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Butterfly species in Bogani Nani Wartabone National Park, North Sulawesi, Indonesia

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Abstract. *Koneri R, Nangoy MJ, Maabuat PV, Wakhid. 2023. Butterfly species in Bogani Nani Wartabone National Park, North Sulawesi, Indonesia. Biodiversitas 24: 1242-1251.* Changes in the landscape spatially and temporally impacted the fauna distribution and diversity, such as butterflies. This research analyzed the diversity in the Bogani Nani Wartabone National Park area, in Toraut Village, West Dumoga Sub-district, Bolaang Mongondow District, North Sulawesi, Indonesia. A survey method was used with purposive sampling in 4 habitats: a waterfall located within the national park area, forest edge, agricultural land, and shrubs. The sampling and sweeping techniques following the line transect were applied randomly along 300 m in each habitat type. Furthermore, data analysis included distribution, abundance, richness index, diversity index, species evenness index, the correlation between environmental factors and species diversity, and butterfly species similarity index between habitats. Overall, 1594 individuals from 71 species in 5 families were identified. The family with the highest number of species and individuals was Nymphalidae, while the most common was *Catopsilia scylla* of the orange emigrant. The highest average abundance and evenness were found at the forest edge, while the highest richness and diversity were in the waterfall. According to the analysis of similarity (ANOSIM), the composition of butterflies in four habitats was significantly different. Principal component analysis (PCA) showed that the waterfall habitat was characterized by high relative humidity, low air temperature, and light intensity. The ordinance plot represented a waterfall separated from the three other habitats; hence, the environmental factors differed. Waterfall and forest edges had the highest diversity due to the complex vegetation structure and environmental factors supporting survival.

Keywords: Butterflies, *Catopsilia scylla*, ecotourism, Nymphalidae, waterfall

INTRODUCTION

Bogani Nani Wartabone National Park is a conservation area in North Sulawesi and Gorontalo Provinces. This national park covers an area of 287,115 hectares, following the Decree of the Minister of Forestry. It functions as the protection of flora and fauna as well as water and soil conservation. Forests in conservation areas are habitats that host a large part of global biodiversity and are very important for ecosystem functioning (FAO and UNEP 2020; Wurz et al. 2022). The area contains various ecosystems: river, waterfall, secondary forest, and lowland primary forest. In addition, there are garden ecosystems, rice fields, and rivers outside the area inhabited by various flora and fauna (Bashari et al. 2020).

The butterfly belongs to the order Lepidoptera and is the second-largest after Coleoptera in terms of species richness (Suhaimi et al. 2017; Ismail et al. 2018). As described, this species reaches about 20,000, and 90% are found in the tropics (Suwarno et al. 2018). Therefore, the tropics have more butterfly species than temperate regions, for example, 292 from Canada (Kerr 2001) and 482 from Europe (Van Swaay et al. 2010). For comparison, 1038 and 944 species were reported in the Peninsular Malaysian (Eliot and Kirton 2000) and Kalimantan (Otsuka 2001), respectively. Based on the report, 2000 species of butterflies are in Indonesia (Peggie 2014), and around 557 are on Sulawesi Island (Med 2003).

Butterflies play an important role in an ecosystem as good pollinators after bees (Thangjam et al. 2018). That is because they depend on nectar and flower pollen for food, while the larval stage of certain host plants feeds on leaves (Nimbalkar et al. 2011). Furthermore, the adults have aesthetic value with various beautiful shapes and colors of their wings (Ghazanfar et al. 2016; Medhi et al. 2018). In addition, they have various flight and perch behaviors as a particular attraction for tourists in ecotourism areas (Ismail et al. 2018).

Bogani Nani Wartabone National Park is being developed as an ecotourism destination due to its natural tourism potential, such as waterfalls, hot springs, rock caves, white water rafting, and natural panoramas. However, there is limited information on this park's potential regarding the many flora and fauna used as tourist attractions, such as butterfly diversity. For example, butterflies can be a tourist attraction in terms of the beauty of the color and shape of the wings and the different flying patterns (Kurnianto et al. 2016).

Research on the diversity of butterflies in conservation areas has been carried out in Sumatera, Java, Borneo, and Sulawesi (Widhiono 2015; Koneri and Maabuat 2016; Rusman et al. 2016; Aprilia et al. 2018; Panjaitan et al.

2020; Harmonis et al. 2022). Bogani Nani Wartabone National Park, one of Sulawesi's largest conservation areas, needs to get the latest data on butterfly diversity. The last survey of the diversity of butterflies in Bogani Nani Wartabone National Park was carried out in 2010 (Koneri 2010). Data on the diversity of butterfly species in the Bogani Nani Wartabone National Park is the object of the earliest exploration since the Bogani Nani Wartabone National Park was designated. The result of the Wallace Project in 1985, reported by Heppner (1992), stated that in Bogani Nani Wartabone National Park, there are 200 species of butterflies. However, the data from Wallace Project was incomplete and did not mention the species (Bashari et al. 2020).

