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ORIGINAL

Butterfly diversity and habitat associations in a Montane ecosystem: A Case study of Mt. Ibot, Philippines

Diversidad de mariposas y asociaciones de hábitats en un ecosistema montañoso: Un estudio de caso del Monte Ibot, Filipinas

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ABSTRACT

Butterflies help plants reproduce, and their caterpillars break down a lot of plant material into waste, which goes back into the ecosystem in different ways. This study aimed to identify butterfly species diversity, local and national distribution, endemism, conservation status, habitat association, and spatial distribution. Transect walks, sweep netting, and bait trapping were utilized during the collection of samples from June 21 to 26, 2024; July 23 to 28, 2024; and August 23 to 28, 2024. A total of 653 individual butterflies were recorded, representing 47 species and three identified at the genus level, across five families: Nymphalidae, Pieridae, Papilionidae, Lycaenidae, and Hesperiidae. Nymphalidae has the most abundant species (52 %). Site 2, the riparian area, exhibited the highest species recorded (N=46 spp), with a diversity index value of H' = 3,694 and species evenness of E=0,873 . Site 1, agroforest, had 45 species (H'=3,543, E=768) with 294 individuals of butterflies. Site 3, the ecotourism area, recorded the fewest species, with only 44 (H'=3,598). Of the 47 identified species, 10 are endemic to the Philippines, while 5 are endemic to Mindanao. Discophora sondaica semperi stands out as a very rare species, both locally and nationally. Environmental factors such as temperature, humidity, canopy cover, and elevation have significantly influenced butterfly distribution. The observed floral associations suggest that the 21 plant families, especially Poaceae, Fabaceae, Moraceae, and Araceae, are potential butterfly host plants. The local distribution map was made to highlight butterflies' habitat-specific characteristics that signify Mt. Ibot's ecological value and the need for continuous monitoring for conservation efforts.

Keywords: Butterfly Diversity; Species Richness; Habitat Associations; Conservation; Potential Host Flora.

RESUMEN

Las mariposas desempeñan un papel crucial en la reproducción de las plantas, mientras que sus orugas contribuyen a la descomposición del material vegetal en desechos, los cuales se reintegran al ecosistema de diversas maneras. Este estudio tuvo como objetivo evaluar la diversidad de especies de mariposas, su distribución local y nacional, endemismo, estado de conservación, asociaciones de hábitat y distribución espacial. El muestreo se realizó mediante transectos, redes de barrido y trampas de cebo, durante los períodos del 21 al 26 de junio de 2024; 23 al 28 de julio de 2024; y 23 al 28 de agosto de 2024. Se registraron 653 individuos de mariposas, correspondientes a 47 especies y tres identificadas a nivel de género, distribuidas en cinco familias: Nymphalidae, Pieridae, Papilionidae, Lycaenidae y Hesperiidae. La familia Nymphalidae presentó la mayor abundancia (52 %). El sitio 2 (zona ribereña) registró la mayor riqueza de especies (N=46 spp), con un índice de diversidad de H'=3,694 y equitatividad E=0,873. El sitio 1 (agrobosque) presentó 45 especies (H'=3,543, E=0,768) y 294 individuos. El sitio 3 (área de ecoturismo) registró la menor riqueza, con 44 especies (H'=3,598). De las 47 especies identificadas, 10 son endémicas de Filipinas y 5 de Mindanao. Discophora sondaica semperi destaca como una especie muy rara, tanto a nivel local como nacional.

Factores ambientales como temperatura, humedad, cobertura del dosel y elevación influyeron significativamente en la distribución de las mariposas. Las asociaciones florales observadas indican que 21 familias de plantas, en particular Poaceae, Fabaceae, Moraceae y Araceae, son potenciales hospederas. Se elaboró un mapa de distribución local que resalta las características específicas del hábitat de las mariposas, enfatizando el valor ecológico del Monte Ibot y la necesidad de esfuerzos continuos de monitoreo y conservación.

Palabras clave: Diversidad de Mariposas; Riqueza de Especies; Asociaciones de Hábitat; Conservación; Flora Hospedera Potencial.

INTRODUCTION

The global diversity of butterflies is around 160 000 described species, with an estimated 17500 being butterflies.[1,2] These insects are important pollinators, food web components, and sensitive indicators of environmental change due to their rapid response to habitat alterations and climatic shifts.[3] However, global assessments reveal substantial knowledge gaps, especially in the tropics, where butterfly richness is highest yet most understudied. Butterflies, belonging to the order Lepidoptera, constitute a significant component of terrestrial biodiversity and are recognized for their vital ecological functions. Their species diversity serves as a key indicator of environmental health, reflecting the integrity and stability of ecosystems.[4,5] As pollinators, butterflies help plants reproduce, and their caterpillars break down a lot of plant material into waste, which goes back into the ecosystem in different ways. With an estimated 18,500 species of butterflies worldwide, butterflies represent a significant portion of global biodiversity.[6,7] Despite their ecological significance, butterflies are facing challenges. The butterfly populations are decreasing by 2 % annually, with approximately 30 % experiencing declines, including both common and rare species.[8,9,10]

Regarding butterfly diversity, Mindanao is home to 528 recorded butterfly species. Of these 219 species, approximately 41,5 % are endemic to the region. Despite this richness, there is noticeable lack of scientific studies focusing on butterflies in Mindanao. The influence of habitat conditions on their survival remains largely underexplored.[11] Many butterfly species remain unidentified, particularly in areas lacking comprehensive biological investigations.[12] In the Caraga region, Surigao del Norte, in the northeastern part of Mindanao, is known for its rich and diverse biological resources.

The diverse habitats, including forests, mountains, coastal areas, lakes, and waterfalls, provide suitable conditions for a wide range of butterfly species. One of the key natural areas in Surigao del Norte is Mt. Ibot, located in Barangay Ferlda, Alegria. It is located at approximately 9,4409°N, 125,6676°E, with an elevation of 684,3 meters above sea level. It was utilized as agricultural land (20 %), forest land (50 %), and residential land (15 %), based on the data of the municipality. Mt. Ibot contributes to the province's biodiversity with its varied habitats, which include forests, agroforestry, and ecotourism areas. These ecosystems provide suitable conditions for a wide range of flora and fauna, including butterflies. The study on butterfly diversity, ecological status, and species richness in Mt. Ibot, Surigao del Norte, sought to assess its ecological condition and species richness. Nevertheless, the research was confined to a certain time range and did not account for seasonal fluctuations. The lack of previous research on butterfly variety in Surigao del Norte impeded comparison analysis. Notwithstanding these constraints, the study offers essential baseline data to further Sustainable Development Goal 15: Life on Land, which prioritizes the cessation of biodiversity loss and the safeguarding of ecosystems. It indirectly supports SDG 13 (Climate Action) by emphasizing butterfly bioindicators of ecosystem vitality. Future research may connect butterfly diversity to SDG 2 (Zero Hunger) and SDG 4 (Quality Education) via local environmental awareness initiatives.

