Diversity and composition of butterflies in three habitats around Rayow Waterfall, Minahasa District, North Sulawesi, Indonesia

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[2]Department of Animal Production, Faculty of Animal Science, Universitas Sam Ratulangi. Jl. Bahu- Malalayang, Manado 95115, North Sulawesi, Indonesia
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Abstract. *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: 1091-1098.* Butterflies play an important role in ecosystems as pollinating agents, and their beautiful colors have a high potential for ecotourism activities. This study aims to analyze the diversity and composition of butterflies on three habitats around Rayow Waterfall, Minahasa District, North Sulawesi, Indonesia, which might be developed as ecotourism paths for butterfly-watching. Butterfly sampling using the sweeping technique was conducted on ecotourism paths in three habitat types: residential, agroforestry, and waterfall. Each ecotourism path consisted of three transect lines with a length of each transect of 300 m. The results showed 5 families of butterflies consisting of 56 species and 943 individuals. The most common family and species found were Nymphalidae and *Eurema tominia* (Snellen van Vollenhoven, 1865), and the highest abundance, number, and diversity index were found in agroforestry habitat. Meanwhile, the composition of butterflies differed significantly across the three habitats. Waterfall habitat was characterized by high relative humidity and low air temperature, while the high air temperature characterized residential habitat. The highest diversity of butterflies was found in the agroforestry habitat, and this was because of the complex vegetation structure that supported the survival of butterflies. The result of this study can serve as baseline information for the development of butterfly-based tourism programs in the Rayow Waterfall.

Keywords: Agroforestry, butterflies, ecotourism, *Eurema tominia*, North Sulawesi

INTRODUCTION

In terms of species richness, butterflies are among the most species fauna groups in the world. Along with moths, butterflies belong to Lepidoptera, the second-largest order after Coleoptera (Suhaimi et al. 2018). So far, the number of described butterfly species in the world is 18,000 (Dantas et al. 2021), with about 90% found in the tropics (Suwarno et al. 2018), making the tropical region an important area for butterflies conservation. For example, a total of 1,038 species were reported in Peninsular Malaysia (Eliot and Kirton 2000) and 944 in Borneo (Otsuka 2001), much larger than that in temperate regions where there are about 292 and 482 butterfly species are identified in Canada and Europe (Ismail et al. 2018). In Indonesia, a total of 2,000 species had been reported (Peggie 2014), in which 557 species were found on Sulawesi Island (Vane-Wright and de Jong 2003).

Butterflies play an important role in delivering ecosystem services. Most importantly, it serves as essential pollinators after bees (Thangjam et al. 2018). In addition, they depend heavily on nectar and flower pollen for food, while the larval stage depends on certain host plants to eat leaves (Nimbalkar et al. 2011). The wings of adult butterflies have an aesthetic value with various beautiful shapes and colors (Nimbalkar et al. 2011; Medhi et al. 2018). They also have various flight and perch behaviors that can be used as a particular attraction in ecotourism areas (Ismail et al. 2018).

Rayow Waterfall in Kembes 2 Village, Minahasa District, North Sulawesi Province, Indonesia, is a tourist attraction developed into an ecotourism destination. The main attraction in this tourist spot is a waterfall with a height of 30 m. While the beauty of the natural landscape of the waterfall has been largely acknowledged, several other tourism resources have the potential to be developed to complement the waterfall, including the high diversity of flora and fauna. Among fauna diversity, butterflies might emerge as an alternative to tourist attractions. Butterflies have a tourist attraction due to the beautiful color and shape of their wings as well as different flying patterns (Kurnianto et al. 2016).

Previously, studies on butterflies around waterfalls and their relationship with ecotourism have been reported across the world. These include the diversity of butterflies in the waterfalls sector in the Barra Honda National Park, Nicoya, Guanacaste, Costa Rica (Vásquez et al. 2021), distribution of butterfly species in the protected area of Mirusha Waterfalls in Kosovo (Zhushi-Etemi et al. 2018), butterflies diversity in Endau-Rompin Johor National Park, Malaysia and prioritizing the potential groups for nature tourism product (Ismail et al. 2018), and assessment on butterfly and its diversity in Tegheria Waterfall, Assam District, India (Medhi et al. 2018).

Similarly, several studies on butterfly diversity in waterfall areas have also been conducted in Indonesia. These include the potential of butterflies in tourism diversification products: Case study at Coban Rais Waterfall, Batu, East Java (Kurnianto et al. 2016), butterflies in the Rampah Menjangan Waterfall Area, South Hulu District (Noor et al. 2016), diversity and abundance of butterflies in the tourist area of Irenggolo Kediri Waterfall (Sulistiyowati and Rahmawati 2018), butterfly inventory (Lepidoptera: Rhopalocera) in two waterfall areas of Padang City (Pratiwi and Dahelmi 2019) and butterflies (Lepidoptera) from Bukit Gatan Waterfall, District of Musi Rawas, South Sumatra Province (Lestari et al. 2020).

Until now, very limited studies of a similar topic in the context of Sulawesi Island despite the high number of butterflies diversity in this region. Moreover, such a study is absent in the Rayow Waterfall, Minahasa District, Indonesia, which has the potential as an ecotourism area. Therefore, this study aims to analyze the diversity and composition of butterflies in three habitats around the Rayow Waterfall area, Minahasa District, North Sulawesi, Indonesia. We expect the result of this study to serve as baseline information for the development of butterfly-based tourism programs in the Rayow waterfall and enrich the biodiversity information of butterflies in Sulawesi in a broader context.

MATERIALS AND METHODS

Study area and period

This study was conducted on several ecotourism paths around the Rayow Waterfall in Kembes 2 Village, Minahasa District, North Sulawesi, Indonesia (Figure 1), from May to August 2021. Butterfly sampling was carried out on three paths, with each path consisting of three transects with a length of 300 m for each transect (Figure 2).