The need for the latest data on butterfly diversity is related to an inventory update of butterfly species. The last data on the diversity of butterflies in Bogani Nani Wartabone national park was obtained in 1985 and 2010 (Heppner 1992; Koneri 2010). The conversion of land functions and human activities causes spatial and temporal changes in the landscape and ecosystem in Bogani Nani Wartabone National Park, which have the potential to affect butterfly diversity. These changes affect species diversity in the area due to complex holometabolic life cycles, specialization of feeding and host plants, thermoregulation, and symbiotic associations (Wurz et al. 2022). In addition, habitat loss and fragmentation, pollution, invasive species, climate change, and overharvesting are seriously reducing insect and other invertebrate abundance, diversity, and biomass across the biosphere (Harvey et al. 2020). Based on these backgrounds, this study aims to analyze the butterfly diversity in Bogani Nani Wartabone National Park, Toraut Village, West Dumoga, North Sulawesi, Indonesia.

MATERIALS AND METHODS

Study area and habitat types

This study was conducted on various habitats outside and inside Bogani Nani Wartabone National Park, in Toraut Village, West Dumoga Sub-district, Bolaang Mongondow District, North Sulawesi, Indonesia (Figure 1). Outside the Bogani Nani Wartabone National Park area, there are two habitats: agriculture and shrubs. In these two habitats, it is necessary to observe the number and species of butterflies compared to those inside the Bogani Nani Wartabone National Park. The habitat types used as sampling sites were waterfalls in national park areas, forest edges, agricultural land, and shrubs (Figure 2). Those locations were selected because many butterflies live there. Furthermore, four line transects were made in each habitat with a length of 300 m each. Sample identification was carried out at the Laboratory of Advanced Biology, Faculty of Mathematics and Science, Sam Ratulangi University, Menado, Indonesia.

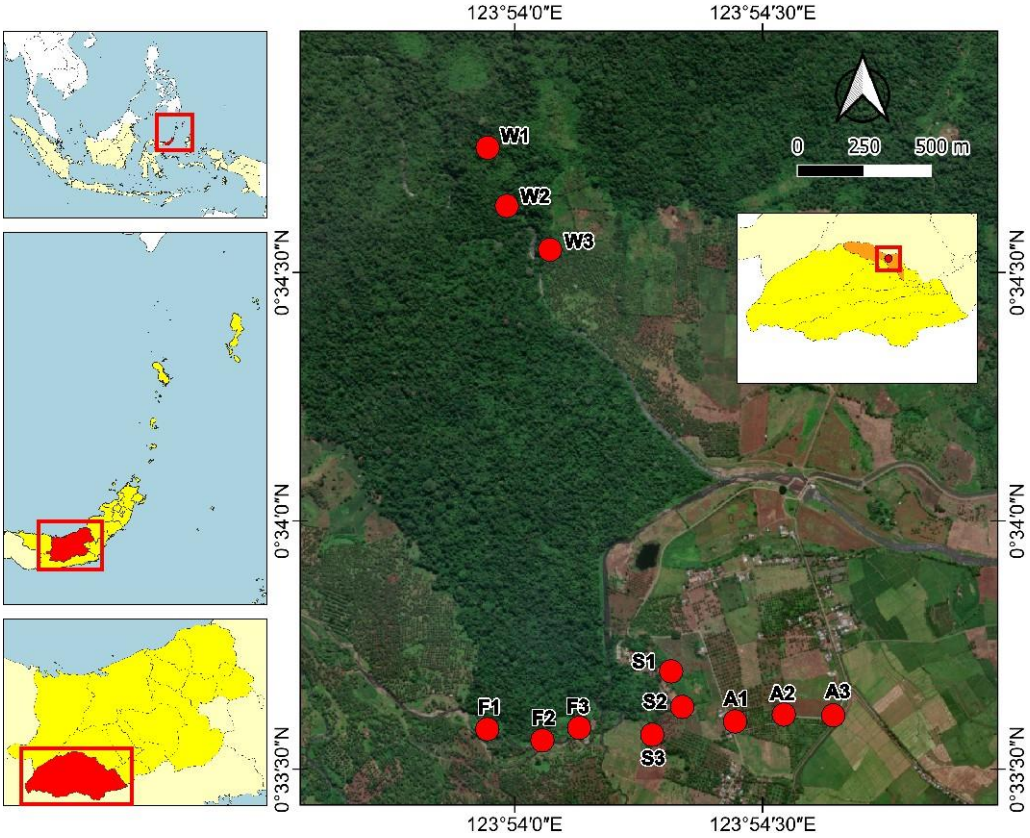

Figure. 1. Map of the study around Bogani Nani Wartabone National Park, Indonesia (W1: 2: 3: Waterfall transect 1;2;3; F1: 2: 3: forest edge transect 1;2;3; S1: 2: 3: shrub transect 1;2;3; S1: 2;3: shrub transect 1;2;3; A1: 2: 3; agricultural land transect 1: 2;3)