METHOD

The study focused on the butterfly diversity of Mt. Ibot in Surigao del Norte, northeastern Mindanao, a mountain located in Barangay Ferlda, Alegria. The area spans 12,5 square kilometers and has a peak elevation of 725,9 meters above sea level. Three sampling sites were selected: agroforestry (site 1), riparian area (site 2), and ecotourism area (site 3). The agro forested region, located at 726 meters, has agricultural crops like corn, abaca, cassava, sweet potato, taro, banana, coconut trees, and falcata. The riparian area, at 678 meters, has significant rainfall and an average relative humidity of 87,4 %. The vegetation includes trees, shrubs, ferns, and an understory of grasses and leaf litter. The ecotourism area, at 598 meters, has a relative humidity of 86,9 % and 80 % canopy cover. The study observed windy and rainy conditions during the sampling period at site 3. The findings provide a representative yet limited spatial scope for the study's findings.

The study focused on collecting and identifying butterflies in three vegetation types: agroforestry, riparian, and ecotourism areas of Mt. Ibot. The collection of butterflies was carried out across three vegetation types: agroforested, riparian, and ecotourism areas of Mt. Ibot. Field sampling occurred over three months, with six days dedicated to sampling each month: June 21-26, 2024; July 23-28, 2024; and August 23-28, 2024. During each sampling period, two days were allocated to each vegetation type, totaling 18 days of sampling. The butterfly collection took place from 8:00 AM to 4:00 PM. Butterflies were collected using sweep nets and bait traps, following standardized methods for assessing butterfly biodiversity. All butterflies were documented, collected, and stored in triangular paper envelopes and plastic containers. Images of each butterfly's ventral and dorsal parts were sent to Professor Alma B. Mohagan of Central Mindanao University for species identification. The butterflies' conservation status, endemism, and Philippine distribution were determined using illustrated lists of Philippine butterflies. The distribution of species within the study area was determined based on their occurrence in three sampling sites.The study used Paleontological Statistics (PAST) version 2.0 software to study ecological diversity. We calculated species richness, abundance, evenness, dominance, and the Shannon-Weiner diversity index to assess ecological balance. Species richness is the total number of distinct species present in a given area, while abundance is the total number of individuals of a particular species within an ecological community. Species evenness is the distribution of individuals evenly among species, with the evenness index categorizing it into low, moderate, and high. Dominance is the extent to which one or a few species numerically prevail over others in a community. The Shannon-Wiener index measures both species richness and evenness within a taxon, providing a comprehensive view of biodiversity in an ecological community.

The conduct of this study adhered to ethical standards in research involving biodiversity and ecological assessments. We secured all necessary permits and approvals prior to the study's conduct to ensure compliance with ethical and legal requirements. All necessary permits for field collection were secured from local authorities. A formal request for permission was submitted and approved by the Office of the Mayor of the Municipality of Alegria, as well as by the Barangay Captain of Barangay Ferlda, granting consent for the research activities within their jurisdiction. A Wildlife Gratuitous Permit (WGP) was also obtained from the Department of Environment and Natural Resources (DENR) Region 13, under Permit No. R13-2024-57, authorizing the collection and documentation of butterfly specimens for scientific purposes. We designed our sampling methods to minimize disturbance to butterfly populations and their natural habitats. Specimens were collected in accordance with ethical guidelines, ensuring that only a limited number were taken for scientific identification and documentation purposes.

RESULTS AND DISCUSSION

Butterfly species and their abundance. The butterfly diversity assessment conducted in Mt. Ibot of Ferlda, Alegria, Surigao del Norte documented the species composition, abundance, endemism, and ecological status of butterfly species across the three sites. A total of 653 butterfly individuals were recorded during the field study, representing 47 species and three additional species identified at the genus level: Celastrina sp., Udara sp., and Allotinus sp. These species were distributed among five families: Nymphalidae, Lycaenidae, Pieridae, Papilionidae, and Hesperiidae (table 1). The family Nymphalidae emerged as the most species-rich and abundant, supporting its known role as a dominant group in tropical forest ecosystems. Out of the total butterflies collected, the agroforested area (Site 1) had the highest number of species, with 294 individuals accounting for 45 % of the total butterflies collected. This region was followed by the riparian area (Site 2) with 198 individuals (30 %) and the ecotourism area (Site 3) with 161 individuals (25 %). These variations reflect the differing ecological conditions and resource availability among the sites.

With a total of 50 documented species, the assessment revealed that Ypthima sempera chaboras had the highest number of individuals, with 59 individuals recorded across all three sites. Zizina otis oriens followed with 47 individuals, and Eurema hecabe tamiathis followed with 45 individuals. These species' relatively high numbers suggest that they are more widespread or better adapted to the varying habitat conditions in Mt. Ibot. The presence of a diverse assemblage of butterfly species emphasizes the ecological value of these habitats in sustaining rich and varied butterfly communities. Among the recorded families, the Nymphalidae exhibited the highest species richness and abundance, comprising 26 species (52 %) across the three study sites. It was followed by the Lycaenidae with nine species (18 %), Pieridae with seven species (14 %), Papilionidae with five species (10 %), and Hesperiidae with the lowest representation of three species (6 %). This pattern of dominance matches what earlier studies by [13,14] found, showing that Nymphalidae is the most common butterfly family.

This The family Nymphalidae, represented by 26 species, is considered as the largest butterfly family, comprising approximately 6,000 species worldwide.[15] Their dominance can be attributed to their adaptability, broad range of larval host plants, and ability to thrive in diverse habitats.[16] The most abundant species recorded from this family was Ypthima sempera chaboras, with 59 individuals, categorized as very common at the local level. This was followed by Mycalesis mineus philippina, with 21 individuals, also considered very common locally, common nationally, but rare globally. Additionally, Junonia atlites atlites and Ypthima stellera stellera were both recorded with 18 individuals each, categorized as common at the local level, and as common and

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very common at the national level, respectively. Notably, Discophora sondaica semperi under this family, was categorized as very rare, indicating the need for monitoring and habitat protection.[17,18]

Table 1. Species composition, abundance, endemism, distribution, and conservation status of butterflies in Mt. Ibot, Ferlda, Alegria, Surigao del Norte