The first path passed through the village, where the left and right sides of the residential area had yards and gardens (Figure 2A). The vegetation along this path included *Hibiscus rosa-sinensis* (Malvaceae), *Allamanda cathartica* (Apocynaceae), *Pachystachys lutea* (Acanthaceae), *Aphelandra squarrosa* (Acanthaceae), *Impatiens balsamina* (Balsaminaceae), *Zinnia violacea* (Asteraceae) and *Musa* sp. (Musaceae). There were tree transects established in this path: Transect 1 (01°23'45.32"N, 124°52'59.35"E), Transect 2 (01°23'38.15"N, 124°52'49.87"E), Transect 3 (01°23'26.88"N, 124°52'51.03"E). This path has an altitude of 401-556 meters above sea level (masl) with an average temperature of 30.37±0.36ºC, a humidity of 73±0.03%, a light intensity of 11240.83±1499.66 Lx and wind velocity of 0.78 ±0.33 m/s.

The second path was located in agroforestry within the community's plantation mixed with secondary forest (Figure 2B). This habitat was composed of vegetation such as *Piper aduncum* (Piperaceae), *Chromolaena odorata* (Asteraceae), *Eupatorium inulifolium* (Asteraceae), *Mimosa pudica* (Mimosaceae), *Urena lobata* (Malvaceae), *Euphorbia heterophylla* (Euphorbiaceae), *Myristica fragrans* (Myristicaceae), *Syzygium aromaticum* (Myrtaceae), *Michelia champaca* (Magnoliaceae), Musa sp. (Musaceae) and *Ficus* sp. (Moraceae). It consisted of three transects: Transect 1 (01°23'12.53"N, 124°52'41.57"E), Transect 2 (01°23'09.57"N, 124°52'33.29"E) and Transect 3 (01°23'11.94"N, 124°52'33.94"). This path has an altitude of 519-638 masl with an average temperature of 30.66±0.53ºC, a humidity of 72±0.02%, a light intensity of 21927.42±14417.25 Lx and wind velocity of 1.20±0.54 m/s.
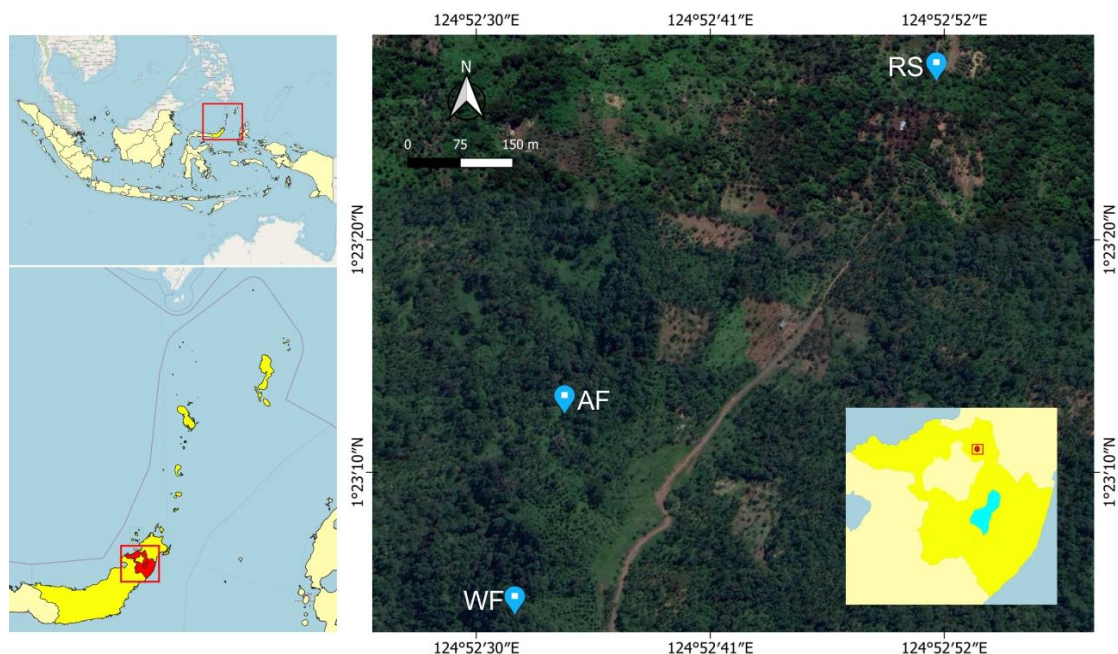

Figure 1. Map of the study area in Rayow Waterfall, Minahasa, North Sulawesi, Indonesia. Note: RS: Residential; AF: Agroforestry; WF Waterfall.

Figure 2. Study sites in Rayow Waterfall, Minahasa, North Sulawesi, Indonesia: A: Residential, B: Agroforestry, C: Waterfall

The third path was located around the waterfall with forest vegetation along the path (Figure 2C). Species from the families of Moraceae (*Ficus* spp.) and Anacardiaceae were dominant in this habitat with species from Euphorbiaceae family were also found. There were three transects in this path: Transect 1 (01°23'02.97"N, 124°52'31.81"E), Transect 2 (01°23'10.89"N, 124°52'29.87"E) and Transect 3 (01°23'14.05"N, 124°52'33.14"). This path has an elevation of 531-615 masl with an average temperature of 28.51±0.28ºC, a humidity of 80±0.02%, light intensity 3642.60±1301.94 Lx, and wind velocity of 0.0±0.00 m/s (Figure 2).

Data collection procedure

The butterfly sampling was conducted by surveying the existing transect line using the scanning method. During this process, the width of 10 m to the left and right along the transect line was considered (Pollard 1977; Martin and Bateson 1993). The samplings were conducted monthly for 4 months from 8:00 am to 3:00 pm. Butterfly observations included the identification of species and counting number of species and individuals. The unidentified butterflies were caught with a sweep net and placed on papilot paper for identification purposes in the laboratory. The identification was based on morphological characters in the butterfly identification books authored by Van-Wright and de Jong (2003), Peggie and Amir (2006), Peggie (2011;2014), and Butterflies of the Southeast 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; 1985; 1991; Tsukada 1982).

The environmental variables recorded included air temperature measured using thermometer, air humidity measured using a hygrometer, wind speed using an anemometer, light intensity using a Lux meter, as well as altitude from sea level and coordinates using the Global Positional System (GPS).

Data analysis

The abundance and richness of butterfly species were tabulated for each habitat on the ecotourism paths using Microsoft Excel. Community structure attributes, such as species abundance, species richness, Shannon-Wiener diversity index (H'=-Σpi ln pi), and Pielou evenness index (J=H'/lnS), were calculated on each habitat (Bashir et al.

