

The diversity of butterflies (Lepidoptera: Rhopalocera) at Tanahbala Island, North Sumatra, Indonesia

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Abstract. Mairawita, Duha S, Herwina H. 2023. *The diversity of butterflies (Lepidoptera: Rhopalocera) at Tanahbala Island, North Sumatra, Indonesia. Biodiversitas 24: 1759-1765.* The research was conducted from April to October 2015 to observe the diversity of butterflies (Lepidoptera: Rhopalocera), complete an inventory, and obtain information about biodiversity on Tanahbala Island, South Nias District, North Sumatra Province, Indonesia. Tanahbala Island is a small island in Indonesia with high biodiversity potential. Sampling in the study was carried out in the Fagugu and Tebolo areas with different habitat types, namely forests, forest edges, and residential areas. The tools used to collect samples are cylinder gauze and insect nets. After sampling, 617 butterflies were collected and identified. The identification results showed 52 species of butterflies consisting of 42 genera and nine families. The Nymphalidae family has the most observed species, namely 17, while the Acraeidae family has only one observed species. The diversity index of all butterflies collected in this study showed a high average value of 3.00. This shows that the biodiversity of butterflies on Tanahbala Island is relatively high. The data obtained from this study will be beneficial to support biodiversity conservation efforts on Tanahbala Island, particularly in managing butterfly habitats. In addition, this data can also be a reference for researchers and conservationists to preserve butterfly biodiversity in Indonesia. This research also shows the importance of inventorying and monitoring biodiversity in Indonesian territory, especially in small islands such as Tanahbala Island, which should be addressed. With better inventory efforts, more complete and accurate data can be produced regarding the biodiversity in Indonesian territory so that more appropriate and effective conservation efforts can be carried out.

Keywords: Cylindrical gage, diversity index, forest edge, inhabitant, Nymphalidae

INTRODUCTION

Indonesia is an archipelagic country located between two continents and two oceans, so it has extraordinary biodiversity. With more than 17,000 islands and various types of ecosystems, such as tropical rain forests, savannas, and coral reefs, Indonesia is one of the megadiverse countries in the world. Indonesia is known as a "country of a thousand islands," with many unique and rare species that can only be found in Indonesia. One of the prominent biodiversity in Indonesia is the butterfly. Butterflies are beautiful insects and attract the attention of many people. Over 1900 butterfly species have been identified in Indonesia, making it one of the countries with the most significant number worldwide (GBIF 2021). The butterfly is an insect in the order of Lepidoptera that has scaly wings. They are beautiful animals with attractive body shapes (Arya et al. 2014). Lepidoptera originates from the Greek words *lepis* (scale) and *pteron* (wing), which are typical in this insect group. It is divided into two suborders based on morphological and behavioral aspects: Rhopalocera (butterflies), which are active during the day, and Heterocera (moths), which are nocturnal (Kunte 2000). They are highly sensitive to habitat disturbance and have been used as an indicator taxon for ecological research. In addition to their aesthetic beauty, butterflies have an essential role in the ecosystem. As insect pollinators, butterflies help speed up the process of plant fertilization

and reproduction. Therefore, the existence of butterflies is necessary to preserve ecosystems in Indonesia. However, butterflies' responses, particularly to disturbances and deforestation, are poorly understood. That indicates further research is still needed to understand the impact of human activities on butterfly habitats. Efforts to conserve biodiversity need to be increased by considering the possible effects of human activities to minimize damage to butterfly habitats and maintain the survival of this species. The current study focused more on the first one.

Ten butterfly families are reported from Sumatra: Acraeidae, Amathusiidae, Danaidae, Hesperidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, Riodinidae, and Satyridae (Dahelmi et al. 2010). There is very little information regarding the families and species of butterflies from offshore islands (Koneri and Nangoy 2019). This shows the importance of conducting further research to identify butterfly species found on offshore islands and understand the role and ecology of these species in the ecosystem. More detailed information on butterfly biodiversity on offshore islands will help broaden the understanding of butterflies and become the basis for more effective conservation efforts. Few studies were conducted to observe the butterflies on small and outer islands in Greater Sunda. A study at an offshore island of Talaud Island, North Sulawesi, collected 32 species (Koneri and Nangoy 2019), while 33 species were recorded at Marak Island, Padang City (Dahelmi et al. 2010). At

Tanjung Balai Karimun, Riau Islands Regency, 42 species were identified (Nofri et al. 2012), and 20 were found at Siberut Island of West Sumatra (Luk et al. 2011).

