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Butterflies (*Lepidoptera: Papilionoidae*) in Fef Forest, Tambrauw District, Southwest Papua

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Abstract: Butterflies of the superfamily Papilionoidae, or true butterflies, play a crucial role as indicators of ecosystem health and pollinators, and in the Papuan biogeographic region. The diversity of butterflies depends on habitat quality. A high ecosystem composition will support high butterfly diversity. Data on butterfly diversity is not yet available from the Fef forest in Tambrauw, making this research crucial. The composition of butterflies will also determine the condition of the forest, as they are used as bioindicators of forest quality. The forests in the Fef District are classified as secondary and primary forests. The research was conducted over six days of observation, from 8:00 AM to 5:00 PM. The study used a scan sampling method along predetermined transects. Butterflies and dragonflies were captured using insect nets, then photographed and identified. This study aims to understand the diversity and species richness in the region and determine the composition of forest richness in Fef. The research in the Ibu forest in the Fef District identified 96 butterfly species (1.87 individuals). The butterflies found were spread across six transects observed over six days. Transects were established in secondary and primary forest habitats. The Shannon-Wiener index for butterfly diversity was high (H'=3.98).

Keywords: Butterflies; Butterfly species diversity; Fef forest

Introduction

The island of Papua, including the region of Southwest Papua, is an integral part of the Indo-Australian biogeographic region, globally recognized as a megabiodiversity center. The richness of insect species, particularly butterflies (Order: *Lepidoptera*), is striking (Yu et al., 2023; Riyanto et al., 2025). Butterflies from the superfamily Papilionoidae (true butterflies) not only play a crucial ecological role as pollinators and environmental indicators, but also exhibit high levels of species richness and endemism in Papua's tropical rainforest ecosystems. Therefore, research focusing on Papilionoidae diversity in this underexplored region is crucial for addressing gaps in basic taxonomic and ecological data. Tambrauw Regency in Southwest Papua has been designated a "Conservation District," highlighting its ecological significance with its vast and relatively undisturbed expanses of tropical forest.

One key area within this landscape is the Fef Forest, thought to harbor representative and potentially unique faunal communities, including butterflies (Mota et al., 2023; Nagy et al., 2020). Despite Tambrauw's rich biodiversity, scientific information on the composition and diversity patterns of Papilionidae butterflies in the Fef Forest remains very limited, thus motivating this research (Hengkengbala et al., 2020). Butterflies are a group of insects that play a crucial role in maintaining ecosystem balance (John et al., 2025; Barragán-Fonseca et al., 2025). Butterfly diversity can vary significantly between locations, so changes in butterfly species diversity can serve as bioindicators of environmental sustainability or quality (Paoletti, 1999; Delgado-Fernández et al., 2025).

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According to Dang et al. (2025) and Kong et al. (2023), changes in species diversity within an ecosystem impact the productivity and services provided by that ecosystem. High species diversity indicates a high level of complexity within the community, resulting in interactions between species involving energy transfer (Bai et al., 2024). Species diversity can be measured using diversity indices. Butterflies are among the most impressive insects in the order Lepidoptera, known for their beautiful colors and wing shapes (Bibi et al., 2022; Bálint et al., 2023; Habel et al., 2021). According to Huang et al. (2024) and Raven et al. (2020), ecologically butterflies play a crucial role in maintaining ecosystem balance and increasing biodiversity. Previously, 355 butterfly species from the order Lepidoptera, superfamily Papilionoidea, were recorded in West Papua (Legal, 2022).

Each habitat has a unique butterfly diversity composition, depending on the specific environmental conditions in the region (Kitahara & Yasuda, 2024). Studying butterfly diversity is very important and interesting, considering that the number of butterfly species can increase or decrease over time (Hermawanto, 2015). Identification and quantification of butterfly (Lepidoptera) species diversity in secondary and primary forest habitats in Fef District, Tambrauw Regency, Southwest Papua has never been conducted. This study aims to understand the diversity and species richness in the region and determine the composition of forest richness in Fef.

Method

The study was conducted over six days (September 15-22, 2025) in secondary and primary forest habitats in Fef District, Tambrauw Regency, Southwest Papua. Butterfly (Lepidoptera: Papilionoidae) observations were conducted from 8:00 AM to 5:00 PM daily.

Field Data Collection

Location and Tracks: Six 2-km transects were used in each habitat type (secondary and primary forest). Methods: Scan sampling was used along the tracks. Butterflies were observed, counted, and captured using a sweep net for identification. Intensity: Each track was observed for an entire day.