2019). Furthermore, one-way ANOVA statistical analysis and Tukey's test at 95% confidence level were used to test the significant differences in the attributes using Statistica software version 6 (Ajerrar et al. 2020).

The statistical test used to assess the differences in the composition of butterflies in each habitat was an analysis of similarity (ANOSIM). Subsequently, the differences in the composition of the community between habitat types on the ecotourism paths were visualized using non-metric dimensional scaling (NMDS). Then, ANOSIM and NMDS were analyzed based on the Bray-Curtis dissimilarity index. Furthermore, principal component analysis (PCA) between environmental factors (independent variable) and sampling location (dependent variable) was performed to determine the relationship. Paleontological Statistics software (PAST software 3.10) was used to analyze ANOSIM, NMDS, and PCA (Cuartas-Hernández and Gómez-Murillo 2015; Wakhid et al. 2021).

RESULTS AND DISCUSSION

Butterfly community structure

The study of butterflies on the Rayow Waterfall ecotourism paths found 5 families of 56 species and 943 individuals butterflies (Table 1). The families consisted of Nymphalidae, Papilionidae, Lycaenidae, Pieridae, and Hesperidae. The most common family was Nymphalidae with 29 species and 416 individuals (44.64%), followed by Papilionidae with 14 species and 205 individuals (21.74%).

The butterfly family composition showed that Nymphalidae had the highest abundance in all observed habitats (40.4-50.4%), followed by Papilionidae (18.9-29.1%). Meanwhile, Hesperidae was the smallest family with only 2 species and 18 individuals (1.91%) (Figure 3). This family was not in the waterfall habitat but residential and agroforestry habitats (Table 1). The dominant species was *Eurema tominia* (Snellen van Vollenhoven, 1865) (11.24%), followed by *Parthenos sylvia salentia* (11.03%). Meanwhile, *Hypolimnas anomala* (Wallace, 1869), *Cethosia myrina* (Felder & Felder, 1865), *Chersonesia rahria celebensis* (Rothschild, 1892), *Hypolimnas misippus* (Linnaeus, 1764), *Moduza lymire* (Hewitson, 1859), *Pareronia tritaea* (Felder & Felder, 1859), and *Papilio jordani* (Fruhstorfer, 1902) were the least abundant species (0.11%) (Table 1).

Table 1. Number of family, species, and individuals of butterflies in three habitat types around Rayow Waterfall, Minahasa, North Sulawesi, Indonesia

Family/species	Number of individuals on each habitat type			Σ	%
	RS	AF	WF		
Nymphalidae					
Parthenos sylvia salentia	32	42	30	104	11.03
Ideopsis vitrea	12	29	14	55	5.83
Junonia hedonia intermedia	12	23	20	55	5.83
Neptis ida celebensis	11	19	0	30	3.18
Idea blanchardii	1	4	17	22	2.33
Ypthima nynias	8	13	0	21	2.23
Danaus genutia leucoglene	5	10	0	15	1.59
Danaus ismare alba	7	8	0	15	1.59
Ideopsis juventa	1	8	4	13	1.38
Orsotriaena jopas	5	0	7	12	1.27
Hypolimnas bolina	5	6	0	11	1.17
Lasippa neriphus tawayana	2	5	2	9	0.95
Mycalesis janardana	5	2	0	7	0.74
Cyrestis strigata	0	0	6	6	0.64
Euploea algea	4	0	2	6	0.64
Parantica menadensis	5	1	0	6	0.64
Vindula dejone celebensis	0	6	0	6	0.64
Cyrestis thyonneus celebensis	0	1	4	5	0.53
Euploea westwoodii	2	0	2	4	0.42
Melanitis leda	3	1	0	4	0.42
Euploea phaenareta celebica	0	2	1	3	0.32
Symbrenthia hippalus	0	0	3	3	0.32
Faunis menado	0	2	0	2	0.21
Hypolimnas anomala	0	0	2	2	0.21
Cethosia myrina	1	0	0	1	0.11
Chersonesia rahria celebensis	0	0	1	1	0.11
Hypolimnas misippus	1	0	0	1	0.11
Moduza lymire	0	1	0	1	0.11
Pareronia tritaea	0	0	1	1	0.11
Papilionidae					
Papilio gigon	19	17	13	49	5.20
Papilio ascalaphus	18	9	12	39	4.14
Graphium meyeri	9	16	4	29	3.08
Graphium agamemnon	11	4	2	17	1.80
Papilio sataspes	1	1	15	17	1.80
Troides helena	1	11	2	14	1.48
Papilio blumei	0	3	7	10	1.06
Papilio polytes	1	4	4	9	0.95
Graphium milon	0	3	3	6	0.64
Pachliopta polyphontes	0	5	0	5	0.53
Troides hypolitus	0	3	1	4	0.42
Lamproptera meges ennius	0	0	3	3	0.32
Graphium eurypylus	0	2	0	2	0.21
Papilio jordani	0	0	1	1	0.11
Pieridae					
Eurema tominia	44	32	30	106	11.24
Hebomia glaucippe	4	11	2	17	1.80
Catopsilia pomona	8	3	2	13	1.38
Appias zarinda	1	2	2	5	0.53
Appias hombroni	0	0	2	2	0.21
Catopsilia scylla	0	2	0	2	0.21
Hesperiidae					
Potanthus omaha	6	10	0	16	1.70
Potanthus fettingi	0	2	0	2	0.21
Lycaenidae					
Lampides boeticus	7	42	3	52	5.51
Leptotes plinius	29	16	0	45	4.77
Pithecops phoenix	0	26	6	32	3.39
Jamides celeno	19	4	0	23	2.44
Jamides schatzi	0	2	0	2	0.21
Grand Total	**300**	**413**	**230**	**943**	**100.00**