This study aims to determine the diversity of butterflies (Lepidoptera: Rhopalocera) in the forest edge and the inhabitant area of Tanahbala Island, South Nias District, North Sumatra Province, Indonesia which has high biodiversity potential. Tanahbala Island is part of the offshore satellites in the western sea of Sumatra Island. Before this study, the islands and islets in this cluster were scarcely surveyed for their biodiversity. Hence, the survey of the Rhopalocera butterflies from this island will significantly contribute to the biodiversity database of Sumatra. Furthermore, the data obtained from this survey will provide a complete understanding of the butterfly species that live on Tanahbala Island and become the basis for biodiversity conservation efforts in the area. In addition, the results of this study are also expected to provide a better understanding of the relationship between butterfly biodiversity and habitat conditions on Tanahbala Island. By knowing the state of the habitat inhabited by butterflies,

more appropriate and effective conservation efforts can be made.

MATERIALS AND METHODS

Study area and sampling site

Tanahbala Island is located in the western offshore of South Nias District, North Sumatra Province, Indonesia with an area of 39.67 km². The center of this island is predominantly covered by hilly terrains, with an altitude ranging from 500 to 1000 m above sea level. The surveys and data collection were conducted at two locations, namely Fagugu (0°31'18.44"S, 98°23'52.12"E) and Tebolo (0°20'57.29"S, 98°28'55.42"E), within the island (Figure 1). Fagugu is the location of the reforestation forest carried out by PT. Guruti after the management of forest products and settlements. Tebolo is a residential area with a primary forest area that has not been disturbed by human or company activities.

