

# Butterfly diversity and conservation implications in Real, Quezon, Philippines

EUNICE LOIS O. CABARDO, ELEANOR S. AUSTRIA, JULIUS JOHN DP. SALAMANES<sup>✉</sup>

Biology Department, College of Science, Adamson University, 900 San Marcelino St. Ermita, 1000 Manila, Philippines. Tel./fax.: +63-961-2142318,

<sup>✉</sup>email: julius.john.salamanes@adamson.edu.ph

Manuscript received: 12 July 2025. Revision accepted: 7 September 2025.

**Abstract.** Cabardo ELO, Austria ES, Salamanes JJDP. 2025. Butterfly diversity and conservation implications in Real, Quezon, Philippines. *Biodiversitas* 26: 4363-4373. Butterflies are key bioindicators of environmental health, yet systematic studies on lowland butterfly assemblages in the Philippines are scarce, leaving a crucial gap in biodiversity knowledge and conservation planning. This study aimed to document the diversity, abundance, and habitat associations of butterflies in Brgy. Malapad, Real, Quezon (a lowland barangay within the Sierra Madre Biodiversity Corridor) and to assess their conservation implications. Sampling was conducted from March to June 2024 in two distinct sites: a riparian zone near Nonok Falls and a secondary forest. Using Pollard Walk transects, bait traps, and opportunistic netting, 103 individuals representing 27 species, 22 genera, and 5 families were recorded. Nymphalidae was the most dominant family in terms of species richness and abundance. The riparian zone showed notably higher species richness (20 species), diversity ( $H'$ : 2.8115,  $1-D$ : 0.9486), and evenness ( $J'$ : 0.9385) than the secondary forest with 13 species, diversity ( $H'$ : 2.1630,  $1-D$ : 0.8667), and evenness ( $J'$ : 0.7346). Community composition between the two habitats differed substantially, as indicated by a Bray-Curtis dissimilarity index of 0.748. This dissimilarity was statistically supported by a significant Hutcheson t-test ( $t$ : 4.444), confirming a marked difference in butterfly diversity between sites. One species, *Notocrypta paralysos*, was classified as Vulnerable, while five species were endemic to the Philippines. The presence of both endemic and threatened species highlights the urgent need to prioritize lowland habitats in regional conservation strategies. These findings underscore the conservation importance of lowland ecosystems and highlight the need to integrate butterfly diversity data into local conservation planning. This study offers a vital baseline for biodiversity monitoring and supports sustainable land-use and community-based habitat management efforts.

**Keywords:** Conservation biology, disturbed habitats, Lepidoptera diversity, Philippine butterflies, Shannon-Wiener index

## INTRODUCTION

Butterflies, as essential pollinators and sensitive bioindicators, play vital roles in maintaining ecological balance and reflecting environmental health across ecosystems (Ismail et al. 2020; Subedi et al. 2020). Their presence, abundance, and diversity are not only critical for plant reproduction but also serve as reliable indicators of environmental change, particularly in terms of habitat quality and ecosystem degradation (Badon et al. 2023; Itliong et al. 2024). Globally, there are more than 20,000 described butterfly species, many of which are increasingly under threat from anthropogenic pressures such as land-use change, pollution, and climate change (Dore et al. 2022).

In the Philippines, recognized as a megadiverse country with an exceptionally high level of butterfly endemism, approximately 915 butterfly species have been recorded, of which 354 are endemic, accounting for an estimated 10% of the world's endemic butterfly species (Nacua et al. 2020; Badon et al. 2023). Despite this richness, butterfly populations in Southeast Asia, including the Philippines, have experienced significant declines, driven by rapid deforestation, agricultural intensification, and urban expansion (Dore et al. 2022; Ahmadzai et al. 2023). This regional biodiversity loss is especially alarming in Luzon, where the Sierra Madre Mountain Range, including Real, Quezon, acts as one of the last remaining bastions of

lowland and montane forest ecosystems. However, the conversion of primary forests into coconut plantations, tourism sites, and road infrastructures has fragmented habitats such as Real, compromising ecological connectivity and placing additional pressure on butterfly populations (Singgalen 2022; Chola et al. 2025). These disturbances heighten the urgency for conservation action, especially given that the Philippine lowlands, unlike the more studied montane ecosystems, receive less conservation focus yet contain equally critical biodiversity hotspots (Daipan 2021; Buhay et al. 2023).

Recent studies from Southeast Asia have demonstrated the detrimental impacts of land-use change on butterfly diversity and community structure. Harmonis et al. (2022) documented a reduction in forest specialist species and a shift toward edge-adapted generalists in disturbed Malaysian forests. Winarni et al. (2023) found similar patterns in Indonesia, where butterfly assemblages in oil palm-dominated landscapes showed reduced taxonomic and phylogenetic diversity. In Thailand, Jaturas et al. (2020) reported the local extinction of endemic butterfly species in agroforestry mosaics, underscoring the importance of retaining forest fragments within agricultural matrices. These studies collectively highlight the loss of both functional and evolutionary diversity due to habitat alteration and stress the importance of maintaining ecological integrity in rapidly changing landscapes.

Nevertheless, research has been predominantly centered on well-established protected areas, with limited attention to small-scale, human-modified, or transitional forest habitats.

Forest degradation in Philippine lowland regions not only results in species loss but also alters butterfly community composition, with sensitive forest specialists increasingly replaced by widespread generalists capable of thriving in disturbed environments (Cleary et al. 2025). While such ecological shifts have been well-documented in other parts of Southeast Asia, empirical data on butterfly diversity in lesser-known forest areas of the Philippines, particularly those outside protected zones, remain scarce. Municipal forests such as those in Real, Quezon, are underexplored, despite their potential as critical ecological corridors or biodiversity reservoirs.

This study, therefore, aims to assess butterfly diversity in Real, Quezon, and evaluate the conservation implications of its species richness and community structure across habitat types. Specifically, it seeks to (i) document butterfly species present in selected sites in Real; (ii) analyze species abundance, richness, and diversity patterns across habitat gradients; (iii) identify conservation priorities based on species vulnerability, endemism, and habitat specificity. The findings are expected to provide valuable baseline data on butterfly biodiversity in the region, inform local conservation policy, and raise awareness on the ecological value of insect diversity amid land-use change. Furthermore, this study highlights the importance of integrating butterfly monitoring into broader biodiversity assessments and land management planning, particularly in municipalities located within biodiversity