Figure 2. Photographs of study sites around Bogani Nani Wartabone National Park, Indonesia. A. Waterfall; B. Forest edge; C. Agricultural land; D. Shrub

Sampling technique and measurement of environmental factors

The sampling technique was performed by survey protocol following standard butterfly transect methods with a width of 10 m to the left and 10 m to the right (Pollard 1977; Martin and Bateson 1993; UKBMS 2022). Each area was observed four times and was conducted monthly for four months. Transects should only be walked between 08.00-15.00 (butterfly activity time) when it is not raining (Peggie and Amir 2006), and observations included the number of species and individuals. Butterflies that could not be identified directly were caught with a sweep net and placed on papilot paper for identification purposes based on morphological characters. The identification books by Peggie (2011, 2014), Van-Wright and de Jong (2003), and Butterflies of the South East Asian Island, Part I Papilionidae, Part II Pieridae-Danaidae, Part III Satyridae-Lybytheidae, Part IV Nymphalidae (I), Part V Nymphalidae (II) (Tsukada and Nishiyama 1981, 1982, 1982, 1985, 1991) were used.

During sampling, environmental variables such as temperature, humidity, wind speed, and light intensity were measured using a thermometer, hygrometer, anemometer, and Lux meter. The altitude of the place from sea level and the determination of coordinates used the Global Positional System (GPS).

Data analysis

The species abundance and richness were tabulated for each habitat using Microsoft excel. Community structure attributes such as species abundance, species richness, Shannon-Wiener diversity index ($H'=-\Sigma pi \ln pi$), and Pielou evenness index ($J=H'/\ln S$) were calculated based on each habitat (Bashir et al. 2019). Based on the normality test on the number of taxa and the number of individuals, the Shannon diversity index and Evenness index showed normal data distributions. One-way ANOVA statistical analysis and Tukey's test at a 95% confidence level were used using Statistica version 6 software to test the significant differences in individual abundance, species richness, Shannon diversity index, and evenness index between habitats (Ajerrar et al. 2020).

Statistical tests to assess differences in the composition of butterflies in each habitat used analysis of similarity (ANOSIM). Differences in the composition of communities on the ecotourism route were visualized using non-metric dimensional scaling (NMDS). Meanwhile, ANOSIM and NMDS were analyzed based on the Bray-Curtis dissimilarity index. In addition, principal Component Analysis (PCA) between environmental factors (independent variable) and sampling location (dependent variable) was performed to determine the relationship between the location and the measured environmental factors. PCA analysis used data on environmental variables (temperature, relative humidity, wind speed, and light intensity) on each habitat transect. ANOSIM, NMDS, and PCA were analyzed using Paleontological Statistics software (PAST software 3.10) (Cuartas-Hernández and Gómez-Murillo 2015; Wakhid et al. 2021).

RESULTS AND DISCUSSION

The overall ranking of the 71 species found showed that orange emigrant of *Catopsilia scylla*, Blanchard's wood nymph of *Ideopsis vitrea*, and cream banded swallowtail of

Papilio gigon were ranked 1st, 2nd, and 3rd with relative abundances of 18.76%, 6.65%, and 5.40%, respectively (Figure 3). The high curve steepness from first to second ranks indicates that *Catopsilia scylla* is quite abundant in the habitat around the national park. Furthermore, second to 71 ranks, the curve has a low steepness, showing that the evenness is quite good.

The percentage composition of butterflies based on their abundance is shown in Figure 4. The Nymphalidae family has the highest abundance percentage of the four observed habitat types. It was 51.31%, 42.21%, 41.24%, and 39.65% in forest edge, agricultural land, waterfall, and shrub habitats, respectively. In contrast, the Hesperiidae family has the lowest abundance at 6.98%, 5.61%, and 5.27% in forest edge, shrub, and agricultural land habitats, respectively. In the waterfall habitat, butterflies from the Hesperiidae family are not found, and the Papilionidae family shows an abundance of 7.14%.

This research found 71 species belonging to Nymphalidae, Pieridae, Papilionidae, Hesperidae, and Lycanidae, with a total of 1594 individuals (Table 1). The family has the highest number of species at 42, followed by the Papilionidae, Hesperidae, Pieridae, and Lycanidae with 12, 7, 6, and 4 species. In addition, the sampling found many rare species of butterflies, and 18 have singletons and doubletons values (25.35%).

