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Species richness and dispersion patterns of Lepidoptera (Rhopalocera) in the Nuraksa Forest Park, Lombok, Indonesia

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Abstract. *Ilhamdi ML, Idrus AA, Santoso D, Hadiprayitno G, Syazali M, Hariadi I. 2023. Species richness and dispersion patterns of Lepidoptera (Rhopalocera) in the Nuraksa Forest Park, Lombok, Indonesia. Biodiversitas 25: 62-70.* Butterflies play an important role in maintaining the balance of ecosystems and pollinators. This study aims to analyze the species richness and dispersion patterns of butterflies from the Rhopalocera suborder in this area. The field survey was carried out from January to July 2023. The sampling site was divided into six areas. Specimens that were successfully collected using a hand net were identified at the Biological Laboratory of Mataram University. During this survey, 1576 specimens of Rhopalocera were recorded. This number consists of 47 species. Several species, such as *Junonia atlites* Linnaeus, 1763, *Junonia almana* Linnaeus, 1758, *Danaus genutia* Cramer, 1779, *Hypolimnas misippus* Linnaeus, 1764, *and Amathusia phidippus* Linnaeus, 1763 were found to be new records in the Nuraksa Forest Park area. The habitat types with the highest number of species are the utilization block and the traditional block, with 47 species. The habitat type with the lowest number of species is a special block with only 15 species. However, the highest species richness was found in the protection block, with an R-value of 8.09. The most dominant species is *Leptosia nina* Fabricius, 1793, and the least dominant is *A. phidippus*. Each species depicted a varying distribution in the six habitat types. According to the analysis results, it was found that the dispersion pattern of all Rhopalocera species is clustered. The research results themselves contribute to conservation and ecotourism efforts.

Keywords: Block, butterfly, clustered, dominant species, habitat types

INTRODUCTION

The Rhopalocera suborder plays a key role in maintaining the ecosystem. In their environment, the larvae of this group of insects acquire nutrition from various types of plants, especially young leaves. Adult Rhopalocera draws nectar from host plants, some of which originate from the families Asteraceae, Annonaceae, Aristolochiaceae, Caesalpiniaceae, Rutaceae, Capparidaceae, Verbenaceae, Papilionaceae, Malvaceae, Verbenaceae, Mimosaceae, and Passifloraceae (Aminah et al. 2020). These insects inadvertently help in pollination. Therefore, it can be seen that there are at least two roles of Rhopalocera for the sustainability of the ecosystem: the regeneration of flowering plants crucial for producers in forest areas and as primary consumers that regulate the course of ecological processes in their habitat. These two ecological roles are imperative for the sustainability of ecologically based tourist areas, such as the Nuraksa Grand Forest Park on Lombok Island, Indonesia. Hence, it is evident that the conservation of Rhopalocera is a significant requirement for overall regional conservation efforts. In addition, Rhopalocera reduces pollution and also serves as a bioindicator, a source of nutrition for secondary consumers (Ghazanfar et al. 2016).

Better conservation efforts require data related to biodiversity information from Rhopalocera. Hapsari et al. (2022) found 16 species from the families Lycanidae, Pieridae, Papilionidae, and Nymphalidae in the waterways of the Sesaot forest, located in the Nuraksa Forest Park and is administratively located in the Narmada sub-district, West Lombok Regency. Further research on a wider area scale found more species. Forty-two butterfly species from the families Lycanidae, Hesperidae, Pieridae, Papilionidae, and Nymphalidae have been recorded (Ilhamdi et al. 2023b). The types of habitat used as sampling locations do not include only waterways, but also forest edges and the middle of the forest. The data from this research depicts that the size of the observation area and the number of habitat types are positively correlated with the number of species found.