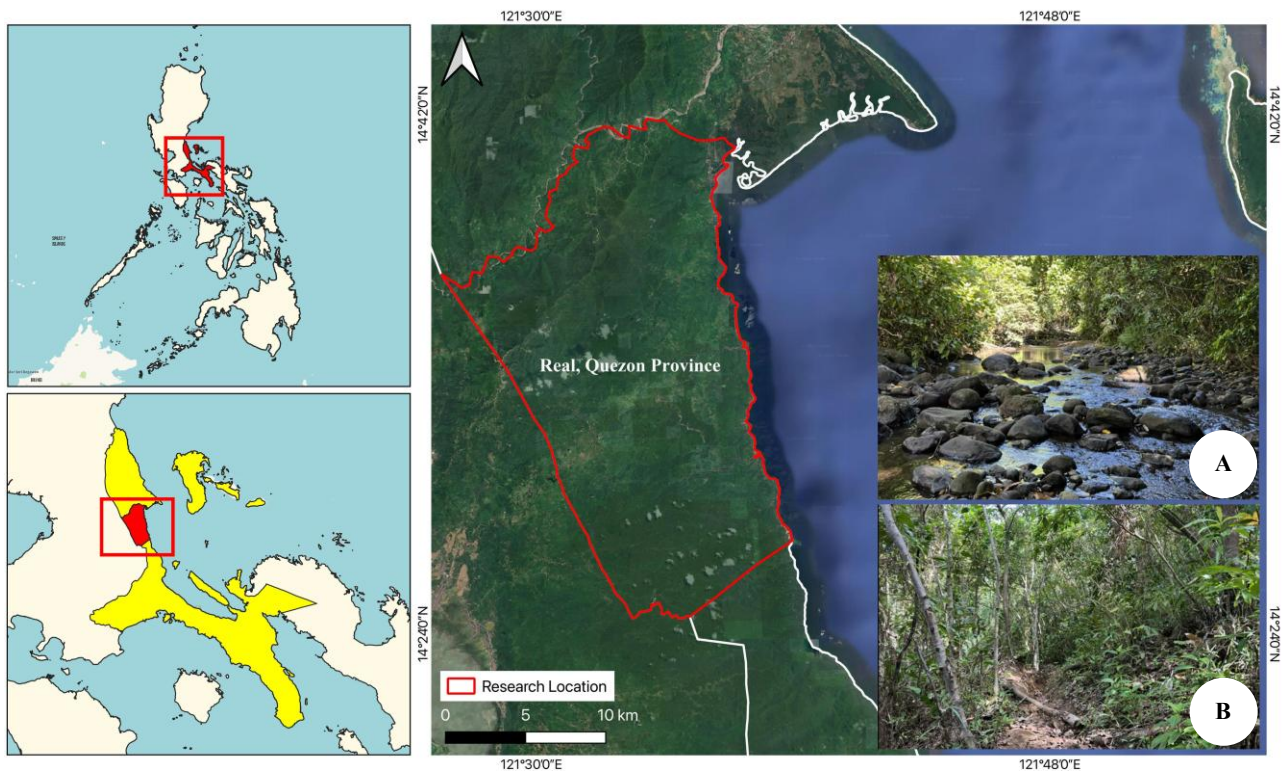
corridors that face intensifying development pressures. In doing so, it supports national and global conservation objectives, aligning with the Philippines' commitments under the Convention on Biological Diversity and the Aichi Biodiversity Targets.

## MATERIALS AND METHODS

### Study area and sampling site

Brgy. Malapad is a 3,648 hectares coastal lowland barangay in southeastern Real, Quezon, Philippines, characterized by a mix of plains, coastal vegetation, and proximity to land and sea ecosystems, making it ecologically valuable. At an elevation of 244.8 meters, it lies in a transitional zone ideal for butterfly diversity (DENR-BMB 2015).

The study was conducted in two ecologically distinct sampling sites within Brgy. Malapad (Figure 1). The first is a riparian zone near Nonok Falls ( $14^{\circ}31'54.6''\text{N}$ ,  $121^{\circ}37'23.6''\text{E}$ ), characterized by gently sloping terrain, a humid microclimate, and vegetation dominated by moisture-loving plants. The second site is a secondary forest ( $14^{\circ}31'56.5''\text{N}$ ,  $121^{\circ}37'21.4''\text{E}$ ), situated at an elevation 350-450 meters, characterized by regenerating native trees and dense undergrowth. This site offers a contrasting habitat that is likely to support distinct forest butterfly communities, thereby enhancing the study's biodiversity assessment.



**Figure 1.** Map of the study area in Brgy. Malapad, Real, Quezon, Philippines, with a photograph of the sampling sites. A: Riparian Zone, B: Secondary Forest

## Data collection

### Specimen collection permit

To ensure compliance with national wildlife regulations, a Wildlife Gratuitous Permit (GP No. R4A-WGP-2024-QUE-018) was secured from the Department of Environment and Natural Resources (DENR), Regional Office No. IV-A Calabarzon. The permit officially authorized the collection of butterflies, ensuring that all activities comply with environmental regulations and conservation efforts.

### Sampling design and method

Butterfly sampling was conducted from March to June 2024, encompassing both the dry and early wet seasons to capture seasonal variations in butterfly diversity and community composition, coinciding with peak butterfly activity in Philippine lowland environments (Badon et al. 2021). Two habitat types in Real, Quezon were selected: the riparian zone near Nonok Falls and an upland secondary forest. At each site, a 500-meter transect was established and divided into ten 50-meter segments, following the Pollard Walk method, with butterflies recorded within a 5 m width and 5 m height (Suman et al. 2021; Ruales et al. 2023). Observations were conducted twice monthly, with four days of sampling per site (eight days per month), and each transect walk lasted approximately two hours during peak butterfly activity from 08:00-11:00 AM and 1:00-3:00 PM under favorable weather conditions (Badon et al. 2021; Ruales et al. 2023). To account for varied feeding guilds and behaviors, active sweep netting (mesh size: 0.5 mm; handle length: 1 meter) was performed within the defined transect area, baited traps using fermented bananas were placed at 10-meter intervals and left for three hours to attract fruit-feeding species (Álvarez et al. 2021; Itliong et al. 2024), and opportunistic hand-netting was conducted to capture elusive or canopy-dwelling species beyond the transects (Freitas et al. 2020). To minimize observer bias and ensure data reliability, all sampling was performed by the same trained observer who followed standardized protocols throughout the study period. Prior calibration through mock transects ensured consistency in detection and identification accuracy (Ruales et al. 2023).

### Butterflies processing and preservation

Butterfly specimens were processed and preserved using standard entomological protocols to ensure precise identification and long-term storage. After collection, each specimen was gently placed in a paper envelope and euthanized using ethyl acetate to minimize damage to key morphological features. Specimens were subsequently mounted on stainless steel insect pins, labeled with complete collection data, and air-dried in a shaded, well-ventilated area to maintain wing coloration and structural features (Igano et al. 2021). All Preservation procedures conformed to the National Plant Biosecurity Diagnostic Network (2024) guidelines, which emphasize minimizing exposure to direct sunlight and high humidity to prevent specimen degradation and maintain taxonomic accuracy.

### Identification of butterflies

Identification of butterfly specimens was conducted using an integrated approach combining photographic guides, taxonomic keys, and expert consultation to ensure accuracy and reliability. Primary references included “Field Guide to Butterflies of the Philippines” by Hardy and Lawrence (2017) and “A Naturalist’s Guide to the Butterflies of the Philippines” by Badon (2023), both of which provided high-resolution images, diagnostic morphological traits, and distributional information essential for accurate species identification. Photographs of previously identified voucher specimens from curated entomological collections were also used for direct comparison. Key morphological features, including wing coloration and patterns, venation, and body structure, were carefully examined to differentiate closely resembling species. Additionally, species identifications were verified with the assistance of an expert from the Philippine National Museum to strengthen taxonomic accuracy and consistency.

### Data analysis

Analysis of data employed several ecological diversity indices to thoroughly assess the butterfly assemblages and their conservation implications in the lowland areas of Real, Quezon. To capture both species richness and the relative abundance of each species, the Shannon-Wiener diversity index ( $H'$ ), calculated as:

$$H' = - \sum_{i=1}^S p_i \ln(p_i)$$

Where,  $H'$ : Shannon-Wiener diversity index,  $S$ : Total number of species,  $p_i$ : Proportion of individuals that belong to species  $i$ ,  $N$ : Total number of individuals in the sample and  $\ln$ : Natural logarithm (base  $e$ ).

Meanwhile, the Simpson's index of diversity ( $1-D$ ), which measures the probability that two randomly selected individuals belong to different species, provides insight into community dominance with less sensitivity to rare species and is expressed as:

$$1 - D = 1 - \sum_{i=1}^S \left( \frac{n_i(n_i - 1)}{N(N - 1)} \right)$$

Where,  $1-D$ : Simpson's index of diversity,  $D$ : Simpson's index (dominance index),  $S$ : Total number of species,  $n_i$ : Number of individuals of species  $i$ , and  $N$ : Total number of individuals in the sample.