Note: RS: Residential, AF: Agroforestry, WF: Waterfall
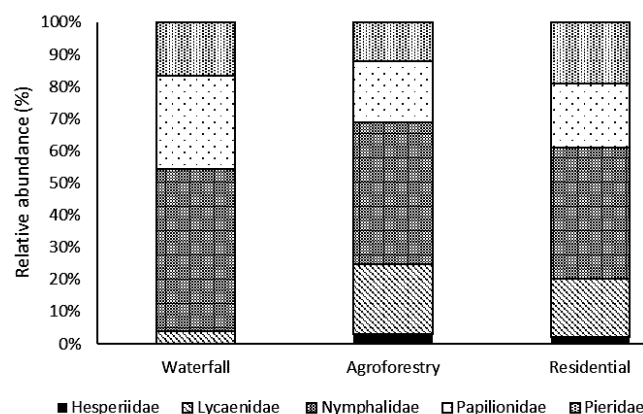
Figure 3. Proportion of butterflies in three types of habitat around Rayow Waterfall, Minahasa, North Sulawesi, Indonesia

The distribution of butterfly species across three habitat types was found to be different. A total of 18 species were found in all three habitat types while 20 and 18 species were found on two and one habitat type, respectively. Furthermore, two butterfly species (i.e., *H. misippus* and *C. myrina*) were only found in the residential habitat while 8 species were found in agroforestry and waterfall habitats (Table 1).

Butterfly species diversity

Analysis of butterfly species diversity across three habitat types showed that the highest average abundance was in agroforestry (137.67 individuals), followed by residential (100 individuals) and waterfall (76.67 individuals) (Figure 4). The highest and lowest species richness and diversity indices were in agroforestry (28 species and 2.89) and waterfall (22 species and 2.75), respectively. There was no dominance of butterfly species based on the Pielou Index that showed a value > 0.6 in the three habitats.

The analysis also showed that the average abundance of individuals differed between the three habitats (ANOVA: F2, 8= 12.52; P= 0.007). Meanwhile, there was no significant difference between average species richness (ANOVA: F2, 8= 2330; P= 0.178), the Shannon diversity index (ANOVA: F2, 8= 1.613; P= 0.275), and Pielou evenness index (ANOVA: F2.8= 0.689; P= 0.538) in the three habitats (Figure 4).

Butterfly composition

The ANOSIM showed that the composition of butterflies in the three habitats was significantly different (R= 0.5802; P= <0.01). The difference in composition between the three habitats was also seen in the NMDS ordinance results that showed the points were far from each other and did not overlap (Figure 5).

Table 2. Environmental in three types of habitat around Rayow Waterfall, Minahasa, North Sulawesi, Indonesia

Environmental factor	Waterfall		Agroforestry		Residential	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**
Air temperature (ºC)	28.51*	0.28	30.66	0.53	30.37	0.60
Humidity (%)	0.80*	0.02	0.72	0.02	0.73	0.03
Wind speed (m/s)	0.00*	0.00	1.20	0.54	0.78	0.33
Light intensity (Lx)	3642.60	1301.94	21927.42	14417.25	11240.83	1499.66

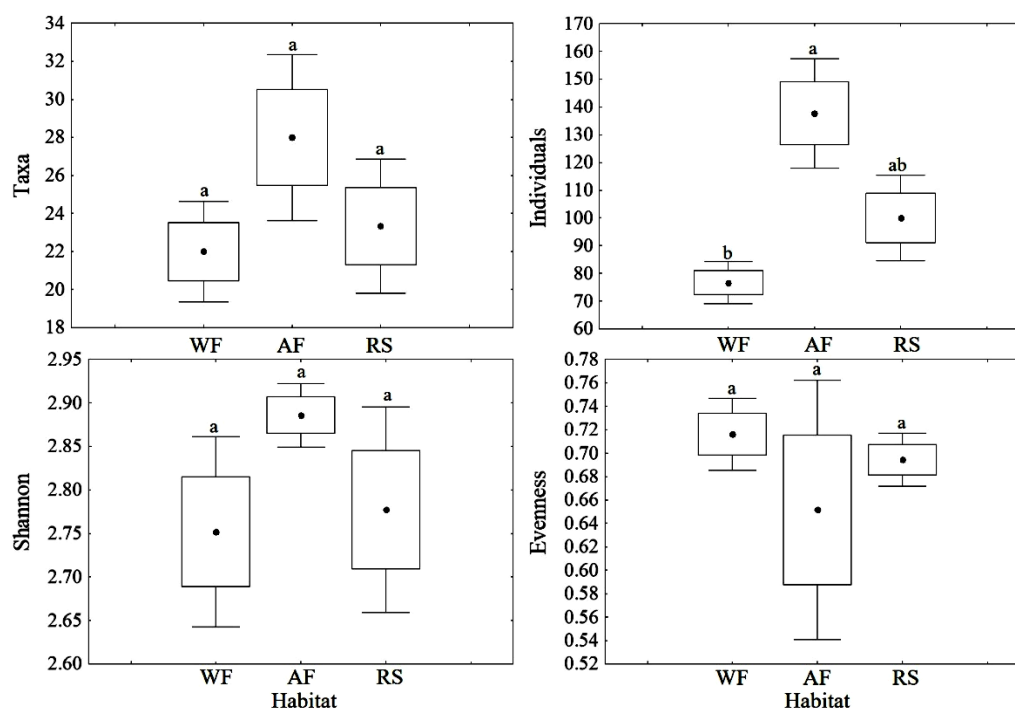Note: * showed significantly different (< 0.05) between habitats

Figure 4. Comparison of mean ± SE of taxa, abundance, diversity index (Shannon), and evenness species index. (WF: Waterfall; AF: Agroforestry, RS: Residential, ●: Mean, □: ±SE, ⊥: ±SD. The same letter in the same plot did not differ significantly according to Tukey's test at 95% confidence level)
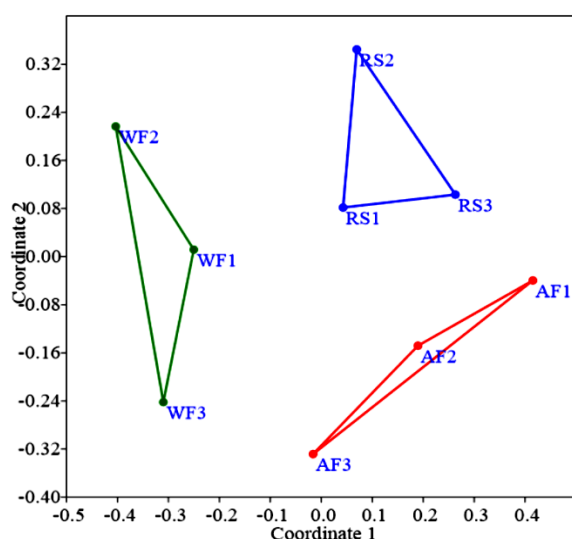