Data Analysis

The data obtained were processed using Microsoft Excel to calculate five key ecological parameters, based on references from Odum (1994) and Magguran (2004), with the following categorization criteria:

Table 1. Five Main Ecological Parameters

Analysis Parameters	Main Formula	Objective
Diversity Index (H')	Shannon-Wiener: $H' = -\sum Pi\ ln\ (Pi)$	Measuring the level of species diversity (Low <1, Medium 1−3, High >3)
Species Richness (DMg)	Margalef: = S−1/ ln N	Measures the number of species relative to the number of individuals (Low <3.5, Medium 3.5−5, High >5).
Species Evenness (E)	Evenness: $E=H'/\ln S$	Measuring the evenness of distribution of individuals between species (Low 0−0.3, Medium 0.3−0.6, High >0.6).
Relative Abundance (KR)	KR= (ni/N) x 100	Measures the proportion of individuals of a particular species to the total number of individuals.
Similarity Index (IS)	Sorensen: IS = $\frac{2c}{a+b}\ x100\%$	Measures the similarity of species composition between two habitats (Very Similar 75−100%, Similar 50−75%).

Result and Discussion

Butterfly Species Diversity (Lepidoptera: Papilionoidea)

Research in the secondary and primary forests of the Fef district identified butterflies from five families (Papilionidae, Pieridae, Lycaenidae, Nymphalidae, and Hesperidae), 15 subfamilies, 96 species, and 1,878 individuals (Table 1). Observations were conducted at four locations with an altitude range of 526–840 meters above sea level (m asl). In the secondary forest, using three transects, 59 species and 624 individuals were identified, while in the primary forest, using three transects, 78 species and 1.25 individuals were identified. The butterfly diversity index, based on the Shannon-Wiener index, was high (H'=3.98). According to Nurhayati et al. (2025) and Grasia et al. (2022), a diversity index value approaching 4 is considered high. The butterfly species diversity in the Fef forest area is high, indicating a complex butterfly community structure, potentially supporting the existence of a butterfly population.

Table 2. Butterfly Species Identified in Primary and Secondary Forests in Fef

Family/		Secondary forest			Primary Forest			
Subfamily	*Species name*	1	2	3	1	2	3	Total
Papilioninae								
Papilioninae	*Ornithoptera priamus* (Linneus, 1758)	0	0	1	0	0	0	3
	Graphium aristeus (Stoll, 1781)	9	23	6	13	10	15	76
	Graphium codrus (Cramer, 1777)	0	2	0	0	0	0	2
	Graphium eurypylus (Linneus, 1758)	11	21	7	19	17	29	104
	Graphium sarpedon (Linneus, 1758)	2	0	2	0	0	0	4
	Graphium wallacei (Hewitson, 1858)	0	0	3	0	3	2	8
	Graphium agamemnon (Linnaeus, 1758)	0	0	1	0	0	2	1
	Papilio aegeus Donovan, 1805	3	6	6	6	7	14	42
	Papilio ambrax Boisduval, 1832	0	3	2	8	4	9	26
	Papilio euchenor Guerin-Meneville,1830	3	11	0	14	18	22	68
	Papilio ulysses Linneus, 1758	4	8	4	7	9	13	45
Pieridae								
Coliadinae	*Catopsilia pomona* (Fabricius, 1775)	4	4	4	0	0	8	20
	Eurema alitha (C. & R. Felder, 1862)	0	13	16	11	19	18	77
	Eurema blanda (Boisduval, 1836)	0	16	0	14	0	13	43
	Eurema hecabe (Linneus, 1758)	6	12	8	9	0	18	53
	Eurema puella (Boisduval, 1832)	3	8	3	6	8	10	38
Pierinae	*Apias ada* (Stoll, 1781)	0	0	6	4	0	9	19
	Apias celestina (Boisduval, 1832)	11	14	11	20	29	22	107
	Apias paulina (Cramer, 1777)	0	0	0	0	0	7	7
	Delias aruna (Boisduval, 1832)	0	0	0	0	0	3	3
	Delias discus Honrath, 1886	0	0	0	0	4	0	4
	Delias lara (Boisduval, 1836)	0	4	0	4	8	6	22
	Elodina andropis Butler, 1876	0	4	0	5	2	4	15
	Saletara cycinna (Hewitson, 1868)	11	16	0	14	22	29	92
Lycaenidae								
Curetinae	*Curetis barsine* C. Felder, 1860	0	0	3	0	0	11	14
Lycaeninae	*Arhopala herculina* Staudinger, 1888	0	0	0	0	0	7	7
	Arhopala leo Druce, 1894	0	5	0	3	2	0	10
	Arhopala madytus Fruhstorfer, 1914	0	3	0	0	0	0	3
	Arhopala widei Miskin, 1891	0	0	0	0	0	3	3
	Candalides cupreus (Semper, 1879)	0	3	0	0	0	0	3
	Danis danis Cramer, 1775	0	9	2	13	0	24	48
	Danis melimnos (Druce & Bethune-Baker 1893)	0	0	2	0	0	0	2
	Erysichton lineata (C. Felder, 1860)	0	0	14	14	0	14	42
	Euchrysops cnejus (Fabricius, 1798)	0	10	0	0	12	0	22
	Everes lacturnus (Godart, 1824)	0	7	0	0	0	0	7
	Hypochrysops pythias C. & R. Felder, 1865	0	0	0	0	0	5	5
	Hypolycaena ancharia (Hewiston, 1869)	0	5	0	0	0	0	5
	Hypolycaena phorbas Fabricius, 1793	2	8	4	6	16	18	54
	Ionolyce helicon C. Felder, 1860	0	0	0	9	0	0	9
	Jamides aleuas (C. & R. Felder, 1865)	0	0	0	23	0	0	23
	Jamides aruensis (Pachenstechter, 1884)	0	0	0	0	0	22	22
	Jamides bochus (Stoll, 1782)	4	0	0	0	0	4	8
	Jamides coritus (Guerin-Meneville, 1831)	0	0	6	0	0	5	11
	Logania hapsoni Fruhstorfer, 1914	0	0	0	4	0	0	4
	Nacaduba berenice (Herrich-Schaffer, 1869)	0	0	0	14	0	0	14
	Nacaduba kurava Moore, 1857	0	0	2	0	0	0	2
	Nacaduba cyane (Cramer, 1775)	0	0	0	0	0	3	3
	Nacaduba ruficirca Tite, 1963	0	0	0	14	0	0	14
	Philiris fulgens Grose-Smith & Kirby, 1897	0	0	0	0	0	2	2
	Philiris moira Sands, 1979	0	0	0	0	0	4	4
	Prosotas nora (C. Felder, 1860	0	0	0	9	0	0	9
	Psychonotis caelius (C. & R. Felder. 1860)	0	0	0	8	0	0	8
Nymphalidae								
Apaturinae	*Cyrestis acilia* Godart, 1819	0	0	0	9	8	18	35