The interpolation-extrapolation rarefaction curve shows a rapid increase at the beginning of the sampling but does not reach the asymptote point (Figure 5). The rarefaction curve interval in the agricultural land is separated from the others. Separating rarefaction curves indicates species richness is lower than in the other three habitats. Based on the extrapolated rarefaction curve, the number of species in the four habitats is higher with the increased number of samples.

The highest average abundance is found on the forest edge at 152.67 individuals, followed by waterfall, agricultural land, and shrub at 144.67, 139, and 95, respectively (Figure 6). The highest species richness and diversity is found in the waterfall at 31.67 species and 3.03, while the lowest is in the agricultural land at 21.33 species and 2.31, respectively. The highest Pielou evenness index is in the Forest edge at 0.66, followed by FE, shrub, and agricultural land at 0.65, 0.54, and 0.48, respectively.

The analysis showed the mean individual abundance (ANOVA: F3,11: 4.656; P: 0.036), species richness (ANOVA: F3,11: 5.795; P: 0.021), and the Shannon diversity index (ANOVA: F3,11: 4.87; P: 0.033) differed between the four habitats. In contrast, the Pielou evenness index (ANOVA: F3,11: 3.243; P: 0.081) did not differ between the four habitats, as shown in Figure 6.

The analysis of similarity (ANOSIM) showed that the composition of butterflies in four habitats is significantly different (R: 0.7531; P: 0.0005). Similarly, the NMDS ordinance showed that the ordinance points between habitats were separated and did not overlap.

Environmental factors measured in four habitats are presented in Table 2. Based on the ANOVA analysis, air temperature (ANOVA: F3,11: 5.163; P: 0.028), humidity (ANOVA: F3,11: 4.573; P: 0.038), and light intensity (ANOVA: F3,11: 17.833; P: 0.001) were significantly different. Meanwhile, the wind speed was not significantly different between the four habitats (ANOVA: F3,11: 0.865; P: 0.498).

PCA showed that the waterfall habitat is characterized by high relative humidity, low air temperature, and low light intensity (Figure 8). In contrast, agricultural land and shrub are characterized by high air temperature, high light intensity, and low humidity. In addition, the ordinance plot showed that the waterfall is separated from the other three habitats; hence, the environmental factors differed from the others.

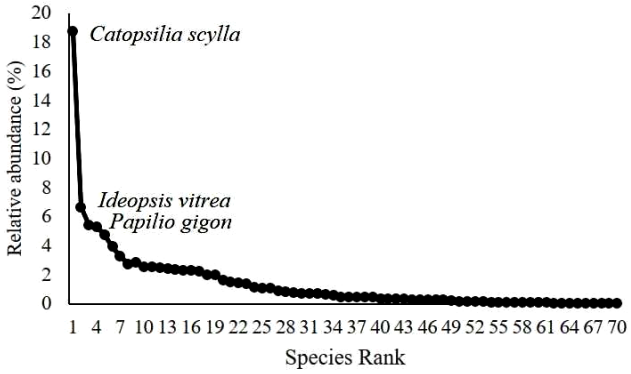

Figure 3. Rank-abundance curve of butterflies around Bogani Nani Wartabone National Park, Indonesia

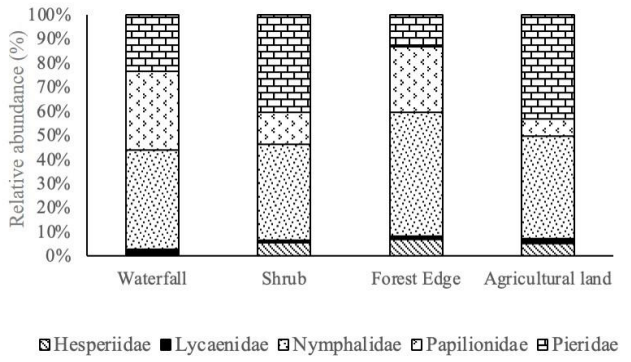

Figure 4. The proportion of butterflies in four types of habitats around Bogani Nani Wartabone National Park, Indonesia

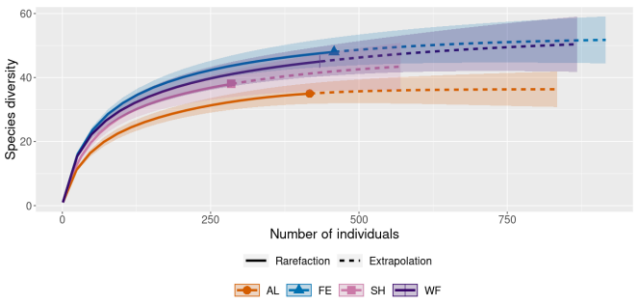

Figure 5. Individual-based rarefaction curves for the four habitats around Bogani Nani Wartabone National Park, Indonesia (WF: waterfall; SH: shrub; FE: forest edge; AL: agricultural land). (data: solid lines; extrapolation: dashed line). Shaded areas indicate 95% confidence intervals