Lastly, Pielou's Evenness index ( $J'$ ), which quantifies how evenly individuals are distributed among the observed species. is expressed as:

$$J' = \frac{H'}{\ln S}$$

Where,  $J'$ : Pielou's Evenness index,  $H'$ : Shannon-Wiener diversity index,  $S$ : Total number of species

(species richness), and  $\ln S$ : Natural logarithm of species richness.

These indices are suitable for this study as they collectively provide a comprehensive quantitative description of butterfly biodiversity, enabling robust comparisons between the riparian zone and secondary forest habitats and informing conservation strategies (Magurran 2013).

To compare butterfly community composition between the riparian zone and upland secondary forest, Bray-Curtis dissimilarity index and Hutcheson t-test were employed as community comparison metrics. The Bray-Curtis dissimilarity index was used to quantify differences in species composition and relative abundance between the two habitat types, providing a robust measure of beta diversity. This index ranges from 0 (identical communities) to 1 (completely dissimilar communities) and is particularly effective in ecological studies dealing with abundance data. The formula used was:

$$\text{Bray-Curtis Dissimilarity} = \frac{\sum |a_i - b_i|}{\sum (a_i + b_i)}$$

Where,  $a_i$  and  $b_i$  represent the abundances of species  $i$  in sites A and B, respectively.

To statistically evaluate whether observed differences in diversity (Shannon-Wiener index,  $H'$ ) between the two sites were significant, the Hutcheson t-test was applied. This test compares the variance of Shannon indices between two samples and is suitable for assessing diversity differences in ecological communities. The formula used was:

$$t = \frac{H'_1 - H'_2}{\sqrt{\text{Var}(H'_1) + \text{Var}(H'_2)}}$$

Where,  $H'_1$  and  $H'_2$  are the Shannon diversity indices of the two sites, and  $\text{Var}(H')$  is the variance of each respective index. These statistical analyses were conducted using PAST v4.11 software to ensure accurate computation and interpretation of ecological patterns across habitats.

### Conservation status

The conservation status, endemism, and Philippine distribution of butterfly species recorded in the study were determined using the references "Illustrated Lists of Philippine Butterflies" by Badon et al. (2023) and the field guide by Hardy and Lawrence (2017). Site-specific distribution was based on species occurrences recorded from the two designated sampling sites: the riparian zone near Nonok Falls and the upland secondary forest in Brgy. Malapad. The national conservation status of each species was assessed using the IUCN Red List of Threatened Species. Version 2024-1 and Hardy and Lawrence (2017), providing insights into species that are endemic, rare, or threatened within the country.

## RESULTS AND DISCUSSION

### Species composition and abundance of butterflies

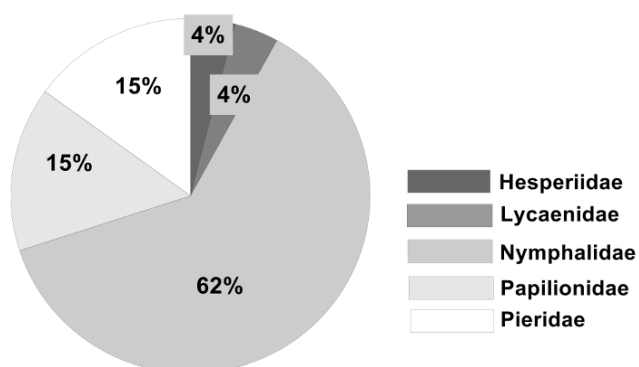
A total of 103 butterfly individuals were collected from the study area, comprising 58 individuals from the Riparian Zone and 45 from the Secondary Forest. These individuals represent 27 species, distributed among 22 genera and 5 families: Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, and Pieridae (Table 1). This level of diversity, while specific to the sampled area, contributes to the growing understanding of Philippine butterfly fauna. For instance, a study in Butuan City, Agusan del Norte, recorded 37 species from 4 families (Ruales et al. 2023), and another in Mt. Matutum Protected Landscape, South Cotabato, found 34 species from 5 families (Mangaoang and Mohagan 2019). These comparisons suggest that lowland areas, even those potentially impacted by human activities, like Brgy. Malapad in Real, Quezon can still harbor significant butterfly diversity, highlighting their ecological value. The overall species richness is influenced by various factors, including habitat heterogeneity, availability of host plants and nectar sources, and the extent of anthropogenic disturbance (Badon et al. 2021). This observed diversity highlights the role of semi-disturbed lowland habitats as important refugia for butterfly communities, supporting both common and habitat-sensitive species that are crucial for ecosystem functioning and pollination networks.

As shown in Figures 2 and 3 Nymphalidae is the most dominant among the identified families, accounting for 17 species (62%) and 13 genera (59%). Papilionidae and Pieridae followed, each represented by four species (15%) each, while Hesperiidae and Lycaenidae were the least abundant. With only one species (4%) each. This predominance of Nymphalidae aligns with global and the Philippines butterfly patterns (Espino and Solania-Naling 2021; Gracia et al. 2021; Grasia et al. 2022). Gracia et al. 2021 reported that Nymphalidae comprised nearly half of the butterfly species in the lowland forests of Surigao del Sur. Espino and Solania-Naling (2021) also reported Nymphalidae as the most speciose family (~58%) in Mt. Magdiwata, and Grasia et al. (2022) found Nymphalidae dominated Awasian Reserve (30 of 57 species). Their ecological success may be attributed to their adaptability, wide host plant range and ecological tolerance, and strong dispersal abilities (Mohagan et al. 2018). Nymphalidae is the largest family of butterflies, comprising over 6,000 species worldwide, and is known for its adaptability and wide range of host plant associations (Rohman et al. 2025). Their caterpillars are generalist feeders, enabling them to thrive in diverse habitats. This broad ecological niche contributes to their high representation in many ecosystems, including the tropical lowland forests of the Philippines. The relatively lower representation of Hesperiidae and Lycaenidae may result from their more specialized habitat requirements, narrower host plant preferences, or potential sampling limitations affecting smaller and often more cryptic groups.

**Table 1.** Species composition, endemism, and conservation status of collected butterfly species

Species	Family	Number of individuals		Total number of individuals	Distribution	Conservation status (IUCN)
		Riparian Zone	Secondary Forest			
<i>Notocrypta paralysos</i>	Hesperiidae	1	0	1	Widespread in South and Southeast Asia	VU*
<i>Jamides cyta amphisissimus</i>	Lycaenidae	6	0	6	Found throughout Southeast Asia	NE
<i>Athyma perius perius</i>	Nymphalidae	5	2	7	India to Southeast Asia	NE
<i>Cupha aria</i>		1	0	1	Southeast Asia	NE
<i>Elymnias melias</i>		0	2	2	Southeast Asia	NE
<i>Euploea climena</i>		0	1	1	Indomalayan, Australasian realms	NE
<i>Hypolimnas bolina</i>		0	7	7	Madagascar to Asia and Australia	NE
<i>Idea leuconoe</i>		2	0	2	Malaysia, Taiwan, and the Philippines, and the Ryukyu Islands	NE
<i>Ideopsis juvena</i>		3	12	15	Widespread throughout Southeast Asia	NE
<i>Junonia hedonia</i>		1	0	1	Southeast Asia, Indonesia, Australia	NE
<i>Junonia</i> sp.		1	0	1		NE
<i>Lasiommata maera</i>		1	0	1	Common in continental Europe	LC
<i>Lexias satrapes</i>		0	1	1	Southeast Asia	NE
<i>Lexias panopus</i>		0	1	1	Southeast Asia	NE
<i>Mycalesis fusca</i>		4	0	4	Afrotropical and Indomalayan realms	NE
<i>Mycalesis</i> sp.		4	0	4		NE
<i>Ragadia annulata</i>		0	1	1	Southeast Asia	NE
<i>Ypthima condamini</i>		6	3	9	Widespread in Africa and Asia	LC
<i>Zethera pimplea</i>		2	9	11	Endemic to the Philippines	NE
<i>Menelaides</i> sp.	Papilionidae	0	3	3		NE
<i>Pachliopta kotzebuea</i>		5	2	7	Endemic to the Philippines	NE
<i>Pachliopta phlegon</i>		3	0	3	Endemic to the Philippines	NE
<i>Troides rhadamantus</i>		1	1	2	Endemic to the Philippines	NE
<i>Catopsilia</i> sp.	Pieridae	4	0	4		NE
<i>Delias henningia</i>		1	0	1	Endemic to the Philippines	NE
<i>Eurema hecabe</i>		4	0	4	Asia, Africa, and Australia	LC
<i>Leptosia nina</i>		3	0	3	South and Southeast Asia	LC
<b>TOTAL</b>		<b>58</b>	<b>45</b>	<b>103</b>		