Species	No. of Individuals	Endemism (Hardy & Lawrence 2022)	Distribution (Hardy & Lawrence 2022; Domine & dela Cruz 2020)	Local Status (Based on the butterfly frequency of occurrence in Mt. Ibot)	National Status (Hardy & Lawrence 2022)	Global Status (Hardy & Lawrence 2022; IUCN, 2025)	Conservation Status (IUCN, 2025)
NYMPHALIDAE							
Cethosia luzonica magindanica Semper, 1888	2	ME	Mindanao	Very rare	Common	NE	NE
Melanitis leda leda (Linnaeus, 1758)	10	NE	Philippines	Rare	Very Common	NE	LC
Danaus melanippus edmondii Lesson, 1837	16	NE	Philippines excluding Balabac	Common	Common	NE	NE
Euploea mulciber mindanaensis Staudinger, 1889	12	ME	Mindanao	Common	Common	NE	NE
Hypolimnas bolina philippensis (Butler, 1874)	13	NE	Philippines excluding Batanes, Bongao, Jolo, Sanga Sanga, Sibutu, Tawi-Tawi	Common	Very Common	NE	NE
Polyura athamas acuta Rothschild, 1899	7	NE	Philippines excluding Balabac, Bongao, Calamian, Camiguin de Luzon, Palawan, Sanga Sanga, Sibutu, Tawi-Tawi, Luzon, Mindoro, Bohol, Mindanao	Rare	Common	NE	NE
Athyma maenas semperi Moore, 1896	9	ME	Basilan, Bohol, Dinagat, Leyte, Mindanao, Panaon, Samar	Rare	Uncommon	NE	NE
Lexias panopus miscus Fruhstorfer, 1913	11	ME	Mindanao	Common	Uncommon	NE	NE
Amathusia phidippus pollicaris (Butler, 1870)	4	NE	Philippines excluding Bongao, Cebu, Masbate, Negros, Panay, Sanga Sanga, Sibutu, Sibuyan, Tawi-Tawi	Rare	Common	NE	NE
Junonia hedonia ida (Cramer, 1775)	13	NE	Philippines	Common	Very common	NE	NE
Zeuxidia sibulana sibulana Honrath, 1884	6	ME	Eastern and Northern Mindanao	Rare	Uncommon	NE	NE
Symbrenthia hippoclus anna (Semper, 1888)	4	NE	Bohol, Cebu, Camiguin de Mindanao, Camotes, Leyte, Mindanao, Panaon, Samar, Siargao	Rare	Common	NE	NE
Ypthima sempera chaboras (Felder, 1863)	59	PE	Alabat, Bohol, Cmamotes, Guimaras, Leyte, Luzon, Marinduque, Masbate, Mindoro, Negros, Panay, Panaon, Samar, Agusan del Sur	Very Common	Common	Common	NE

Junonia atlites atlites (Linnaeus, 1758)	18	NE	Philippines	Common	Common	NE	NE
Mycalesis mineus philippina (Linnaeus, 1758)	21	PE	Alabat, Bohol, Catanduanes, Cuyo, Guimaras, Luzon, Mindoro, Negros, Palawan, Agusan del Sur	Very Common	Common	NE	NE
Discophora sondaica semperi Moore, 1895	1	NE	Eastern and Central Mindanao	Very rare	Very rare	NE	NE
Ypthima stellera stellera Eschscholtz, 1821	18	PE	Basilan, Bohol, Cebu, Camotes, Luzon, Leyte, Marinduque, Mindoro, Mondanao, Negeros, Panay, Panaon, Romblon, Samar, Siargao	Common	Very common	NE	NE
Orsotriaena medus medus (Fabricius, 1775)	5	NE	Philippines	Rare	Common	NE	NE
Mycalesis felderi felderi Butler, 1868	8	PE	Basilan, Cebu, Dinagat, Leyte, Mindanao, Samar, Siargao	Rare	Common	NE	NE
Junonia orithya leucasia (Fruhstorfer, 1912)	4	NE	Philippines excluding Sibutu	Rare	Very Common	NE	LC
Euploea tulliolus pollita (Erichson, 1834)	6	NE	Babuyan, Bohol, Cebu, Camiguin de Mindanao, Camotes, Dinagat, Guimaras, Leyte, Luzon, Marinduque, Masbate, Central and Northern Mindoro, Mindanao (excluding south-western), Negros, Panaon, Samar, Sibuyan, Ticao	Rare	Uncommon	NE	NE
Junonia almana almana (Linnaeus, 1758)	2	NE	Philippines except the south	Very rare	Common	Common	LC
Euploea eunice eunice (Godart, 1819)	8		Philippines excluding Balabac, Calamian, Palawan	Rare	Uncommon	NE	NE
Ragadia melindena melindena C. & R. Felder, 1863	11	PE	Camiguin de Mindanao, Sarangani	Common	Uncommon	NE	NE
Melanitis phedima (Cramer, 1780)	14	NE	Philippines excluding Balabac, Bongao, Palawan	Common		-	NE
Hypolimnas anomala anomala (Wallace, 1869)	4	NE	Philippines	Rare	Common	Common	NE
PIERIDAE							
Delias hyparete mindanaensis Mitis, 1893	13	NE	Dinagat, Mindanao	Common	Common	NE	NE
Eurema hecabe tamiathis Fruhstorfer, 1910	45	NE	Philippines excluding Balabac, Calamian, northern Luzon, Mindoro, Palawan	Very Common	Very Common	NE	LC

Catopsilia pomona pomona (Fabricius, 1775)	8	NE	Philippines	Rare	Very common	NE	NE
Delias henningia ochreopicta (Butler, 1869)	15	PE	Mindanao, Panaon	Common	Uncommon	NE	NE
Catopsilia pyranthe pyranthe (Linnaeus, 1758)	15	NE	Philippines	Common	Common	NE	NE
Appias olferna peducaea Fruhstorfer, 1910	16	NE	Bohol, Cebu, Jolo, Luzon, Marinduque, Mindoro, Mindanao, Negros, Palawan	Common	Very Common	NE	NE
Leptosia nina terentia Fruhstorfer, 1910	4	NE	Basilan, Calamian, Cebu, Cuyo, Mindoro, Mindanao, Palawan, Panay	Rare	Very Common	NE	NE
PAPILIONIDAE							
Troides rhadamantus (Lucas, 1835)	7	PE	Philippines, excluding Balabac, Camian, Palawan, Agusan del Sur	Rare	Common	NE	LC
Menelaides deiphobus rumanzovia (Eschscholtz, 1821)	10	PE	Philippines	Rare	Common	NE	NE
Papilio demoleus libanius Fruhstorfer, 1908	18	PE	Philippines	Common	Very Common	NE	NE
Menelaides polytes ledebouria (Eschscholtz, 1821)	16	PE	Philippines	Common	Common	NE	NE
Graphium agamemnon agamemnon (Linnaeus, 1758)	13	PE	Philippines	Common	Very Common	NE	NE
LYCAENIDAE							NE
Jamides cleodus manias (C. Felder, 1865)	28	NE	Davao City	Very Common	Very Common	NE	NE
Everes lacturnus lacturnus (Godart, 1824)	18	NE	Dinagat, Dumaran, Luzon, Mindanao, Negros, Palawan, Sanga Sanga, awi-Tawi	Common	Common	NE	NE
Allotinus sp.	13	NE		Common		NE	NE
Celastrina sp.	29	NE		Very Common		NE	NE
Zizina otis oriens (Fabricius, 1787)	47	NE	Bohol, Cebu, Dinagat, Dumaran, Jolo, Leyte, Luzon, Marinduque, Mindanao, Negros, Palawan	Very Common	Common	NE	LC
Udara sp.	8	NE		Rare		NE	NE
Allotinus fallax aphacus Fruhstorfer, 1913	3	NE	Camiguin de Mindanao, Dinagat,	Very rare	Common	NE	NE