Family/ Subfamily	Species name	Secondary forest 1	2	3	Primary Forest 1	2	3	Total
	Euthaliopsis aetion (Hewitson, 1862)	0	0	0	0	5	0	5
Charaxinae	*Protoe australis* (Guerin-Meneville, 1831)	0	2	0	0	0	3	5
Danainae	*Euploea netscheri* Snellen van Vollenhoven, 1889	0	0	4	0	0	0	4
	Euploea wallacei C. & R. Felder, 1860	0	0	3	0	4	6	13
Heliconinae	*Cethosia cydippe* (Linneus, 1763)	0	3	0	0	4	3	10
	Cupha prosope (Fabricius, 1775)	3	9	3	9	11	13	48
	Vagrans egista (Stoll, 1780)	0	0	0	0	0	2	2
	Vindula arsinoe (Cramer, 1777)	4	6	0	0	8	8	26
Ithomiinae	*Tellervo assarica* Stoll,1781	0	0	2	4	7	9	22
Libytheinae	*Libythea geoffroy* Godart, 1819	0	0	1	0	0	0	1
Morphinae	*Hyanthis hodeva* Hewitson, 1862	0	0	2	0	0	4	6
	Taenaris catops Westwood, 1851	0	17	3	14	0	17	51
	Taenaris gorgo (Kirsch, 1877)	0	0	0	4	0	0	4
	Taenaris myops (C. & R. Felder, 1860)	0	14	4	11	0	20	49
Nymphalinae	*Cethosia cydippe* (Linneus, 1763)	0	0	0	3	0	0	3
	Hypolimnas alimena (Linneus, 1758)	2	0	0	0	3	0	5
	Hypolimnas antilope (Cramer, 1777)	0	0	0	0	0	3	3
	Hypolimnas bolina (Linneus, 1764)	2	0	0	0	0	0	2
	Junonia vilida (Fabricius, 1787)	0	7	6	0	0	9	22
	Lexias aeropa (Fabricius, 1787)	0	0	0	5	0	4	9
	Neptis bresbissonii (Boisduval, 1832)	0	0	0	0	0	4	4
	Neptis praslini (Boisduval, 1832)	0	0	0	0	0	3	3
	Pantoporia consimilis (Boisduval, 1832)	3	5	2	0	8	6	24
	Pantoporia venilia (Linneus, 1758)	3	7	8	9	12	17	56
	Phaedyma shepherdi (Moore, 1858)	0	0	1	0	0	0	1
	Vagrans egista (Stoll, 1780)	0	0	0	2	0	0	2
	Vindula arsinoe (Cramer, 1777)	0	0	0	7	0	0	7
	Yoma algina (Boisduval, 1832)	0	0	1	0	0	4	5
Satyrinae	*Elymnias agondas* (Boisduval, 1832)	0	0	0	0	4	3	7
	Elymnias papua Wallace, 1869	0	3	0	0	0	2	5
	Melanitis amabilis (Boisduval, 1832)	0	0	0	0	0	2	2
	Mycalesis aethiops Butler, 1868	0	0	0	0	3	0	3
	Mycalesis duponchelii (Guerin-Meneville, 1831)	0	0	0	0	0	2	2
	Mycalesis giamana	0	0	0	3	0	0	3
	Mycalesis mehadeva (Boisiduval, 1832)	0	0	0	0	0	4	4
	Mycalesis phidon Hewitson, 1862	0	0	0	14	22	15	51
	Mycalesis terminus Fabricius, 1775	4	16	0	9	0	0	29
	Ypthima arctoa (Fabricius, 1775)	8	29	0	0	0	0	37
Hesperidae								
Hesperinae	*Archenes dschilus* (Plotz, 1885)	0	4	0	0	6	0	10
	Archenes marnas (C. Felder, 1986)	0	15	0	0	14	0	29
	Archenes martha Evans, 1934	0	0	0	0	0	13	13
	Pontathus taxilus (Mabille, 1879)	0	17	0	0	0	0	17
	Tagiades sp	0	0	0	0	0	2	2
	Grand Total	102	369	153	374	309	571	1878