Table 1. Number of families, species, and individuals of butterflies in four habitats around Bogani Nani Wartabone National Park, Indonesia

Family/species	Common names	Habitat types in the routes/number of individuals				Σ	%
		WF*	FE	AL	SH		
Nymphalidae							
Ideopsis vitrea	Blanchard's wood nymph	9	58	0	39	106	6.65
Junonia atlites	Grey Pansy	21	0	58	6	85	5.33
Amathusia phidippus	Palmking	40	0	31	5	76	4.77
Parthenos sylvia salentia	The clipper	5	40	2	5	52	3.26
Ideopsis juventa	Wood nymph	11	17	1	10	39	2.45
Ypthima nynias	Ring butterfly	0	18	15	3	36	2.26
Neptis ida	Sailers butteliy	0	11	14	7	32	2.01
Lohora dexamenus	-	10	16	0	0	26	1.63
Euploea eupator	Sulawesi pied crow	4	5	13	2	24	1.51
Danaus ismare alba	Ismare tiger	4	4	5	10	23	1.44
Melanitis leda	Common Evening Brown	0	6	15	1	22	1.38
Vindura celebensis	-	17	1	0	0	18	1.13
Faunis menado	-	13	4	0	0	17	1.07
Junonia hedonia intermedia	Chocolate Pansy	0	10	2	5	17	1.07
Ypthima loryma	Ring butterfly	0	0	3	9	12	0.75
Hypolimnas bolina	Blue moon	2	5	4	0	11	0.69
Danaus genutia	Common tiger	4	5	1	0	10	0.63
Euploea hewitsonii	Hewitson's dwarf crow	0	9	0	0	9	0.56
Idea blanchardii	Rice Paper Butterfly	3	2	0	2	7	0.44
Mycalesis janardana	Common Bushbrown	1	5	0	1	7	0.44
Cethosia myrina	Violet lacewing	3	3	0	0	6	0.38
Cyrestis paulinus	-	6	0	0	0	6	0.38
Mycalesis horsfieldi	Horsfield's Bushbrown	0	0	6	0	6	0.38
Orsotriaena jopas	The Jungle brown butterfly	4	2	0	0	6	0.38
Elymnias cumaea	The palmfly	1	4	0	0	5	0.31
Hypolimnas misippus	Danaid eggfly	3	0	1	1	5	0.31
Lasippa neriphus	-	0	0	3	2	5	0.31
Lexias aeetes	-	5	0	0	0	5	0.31
Rhinopalpa polynice	-	1	3	0	1	5	0.31
Athyma libnites	-	2	0	0	1	3	0.19
Hypolimnas anomala	-	2	1	0	0	3	0.19
Parantica cleona	-	2	1	0	0	3	0.19
Danaus chrysippus	-	2	0	0	0	2	0.13
Euploea leucostictos	-	0	2	0	0	2	0.13
Lohora ophthalmica	-	0	2	0	0	2	0.13
Medusa libnites	-	0	0	0	2	2	0.13
Moduza lymire	-	1	1	0	0	2	0.13
Ypthima horsfieldi	-	0	0	2	0	2	0.13
Chersonesia rahria	-	1	0	0	0	1	0.06
Cyrestis strigata	-	1	0	0	0	1	0.06
Junonia orithya	The blue pansy	1	0	0	0	1	0.06
Medusa lymire	-	0	0	0	1	1	0.06
Papilionidae							
Papilio gigon	Cream Banded Swallowtail	35	41	2	8	86	5.40
Graphium meyeri	-	31	15	10	7	63	3.95
Graphium milon	Milon Swallowtails	16	25	2	3	46	2.89
Papilio sataspes	-	28	8	2	6	44	2.76
Papilio ascalaphus	Ascalaphus swalowtails	1	27	3	6	37	2.32
Graphium agamemnon	The tailed jay	18	4	7	3	32	2.01
Graphium androcles	Giant swordtail butterfly	7	2	2	0	11	0.69
Papilio blumei	Peacock or green swallowtail	3	1	0	3	7	0.44
Papilio polytes	Common mormon	0	2	2	0	4	0.25
Papilio jordani	Jordan's Swallowtail	3	0	0	0	3	0.19
Chilasa veiovis	-	0	0	0	1	1	0.06
Papilio demoleus	Lime butterfly	0	0	0	1	1	0.06
Pieridae							
Catopsilia scylla	Orange Emigrant	47	25	143	84	299	18.76
Appias zarinda	Eastern orange albatross	15	10	12	4	41	2.57
Eurema tominia	Grass yellow butterfly	7	10	8	15	40	2.51
Catopsilia pomona	The Lemon Emigrant	23	0	11	4	38	2.38
Hebomoia glaucippe	Great orange-tip	8	15	6	8	37	2.32
Appias hombroni	Puffin And Albatross Butterflies	1	0	0	0	1	0.06