Note: VU\*: Vulnerable (Igano et al. 2021), LC: Least Concern, NE: Not Evaluated

**Figure 2.** Relative species richness of butterfly families in the study area

At the species level, *Ideopsis juvena* was the most abundant overall, with 15 individuals collected (14.56% of

the total), closely followed by *Zethera pimplea* with 11 individuals (10.68%) (Table 1). Their high abundance suggests they are well-adapted to the environmental conditions of the study area and likely utilize common host plants available in both the Riparian Zone and Secondary Forest. *Ideopsis juvena* are known to be generalists and are often associated with disturbed or edge habitats, which may explain their prevalence in the study area. The dominance of *I. juvena* and *Z. pimplea* may indicate that butterfly community structure shaped by habitat modification, favoring adaptable and edge-tolerant species over specialists, thereby reflecting moderate to high levels of ecological disturbance in the study area (Aprillia et al. 2024).

Habitat-specific abundance showed *Jamides cyta amphisissimus* and *Ypthima condamini* as the most abundant species in the Riparian Zone, each with 6 individuals (10.34%). In the Secondary Forest, *I. juvena* was notably dominant, accounting for 12 individuals

(20.69%) of the butterflies collected in that specific habitat (Table 1). The specific dominance of *J. c. amphissimus* and *Y. condamini* in the Riparian Zone indicates their preference for the conditions found near water bodies, possibly due to the availability of specific host plant, microclimatic conditions (higher humidity, cooler understory), and the presence of specific host plant in riparian areas favor these species. Similar patterns were observed in riparian buffers elsewhere, where environmental heterogeneity and moisture gradients supported unique butterfly assemblages. The pronounced abundance of *I. juventa* in the Secondary Forest (20.69%) further supports its generalist nature and ability to thrive in disturbed or regenerating forest environments. It may reflect its preference for shaded understory environments and host plants commonly found in regenerating forests. This mirrors findings by Reeves and Daniels (2020) in Mount Kanlaon, where certain endemic species thrived in secondary growth habitats.

Five butterfly species (*Athyma perius perius*, *I. juventa*, *Y. condamini*, *Z. pimplea*, and *Troides rhadamantus*) were documented in both the Riparian Zone and Secondary Forest, underscoring their ecological generalist tendencies and capacity to utilize a range of lowland habitats. This pattern aligns with findings from PC Hills, Leyte, where butterfly occurrence across riparian and forested habitats highlighted how species distributions are shaped by vegetation structure and habitat heterogeneity (Igano et al. 2021). In particular, *T. rhadamantus*, an endemic birdwing frequently observed along riparian corridors, has been noted mating and nectaring in riparian and agroforestry settings in Mt. Banahaw, suggesting its resilience in both forested and disturbed landscapes (Gestiada et al. 2014). Research in Amazonian riparian buffers similarly showed that riparian reserves can sustain butterfly assemblages comparable to adjacent intact forests, particularly by supporting canopy-dwelling taxa (Kovacevich et al. 2022). Thus, the co-occurrence of these genera in both sites in Real, Quezon reflects their adaptability to habitat mosaics and supports the notion that conserving riparian corridors alongside secondary forests is critical for maintaining landscape-wide butterfly diversity.

#### Diversity of butterflies in the two study sites

The riparian zone exhibited higher species richness, with 20 species and 16 genera, compared to the secondary forest's 13 species and 12 genera (Table 2 and Figure 3). This suggests that riparian habitats provide more favorable microhabitats and abundant floral resources for butterflies. The observed higher species and generic richness in the Riparian Zone is consistent with results from other studies on butterfly distribution. This pattern aligns with findings from Igano et al. (2021) in Leyte, Philippines, where riparian ecosystems supported greater butterfly diversity than agroecosystems due to increased vegetation heterogeneity and nectar availability. Similarly, An and Choi (2021) emphasized the role of riparian zones as ecological corridors that facilitate species dispersal and enhance landscape-level biodiversity conservation. Riparian areas are often characterized by unique

microclimates, higher humidity, diverse vegetation, and consistent water sources, creating conditions favorable for a wider range of butterfly species (Kovacevich et al. 2022). The presence of varied larval host plants and nectar resources along riverbanks supports both larval development and adult sustenance. In contrast, secondary forests, while ecologically important, may lack the structural complexity and resource diversity of riparian habitats, leading to reduced lepidopteran richness (Harmonis et al. 2022). Critically, this pattern reflects broader ecological principles such as metapopulation dynamics, where patches of habitat like riparian zones function as population sources, buffering against local extinctions in sink habitats such as isolated or degraded secondary forests. The edge effects resulting from fragmentation in Real, Quezon—driven by agricultural expansion, logging, and settlement encroachment—reduce habitat quality, particularly in secondary forests. These edge effects not only alter microclimates and vegetation structure but also increase the exposure of sensitive butterfly species to human disturbance, invasive species, and stochastic environmental events. The riparian habitat's function as a refugial stronghold becomes even more critical in fragmented landscape. Butterflies are widely recognized as sensitive bioindicators due to their rapid responses to environmental changes, narrow ecological niches, and close dependence on host plants. Their presence, abundance, and diversity reflect underlying ecological integrity. The significantly higher Shannon-Wiener diversity index and evenness in the Riparian Zone indicate not only a richer community but also a more balanced one, further supporting the idea that riparian systems are less disturbed and more ecologically stable. Species like *I. juventa* are commonly associated with open and regenerating habitats and were observed in both zones, but their higher abundance in secondary forests might suggest adaptation to edge conditions. Conversely, species such as *J. c. amphissimus* and *Y. condamini*, both of which have narrower ecological requirements, were primarily restricted to the riparian zone, indicating higher habitat sensitivity and possible vulnerability to microhabitat alterations. Importantly, *J. c. amphissimus* is currently listed under the Philippine Red List as near threatened due to habitat specificity and declining host plant availability, while others like *Appias lyncida* and *Papilio demoleus* remain of least concern (IUCN 2024), but may still face local threats from pesticide use and larval host plant loss. Conservation planning must account for butterflies' ecological roles, dispersal abilities, and disturbance sensitivity, recognizing that some species act as early-warning indicators of broader ecosystem health.