Poritia philota phare H. H. Druce, 1895	4	NE	Basilan, Bohol, Dinagat, Leyte, Marinduque, Mindanao, Negros, Panaon, Samar	Rare	Common	NE		NE
Lampides boeticus (Linnaeus, 1767)	17	NE	Balabac, Luzon, Marinduque, Mindoro, Negros, Palawan	Common	Very Common	NE		LC
HESPERIIDAE								NE
Ancistroides nigrita fumatus (Mabille, 1876)	11	NE	Babuyan, Balabac, Basilan, Biliran, Bohol, Camiguin de Mindanao, Cebu, Guimaras, Leyte, Luzon, Masbate, Mindanao, Mindoro, Negros, Palawan, Panay, Samar, Sarangani, Sibuyan	Common	Common	NE	NE	
Tagiades gana elegans (Mabille, 1877)	4	NE	Basilan, Biliran, Bohol, Camiguin de Mindanao, Camotes, Dinagat, Leyte, Luzon, Marinduque, Masbate, Mindanao, Mindoro, Negros, Panaon, Pilillo, Samar, Siargao, Sibuyan	Rare	Common	NE	NE	
Tagiades japetus titus (Plötz, 1884)	5		Babuyanes, Basilan, Biliran, Bohol, Bongao, Calamian, Camiguin de Luzon, Camiguin de Mindanao, Camotes, Cebu, Guimaras, Leyte, Lubang, Masbate, Mindanao, Mindoro, Negros, Palawan, Panay, Polillo, Samar, Siargao, Sibutu, Sibuyan, Tawi-Tawi	Rare	Common	NE	NE	

Note: NE: Non-Endemic, ME: Mindanao Endemic, PE: Philippine Endemic, CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern, DD: Data Deficient, NE: Not Evaluated

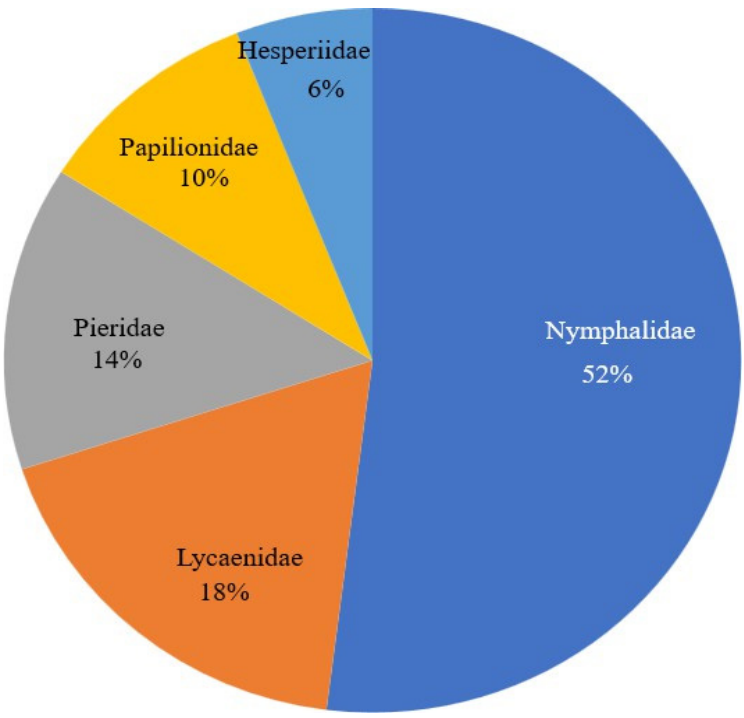

Figure 1. The abundance of the five families of butterflies in Mt. Ibot, Surigao del Norte

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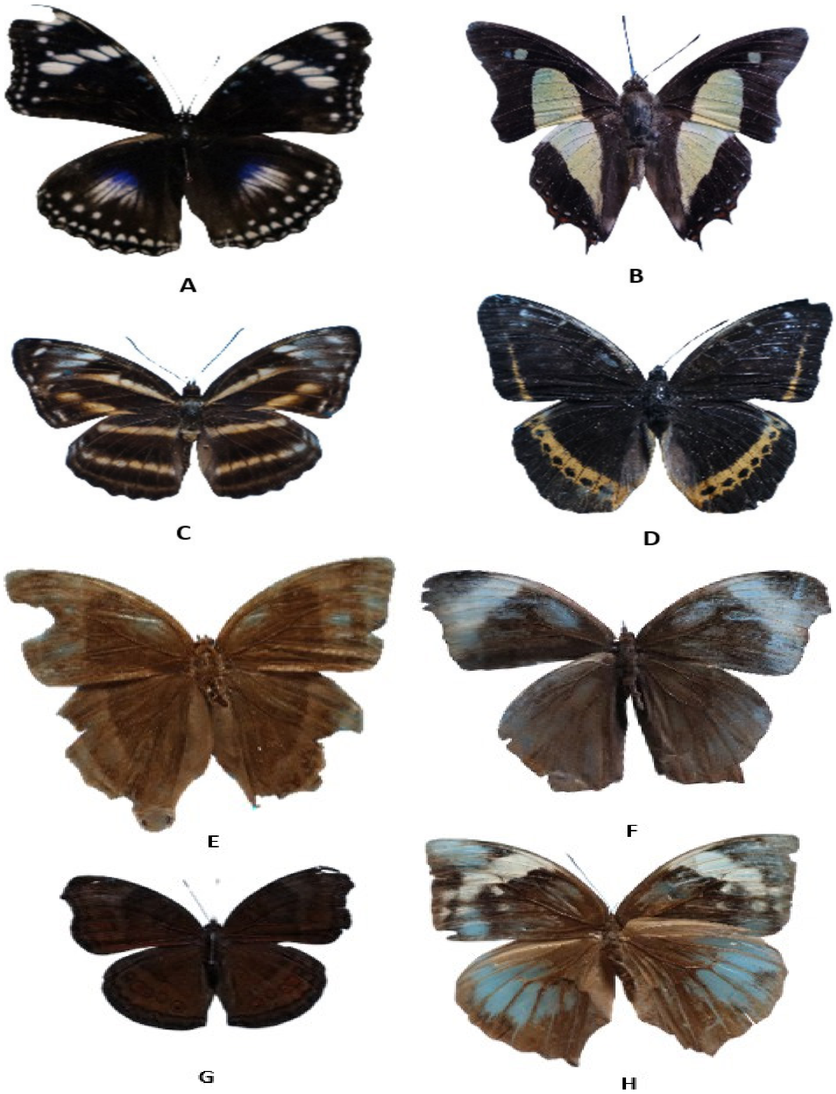

Figure 2. Butterflies belonging to the family Nymphalidae collected in Mt. Ibot, Alegria, Surigao del Norte.