The number of butterfly species identified by day 3 in each habitat continued to increase (Figure 1). Therefore, if the number of observation days were increased, it would still be possible to increase the number of species found in secondary and primary forests.

Butterfly diversity in primary forests is higher than in secondary forests, but the butterfly diversity index in both habitats is relatively high (Table 2). This indicates that the community structure composition between secondary and primary forests is not significantly different. The species richness index in primary forests (10.79) is higher than in secondary forests (9.01). The species evenness index in secondary and primary forests is the same (0.89), indicating that the species composition in both habitats is similar. The species similarity index in secondary and primary forest habitats is also relatively high at 61.31%.

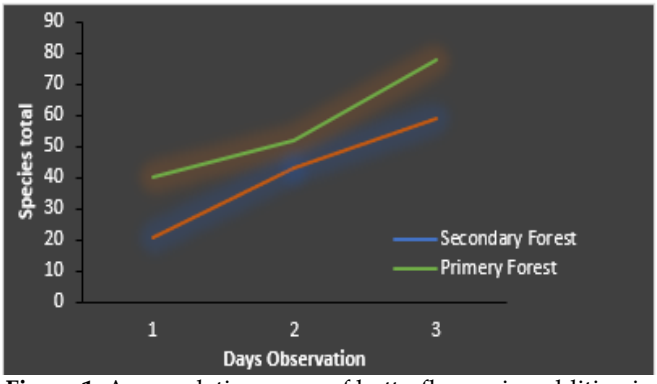

Figure 1. Accumulation curve of butterfly species addition in secondary and primary forests

Table 3. Diversity Index (H'), Richness Index (R), Evenness Index (E), and Habitat Similarity Index (IS) of Butterfly Species in Secondary and primary forests

Analysis	Secondary Forest	Primery Forest	Total
Species (S)	59	78	96
Individual (N)	624	1254	1878
Diversity Index (H')	3.66	3.91	3.98
Richness Index (R)	9.01	10.79	12.60
Evenness Index (E)	0.89	0.89	0.87
Similarity Index (IS)	61.31%		

When compared between families, the number of butterfly species identified varies (Figure 2). The Nymphalidae family had the highest number of species, representing 36.39% (36 species). The high number of species identified in this study is likely due to the availability of food (hostplants) and high survival rates. Research conducted by Panjaitan (2016) and Ningrum (2023) in a transformation forest also identified the highest number of species from the Nymphalidae family compared to other families. The Hesperidae family had the lowest number of species, representing 5.5% (5 species).