Hesperiidae							
Potanthus omaha	The lesser dart	0	13	19	9	41	2.57
Potanthus fettingini	Darts butterfly	0	11	0	0	11	0.69
Borbo cinnara	The rice swift	0	6	1	0	7	0.44
Potanthus confucius	Chinese dart	0	0	0	7	7	0.44
Pelopidas mathias	Dark small-branded swift	0	0	2	0	2	0.13
Notocrypta paralysos	Common banded demon	0	1	0	0	1	0.06
Tagiades trebellius	Snow flats butterfly	0	1	0	0	1	0.06
Lycaenidae							
Pithecops phoenix	-	12	1	0	1	14	0.88
Psychonotis piepersii	-	0	3	8	2	13	0.82
Rapala manea	Slate flash	0	2	0	0	2	0.13
Jamides pura	White Cerulean	0	0	1	0	1	0.06
Grand Total		434	458	417	285	1,594	100.00

Note*: WF: waterfall; FE: forest edge; AL: agricultural land; SH: shrub

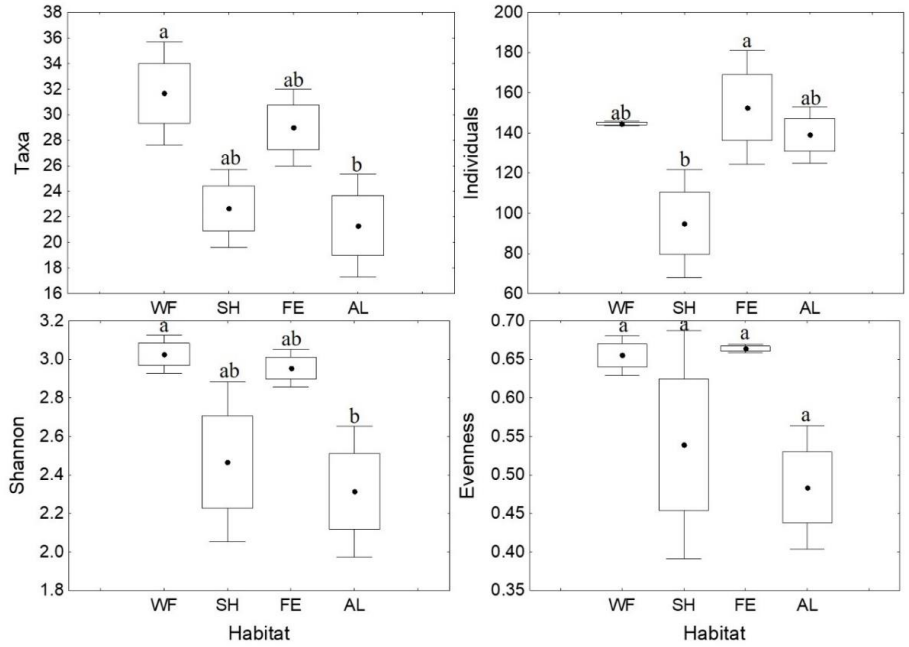

Figure 6. Comparison of mean ± SE of taxa, abundance, the diversity index (Shannon), and evenness species index. (WF: waterfall; SH: shrub; FE: forest edge; AL: agricultural land, ●: Mean, □: ±SE, : ±SD. The same letter in the same plot did not differ significantly according to Tukey's test at a 95% confidence level)

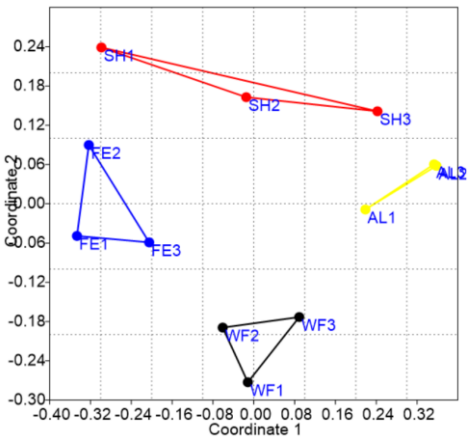

Figure 7. Non-metric dimensional scaling (NMDS) of butterfly community composition in the four types of habitat (stress value: 0.1316) (WF: waterfall; SH: shrub; FE: forest edge; AL: agricultural land)