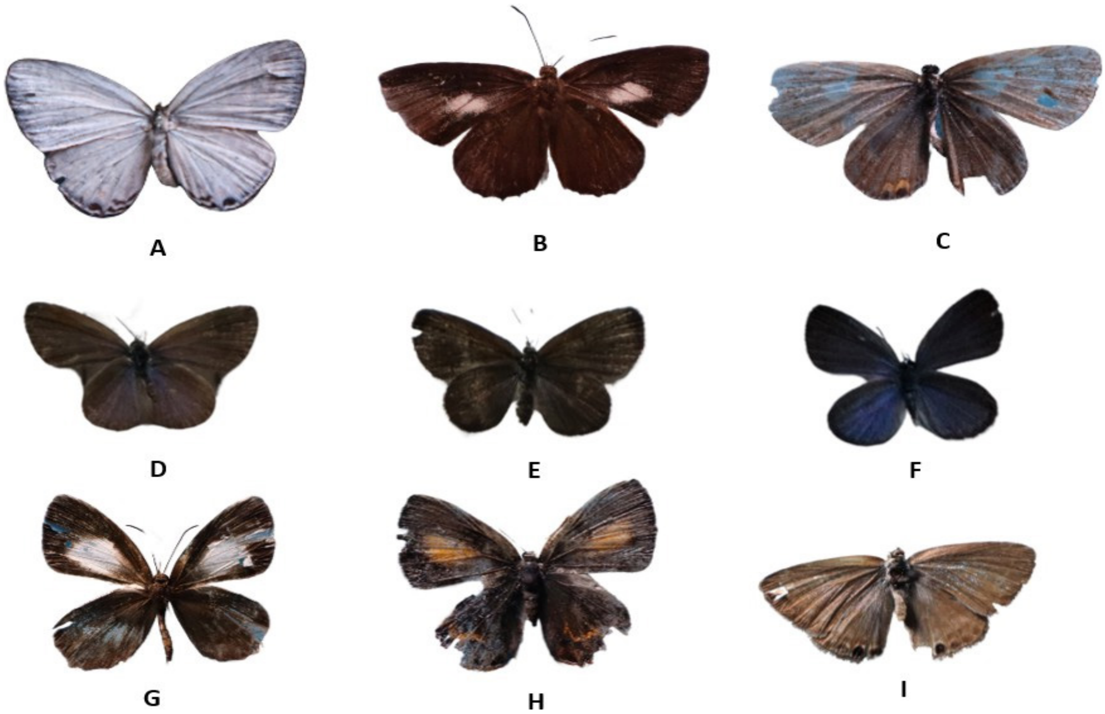

Figure 3. Butterflies belonging to the family Lycaenidae collected in Mt. Ibot, Alegria, Surigao del Norte

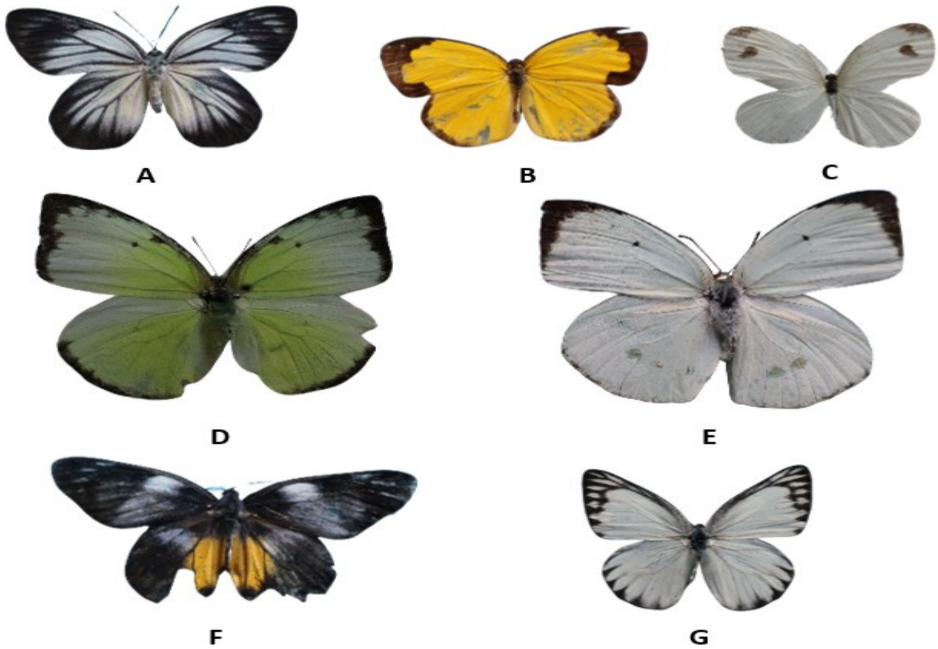

Figure 4. Butterflies belonging to the family Pieridae collected in Mt. Ibot, Alegria, Surigao del Norte