From a conservation biology standpoint, the Real, Quezon area holds strategic value within the Sierra Madre Biodiversity Corridor, one of the last strongholds of lowland rainforest in the Philippines. This region lies at a biogeographic convergence zone between Eastern Luzon lowland forests and montane systems, supporting both endemic and migratory species. Its ecological importance is compounded by its role as a watershed and climate buffer for local communities. However, anthropogenic pressures

such as riverbank conversion, agricultural runoff, charcoal production, and unsustainable tourism continue to threaten its ecological integrity. These localized threats exacerbate broader processes of habitat fragmentation, reducing population viability and disrupting connectivity among butterfly populations—especially for those with poor dispersal abilities or high host plant fidelity. In line with metapopulation theory, the long-term persistence of butterfly assemblages in such landscapes relies heavily on habitat patches being large enough, well-connected, and managed to minimize local extinction risks. Comparisons with other regional studies, such as those in Northern Luzon and Southeast Asia, reinforce the crucial role of riparian corridors in biodiversity maintenance. Jaturas et al. (2020) found similar richness trends in Thai riparian reserves, and Winarni et al. (2023) observed consistent patterns in Indonesian lowland forests, underscoring the universality of riparian habitat value across tropical Asia. To strengthen conservation outcomes, local authorities should explicitly enforce existing ordinances on riparian buffer protection (e.g., Philippines’ DENR DAO 2017-11) and integrate butterfly habitat considerations into municipal land-use planning, creating a direct policy mechanism to safeguard ecological connectivity. Thus, conserving riparian zones in Real not only sustains butterfly communities but also maintains broader ecosystem functions such as pollination, nutrient cycling, and trophic interactions essential for forest regeneration and agricultural productivity. Strategic habitat protection, ecological restoration, and integration of butterfly monitoring into environmental impact assessments should therefore be prioritized in Real, Quezon and similar biodiversity hotspots.

**Biodiversity analysis**

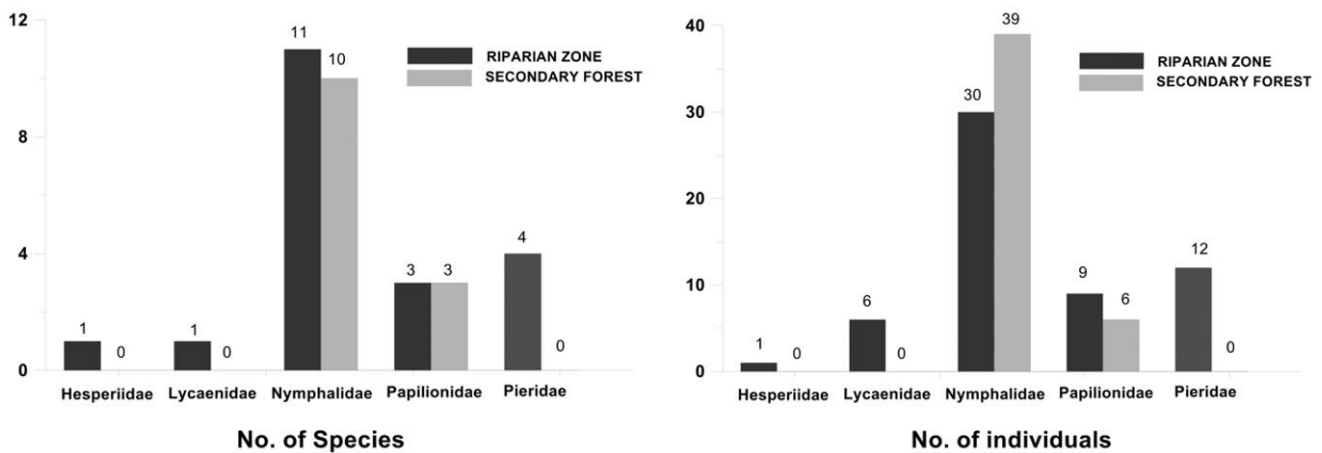
The biodiversity analysis (Table 2) revealed that the riparian zone exhibited higher species richness (S: 20) and total abundance (N: 58) compared to the secondary forest (S: 13, N: 45), indicating that more butterfly species and

individuals were present in this habitat. This was further supported by higher diversity values in the riparian zone, with a Shannon-Wiener index ( $H'$ ) of 2.8115 and a Simpson’s index of diversity ( $1-D$ ) of 0.9486, compared to lower values in the secondary forest ( $H'$ : 2.1630,  $1-D$ : 0.8667), reflecting both greater species richness and dominance in the riparian zone. Additionally, Pielou’s evenness ( $J'$ ) was notably higher in the riparian zone (0.9385) than in the secondary forest (0.7346), suggesting a more balanced distribution of individuals among species. Collectively, these metrics highlight the ecological value of riparian habitats in supporting diverse, abundant, and evenly structured butterfly communities.

The study demonstrates that the riparian zone harbors a higher butterfly diversity and species evenness compared to the adjacent secondary forest. The Shannon-Wiener index, which accounts for both species’ richness and evenness, was notably higher in the riparian zone. This suggests that the riparian habitat not only supports a greater number of species but also a more balanced distribution of individuals among those species. Similarly, the higher Simpson’s index of Diversity further reinforces this finding, as it is less sensitive to rare species and more influenced by the abundance of common species (Magurran 2013). This implies that the riparian zone possesses a richer and more equitably distributed butterfly community.

**Table 2.** Butterfly species richness, abundance, and diversity indices in the two study sites

	Riparian Zone	Secondary Forest
Species richness (S)	20	13
Total of individuals (N)	58	45
Shannon-Wiener diversity index ( $H'$ )	2.8115	2.1630
Simpson's index of diversity ( $1-D$ )	0.9486	0.8667
Pielou's Evenness index ( $J'$ )	0.9385	0.7346



**Figure 3.** Species richness and abundance in the two study sites

The significantly higher Pielou's Evenness index in the riparian zone ( $J'$ : 0.9385) compared to the secondary forest ( $J'$ : 0.7346) is a critical finding. This suggests that the riparian zone's resources are more evenly utilized by the present butterfly species, preventing the overwhelming dominance of a few species. In contrast, the lower evenness in the secondary forest implies that a few species are highly abundant, potentially outcompeting or limiting the presence of other species. This pattern is consistent with previous species composition data presented previously, where *I. juvena* was notably dominant in the secondary forest.

This disparity in butterfly community structure provides important insights into the ecological health and resilience of both habitats, with the riparian zone as a crucial biodiversity hotspot in the fragmented landscape of Real, Quezon. As sensitive bioindicators, butterflies readily reflect environmental changes, and their higher diversity and evenness in the riparian zone suggest greater habitat quality and resource availability, in line with findings from other regional studies, such as those conducted in Mindanao (Gracia et al. 2021) and other parts of Southeast Asia (Jaturas et al. 2020; Koneri et al. 2022; Winarni et al. 2023). The strong dominance of *I. juvena* in the secondary forest might point to a more homogenous and disturbed environment, potentially experiencing edge effects that favor generalist species while specialist species, often reliant on specific host plants found in less disturbed riparian areas, are excluded. From a conservation biology perspective, the riparian zone likely serves as a vital corridor or a key patch within a larger metapopulation network, mitigating the negative impacts of habitat fragmentation prevalent in the Luzon region, which is often subject to intense land-use changes (Nacua et al. 2020). The unique biogeographical position of Real, Quezon on the eastern seaboard of Luzon, influenced by both terrestrial and coastal factors, makes its riparian ecosystems particularly significant for supporting unique and potentially vulnerable butterfly assemblages. This underscores the urgent need for targeted conservation efforts that protect these vital linear habitats from further degradation.