Figure 5. Non-metric dimensional scaling (NMDS) of butterfly community composition in the three types of habitat types (Stress value: 0.24). WF: Waterfall; AF: Agroforestry, RS: Residential

Environmental factor

The ANOVA results of air temperature (ANOVA: $F_{3, 8}$= 10.01; P= 0.012), humidity (ANOVA: $F_{3, 8}$= 34.59; P= 0.001), and wind speed (ANOVA: $F_{3, 8}$= 15.82; P= 0.004) were significantly different between the three habitats but the light intensity was not significantly different (ANOVA: $F_{3, 8}$= 1.40; P= 0.317) (Table 2).

PCA analysis showed that the first axis explained 72.86% of the total variety of butterfly species composition, while the second axis explained 19.83% (Figure 3). In addition, the results showed that the waterfall habitat was characterized by high relative humidity and low air temperature, while the high air temperature was characterized residentially.

Discussion

Butterflies species around the Rayow Waterfall ecotourism paths only reached 0.31% of the 18,000 in the world (Dantas et al. 2021), 2.80% of the approximately 2,000 species in Indonesia (Peggie 2014), and 10.5% of the 557 species recorded on Sulawesi Island (Vane-Wright and de

Jong 2003). Nonetheless, the number of species found in this study (56) was higher than that in the Kediri Irenggolo Waterfall with 35 species (Sulistiyowati and Rahmawati 2018), the Padang City Waterfall with 51 species (Pratiwi and Dahelmi 2019), and the Bukit Gatan Waterfall, South Sumatra with 21 species (Lestari et al. 2020). Yet, several other studies found more species, such as Kurnianto et al. (2016) with 106 species in Coban Rais Waterfall, Vásquez et al. (2021) with 68 species in the waterfalls sector in the Barra Honda National Park, Zhushi-Etemi et al. (2018) with 83 species in Mirusha Waterfalls in Kosovo, and Medhi et al. (2018) with 65 species in Tegheria Waterfall (India).

The difference in the number of species was due to the sampling methods. This study only used the catching technique using insect nets while other studies used this sampling method with bait traps (Vásquez et al. 2021). In addition, the difference is likely due to the variation in location and period (season). The possibility of differences in the number of butterfly species may also be affected. Furthermore, differences in environmental disturbances significantly affect the number of butterfly species in a habitat (Basri and Zakaria 2021).

The Nymphalidae family was dominantly found in all three habitat types in the ecotourism paths because this family has the largest number of species, polyphagous, and is widely distributed compared to others. These butterflies have varied colors such as brown, orange, yellow, and black and sizes ranging from small to large. Furthermore, there is an increased number of Nymphalidae because the study site contains plants that support lives as a source of food and shelter. According to Bora and Meitei (2014), Nymphalidae is the most dominant group of butterflies among all families in the tropics. This result is consistent with Kemabonta et al. (2015), Ojianwuna (2015), and Efenakpo et al. (2021), where Nymphalidae has the highest family composition. The dominance is found in the conditions of its environmental adaptability. This is because it has the largest members compared to other families and tends to be polyphagous. The polyphagous nature fulfills the needs of the host plants even though the main host plant is unavailable. The host plants are Fabace, Annonaceae, Asteraceae, Verbenaceae, Moraceae, Rubiaceae, Malvaceae, and Anacardiaceae. Nymphalidae depends not only on the availability of flower nectar since food sources and urine can be obtained from rotting fruits and other animals, respectively (Sarma et al. 2012; Sari et al. 2013; Widhiono 2015). The least family was Hesperidae, which has dark brown wings. Sutra et al. (2012) stated that the Hesperidae is difficult to find because it hides under leaves.

The dominant species in the study area was *E. tominia*. At the time of observation, the species was found close to the ground in open areas and was occasionally found in high trees. Meanwhile, adult *E. tominia* is frequently perched on the underside of the leaves. Dominant species are found because their host plants and forage are abundantly available. Therefore, the number of individuals and imagos tend to be higher in number and the frequency of their encounters becomes higher. According to Sreekumar and Balakrishnani (2001), *Eurema* dominates in different habitats because these species are polyphagous. The polyphagous nature causes these species to thrive in several types of habitats. The forage plants of *Eurema* are Caesalpiniaceae, Fabaceae, Euphorbiaceae, Asteraceae, and Mimosaceae (Braby 2000; Peggy and Amir 2006). During observations, *E. tominia* often perched on flowering plants of *M. pudica* and *Ageratum conyzoides*. Meanwhile, Vane-Wright and de Jong (2003) stated that *M. pudica* is a feed for *E. tominia*.
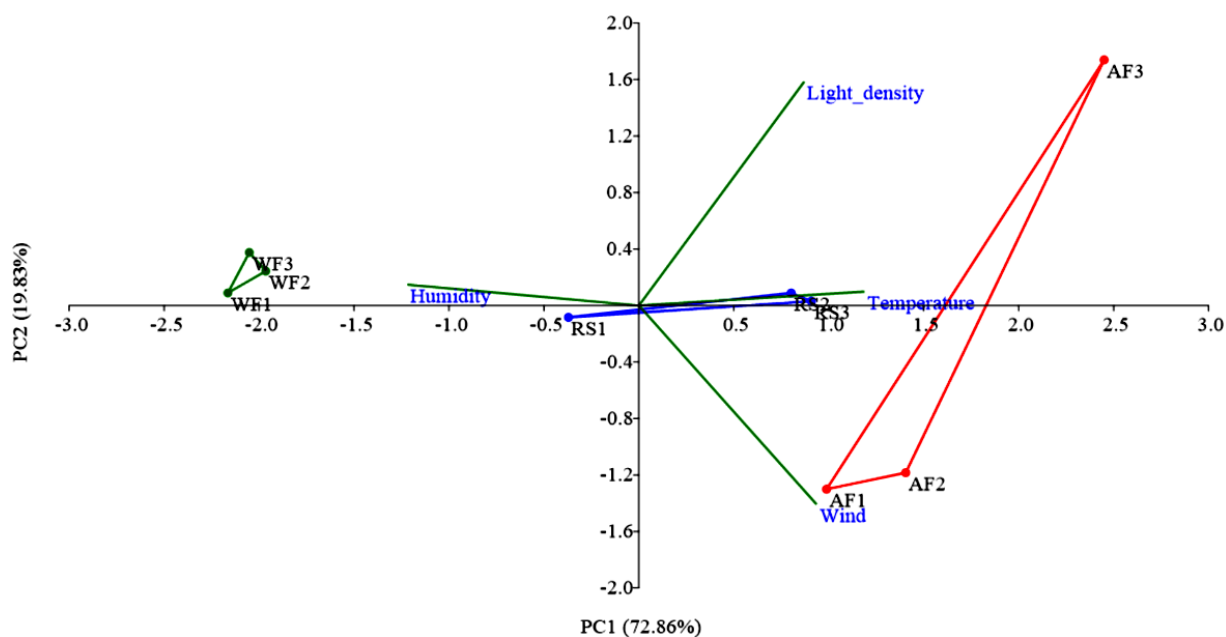