Based on the official map from the West Nusa Tenggara Provincial Environment and Forestry Service at the Nuraksa Forest Park (DISLHK NTB 2018), the Nuraksa area is divided into six management blocks, namely special blocks, collection blocks, utilization blocks, protection blocks, historical and cultural blocks, and traditional blocks. Due to the various functions, the environmental carrying capacity, including biotic and abiotic conditions, also differs. This difference has the potential to influence the survival of each species from the Rhopalocera suborder and is proven empirically by results from a study conducted in Gunungan Ungaran, Indonesia (Rahayuningsih et al. 2019). Biological factors, such as flora diversity in the habitat, vegetation conditions, and food availability, have a close relationship with the presence of butterflies (Craioveanu et al. 2021; Neu et al. 2021). However, little information is known regarding the distribution of Rhopalocera in the Nuraksa Area.

In this research, we complement the results of research conducted previously in Nuraksa (Ilhamdi et al. 2023a). This research aims to analyze the species richness and distribution of Rhopalocera. The distribution in this study is the dispersion pattern of each population in the Rhopalocera community. Habitat types are taken from six types of mapped management blocks. The results of this research can help the provincial government through the NTB Provincial Environment and Forestry Service, Nuraksa Forest Park Center, in the management of sustainable areas. This would enable tourist areas to experience minimal damage, especially in terms of natural ecological processes. Therefore, various interests, including economics, customs, culture, and customs of the surrounding community and the interests of related stakeholders, can be addressed without sacrificing the ecological function of the Nuraksa area. Educators can also employ the results of this research as a learning resource, especially on the topic of the diversity of living organisms and ecosystems at primary, secondary, and higher education levels.

MATERIALS AND METHODS

Research location

Rhopalocera research activities were performed in the Nuraksa Grand Forest Park, Lombok Island, West Lombok District, West Nusa Tenggara Province, Indonesia. Sample collection was carried out in six types of habitats, namely B1 = Special blocks; B2 = Collection blocks; B3 = Utilization blocks; B4 = Protection blocks; B5 = Historical cultural blocks and; B6 = Traditional blocks (Figure 1). Each block has different habitat characteristics. Based on data from (DISLHK NTB 2018), B1 covers an area of 25 Ha, B2 547.78 Ha, B3 593.76 Ha, B4 1150.42 Ha, B5 50 Ha, and B6 788.04 Ha. Geographically, B1 is located at coordinates 116º,18'40"E and 8º,30'40"S. B2 is located at coordinates 116º,33'50"E and 8º,47'76"S. B3 is located at coordinates 116º,19'30"E and 8º,28'45"S. B4 is located at coordinates 116º,29'38"E and 8º,48'31"S. B5 is located at coordinates 116º,29'40"E and 8º,48'93"S. B6 is located at coordinates 116º,18'30"E and 8º,29'30"S. Each block experiences varying environmental conditions. Data on environmental conditions, including temperature (Temp), altitude (Alt), humidity (Hum), light intensity (IC), and canopy (Ca) can be observed in Table 1. Measurements are carried out every month at 3 different points in each block.