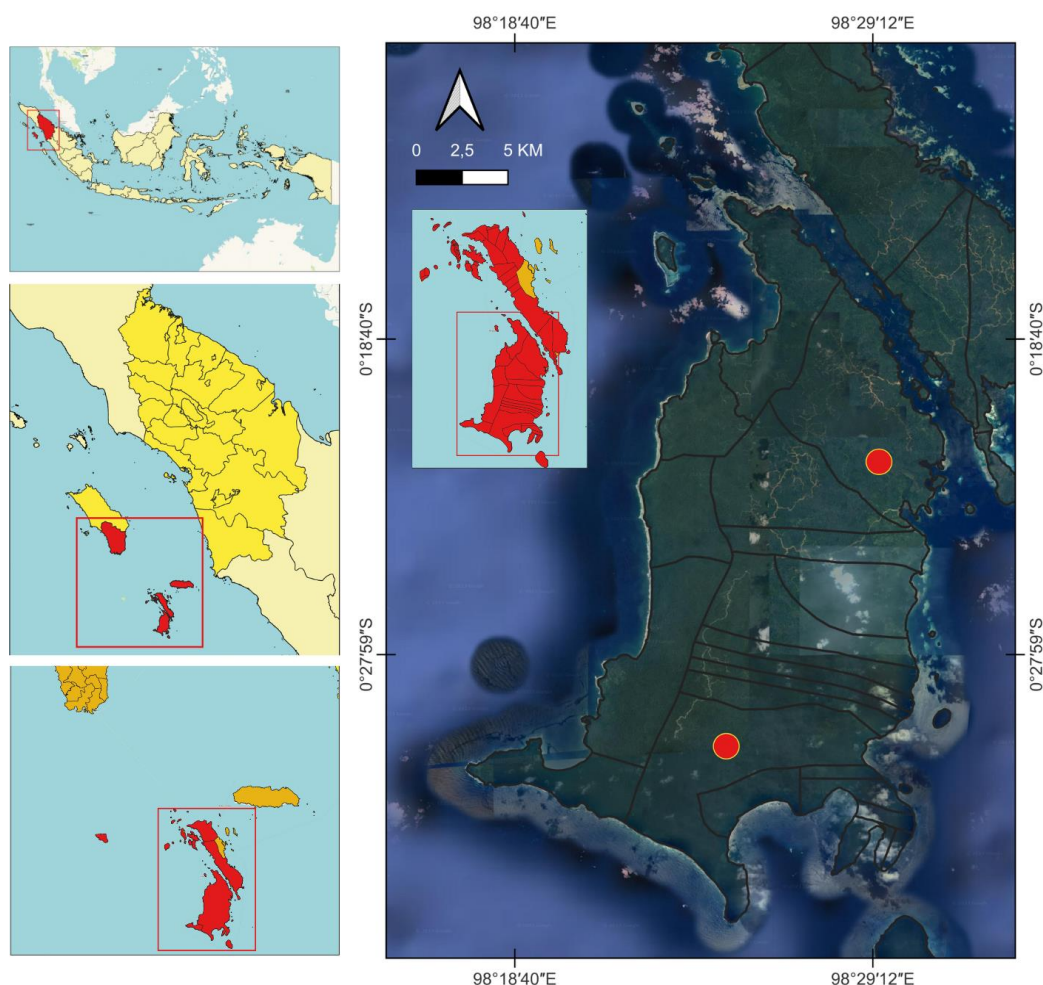


Figure 1. Sampling sites in Tebolo and Fagugu of Tanahbala Island, South Nias District, North Sumatra Province, Indonesia

Data collection

Sampling method

Butterfly sampling was conducted in two collection periods, from April to May 2015 and September to October 2015. The length of time for collection for each location was the same. The samples were collected using cylindrical gauze with mashed bananas as bait. A total of 10 bait traps were set at the inside of the forest and hung on two different heights, where five traps were 1 m above ground for the understory stratum, and the other five were at a 15 m height for the canopy stratum. The traps were regularly checked every 24 hours, except during heavy rain. Butterflies at the forest edge and human settlements were sampled directly with an insect net from 08:30 AM to noon and from 2:00 to 5:00 PM on sunny days. After netting a butterfly with an insect net, the butterfly was killed by pinching its thorax (middle body segment) between the thumb and the forefinger. The samples were then stored within the marked triangle glassine envelopes and transported to the laboratory for a different process. Each flowering vegetation and the presence of larvae found in each habitat were collected and labeled. The vegetation specimens were then sent to the Taxonomy Laboratory at Andalas University, Padang, Indonesia for species identification.

Butterflies handling and preservation

The collected specimens were processed according to a standard procedure for preserving butterflies, which included wing-spreading, styrofoam board-pinning, and drying. The drying was conducted under a constant 32.2° Celsius using an oven for two days or until specimens became dried. The specimens were labeled by their taxonomy, sampling location, collector, and other relevant information upon identification.

Identification of butterflies and plants

Captured butterflies were identified using the books Tsukada (1982, 1985) and Tsukada et al. (1991). All specimens were then deposited in the Laboratory of Animal Taxon, Andalas University, Padang, West Sumatra. Each flowering vegetation and the presence of larvae found were collected and labeled, then to be identified based on the plant taxon key.

Data analysis

The diversity index of the samples was calculated using the Shannon-Wiener formula, whereas the dominance index was calculated using the Simpson formula (Magurran 2013), as presented below:

$$H' = - \sum_{i=1}^s p_i \ln p_i,$$

$$p_i = n_i/N, \text{ and}$$

$$D = \sum \left(\frac{n_i}{N} \right)^2$$

Where, H' : diversity index; n_i : number of individuals for species- i ; N : number of all individuals sampled; D : Simpson Dominance Index.

The species similarity across sites was counted using the Jaccard formula (Magurran 2013):

$$C_j = \frac{c}{a+b+c},$$

RESULTS AND DISCUSSION

Collected butterflies from Tanahbala Island

The survey collected 617 butterflies, where 368 individuals were caught using cylindrical gauze, and 249 individuals was captured using an insect net. The specimens were divided into 52 species belonging to 42 genera and nine families. The Nymphalids were the family with the highest species diversity (15), followed by Satyrids (11), Pierids (7), Lycaenids (6), Danaids (3), Hesperids (3), and Papilionids (2). Acraeid has only one observed species (Table 1).

The number of butterflies found on the island of Tanahbala is lower than the number of butterflies on the Sumatra mainland. This is because the area of Tanahbala Island is smaller and far from the mainland. Based on the Biogeographic Theory, the islands that are large and close to the mainland have more butterfly species than the small and far from the mainland ones (Sumarto and Siahaan 2012). Therefore, the diversity of the number of species and living creatures on an island depends on the area of the island (Kurniawati et al. 2014).

At Fagugu, the study recorded 360 individuals from 42 butterfly species of 36 genera and nine families, whereas, at Tebolo, there were 252 individuals from 38 species of 31 genera and nine families (Table 2). The butterflies were distributed along with the number of scattered plants. Therefore, the vegetation typology could lead to the diversity of butterfly communities in each habitat, and the variety of these butterflies could be observed based on the genus or family.