Figure 6. PCA of the relationship between ecotourism sampling path habitat type and environmental factors. WF: Waterfall; AF: Agroforestry, RS: Residential

Ecotourism path in agroforestry habitat had the highest species abundance, number, and diversity index compared to other habitat types. Agroforestry utilizes land by combining forestry and agricultural activities. Plantation and vegetation plants, as well as trees found in this habitat, are more complex than residential and waterfall habitats. In agroforestry, vegetation from the Asteraceae, Fabaceae, Mimosaceae, Malvaceae, and Euphorbiaceae families serves as food for butterflies. Habitat variation and heterogeneity can also affect the presence and level of species diversity. These habitats have the potential to support life by providing food and shelters (Rembold et al. 2017; Schultz et al. 2019).

The existence of butterflies is closely related to the presence of host plants, which are used by imago to lay eggs and as food for larvae. Therefore, the complexity of the vegetation greatly affects the diversity (Nidup et al. 2014). Several studies stated that the structural complexity of the habitat and the diversity of vegetation are correlated with the butterfly species. These species are more affected by food quality where the host plant is utilized when sufficient nectar is available (Alarape et al. 2015; Ismail et al. 2020; Han et al. 2021).

The waterfall had the highest evenness index compared to other habitat types but the difference was not significant. In a study conducted by Rahayuningsih et al. (2012), a high species evenness index in an area showed that the habitat is more stable than those with low species evenness. The lowest evenness was found in the agroforestry habitat. This shows that some butterfly species tended to dominate the community. Three species that dominated the agroforestry habitat were *P. s. salentia, Lampides boeticus* (Linnaeus, 1767), and *E. tominia*. The differences were indicated in the composition of the three habitats. Based on the NMDS results, the ordinance points were far from each other and did not overlap. Furthermore, the differences in the composition are closely related to biotic and abiotic factors of the place. Biotic factors are strongly influenced by plant species that make up vegetation, while abiotic factors include air temperature, humidity, wind speed, and light intensity (Ojianwuna 2015). According to Panjaitan et al. (2020), the cause of differences in butterfly composition includes land-use systems and food (host plants) as well as abiotic variables related to canopy openness.

Temperature affects the activity, distribution, growth, and reproduction of butterflies. The PCA results showed that the waterfall habitat was characterized by high relative humidity and low air temperature, while the high air temperature characterized the residential habitat. Therefore, the finding of our study implies that butterflies prefer habitats with moderate temperatures, such as agroforestry. According to Ramesh et al. (2012), butterflies are poikilothermic organisms and the body temperature is greatly affected by environmental temperature. Since high air temperatures decrease the volume of nectar secretion in flowers, the activities of butterflies are reduced in this area to conserve energy and reduce the evaporation of body fluids. Alarape et al. (2015) stated that temperature can affect oviposition, mating behavior, larval development, and growth of butterfly feed plants. Borror et al. (1996)

stated that the optimal humidity required to breed ranges from 84-92%. Furthermore, tree canopy can affect the diversity of species because it is associated with shelter and foraging. Therefore, some species live in habitats with thick or loose forest canopies. Several studies stated that butterflies are more commonly found in semi-enclosed or closed areas and natural habitats (Vu and Vu 2011; Koneri et al. 2019).

Based on the study results, it was concluded that the butterflies found in the study were 5 families consisting of 56 species and 943 individuals. The most common family and species were Nymphalidae and *E. tominia*, while the highest abundance, number, and diversity index were found in the agroforestry habitat. Furthermore, the composition of butterflies differed significantly between habitats, where the waterfall was characterized by high relative humidity and low air temperature, while the high air temperature characterized residentially. Ecotourism paths in agroforestry habitats had the highest diversity due to the complex vegetation structure and environmental factors that support their survival. Therefore, the ecotourism path in agroforestry habitats can be developed for butterfly-watching programs.

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REFERENCES

Ajerrar A, Akroud H, Ait Aabd N, Qessaoui R, Amarraque A, Lahmyd H, Zaafrani M, Chebli B, Mayad EH, Bouharroud R. 2020. Pollination system and effective pollinators of *Argania spinosa* (L. Skeels). J Saudi Soc Agric Sci 19 (6): 375-382. DOI: 10.1016/j.jssas.2020.04.002.

Alarape AA, Omifolaji JK, Mwansat GS. 2015. Butterfly species diversity and abundance in University of Ibadan Botanical Garden, Nigeria. Open J Ecol 5 (8): 352-360. DOI: 10.4236/oje.2015.58029.

Borror DJ, Triplehorn CA, Johnson NF. 1996. Introduction to the Study of Insects, 6th Edition. Saunders College Publishing, Ohio.

Braby MF. 2000. The Butterflies of Australia: Their Identification, Biology and Distribution. CSIRO Publishing, Collingwood. DOI: 10.1071/9780643100770.