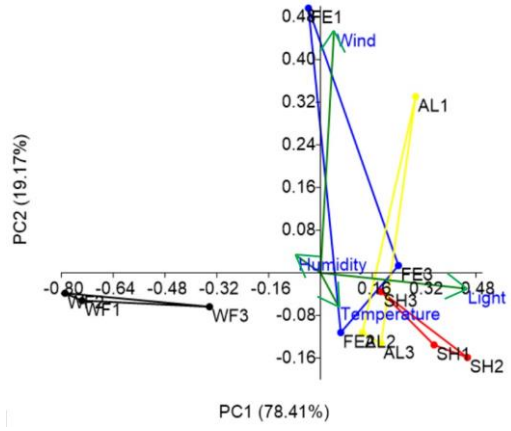

Figure 8. PCA of the relationship between habitat type and environmental factors (WF: waterfall; SH: shrub; FE: forest edge; AL: agricultural land)

Table 2. Environmental in four types of habitat around Bogani Nani Wartabone National Park, Indonesia

Environmental factor	Waterfall		Forest Edge		Shrub		Agricultural land	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Humidity relative (%)	86.67*	2.01	81.13	1.60	72.83	2.09	74.83	3.24
Air temperature (°C)	27.77*	0.68	29.18	0.79	31.90	0.49	30.77	0.46
Wind velocity (m/s)	0.00	0.00	0.32	0.26	0.03	0.03	0.20	0.20
Light intensity (lux)	6823.50*	856.69	13395.00	781.44	16984.00	889.57	14790.33	1383.64

Note: *showed significantly different (< 0.05) between habitats

Discussion

The butterflies found in Bogani Nani Wartabone National Park, Toraut Village, are 0.31% of the 20,000 species in the world (Subedi et al. 2021), 2.80% in Indonesia (Peggie 2014) and 10.05% of the 557 species scattered on Sulawesi Island (Vane-Wright and de Jong 2003). The butterfly species found during the study are higher than the diversity research in Tegheria (Waterfall), India (Medhi et al. 2018); Taka Melor Amenity Forest, Labis Forest Reserve, Segamat, Johor, Malaysia (Aqilah et al. 2019); Barra Honda National Park (Vásquez et al. 2021), and Kawa-Kawa Hill Natural Park, Ligao City, Southern Luzon, Philippines (Mape and Concepcion 2020), consisting of 65, 61, 68 and 50, respectively. Moreover, several researchers found more species, such as Kurnianto et al. (2016), which found 106 species in Coban Rais waterfall, and Zhushi-Etemi et al. (2018) reported 83 species in the Mirusha Waterfall in Kosovo.

The difference in the number of species found was due to the variation in sampling methods (Vásquez et al. 2021), location, and period. Furthermore, differences in environmental disturbances significantly affected the number of butterflies species found (Rosin et al. 2012).

The Nymphalidae family is dominantly found in all habitat types in the ecotourism route because it has the largest number of species and is polyphagous. It has varied coloration, including brown, orange, yellow, and black, with different sizes ranging from small to large. It is found in large numbers at the research site because plants provide food and shelter for life. According to Bora et al. (2014), it is the most dominant group of butterflies among all families in the tropics. Research also reported that Nymphalidae has the highest family composition (Kemabonta et al. 2015; Ojianwuna 2015; Efenakpo et al. 2021).

Due to its ability to adapt to environmental conditions, the dominance has the largest members compared to other families and tends to be polyphagous. The polyphagous nature allows it to meet the needs of host plants even though it is unavailable. The host plants are Fabaceae, Annonaceae, Asteraceae, Verbenaceae, Moraceae, Rubiaceae, Malvaceae, and Anacardiaceae. For example, the presence of the Nymphalidae butterflies does not depend on the availability of flower nectar. Still, it can obtain a source of food from rotting fruit and urine from other animals (Sarma et al. 2012).

The family with the least number of species is the Lycaenidae, with dark brown color and wing shape. It hides under the leaves and flies slowly around the bushes and grasses. According to Sutra et al. (2012), Lycaenidae prefers to hide under the leaves, making it difficult to find.

The dominant species is *Catopsilia scylla*, which belongs to the Pieridae family. During observation, this species flies low very quickly without rest and is dominantly found on agricultural land. The host and food plants are abundantly available; therefore, the number of individuals increases with the frequency. The difference in abundance can be caused by the lack of host plants as a food source. Therefore, the success of colonization depends on the appropriate habitat, which is the availability of food sources (Vane-Wright and de Jong 2003). *Catopsilia scylla* is polyphagous with abundant food sources, host plants, and places to lay eggs. According to Lamatoa et al. (2013) and Rusman et al. (2016), the host plants and food sources of *Catopsilia scylla* are Amarilidaceae, Asteraceae, Caesalpiniaceae (*Caesalpinia pulcherrima* and *Cassia obtusifolia*), Fabaceae (*Cassia tora, Bauhinia purpurea*), Papilionaceae (*Pterocarpus indicus, Sesbania grandiflora*), and Verbenaceae (*Lantana camara*).