Several ecological factors could contribute to the observed higher diversity and evenness in the riparian zone. Riparian zones are ecotones, transitional areas between aquatic and terrestrial ecosystems, often characterized by a greater variety of microhabitats and resources (Bullong et al. 2025). The presence of diverse flora, including water-dependent plants and those adapted to fluctuating moisture levels, can provide a wider range of nectar sources, larval host plants, and shelter for various butterfly species (Espino and Solania-Naling 2021). Additionally, the relatively stable microclimate, often cooler and more humid due to proximity to water bodies, might be more favorable for a broader spectrum of butterfly species compared to the potentially drier and more exposed conditions of a secondary forest (Cleary et al. 2025). The lower diversity and evenness in the secondary forest could be attributed to several factors. Secondary forests, especially those in early to mid-successional stages, may have a less complex vertical structure and a more

uniform plant community compared to mature or undisturbed forests. This reduced habitat heterogeneity can limit the availability of specific resources or microclimates required by a diverse array of butterfly species. Furthermore, disturbances inherent in secondary succession, such as past logging or agricultural activities, can initially reduce biodiversity and favor generalist species over specialists (Cleary et al. 2025). The dominance of *I. juvena* in the secondary forest could be indicative of a species well-adapted to the prevailing conditions in this habitat, potentially due to its broad dietary or reproductive strategies. The findings underscore the ecological importance of riparian zones as biodiversity hotspots within the broader landscape matrix. Their role in maintaining local and regional butterfly diversity should be recognized and prioritized in conservation efforts, particularly in areas undergoing habitat fragmentation or degradation.

Community comparison metrics in Table 3 reveals significant differences in butterfly assemblages between the riparian zone and the secondary forest. The Bray-Curtis dissimilarity index of 0.748 indicates that these habitats share only a small fraction of species and their relative abundances (Magurran 2013). This substantial dissimilarity is statistically supported by the Hutcheson t-test, which yielded a t-statistic of 4.444 and an exceptionally low p-value of 0.0000615. This highly significant p-value strongly rejects the null hypothesis that the diversity indices (specifically, the Shannon-Wiener diversity index) of the two habitats are similar, confirming a statistically significant difference in butterfly diversity between the riparian zone and the secondary forest. The sharp contrast in diversity indices observed between riparian zones and secondary forests in this study may also reflect the effects of edge influence and habitat fragmentation, which typically favor generalist or disturbance-tolerant species in degraded landscapes. The high Bray-Curtis dissimilarity value supports the conclusion of distinct faunal compositions between the two habitats, consistent with findings from Anderson et al. (2021) and Mahata et al. (2023). Furthermore, the significant difference revealed by the Hutcheson t-test underscores the ecological distinctiveness of riparian zones and their vital role in sustaining richer and more unique butterfly communities, reinforcing their importance for targeted conservation initiatives in fragmented tropical landscapes.

The high Bray-Curtis dissimilarity and significant Hutcheson t-test reinforce the ecological value of riparian zones as biodiversity hotspots. These zones potentially serve as refugia for specialist species and act as dispersal corridors essential to sustaining metapopulations within fragmented tropical landscapes. Such habitat-specific community patterns underscore the necessity of incorporating riparian habitats into local conservation strategies, especially in biodiversity-sensitive areas like Real, Quezon, part of the Sierra Madre biodiversity corridor. Conservation efforts must therefore prioritize minimizing habitat degradation and maintaining ecological connectivity to safeguard butterfly diversity and ecosystem function.

**Table 3.** Community comparison metrics for butterfly assemblages in the two habitat types

<b>Bray-Curtis dissimilarity</b>		0.748
<b>Hutcheson t-test</b>	t-statistic	4.444
	p value	0.0000615

### Assessment of butterfly conservation status and its ecological significance

As shown in Table 1, among the 27 butterfly species documented in the lowland habitats of Real, Quezon, one species (*Notocrypta paralyos*) is classified as Vulnerable based on the localized conservation assessment by Igano et al. (2021), suggesting a high risk of extinction in the wild due to its habitat-specific requirements, reduced distribution range, and observed population decline. This species is particularly sensitive to forest degradation and canopy disturbances, and its vulnerability is further exacerbated by the intensifying habitat fragmentation in the Sierra Madre landscape, including the Real region (Zhang et al. 2022). On the other hand, four species (*Eurema hecabe*, *Lasiommata maera*, *Leptosia nina*, and *Y. condamini*) are listed as Least Concern under the IUCN Red List (IUCN 2024), attributed to their broad geographic distribution and ecological plasticity. However, the conservation status of most species observed in the study remains Not Evaluated, underscoring significant knowledge gaps in tropical butterfly assessments. This limitation reflects broader shortcomings in taxonomic and conservation data coverage for invertebrates in the Philippines, a biodiversity-rich country that remains poorly represented in global conservation frameworks (Legal et al. 2020). Notably, five butterfly species recorded in Real (*Z. pimplea*, *Pachliopta kotzebuea*, *Pachliopta phlegon*, *T. rhadamantus*, and *Delias henningia*) are Philippine endemics. Their presence reaffirms the high levels of endemism in Philippine Lepidoptera, as emphasized by Ruales et al. (2023), and suggests that the Real provides critical habitat for species found nowhere else on Earth. These endemic butterflies are often highly specialized in their habitat and host plant use, making them more vulnerable to anthropogenic disturbances. Their continued survival in Real indicates that remnants of suitable microhabitats still exist, although these may be shrinking.

From a broader ecological and conservation perspective, the butterfly assemblages in Real are shaped by critical processes, including habitat fragmentation, metapopulation dynamics, and edge effects. Habitat fragmentation due to agriculture, infrastructure development, and residential encroachment leads to the isolation of forest patches, reducing habitat connectivity essential for gene flow and species movement. According to Anderson et al. (2021), species in fragmented landscapes often persist as metapopulations, spatially separated populations that rely on occasional dispersal between habitat patches. In Real, this likely explains the distribution of specialist butterflies with limited dispersal abilities. Fragmentation also amplifies edge effects, where microclimatic and ecological changes at habitat boundaries,

such as increased sunlight, wind, and invasive species, disrupt the conditions required by forest-dependent butterflies, as shown in studies by Winarni et al. (2023).

Butterflies also serve as bioindicators and indicator species due to their sensitivity to environmental changes, host plant dependency, and tight links to ecosystem integrity (Ismail et al. 2020; Subedi et al. 2020). Their population trends can reflect underlying shifts in habitat quality, floristic diversity, and climatic conditions. In Real, the presence or decline of certain butterfly taxa, especially endemic or host-specific ones, can signal larger-scale ecosystem stress or degradation. This is consistent with findings from Southeast Asia, where butterfly declines were strongly correlated with forest conversion and degradation (Harmonis et al. 2022; Jaturas et al. 2020).

Species-specific threats in Real include habitat loss from slash-and-burn farming, illegal logging, road expansion, and quarrying. These activities not only eliminate larval host plants and nectar sources but also introduce disturbances that fragment ecological corridors necessary for butterfly movement and reproduction. For instance, *P. phlegon* and *T. rhadamantus* rely on *Aristolochia* vines for larval development, which are increasingly scarce in disturbed areas. Furthermore, Real's location within the Sierra Madre Biodiversity Corridor makes it a biogeographically and management-critical area. This corridor is one of the last remaining contiguous forest systems in Luzon and serves as a refuge for endemic flora and fauna (Forest Foundation Philippines 2022). Thus, preserving butterfly diversity in Real is not only vital for local species conservation but also contributes to broader ecological resilience, climate adaptation, and the integrity of the Philippine lowland forest biome.

Furthermore, the documentation of a Vulnerable species, several Philippine endemics, and numerous unassessed species in Real, Quezon, highlights its ecological and conservation significance. The findings align with global conservation principles that emphasize the importance of safeguarding habitat heterogeneity and ecological connectivity in biodiversity hotspots. As a part of the Sierra Madre Mountain range, home to many threatened and endemic species, Real represents a key area for conservation planning, ecological monitoring, and targeted habitat management. Urgent conservation attention, integrating both species-specific protection and landscape-level habitat preservation, is critical to sustaining the butterfly assemblages and broader biodiversity of this region.