Dantas C, Zacca T, Bravo F. 2021. Checklist of butterflies (Lepidoptera: Papilionoidea) of an urban area of Caatinga-Atlantic Forest ecotone in Bahia, Brazil. Entomo Brasilis 14: 1-11. DOI: 10.12741/ebrasilis.v14.e959.

Efenakpo OD, Zakka U, Omanoye DT. 2021. Butterfly diversity, distribution, and abundance in the University of Port Harcourt River State, Nigeria. J For Environ Sci 37 (3): 243-250.

Eliot JN, Kirton L. 2000. Revisional notes and nomenclatural changes of some Peninsular Malaysian butterflies. Malay Nat J 54 (2): 131-145.

Bashir MA, Saeed S, Sajjad A, Khan KA, Ghramh HA, Shehzad MA, Mubarak H, Mirza N, Mahpara S, Rehmani MIA, Ansari MJ. 2019. Insect pollinator diversity in four forested ecosystems of Southern Punjab, Pakistan. Saudi J Biol Sci 26 (7): 1835-1842. DOI: 10.1016/j.sjbs.2018.02.007.

Basri NIA, Zakaria N. 2021. Butterfly communities (Insecta: Lepidoptera) at two recreational areas in Sungai Petani, Kedah, Peninsular Malaysia: Diversity of butterflies in Kedah. Biodiversitas 22 (11): 5039-5046. DOI: 10.13057/biodiv/d221140.

Bora A, Meitei LR. 2014. Diversity of butterflies (Order: Lepidoptera) in

Assam University Campus and its vicinity, Cachar District, Asssam, India. J Biodiv Environ Sci 5 (3): 328-339.

Cuartas-Hernández SE, Gómez-Murillo L. 2015. Effect of biotic and abiotic factors on diversity patterns of anthophyllous insect communities in a tropical mountain forest. Neotrop Entomol 44 (3): 214-223. DOI: 10.1007/s13744-014-0265-2.

Han D, Zhang C, Wang C, She J, Sun Z, Zhao D, Bian Q, Han W, Yin L, Sun R, Wang X, Cheng, H. 2021. Differences in response of butterfly diversity and species composition in urban parks to land cover and local habitat variables. Forests 12 (2): 140. DOI: 10.3390/f12020140.

Ismail N, Mohamed M, Salleh KM, Khim PC, Tokiman L. 2018. Butterflies (Lepidoptera: Papilionoidea) diversity at Endau-Rompin Johor National Park, Malaysia and prioritising the potential groups for nature tourism product. J Wildlife Parks 33: 31-55.

Ismail N, Rahman AAA, Mohamed M, Bakar MFA, Tokiman L. 2020. Butterfly as bioindicator for development of conservation areas in Bukit Reban Kambing, Bukit Belading and Bukit Tukau, Johor, Malaysia. Biodiversitas 21 (1): 334-344. DOI: 10.13057/biodiv/d210141.

Kemabonta KA, Ebiyon AS, Olaleru F. 2015. The butterfly fauna of three varying habitats in South Western Nigeria. FUTA J Res Sci 1: 1-6.

Koneri K, Nangoy MJ, Siahaan P. 2019. The abundance and diversity of butterflies (Lepidoptera: Rhopalocera) in Talaud Islands, North Sulawesi, Indonesia. Biodiversitas 20 (11): 3275-3283. DOI: 10.13057/biodiv/d201121.

Kurnianto AS, Wafa IY, Alifianyo F, Kurniawan N. 2016. The potential of butterflies in tourism diversification product: Case study at Coban Rais waterfall, Batu, East Java. J Indones Tour Dev Stud 4 (3): 115-122. DOI: 10.21776/ub.jitode.2016.004.03.04.

Lestari A, Harmoko H, Susanti I. 2020. Butterflies (Lepidoptera) from Bukit Gatan Waterfall STL Ulu Terawas Sub-district, Musi Rawas District of South Sumatra Province. J Biotik 8 (2): 126-134. DOI: 10.22373/biotik.v8i2.7379. [Indonesian]

Martin P, Bateson P. 1993. Measuring Behavior: An Introductory Guide. Cambridge University Press, Cambridge. DOI: 10.1017/CBO9781139168342.

Medhi J, Barman J, Sharma S. 2018. Assessment on butterfly and its diversity in Tegheria (Waterfall), Dimoria development Block, Kamrup (M) district of Assam, India. J Entomol Zool Stud 6 (3): 1746-1750.

Nidup T, Dorji T, Tshering U. 2014. Taxon diversity of butterflies in different habitat types in Royal Manas National Park. Entomol Zoo Stud J 2 (6): 292-298. DOI: 301887084.

Nimbalkar RK, Chandekar SK, Khunta SP. 2011. Butterfly diversity in relation to nectar food plants from Bhor Tahsil, Pune District, Maharashtra, India. J Threat Taxa 3 (3): 1601-1609. DOI: 10.11609/JoTT.o2612.1601-9.

Noor P, Dharmono, Muchyar. 2016. Butterflies in the Rampah Menjangan Waterfall area, South Hulu District. Proceedings of National Seminar the Wetlands. Institute for Research and Community Service, Lambung Mangkurat University, Banjarmasin 1: 109-112. [Indonesian]

Ojianwuna CC. 2015. Climatic variables as factors affecting diversity and abundance of butterflies in Okomu National Park, Edo State, Nigeria. J Nat Sci Res 5 (2): 70-76.

Otsuka K. 2001. A Field Guide to the Butterflies of Borneo and South East Asia. Hornbill Books Adivision of Iwase Bookshop Sdn. Bhd, Malaysia.

Panjaitan R, Drescher J, Buchori D, Peggie D, Harahap IS, Scheu S, Hidayat P. 2020. Diversity of butterflies (Lepidoptera) across rainforest transformation systems in Jambi, Sumatra, Indonesia. Biodiversitas 21 (11): 5119-5127. DOI: 10.13057/biodiv/d211117.

Peggie D, Amir M. 2006. Practical Guide to the Butterflies of Bogor Botanic Garden. Pusat Penelitian Biologi LIPI Cibinong, Bogor.

Peggie D. 2011. Precious and Protected Indonesian Butterflies. PT. Binamitra Megawarna, Jakarta.