One protected butterfly species was found in this study, namely *Cethosia myrina* of violet lacewing. This species is included in Government Regulation of the Republic of Indonesia Number 7 of 1999 concerning the law on preserving plant and animal species. *Cethosia myrina* belongs to the Nymphalidae family (Vane-Wright 2012), mostly found in forest edges from the Asteraceae, Verbenaceae, and Fabaceae.

Waterfall and forest edges have the highest abundance, number of species, and diversity index compared to others. The forest edges are a mixture of tree and cultivated plants and a habitat that utilizes land by combining forestry and agricultural activities. In addition to plantation crops, there are trees in this environment, making the vegetation more complex than agricultural land and shrub. At the forest edges and waterfall path, there is much vegetation from the Asteraceae, Fabaceae, Mimosaceae, Malvaceae, and Euphorbiaceae as food sources for butterflies. Habitat variation and heterogeneity affect the presence and diversity of butterflies. These habitats can potentially support life for butterflies as food sources and shelters (Brown and Crone 2016; Rembold et al. 2017).

The existence of butterflies is closely related to the host plants, which are used by imago to lay eggs and as food for larvae. Therefore, the vegetation complexity greatly affects the species diversity (Nidup et al. 2014). The structural complexity is correlated with species diversity, and butterflies are more affected by the food quality. Host plants are utilized only when sufficient nectar is available

(Ramesh et al. 2012; Alarape et al. 2015). In the tropics, the number of species is highest at the forest edges (Vu et al. 2015). The diversity may be higher in a waterfall with a forest than in a closed canopy, usually dominated by generalist butterflies (Martínez-Sánchez et al. 2020) or common species (Vu and Vu 2011). Tree canopy greatly affects species diversity because it is associated with shelter and foraging. It was reported that butterflies are more commonly found in semi-enclosed or closed areas and natural habitats (Vu and Vu 2011).

The forest edges and waterfall have the highest evenness index compared to other habitats. However, no species dominates the forest edges and waterfall. The high evenness index in an area indicates that the habitat is more stable than those with a low value (Rahayuningsih et al. 2012), such as agricultural land. Several species dominate in the number of individuals per species. The result showed that *Catopsilia scylla*, *Junonia atlites*, and *Melanitis leda* dominate the agricultural land habitat.

The composition of butterflies between the three habitats showed differences. However, the NMDS ordinance results showed that the points are far from each other and do not overlap. Differences in composition are closely related to variations in biotic and abiotic factors. Biotic factors are strongly affected by plant species that make up vegetation, while abiotic factors include temperature, humidity, wind speed, and light intensity. According to Panjaitan et al. (2020), the cause of differences in butterfly composition between habitats is due to land use systems.

Temperature affects butterfly activity, distribution, growth, and reproduction. PCA showed that the waterfall habitat is characterized by high relative humidity, low air temperature, and low light intensity. Meanwhile, agricultural land and shrubs are characterized by high air temperature, high light intensity, and low humidity. The ordinance plot showed that the waterfall is separated from the other three. Butterflies prefer habitats with moderate temperatures, such as waterfalls and forest edges, to agricultural land and shrubs. They are poikilothermic organisms, and the environment affects body temperature (Ramesh et al. 2012). High air temperatures decrease the volume of nectar secretion in flowers. Therefore, butterflies will reduce their activity or move to warmer forest areas to conserve energy. According to Alarape et al. (2015), temperature affects oviposition, mating behavior, and larval development. The humidity of the air in the habitat strongly influences the existence of butterflies (Gupta et al. 2019). The humidity in the environment ranges from 60-75% to perform optimally (Nuraini et al. 2020). As Febrita et al. (2014) explain, humidity is inversely influenced by temperature.

Based on the study results, it was concluded that this research found 5 butterfly families of 71 species and 1,594 individuals. The frequently found family and species are Nymphalidae and *Catopsilia scylla*. In abundance, the highest number and index of species are found in forest edges and waterfalls. One species that we survey is included in the list of protected animal species through Government Regulation of the Republic of Indonesia Number 7 of 1999, namely *Cethosia myrina*. PCA showed that a waterfall is characterized by high relative humidity, low air temperature, and low light intensity. The ordination plot indicated that the habitat is separated from others, with different environmental factors. Waterfall and forest edges have the highest diversity of butterflies due to complex vegetation structures and environmental factors supporting their survival.

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