Seventeen Nymphalid species were collected in this study, making it the family with the most recorded species. The Nymphalid is known for its large species members and wide distribution. Butterflies from this family inhabit the forest and open area and gather around rotten fruits, which are thought to be their food source. It was previously reported that some Nymphalid genera prefer flowers and rotting fruits as sources of nutrition (Pena and Esplenad 2013). By contrast, the finding of only one species of Acraeid (8 individuals) might be related to the scarcity of its host plants that are essential for supporting the sustenance of its larva. This is supported by the inappropriate vegetation structure in the study sites that imposed the least number of species of this family. In addition, a previous study reported a positive correlation between host plants' abundance and butterfly species' relative abundance.

Table 1. The list of butterflies collected in Tanahbala Island, North Sumatra, Indonesia

Family/species	Collection methods		Total
	CG	IN	
Acraeidae			
<i>Acraea violae</i>		8	8
Amathusiidae			
<i>Amathusia phidippus</i>	3	1	4
<i>Faunis stomphax</i>	2		2
<i>Thaumantis</i> sp.	1		1
<i>Zeuxidia amethystus</i>	4		4
Danaidae			
<i>Euploea leucostictos</i>		1	1
<i>Euploea mulciber</i>		8	8
<i>Idea stoll</i>		2	2
Hesperiidae			
<i>Gerosis</i> sp.		2	2
<i>Potanthus ganda</i>		8	8
<i>Suastus gremius</i>		8	8
Lycenidae			
<i>Allotinus pseudocentaurus</i>		1	1
<i>Catochrysops ancyra</i>		24	24
<i>Euchrysops cnejus</i>		17	17
<i>Jamides pura</i>		3	3
<i>Miletus biggsii</i>		3	3
<i>Remelana jangala</i>		1	1
Nymphalidae			
<i>Cethosia hypsea</i>		2	2
<i>Cupha erymanthis</i>		2	2
<i>Charaxes bernardus</i>	2		2
<i>Cynthia godartii</i>		1	1
<i>Ditcophora necode</i>	9	1	10
<i>Dophla evelina</i>	1		1
<i>Euthalia monina</i>	2	1	3
<i>Hypolimnas bolina</i>		17	17
<i>Junonia hedonia</i>	1	5	6
<i>Junonia almana</i>		7	7
<i>Junonia atlites</i>		19	19
<i>Neptis hylas</i>		27	27
<i>Prothoe franck</i>		1	1
<i>Tanaecia peleia</i>	2		2
<i>Tanaecia yupana</i>	25	1	26
Papilionidae			
<i>Papilio memnon</i>		1	1
<i>Papilio polytes</i>		9	9
Pieridae			
<i>Appias olferna</i>		3	3
<i>Catopsilia pomona</i>		3	3
<i>Catopsilia pyranthe</i>		2	2
<i>Cepora iudith</i>		1	1
<i>Delias</i> sp.		1	1
<i>Eurema sari</i>		22	22
<i>Leptosia nina</i>		2	2
Satyridae			
<i>Elymnias hypermnestra</i>	22	2	24
<i>Elymnias nesaea</i>	48		48
<i>Elymnias panthera</i>	38		38
<i>Lethe candica</i>		1	1
<i>Melanitis leda</i>	72	3	75
<i>Mycalesis fusca</i>	1		1
<i>Mycalesis orseis</i>	126	1	127
<i>Mycalesis horsfieldi</i>	1		1
<i>Orsotriaena medus</i>	6	6	12
<i>Ypthima horsfieldii</i>	1	20	21
<i>Ypthima baldus</i>		2	2
Σ Individuals	368	249	617
Σ Species	21	40	52
Σ Genera	17	35	42
Σ Families	3	9	9
Diversity Index	2.00	3.13	3.00
Dominance Index	0.04	0.20	0.46

Note: CG: Cylindrical Gauze; IN: Insect Net

Table 2. The identified potential host plants in Tanahbala Island, North Sumatra, Indonesia

Species	Site	
	Fagugu	Tebolo
<i>Ageratum conyzoides</i>	+	
<i>Aquilaria moluccensis</i>	+	+
<i>Calliandra calothyrsus</i>	+	
<i>Capsicum annuum</i>	+	
<i>Citrus grandis</i>	+	
<i>Crotalaria mucronata</i>	+	+
<i>Eupatorium inulifolium</i>	+	
<i>Lantana camara</i>	+	+
<i>Lilium longiflorum</i>	+	+
<i>Mikania micrantha</i>	+	
<i>Mimosa pudica</i>	+	
<i>Mussaenda pubescens</i>	+	+
<i>Mussaenda</i> sp.		+
<i>Schima wallichii</i>	+	+
<i>Stachytarpheta jamaicensis</i>	+	