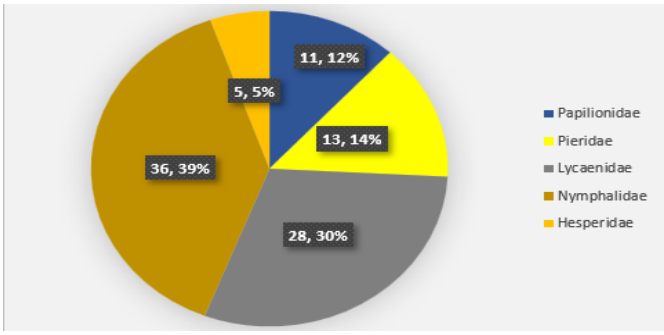

Figure 2. Percentage of butterfly species within the family

The number of butterflies in the Fef forest is 96, or approximately 25% of the total number of butterflies identified throughout West Papua and Southwest Papua, which is 390 species (Paz et al., 2022; Mahata et al., 2023; Mercado-Gómez et al., 2023). This study identified 29 butterfly species, the distribution of which has been reported as far away as Tambrauw, which is endemic to New Guinea (Appendix 1). The most dominant butterflies identified across all transects were Apias celestina (107 individuals) from the Pieridae family and Graphium eurypylus (104 individuals) from the Papilionidea family. These butterflies were often found sucking minerals around rivers (Suwarno et al., 2019; Lehnert et al., 2017). On the transect, the Ornithoptera priamus (Papilionidae) butterfly was also found, which is protected under Government Regulation Law number 32 of 2024. O. priamus is also an endemic species in Maluku and New Guinea (Munisi et al., 2024).

Figure 3. Dominant butterflies on the transect and those protected; a. *Apias celestina*; b. *Graphium eurypylus* c. *Ornithoptera priamus*

Species Distribution in Fef District

Research conducted in Fef District focused on primary and secondary forests surrounding the "Mother Forest." Butterflies were found distributed between 526 and 840 meters above sea level. *D. duscus* was only found once in primary forest at 840 meters above sea level (Figure 4).

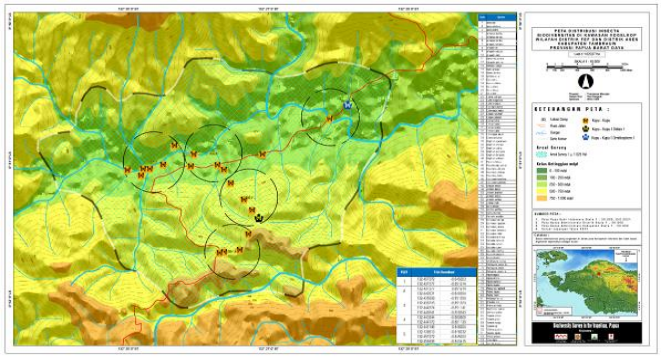

Figure 4. Distribution of butterfly species found in primary and secondary forests in Fef District

The high species diversity in Tambrauw is also closely related to the ecological conditions of the Fef area, which has an altitude of between 520–840 meters above sea level, relatively cool temperatures, and the presence of water sources and riparian vegetation that support the life of butterflies. According to Rocha-Ortega et al. (2019), Chowdhury et al. (2023), Deacon et al. (2021), dragonflies are bioindicators that are sensitive to changes in the quality of habitats, so the high diversity and evenness values at this location indicate that the ecosystem in Fef is still relatively healthy and well-maintained. Ecologically, these results indicate that the ecosystem habitat in the Fef District is still capable of supporting a balanced butterflies community. The relatively natural environment and diverse vegetation are key factors supporting butterflies life in this area (Reiss-Woolever et al., 2023; Zeng et al., 2025).

Synthesis of Development Potential and Threats

The forests in Fef District have high potential for biodiversity development, particularly for butterflies. The high diversity of butterflies indicates that the ecosystem composition is still relatively healthy and diverse. Therefore, it can be said that butterfly diversity is still maintained within the secondary and primary forests in Fef District (Sulaiman et al., 2022; Aguirre-Gutiérrez et al., 2017). However, road clearing and frequent landslides during the research period could pose a threat to the diversity of animal species within the forest, facilitating access for hunters if not strictly monitored by the indigenous community and the government (Wilson, 2025; Kaiser et al., 2019; Snook et al., 2022).

Conclusion

Research in the secondary forest and primary forest in Fef District was identified 96 butterfly species (1,878 individuals). Butterfly diversity in the forests of Fef District is considered high. The protected butterfly by Indonesia law and IUCN, *O. priamus,* is found in the forests of Fef District. 29 butterfly species were found, setting a new record for butterfly distribution in Tambrauw.

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Author Contributions

Conceptualization; methodology.; validation; formal analysis; investigation; V. D..; resources; data curation; writing—original draft preparation; Y. D. F.; writing—review and editing.; visualization: K. K. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The researchers funded this research independently.

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