resources essential to the butterflies (Ohwaki *et al.*, 2017).

Furthermore, the influence of seasonality could also serve as one of the main factors that contributes to the high diversity in Mat-e compared to Gamut. As noted, with respect to phenology, various plants in Mat-e were flowering during the fieldwork. This

tempo-biological event in the area potentially attracts more butterfly species and individuals. Anent to this, considering the idea that these organisms are pollinators by nature, and nectar is their food, it does strongly support the claim. This report is anchored on the report of Ghosh and Saha (2016) that seasonal factors are among the ecological factors that dictates butterfly diversity. This is further supported by the report of Ferrer-Paris *et al.* (2013) that there is a strong correlation between the presence of host-plants and butterfly diversity.

However, from a general perspective, the representation of butterfly diversity in both sites is considered low as compared to other sampled habitats in the Philippines. The documented richness per site was observed to be lower as compared to other habitats like Mt. Nebo (Sumagaysay & Sumagaysay, 2012), Canopy forest in Cadaclan (Nacua *et al.*, 2015), and other forest areas in Mindanao (Mohagan *et al.*, 2011), with a median difference of 50 species. The disparity between this observation is associated with multiple limitations incurred during the study. First, in contrast with the current study, the previously cited studies' sampling effort was way more rigorous, covering multiple stations in a single habitat with longer sampling duration. Thus, giving more area and time to sample and collect more data. Moreover, the current study is limited only to captured individuals' documentation, while uncaptured individuals and visually observed species were excluded due to the uncertainty in identification. This observation conforms with the statement of Guadalquiver *et al.* (2019) that sampling effort, in general, is one of the significant factors that affect the representation of the species richness and diversity of butterflies in any sampled area.

On the other note, the richness observed in Mat-e was noted to be relatively higher than the report of Zapanta *et al.* (2016) from San Idelfo, Bulacan. While both records from the two habitats were higher than the findings from Bega Watershed with 14 species (Nuñez *et al.*, 2016), and report from Pasay with 11 noted species (Nacua *et al.*, 2019). With this comparison, it could suggest that Mat-e is a more favorable habitat for a butterfly species as it supports more butterfly species. A result that could be attributed to a well-defined ecological support such as food availability.

Table 2. Comparative species ecological information between Mat-e and Gamut forests

Ecological Information	Site	
	Mat-e	Gamut
Abundance	103	56
Richness	22	15
Shannon-weinner Diversity Index (H')	1.22	1.00
Species Evenness (J')	0.91	0.83
Species Equitability (Hmax)	1.34	1.20
Evenness difference (1-J')	0.09	0.17
Equitability difference (Hmax-H')	0.12	0.20

Endemism and Ecological Status Assessment

A total of nine species were assessed as endemic, revealing a 31% of endemism out of the entire list, and 34% with the exclusion of the undetermined species. Among the sites, the lowland forest of Mat-e showed to have a higher endemism, with 36% of the species assessed, while only 20% were noted in Gamut (Table 1). The differences in the pattern of endemism between the two sites are attributed to the habitat itself, concerning the disturbance. The habitat in Gamut was previously elaborated to cover a larger area of agroecosystem with a higher level of human disturbance. As reported by Guadalquivir *et al.* (2019), endemic butterflies are mostly found in a much-forested area with less disturbance. Not to mention these kinds of butterfly species are restricted to a smaller range with a high susceptibility rate to any threats (Bae & Park, 2017). Habitat homogeneity is considered as another plausible reason as well. The agroecosystem is generally homogenous; thus, offering a limited food source and resources related to plant composition. Considering that endemic species are reported to be specialists and require special food plants (Janzen, 1988; Singer & Ehrlich, 1991; Veddeler *et al.*, 2005), the limited resources could lead to the absence of such species.

The recorded endemism in Mat-e was noted to be relatively higher than the reported endemism in Bega Watershed (Nuñez *et al.*, 2016), lowland forest of Maitum (Ramirez & Mohgan, 2012), Mt. Hibok-hibok (Toledo & Mohagan, 2011), and Mt. Pinamantawan (Mohagan *et al.*, 2018) with percentage endemism difference of 9% to 26%. Considering that the overall butterfly endemism of the country is one-third of the overall species richness (Hardy & Lawrence, 2017). The result suggests that the butterfly endemism in the locality

follows the same trend as the national perspective. In fact, even in comparison with the major forest reserves in the country such as Mt. Hamiguitan (Mohagan & Treadaway, 2010) and Mambilsan Protected Area (Guadalquivir *et al.* 2019), the discrepancy of endemism between Mat-e and those mentioned forest reserves was noted to be only at least two percent – with the forest reserves on the lead (38%). This finding implies that the assemblage of butterfly in Mat-e in terms of endemic species is comparable to a more pristine environment.

A couple of nationally and globally assessed as rare species were documented in both sites. These species are *Jamides celeno*, *Mycalesis mineus philippinensis*, *Atrophaneura semperi aphtonia*, and the Mindanao endemic species *Acroptalmia leto ochine*. However, even though these are rare butterflies, the species *A. leto ochine* and *J. celeno* were observed to be locally common in Mat-e. The result suggests that the area is unique, for it houses more endemic and some rare species. Not to mention that the ecologically assessed as threatened species *A. semperi aphtonia* was also recorded in the site. Meanwhile, 15 and 2 butterfly species do not have global and national assessments, respectively. Thus, it emphasises the importance of the study's findings as one of the benchmark information for any analysis that will be made to understand butterfly communities better.

CONCLUSION

The two sampled habitats were observed to have a poor representation of butterflies in general. However, this finding is primarily affected by various limitations that hinders the maximum collection of data. On the other note, between the two sites, Mat-e showed to be a more diverse habitat as compared to Gamut. Endemism was also

relatively higher in the area, and is comparable to major forest ecosystems in the Philippines. The number of rare and threatened species are also more evident in Mat-e. With all of these, it is recommended that a more rigorous study should be carried out to clearly document the diversity pattern in these underexplored areas for lepidopteran survey.

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