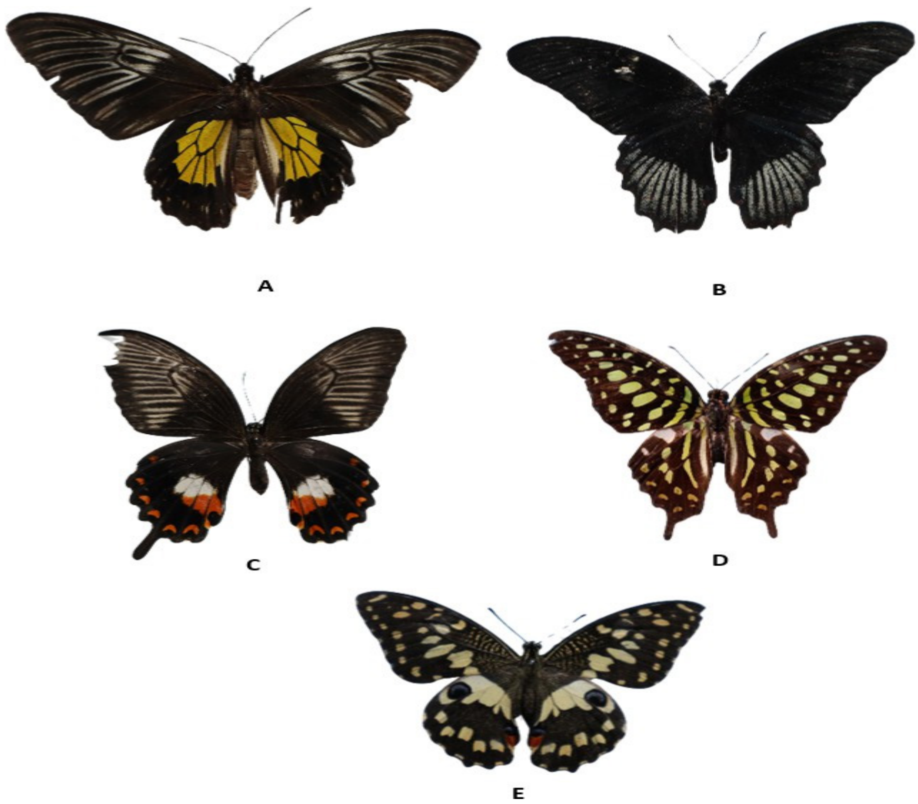

Figure 5. Butterflies belonging to the family Papilionidae collected in Mt. Ibot, Alegria, Surigao del Norte

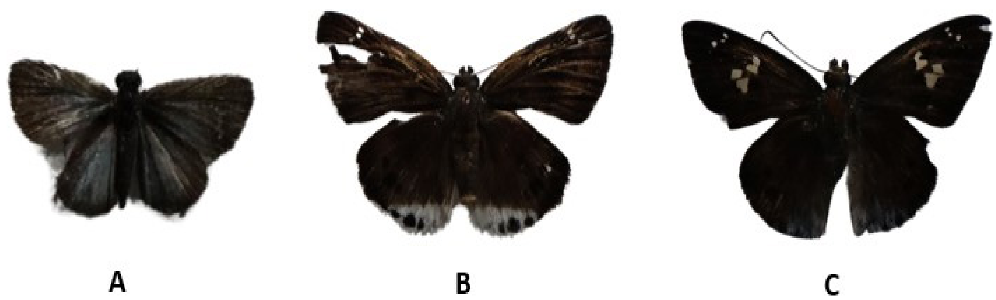

Figure 6. Butterflies belonging to the family Hesperiidae collected in Mt. Ibot Alegria, Surigao del Norte

The Lycaenidae family, represented by nine species, was the second most diverse group recorded in the study. Lycaenid butterflies are typically small and are known to have beneficial relationships with ants. Their ability to thrive in various environments may explain their moderate presence in the areas we examined. The most abundant species was Zizina otis oriens, with 47 individuals, classified as very common at the local level. This species was also reported as common in the study by [19] at selected waterfalls in Caraga, Davao Oriental, and noted as common in both Lauan Eco Park and Bood Promontory Eco Park, Butuan City, in the study.[13] Additionally, Ruales et al.[13] recorded 29 individuals of Celastrina sp., which was also categorized as very common locally.The Papilionidae family, recognized for its large and visually striking butterflies, was represented by five species across the study sites. This lower abundance may be attributed to their specialized habitat requirements and host plant specificity, primarily depending on Rutaceae, Lauraceae, and Magnoliaceae. Such specialization renders them vulnerable to habitat fragmentation[20] Menelaides polytes ledebouria, with 16 individuals, is considered common both locally and nationally; however, it is classified as rare by [13] Notably, Troides rhadamantus was observed and identified as rare at the local level. Lastly, the Hesperiidae family was the least represented, with only three species recorded. This family typically finds skippers in forested habitats and grassy areas.[21] Their lower numbers in the study areas may be attributed to various ecological and behavioral factors, such as their preference for habitats that were not common in the sampling locations, their small size and quick flying making them harder to spot, and potential environmental changes. Among the three recorded species, Ancistroides nigrita fumastus was the most abundant, with 11 individuals, classified as common at both the local and national levels. This species was followed by Tagiades japetus titus, with 5 individuals classified as rare locally but common nationally, and Tagiades gana elegans, with 4 individuals categorized as rare locally and common nationally.

Diversity indices

Table 2 presents the diversity indices of butterflies in the three sampling sites within Mt. Ibot: Site 1 (agroforestry), Site 2 (riparian), and Site 3 (ecotourism). Among the sites, the riparian area exhibited the highest species richness, with 46 species. This finding was followed closely by the agro forested area with 45 species and the ecotourism area with 44 species. This marginal variation suggests that all three habitats support a comparable range of butterfly species. However, the riparian area's higher richness may be attributed to its stable microclimate and higher plant diversity due to the proximity to water sources, which are favorable conditions for butterflies.[22,23]

Table 2. Diversity indices of Butterflies in Mt. Ibot, Alegria, Surigao del Norte

Sampling Sites	Species Richness (S)	Abundance (N)	Species Dominance (D)	Species Diversity (H')	Species Evenness (E)
Agro-Forested Area	45	294	0,036	3,543	0,768
Riparian Area	46	198	0,029	3,694	0,873
Ecotourism Area	44	161	0,037	3,598	0,829

The agro-forested area recorded the highest number of individual butterflies (N=294), followed by the riparian area (N=198) and the ecotourism area (N=161). The greater abundance in the agro-forested area could be influenced by the presence of edge habitats and cultivated plants that attract generalist species.[24] Despite this, individual butterfly abundance alone does not directly equate to ecological health, as high numbers may result from the dominance of a few adaptable species. The ecotourism area had the highest dominance index value (D=0,036), indicating a few species were more prevalent. The riparian area had the lowest dominance (D=0,029), suggesting a more balanced distribution of individuals across species. This finding is supported by the Shannon diversity index (H'), which combines richness and evenness to measure overall diversity.[25] The riparian area had the highest species diversity index (H'= 3,694), indicating the most ecologically diverse site, followed by the ecotourism area (H'=3,598) and agro-forested area (H'=3,543).