Peggie D. 2014. Recognizing of Butterflies. Pandu Aksara Publishing, Jakarta. [Indonesian]

Pollard E. 1977. A method for assessing changes in the abundance of butterflies. Biol Conserv 12: 115-134. DOI: 10.1016/0006-3207(77)90065-9.

Pratiwi EA, Dahelmi. 2019. Butterfly inventory (Lepidoptera: Rhopalocera) in two waterfall areas of Padang City, West Sumatra. Bioconcetta-J Biologi Pendidikan Biologi 5 (2): 85-92. [Indonesian]

Rahayuningsih M, Oqtafiana R, Priyono B. 2012. Diversity of butterfly species in the superfamily Papilionoidea at Banyuwindu Hamlet, Limbangan Village, Limbangan District, Kendal District. J MIPA 35: 11-20.

Ramesh T, Hussain KJ, Satpathy KK, Selvanayagam M. 2012. A note on annual bidirectional movement of butterflies at South-Eastern Plains of India. Res Zool 2: 1-6.

Rembold K, Mangopo H, Tjitrosoedirdjo SS, Kreft H. 2017. Plant diversity, forest dependency, and alien plant invasions in tropical agricultural landscapes. Biol Conserv 213: 234-242. DOI: 10.1016/j.biocon.2017.07.020.

Sarma K, Kumar A, Devi A, Mazumdar K, Krishna M, Mudoi P, Das N. 2012. Diversity and habitat association of butterfly species in Foothilss of Itanagar, Arunchal Paradesh, India. Zoology 1: 67-77.

Sari EFW, Soekardi H, Nukmal N, Martinus. 2013. Diversity of Nymphalidae in Tegal Island and Puhawang Kecil Island, Lampung Bay. Conference Paper: Seminar Nasional Sains & Teknologi V Lembaga Penelitian Universitas Lampung, Bandar Lampung. [Indonesian]

Schultz CB, Haddad NM, Henry EH, Crone EE. 2019. Movement and demography of at-risk butterflies: Building blocks for conservation. Ann Rev Entomol 64: 167-184. DOI: 10.1146/annurev-ento-011118-112204.

Sreekumar PG, Balakrishnan M. 2001. Habitat and altitude preferences of butterflies in Aralam Wildlife Sanctuary, Kerala. J Trop Ecol 42: 277-281.

Suhaimi S, Zakaria A, Sulaiman A, Yaakob MZM, Juhary MAA, Sulaiman N. 2018. Species diversity and abundance of butterfly (Lepidoptera: Rhopalocera) at different altitudes along the Raub Corridor to Fraser's Hill, Pahang, Malaysia. Serangga 22 (1): 123-145.

Sulistiyowati TI, Rahmawati I. 2018. Diversity and abundance of butterflies in the tourist area of Irenggolo Kediri Waterfall. Stigma 11 (2): 1-8. DOI: 10.36456/stigma.vol11.no02.a1658. [Indonesian]

Sutra NSM, Dahelmi S, Siti S. 2012. Butterflies species (Rhopalocera) in Tanjung Balai Karimun, Kabupaten Karimun District, Riau Islands. J Biologi Universitas Andalas 1: 35-44.

Suwarno, Hanum I, Yasmin Y, Rasnovi S, Dahelmi. 2018. Diversity and abundance of butterfly (Lepidoptera rhopalocera) in the City Garden of Banda Aceh, Indonesia. Eco Env Cons 24 (3): 1009-1017.

Thangjam R, Kadam V, Hemochandra L, Ramalaxmi V, Krishna DG, Patnaik L. 2018. Studies on the diversity and abundance of butterfly in and around CUTM, Paralakhemundi Campus, Odisha (India). J Entomol Zool Stud 6 (5): 2484-249.

Tsukada E. 1982. Butterflies of the South East Asian Islands: Papilionidae. Palapa Co. Ltd., Minatok, Tokyo.

Tsukada E, Nishiyama Y. 1981. Butterflies of the South East Asian Island: Pieridae-Danaidae, Part II. Palapa Co. Ltd., Minatok,Tokyo.

Tsukada E, Nishiyama Y. 1982. Butterflies of the South East Asian Island: Part III Satyridae-Lybytheidae. Palapa Co. Ltd., Minatok, Tokyo.

Tsukada E, Nishiyama Y. 1985. Butterflies of the South East Asian Island: Part IV Nymphalidae (I). Palapa Co. Ltd., Minatok, Tokyo.

Tsukada E, Nishiyama Y. 1991. Butterflies of the South East Asian Island: Part V Nymphalidae (II). Palapa Co. Ltd., Minatok, Tokyo.

Vane-Wright RI, de Jong R. 2003. The butterflies of Sulawesi: Annotated checklist for a critical island fauna. Zoologische Verhandelingen 343: 3-267.

Vásquez OMC, Matarrita OMR, Matarrita OMR, Durán EA. 2021. Biodiversity of Butterflies in the Waterfalls sectorin the Barra Honda National Park, Nicoya, Guanacaste, Costa Rica. Projects Aboard. http://docs.projects-abroad.org.za/uk/conservation-management-plan/data-andreports/costa-rica/butterfly-research-paper.pdf. [2 Februari 2021].

Vu LV, Vu CQ. 2011. Diversity pattern of butterfly communities (Lepidoptera, Papilionoidae) in different habitat types in a tropical rain forest of Southern Vietnam. Int Sch Res Notices 818545: 1-8. DOI: 10.5402/2011/818545.

Wakhid W, Rauf A, Krisanti M, Sumertajaya IM, Maryana N. 2021. Aquatic insect communities in headwater streams of Ciliwung River watershed, West Java, Indonesia. Biodiversitas 22 (1): 30-41. DOI: 10.13057/biodiv/d220105.

Widhiono I. 2015. Diversity of butterflies in four different forest types in Mount Slamet, Central Java, Indonesia. Biodiversitas 16 (2): 196-204. DOI:10.13057/biodiv/d160215.

Zhushi-Etemi F, Bytyqi P, Musliu M, Ceka R. 2018. Distribution of butterfly species (Lepidoptera: Papilionoidea) in the protected area "Mirusha waterfalls" in Kosovo. Natura Croatica: Periodicum Musei Historiae Naturalis Croatici 27 (2): 305-314. DOI: 10.20302/NC.2018.27.19.