In conclusion, this study recorded 103 butterflies representing 27 species, 22 genera, and five families across two habitat types in Real, Quezon, Philippines. Nymphalidae was the most dominant family, highlighting its ecological importance. The riparian zone exhibited higher species richness, diversity ( $H'$ : 2.8115, 1-D: 0.9486), and evenness ( $J'$ : 0.9385) than the secondary forest ( $H'$ : 2.1630, 1-D: 0.8667,  $J'$ : 0.7346). Community composition differed markedly between habitats (Bray-Curtis dissimilarity: 0.748, Hutcheson t-test t: 4.444), reflecting the influence of habitat characteristics. *Ideopsis juventa* was most abundant in the secondary forest,

suggesting disturbance tolerance, while *J. c. amphisissimus* and *Y. condamini* dominated the riparian zone, underscoring its role as a refuge for sensitive species.

The marked habitat-based differences highlight the need for habitat-specific conservation strategies. Riparian habitats serve as biodiversity hotspots and refugia for generalist and specialist species, while degraded secondary forests remain vulnerable to biodiversity loss. Maintaining and restoring riparian corridors can enhance landscape resilience to climate change by providing continuous refuges and migration pathways for species responding to shifting environmental conditions, thereby engaging broader stakeholder interest in ecosystem-based adaptation. Projected shifts in rainfall patterns in the region further underscore the role of riparian zones as natural buffers that regulate water flow, mitigate flooding, and sustain habitat stability under changing climatic conditions. Conservation should focus on protecting riparian zones, restoring degraded habitats, and maintaining connectivity to support resilient butterfly populations.

Community-based initiatives in riparian areas, including habitat restoration, buffer zones, and ecological corridors, can strengthen environmental stewardship. Long-term biodiversity monitoring through citizen science and academic partnerships can track species trends and habitat conditions. By integrating research with participatory approaches, Real, Quezon can serve as a model for butterfly conservation in similarly diverse and threatened ecosystems across the Philippines and Southeast Asia. Local communities are encouraged to embrace their role as co-custodians of these butterfly habitats, as their active participation and stewardship can transform conservation from a passive obligation into a shared, empowering responsibility.

## ACKNOWLEDGEMENTS

The authors would like to express their heartfelt gratitude to Fr. Rafael K. Eloriaga, Vice President for Financial Affairs of Adamson University, Manila, Philippines, for graciously granting permission to carry out the study at the Adamson University Ecological and Anthropological Research in Terrestrial and Aquatic Habitat (AdU EARTH) Field Laboratory of the College of Science. His support was instrumental in the successful completion of this research. The authors also sincerely acknowledge Perry Archival Buenavente, researcher at the Entomology Section, Zoology Division of the National Museum of Natural History, Philippines, for his invaluable assistance in verifying the identity of the collected butterfly species. Special thanks are also extended to Marlou Naboa and Rey Tamis for their invaluable assistance during the sample collection process. Their help greatly contributed to the success of the fieldwork.

## REFERENCES

Ahmadzai MR, Zaki PH, Ismail MH, Bawon P, Karam DS. 2023. The societal and economic impact of reforestation strategies and policies

- in Southeast Asia: A review. *Forests* 14 (1): 1-15. DOI: 10.3390/f14010001.
- Álvarez CF, Clavijo-Giraldo A, Inés US, Pyrcz TW, Iserhard CA, Lucci FAV, Marín MA. 2021. Sampling performance of bait traps in high Andean fruit-feeding butterflies. *Neotrop Biodivers* 7 (1): 507-513. DOI: 10.1080/23766808.2021.2004802.
- An JS, Choi SW. 2021. Butterflies as an indicator group of riparian ecosystem assessment. *J Asia-Pac Entomol* 24 (1): 195-200. DOI: 10.1016/j.aspen.2020.12.017.
- Anderson MJ, Crist TO, Chase JM. 2021. *Community Ecology: Analytical Methods and Case Studies*. Oxford University Press, Oxford.
- Aprillia I, Lamin S, Setiawan D. 2024. Host plant preferences of butterflies (Lepidoptera: Rhopalocera) in Sriwijaya University campus of Indralaya, South Sumatra. *Biopalembanica* 1 (1): 14-20. DOI: 10.36982/bio.v1i1.4277.
- Badon JAT, General DEM, Lohman DJ. 2023. The larval host plant and ant associate of *Nacaduba pavana georgi* (Lepidoptera: Lycaenidae) in Negros, Philippines. *Trop Lepidoptera Res* 33 (22): 124-129.
- Badon JAT, Miller JY, Covell CV, Emmel TC. 2021. Typhoon in the Philippines may not negatively affect butterfly diversity, but land use changes does. *Philipp J Syst Biol* 15 (1): 1-20. DOI: 10.26757/pjsb2021a15003.
- Badon JAT. 2023. *A naturalist's Guide to the Butterflies of the Philippines*. John Beaufoy Publishing, Oxford, UK.
- Buhay AFV, Cruz RVO, Tiburan Jr CL, Pulhin JM. 2023. Factors affecting land use and land cover change and fragmentation in selected protected areas in the Philippines. *Sci Eng J* 16: 37-48. DOI: 10.54645/202316SupBVS-41.
- Bullong JRT, Poycoy MP, Kyaw TZ, Quimio JMUPH, Cando ENT III, Napaldet JT. 2025. Riparian floristic diversity and carbon stock assessment of an urban landscape: The case of Marjaya River in Batangas City, Philippines. *Taiwania* 70 (3): 540-559.
- Chola A, Dhadse S, Sakhare P. 2025. Biodiversity loss due to road widening and a new highway. *Sustain Biodivers Conserv* 4 (2): 38-52. DOI: 10.5281/zenodo.15623245.
- Cleary DFR, Bijlmer AM, Wielakker D, de Voogd NJ. 2025. Impact of landscape disturbance on butterfly communities. *Glob Ecol Conserv* 59: e03561. DOI: 10.1016/j.gecco.2025.e03561.
- Daipan N. 2021. Patterns of forest cover loss in the terrestrial key biodiversity areas in the Philippines: Critical habitat conservation priorities. *J Threat Taxa* 13 (13): 20019-20032. DOI: 10.11609/jott.6904.13.13.20019-20032.
- DENR DAO 2017-11. 2017. Updated National List of Threatened Plants. <https://www.philippineplants.org/dao-2017-11.pdf>
- Department of Environment and Natural Resources – Biodiversity Management Bureau (DENR-BMB) 2015. *Sierra Madre Biodiversity Corridor Management Plan 2015-2025*. DENR-BMB, Quezon City.
- Dore M, Willmott K, Leroy B, Chazot N, Mallet J, Freitas AVL, Hall JPW, Lamas G, Dasmahaptra KK, Fontaine C, Elias M. 2022. Anthropogenic pressures coincide with Neotropical biodiversity hotspots in a flagship butterfly group. *Divers Distrib* 28: 2912-2930. DOI: 10.1111/ddi.13455.
- Espino NP, Solania-Naling CL. 2021. Relationship of adult butterfly (Lepidoptera: Rhopalocera) diversity with plant species diversity in selected areas of Mt. Magdiwata, San Francisco, Agusan del Sur, Philippines. *J Ecosyst Sci Eco-Gov* 3 (2): 27-38.
- Forest Foundation Philippines. 2022. *Sierra Madre Mountain Range: Backbone of Luzon*. Forest Foundation Philippines, Manila. [https://www.forestfoundation.ph/wp-content/uploads/2022/04/Sierra-Madre-Mountain-Range\\_Landscape-Profile.pdf](https://www.forestfoundation.ph/wp-content/uploads/2022/04/Sierra-Madre-Mountain-Range_Landscape-Profile.pdf).
- Freitas AVL, Santos JP, Rosa AHB, Iserhard CA, Richter A, Siewert RR, Gueratto PE, Carreira JYO, Lourenço GM. 2020. Sampling methods for butterflies (Lepidoptera). In: Santos JC, Fernandes GW (eds). *Measuring Arthropod Biodiversity: A Handbook of Sampling Methods*. Springer, Cham. DOI: 10.1007/978-3-030-53226-0\_5.
- Gestiada EC, Castillo ML, Bantayan NC, Balatibat JB. 2014. Butterfly species diversity and habitat heterogeneity across altitudinal gradients of Mt. Banahaw de Majayjay, Philippines. *Ecosyst Dev J* 5 (1): 3-10.
- Gracia AG Jr, Albios LP, Alvero RLB. 2021. Faunistic study on butterflies in the lowland forests of Central Surigao del Sur, Philippines. *Borneo J Res Sci Technol* 11 (1): 1-10. DOI: 10.33736/bjrst.2548.2021.
- Grasia A, Abao MCG, Quiñonez KC, Suarez MFD, Elegio LJJ, Mohagan AB. 2022. Diversity and status of butterflies in Awasian water forest