Evenness, which measures how equally individuals are spread across species, was highest in the riparian area (E=0,873) (table 2), suggesting a stable and undisturbed habitat. The ecotourism area also showed relatively high evenness (E=0,829), whereas the agro-forested area had the lowest (E=0,768), reflecting a community where certain species are much more abundant than others. These results suggest that the riparian area supports more species and has a balanced ecosystem, making it a vital habitat for butterfly conservation.[26] The data indicates that habitat characteristics strongly influence butterfly diversity and distribution. The riparian area provides stable environmental conditions, allowing a wider range of species to thrive. The agro forested area, while diverse, shows signs of species competition. The ecotourism area, potentially affected by human activities, demonstrates lower species diversity, indicating the need for conservation measures.

Cluster analysis of butterfly species composition

Based on the chart showing butterfly species at different locations, sites 2 and 3 are very similar, with about 0,75 similarity. This indicates that the two sites share common butterfly species. This similarity suggests that these two sites have comparable environmental conditions, such as elevation, canopy cover, temperature, and relative humidity. Based on the recorded environmental parameters, Site 2 (riparian area) recorded a relative humidity of 87,4 %, which is closely comparable to Site 3 (ecotourism area) at 86,9 %, indicating that both sites experience similar levels of atmospheric moisture. These nearly identical humidity levels reflect consistent atmospheric moisture, supporting similar butterfly assemblages.[27]

In terms of temperature, Site 2 recorded 26,3°C, while Site 3 showed a slightly lower reading of 25,8°C, indicating similar microclimatic conditions. Elevation also showed minimal variation, with Site 2 at 180 meters above sea level, while Site 3 is slightly higher at 190 meters. These relatively close values across multiple environmental variables imply that both sites provide comparable ecological conditions. This consistency in microclimate and vegetation structure can significantly influence butterfly behavior and distribution.[28] These factors also affect host plant availability and habitat preference, contributing to the similarity in butterfly species composition.[29]

Endemism and conservation status

The presence of 10 Philippine endemic species (20 %) and 5 Mindanao endemic species (10 %) among the 50 butterfly species recorded indicates the ecological importance of the study area as a habitat for regionally restricted taxa. This level of endemism aligns with national patterns, as approximately 360 butterfly species are endemic to the Philippines, highlighting the country's rich lepidopteran biodiversity.[30] The Philippine endemic species found in this study are Ypthima sempera chaboras, Mycalesis mineus philippina, Ypthima stellera stellera, Mycalesis felderi felderi, Ragadia melindena melindena, Delias henningia ochreopicta, Troides rhadamantus, Menelaides deiphobus rumanzovia, Papilio demoleus libanius, and Graphium agamemnon agamemnon. Among these, five species belong to the family Nymphalidae, four to the family Papilionidae, and one to the family Pieridae. Notably, Troides rhadamantus, commonly known as the Philippine golden birdwing, is among the Philippine endemics recorded. This species is listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora[31] indicating that, while not currently threatened with extinction, it may become so unless trade is closely controlled.

The identification of five Mindanao endemic butterfly species—Cethosia luzonica magindanica, Euploea mulciber mindanensis, Athyma maenas semperi, Lexias panopus miscus, and Zeuxidia sibulana sibulana—all belonging to the family Nymphalidae, underlines the ecological importance of Mt. Ibot as a habitat for regionally restricted taxa. Specific habitats within Mindanao confine these species, making their conservation crucial for maintaining the island's unique biodiversity. The presence of these endemics suggests that Mt. Ibot offers suitable environmental conditions, such as host plant availability and microclimatic factors, essential for their survival. This aligns with the findings of [32], who emphasized the importance of preserving habitats that support endemic butterfly species in the Philippines. Furthermore, Burlakova et al.[33] highlighted that endemic species often have specialized habitat requirements, making them particularly vulnerable to environmental changes.

Seven species found in the study area are considered Least Concern by the International Union for Conservation of Nature [IUCN][34] Lampides boeticus, Zizina otis oriens, Troides rhadamantus, Eurema hecabe tamiathis, Junonia almana almana, Junonia orithya leucasia, and Melanitis leda leda. However, it is important to note that even species categorized as Least Concern can face local threats that may not be reflected in their global assessments. Notably, Troides rhadamantus and Menelaides deiphobus rumanzovia are of particular conservation concern due to their restricted distributions and habitat specificity. Bauhus et al.[35] documented that these species are sensitive to habitat disturbances, and their survival is closely tied to the preservation of primary forests and specific host plants. The inclusion of T. rhadamantus in Appendix II of the Convention on International Trade in Endangered Species (CITES) further draws attention to the importance of monitoring and protection against overexploitation.

Physicochemical conditions at the sampling sites

The data on the microclimate and habitat structure from the three sampling sites—Site 1 (agro-forested area), Site 2 (riparian area), and Site 3 (ecotourism area)—helps us understand the environmental conditions that might affect butterfly diversity in Mt. Ibot. Four key parameters were recorded: relative humidity, temperature, canopy cover, and elevation (table 3). In terms of average relative humidity, all three sites show high humidity levels, ranging from 86,7 % to 87,4 %, with the riparian area (Site 2) having the highest value at 87,4 %. High humidity is generally favorable for butterflies, as it helps maintain their body hydration, supports the availability of host plants, and enhances microhabitat stability.[3] The minimal variation among the sites suggests that humidity is consistently suitable for butterfly survival across the landscape. Table 3 displays the average relative humidity, temperature, canopy cover, and elevation for the three sites.

Table 3. Average relative humidity, temperature, canopy cover, and elevation across three sites				
Sites	**Average Relative Humidity (%)**	**Average Temperature (˚C)**	**Average Canopy Cover (%)**	**Average Elevation (m)**
Site 1	86,7	25,40	35	691,32
Site 2	87,4	24,58	75	673,96
Site 3	86,9	25,37	80	590,6

The data for temperature across the three sites remains within a narrow range of 24,58˚C to 25,40˚C, with Site 2 having the lowest average temperature at 24,58˚C and Site 1 recording the highest at 25,40˚C. SlightCooler temperatures in the riparian zone could be attributed to evaporative cooling effects from nearby water sources and denser vegetation cover, which may provide thermal refuge for certain butterfly species. Such microclimatic variations, although subtle, can influence species composition, particularly for thermally sensitive or shade-loving species.[36] Canopy cover shows the most significant variation among the environmental parameters. Site 1 has the lowest canopy cover at 35 %, likely reflecting its semi-open, cultivated nature. In contrast, Site 2 and Site 3 have significantly higher canopy covers of 75 % and 80 %, respectively. Dense canopy cover contributes to habitat complexity and provides shelter, cooler microhabitats, and more stable environmental conditions—all essential for many forest-dependent butterfly species.[1] The tall trees in Sites 2 and 3 help explain the high number of different species and their even distribution, as they allow different species to share resources and prevent any one species from taking over.