The diversity index of butterflies at Tanahbala Island was categorized as high (3.00, Table 1) and indicates that the habitat is still in good condition despite the disturbance by the community's agricultural activities. However, this number varied with the collection methods in this study. The cylindrical gauze captured butterflies in moderate diversity (2.00), while the insect net resulted in a much higher diversity variety (3.13). This is because the net actively sought the butterflies within the study sites rather than only passively waiting for butterflies to be trapped. Fagugu had higher diversity (3.01) and indicated that the Guruti company's forest reforestation did not negatively affect butterfly diversity. Due to forest reforestation, it is suspected that more flowering plants (nectar-producing butterflies) were observed at this location (Table 2).

The diversity index of Tebolo is in a low category. This is influenced by habitat disturbance due to the clearing activity of community agriculture, leaving much barren space or only covered by bushes. The abundance of butterflies will increase when sufficient food is available. More butterflies are observed in the adult area because it provides more food sources (Fermon et al. 2001). Using the banana in cylindrical gauze influences the number of species caught (Table 3) for fruit-eating butterflies, not nectar-eating butterflies. However, it is used only in forest habitats and edges at each collected location.

In general, Fagugu and Tebolo sites had a low butterfly diversity (Table 2), indicating the vegetation structure difference in each habitat type. As reported earlier, vegetation type plays a major role in determining butterfly communities' diversity and density patterns (Ramesh et al. 2010; Vu and Vu 2011). The forest edge showed the highest diversity of butterfly species and genera. This phenomenon was in line with the observed ecological tendency of various animals toward the edge habitats (Potts et al. 2016), where butterflies seem to respond positively to the dynamics at the forest edge. At the end of the sampling surveys, the Fagugu forest edge had the highest accumulative species diversity compared to the other surveyed habitats.

The most dominant species observed at Tanahbala Island was *Mycalesis orseis* Hewitson (N: 127, D: 0.88). This species seemed to prefer a forest habitat where it could consume rotting fruits and animal feces and the availability of various plants that serve as hosts for its larvae. Satyrid butterflies are renowned for their many species, most of which inhabit the forest habitat (Lin 2015; Matsumoto et al. 2015). It was indicated that the availability of food plants drove butterflies' distribution and population abundance. In contrast, habitat alteration is essential in reducing this resource's scarcity (Mihindukulasooriya et al. 2014; Curtis et al. 2015).

Ten days of the survey at each habitat (forest, forest edge, and human settlement) in Fagugu and Tebolo sites have brought what seems to be a complete result on the diversity of butterflies at Tanahbala Island. The accumulation of species increment showed an asymptotic tendency toward the end of the survey, which presumably indicated that the study had successfully collected ample representatives of the butterfly community in all study sites using the cylindrical gauze and insect net method (Figure 2). This result brought important knowledge regarding butterfly diversity on the western Sumatran Islands. The

current study confirmed that 9 out of 10 Sumatran butterfly families in Tanahbala Island have potential butterfly diversity on the Sumatran offshore islands. In addition to having a higher number compared to those in some previous studies, such as those conducted at Marak Island (Dahelmi et al. 2010) and Siberut Island (Luk et al. 2011), the butterflies of Tanahbala Island were novel to the species inventory (see the comparison in Table 4). As many as 45 Tanahbala Island butterflies (85.89%) were not recorded at Marak Island, while 48 species (91.67%) were not observed at Siberut Island.

The important number and diversity of Tanahbala Island butterflies might also be influenced by the size and distance of each island in the clusters, which restrict the butterfly population and create separation among islands. In addition, the complexity of the habitat structure and the diversity of island vegetation contributed to the presence and variety of butterflies (Liivamagi 2014; Castro and Espinosa 2015). The offshore island butterflies can also limitedly interconnect with the mainland (Dapporto et al. 2017). The fundamental factors and mechanisms in this regard must be studied following the continuous recording of the species inventory for this region.