- reserve, Mt. Hilong-hilong, Philippines. *Biotropia* 29 (3): 1569. DOI: 10.11598/btb.2022.29.3.1569.
- Hardy PB, Lawrence JM. 2017. *Field Guide to Butterflies of the Philippines*. Siri Scientific Press, Manchester.
- Harmonis, Rahim A, Hidayat HA. 2022. Diversity of butterflies in the tropical wetland of Kayan-Sembakung Delta, North Kalimantan, Indonesia. *Biodiversitas* 23 (6): 3303-3312. DOI: 10.13057/biodiv/d230660.
- Igano SEG, Gabor RB, Cabalona BA, Gutierrez NA. 2021. Diversity and status of butterflies (Lepidoptera: Rhopalocera) found in PC Hills, Leyte (Philippines). *Anatol J Biol* 2 (1): 25-37.
- Ismail N, Rahman AAA, Mohamed M, Abu-Bakar MF, Tokiman L. 2020. Butterfly as bioindicator for development of conservation areas in Bukit Reban Kambing, Bukit Belading and Bukit Tunku, Johor, Malaysia. *Biodiversitas* 21 (1): 334-344. DOI: 10.13057/biodiv/d210141.
- Itliong MGA, Dagamac NHA, Badon JAT. 2024. Assemblages of frugivorous butterflies in two urban parks in Quezon City, Philippines. *J Threat Taxa* 16 (7): 25516-25527. DOI: 10.11609/jott.8930.16.7.25516-25527.
- IUCN. 2024. The IUCN Red List of Threatened Species. Version 2024-1. <https://www.iucnredlist.org>.
- Jaturas N, Sing K-W, Wilson J-J, Dong H. 2020. Butterflies in urban parks in the Bangkok Metropolitan Region, Thailand. *Biodivers Data J* 8: e56317. DOI: 10.3897/BDJ.8.e56317.
- Koneri R, Nangoy MJ, Maabuat PV, Saroyo, Wakhid. 2022. Diversity and composition of butterflies in three habitats around Rayow Waterfall, Minahasa District, North Sulawesi, Indonesia. *Biodiversitas* 23 (2): 1091-1098. DOI: 10.13057/biodiv/d230253.
- Kovacevich GM, Marsh CJ, Smith SH. 2022. Riparian reserves protect butterfly communities in selectively logged tropical forest. *J Appl Ecol* 59 (6): 1524-1535. DOI: 10.1111/1365-2664.14162.
- Legal L, Valet M, Dorado O, de Jesus-Almonte JM, Lopez K, Cereghino R. 2020. Lepidoptera are relevant bioindicators of passive regeneration in tropical dry forests. *Insects* 12 (6): 231. DOI: 10.3390/d12060231.
- Magurran AE. 2013. *Measuring Biological Diversity*. Wiley-Blackwell, New Jersey.
- Mahata A, Panda RM, Dash P, Naik A, Naik AK, Palita SK. 2023. Microclimate and vegetation structure significantly affect butterfly assemblages in a tropical dry forest. *Climate* 11 (220): 1-16. DOI: 10.3390/cli11110220.
- Mangaoang CC, Mohagan AB. 2019. Short communication: Butterfly species in disturbed ecosystem of Mt. Matutum Protected Landscape, South Cotabato, Philippines. *SDSSU Multidiscip Res J* 7: 20-23. DOI: 10.69546/v742n0b6.
- Mohagan AB, Remulta SGB, Mohagan DJB. 2018. Species composition and status of butterflies across vegetation types in Mt. Pinamantawan Sto. Domingo, Quezon, Bukidnon, Philippines. *Asian J Biodivers* 9 (1): 1-20. DOI: 10.7828/ajob.v9i1.1237.
- Nacua AE, Clemente KJ, Macalalad EP, Deocaris CC, Galvez MC. 2020. Urban diversity of butterflies as a biological indicator of air quality in Manila, Philippines. *Asian J Conserv Biol* 9 (2): 315-321.
- National Plant Biosecurity Diagnostic Network. 2024. Guidelines on the Preparation of Biological Materials for Accessioning into Long-term Collections. [https://www.plantbiosecuritydiagnostics.net.au/app/uploads/2024/01/Manual\\_The-preparation-of-biological-materials-for-accessioning\\_16.01.2024.pdf](https://www.plantbiosecuritydiagnostics.net.au/app/uploads/2024/01/Manual_The-preparation-of-biological-materials-for-accessioning_16.01.2024.pdf).
- Reeves LE, Daniels JC. 2020. Conservation value of secondary forest habitats to endemic frugivorous butterflies at Mount Kanlaon, Negros Occidental, Philippines. *J Insect Conserv* 24: 913-926. DOI: 10.1007/s10841-020-00263-x.
- Rohman A, Subchan W, Buana YC. 2025. Butterfly (Lepidoptera) community structure in several habitat types of Tancak Maesan Forest, Bondowoso, East Java, Indonesia. *Biodiversitas* 26 (2): 651-661. DOI: 10.13057/biodiv/d260212.
- Ruales JJJ, Demetillo MT, Along AA, Mohagan AB, Jumawan JH. 2023. Diversity and status of true butterflies (Lepidoptera: Papilionoidea) in two ecological parks of Butuan City, Agusan del Norte, Philippines with new locality record. *Species* 24: e46s1539. DOI: 10.54905/diss/v24i73/e46s1539.
- Singgalen YA. 2022. Tourism infrastructure development and transformation of vegetation index in Dodola Island of Morotai Island Regency. *J Inf Syst Inform* 4 (1): 130-144. DOI: 10.51519/journalisi.v4i1.230.
- Subedi B, Stewart AB, Neupane B, Ghimire S. 2020. Butterfly species diversity and their floral preferences in the Rupa Wetland of Nepal. *Ecol Evol* 10 (5): 2086-2099. DOI: 10.1002/ece3.7177.
- Suman A, Ravikanthachari N, Kunte K. 2021. A comparison between time-constrained counts and line transects as methods to estimate butterfly diversity in tropical habitats. *Insect Conserv Divers* 17 (1): 88-101. DOI: 10.1101/2021.09.04.458959.
- Winarni NL, Nuruliawati, Anugra BG. 2023. Can cities provide butterfly-friendly habitats? *Biodiversitas* 24 (4): 2334-2341. DOI: 10.13057/biodiv/d240447.
- Zhang J, Cong Q, Shen J, Grishin NV. 2022. Taxonomic changes suggested by the genomic analysis of Hesperidae (Lepidoptera). *Insecta Mundi* 921: 1409.