The elevation data also varied slightly across the sites. Site 1 Site 1 is located at the highest elevation (691,32 m), followed by Site 2 at 673,96 m, and Site 3 at the lowest elevation of 590,6 m.at Elevation gradients are known to influence butterfly diversity by affecting temperature, vegetation types, and resource availability.[11] Although the differences in elevation are moderate, they may still influence species composition. This information is particularly relevant for endemic and montane specialists.

Potential host flora for butterflies in Mt. Ibot

Butterfly life cycle relies heavily on host plants, which are found in 21 plant families in Mt. Ibot. These include Poaceae (grasses), Fabaceae (legumes), Moraceae (fig trees), and Araceae (palm trees). These plants are crucial for butterfly species' oviposition, larval feeding, and adult sustenance. Grasses from Poaceae and herbs from Zingeberaceae and Acanthaceae are essential larval hosts, while trees like Ficus variegata, Artocarpus heterophyllus, and Nephelium lappaceum provide habitat and food for larvae and adult sustenance. Moraceae species, like Ficus, are particularly important for certain butterfly groups, while Fabaceae species like Albizia falcataria and Arachis pintoi provide nitrogen-rich leaves. The diversity of host plants reflects the ecological adaptability of butterfly species and their dependency on specific vegetation types.[37,38]

Table 4. Associated potential hostplants of butterflies in Mt. Ibot (Reference: Database of Host Plants of the World's Lepidoptera)			
Family Name	**Plant Species Scientific Name**	**Common Name**	**Plant Habit**
Acanthaceae	Blechnum pyramidatum	Browne's blechum	herb
Annonaceae	Annona muricata	Soursop	tree
Araliaceae	Osmoxylon fenicis		shrub
Arecaceae	Arenga pinnata	Palm tree	perennial tree
	Cocos nucifera	Coconut	tree
	Colocasia esculenta	Taro	herb
Convolvulceae	Ipomea batatas	Sweet potato	perrenial vine
Costaceae	Costus barbatus	Spiral ginger	ginger
Cyatheaceae	Sphaeropteris lepifera	Brush Pot Tree	fern
Euphorbiaceae	Euphorbia tithymaloides	Luhang-dalaga	herb
Fabaceae	Albizia falcataria	Falcata	tree
	Arachis pintoi	Mani-manian	legume
Gleicheniaceae	Dicranopteris linearis	False staghorn Fern	fern
Gramineae	Bambusa vulgaris	Kawayan	grass
	Capillipedium parviflorum	Scented top	grass
	Zea mays	Mais	grass
Heliconiaceae	Heliconia indica	Wild Plantain	herb
Lamiaceae	Clerodendrum brachyanthum	Bag flower	tree

Malvaceae	Urena lobata	Caesar weed	shrub
Melastomataceae	Melastoma malabathricum	Malatungaw	shrub
	Artocarpus heterophyllus	Nangka	tree
Moraceae	Ficus variegata	Green fruited fig	deciduous tree
Myrtaceae	Psidium guajava	Bayabas	shrub
Osmundaceae	Plenasium banksiifolium	Salindugok	fern
Piperaceae	Piper aduncum	Spiked pepper	shrub
Poaceae	Coix lacryma-jobi L	Adlay	grass
	Ischaemum muticum	Seashore Centipede Grass	grass
	Imperata cylindrica	Cogon grass	grass
	Urochloa mutica	Para Grass	grass
Polypodiaceae	Goniophlebium percussum	Percussed Angle-vein Fern	fern
Sapindaceae	Nephelium lappaceum	Rambutan	tree
Verbenaceae	Stachytarpheta jamaicensis	Blue porterweed	shrub
Vitaceae	Leea rubra	Red Leea	shrub
Zingiberaceae	Alpinia elegans	Tagbak	herb
	Curcuma aromatica	Wild turmeric	herb

While ferns such as Plenasium banksiifolium (Salindugok) and Dicranopteris linearis (false staghorn fern) play a significant role in butterfly ecology by offering shelter and larval food sources. These plants contribute to the maintenance of microhabitats, particularly in shaded or moist forest environments where butterfly larvae develop. Shrubs like Piper aduncum (spiked pepper) and Stachytarphete jamaicensis (blue porterweed) provide important nectar for adult butterflies, which helps with pollination in the ecosystem.[39] The high diversity of host plants in Mt. Ibot highlights its ecological importance as a butterfly habitat. The presence of endemic and economically significant plant species, such as Cocos nucifera (coconut) and Arthrocarpus heterephyllus (nangka), further illustrates the importance of conservation efforts to maintain habitat integrity. Habitat loss due to deforestation and land conversion poses a major threat to butterfly populations by reducing the availability of essential host plants. The dominance of grasses, trees, shrubs, and ferns suggests a well-structured ecosystem with abundant resources for butterfly survival.[7] Conservation initiatives should prioritize the protection of these plant species to sustain butterfly populations and maintain the ecological balance of Mt. Ibot.

CONCLUSIONS

This study successfully documented the diversity of butterfly species in Mt. Ibot, Barangay Ferlda, highlighting its ecological significance as a refuge for both widespread and endemic species. Across the three surveyed habitats—riparian, agroforested, and ecotourism areas—the riparian zone was found to be the most critical habitat, supporting the highest species diversity and balanced ecological conditions. The agroforested area, although less diverse, showed a notable abundance of butterflies, likely due to the availability of resources. Importantly, the discovery of 10 Philippine-endemic species, including five exclusive to Mindanao, emphasizes the area's significance for regional biodiversity conservation. Among these, Discophora sondaica semperi was noted as a rare species that requires urgent protection.

The strong association between butterfly communities and specific habitats underscores the influence of environmental factors such as vegetation structure, humidity, and elevation on species distribution. Plant families like Poaceae and Fabaceae were linked to butterfly abundance, illustrating the interdependence of flora and fauna. Additionally, spatial analysis revealed distinct clustering patterns, reflecting habitat-specific preferences and the ecological complexity of Mt. Ibot. By meeting the study's objectives, these findings affirm that Mt. Ibot is a crucial conservation priority. Protecting its habitats—especially the riparian zone—and their interconnected vegetation is essential not only for preserving butterfly populations but also for maintaining the ecological integrity of the region. Future efforts should combine habitat preservation with community-based strategies to address threats from land-use changes and promote sustainable ecotourism.

RECOMMENDATION

To sustain and enhance butterfly diversity in Mt. Ibot, it is recommended that conservation initiatives, like host plant restoration and rare species monitoring should be put in place; also prioritize the protection of the three sites: agroforestry, riparian, and ecotourism. These habitats provide essential conditions for various butterfly species and must be preserved. Further research should monitor potential host plants and study butterfly behavior. Involving local communities in conservation education can raise awareness of the ecological importance of butterflies, while responsible ecotourism can help protect butterflies and their habitats.

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