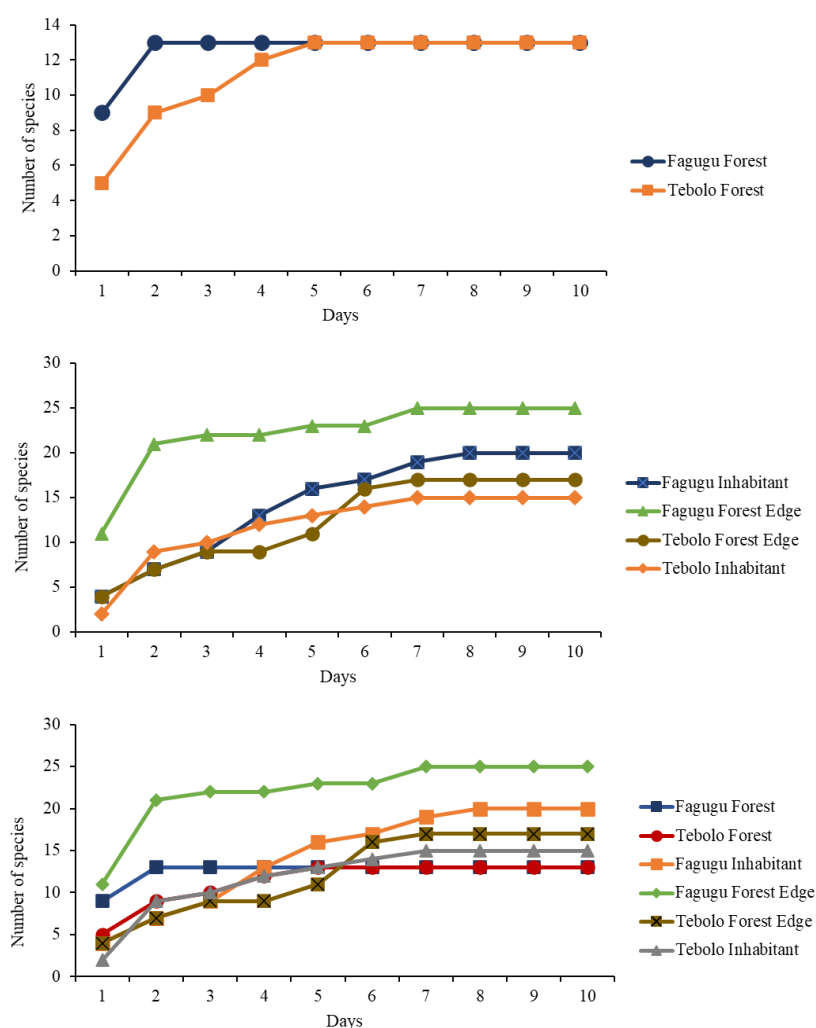


Figure 2. During the Tanahbala Island survey, the accumulated butterfly species were A. Cylindrical gauze; B. Insect net; and C. Both collection methods

Table 3. The comparison of observed butterflies in the three habitat types of each sampling site

Total	Fagugu				Tebolo			
	Forest	Forest Edge	Settlement	N	Forest	Forest Edge	Settlement	N
Total of individual	157	110	52	360	119	100	35	252
Total of species	14	39	22	42	16	27	17	38
Total of genera	11	34	19	36	10	18	14	31
Total of family	3	9	7	9	3	9	7	7
Diversity Index	1.88	3.03	2.51	3.01	1.40	2.74	2.57	2.80
Similarity Index				0.46				

Table 4. A total number of families, genera, species, and individuals among three offshore islands of Sumatra, Indonesia

Study sites	Study period	Total number			
		Families	Genera	Species	Individuals
Marak Island, Pesisir Selatan District, West Sumatra Province (Dahelmi et al. 2010)	March-May 2009	8	28	33	185
Tanahbala Island, South Nias District, North Sumatra Province (this study)	April-May 2015 and September-October 2015	9	42	52	617
Siberut, Mentawai Islands, West Sumatra Province (Luk et al. 2011)	June 6-July 17 2009	3	14	20	244

In conclusion, a total of 617 butterfly individuals were collected in this study from two sampling methods, which were then identified as 52 species, 42 genera, and nine families. The diversity index for Tanahbala Island butterflies was considerably high (H' : 3.00). Between the surveyed sites, Fagugu (H' : 3.01) was collectively more diverse than Tebolo (H' : 2.80), whereas the similarity index between the two sites was low (0.46). The dominant species recorded on this island was *Mycalesis orseis* Hewitson (D : 0.94). Therefore, further study of morphological species to identify is needed.

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