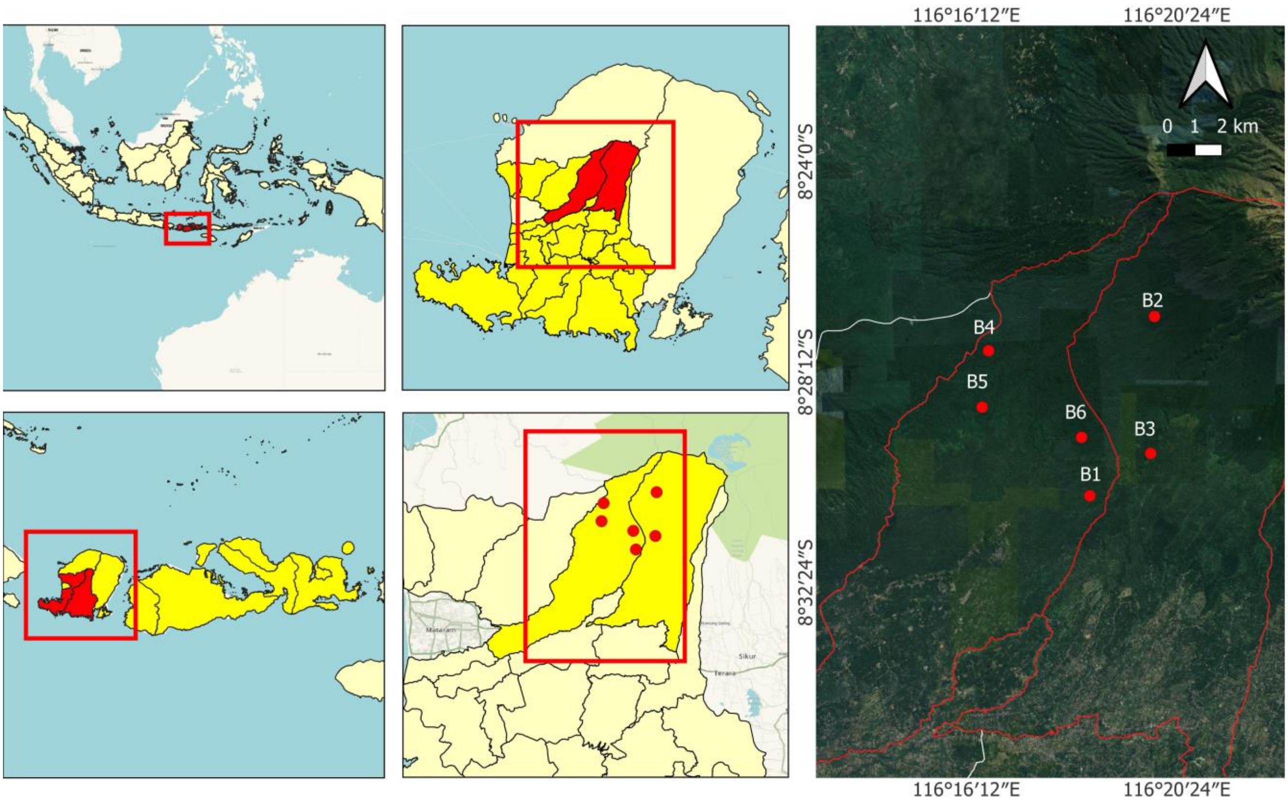

Figure 1. Map of the Rhopalocera research location in Nuraksa, West Lombok District, West Nusa Tenggara Province, Indonesia. B1: Special blocks; B2: Collection blocks; B3: Utilization blocks; B4: Protection blocks; B5: Historical cultural blocks and; B6: Traditional blocks

Table 1. Environmental conditions for each habitat type in Nuraksa, West Lombok District, West Nusa Tenggara Province, Indonesia

Habitat type	Environmental parameters				
	Temp (°C)	Alt (m asl.)	Hum (%)	IC (Cd)	Ca (%)
Special block	19-21	352	70-73	1400-1500	86
Collection block	19-21	357	70-73	1500-1600	85
Utilization block	25-27	352	70-73	2300-2400	80
Protection block	19-22	360	73-75	2100-2200	80
Historical cultural block	19-21	359	73-75	1200-1400	95
Traditional block	25-27	351	70-73	2300-2400	83

Data collection and species identification

Field surveys were carried out from January to July 2023. At each sampling location, specimens were collected by utilizing the roaming method. The roaming method is carried out by exploring all blocks of the research location. The species name of each observed Rhopalocera was recorded. For species that could not be identified by direct observation, documentation was carried out in the form of photos or videos, and the specimens were captured using a hand net. This was done to facilitate their identification at the species level. Direct observations in the field were also performed when Rhopalocera was active, namely in the morning from 08:00 to 11:30 and continued in the afternoon from 13:30 to 15:30. This activity was executed four times per month. Collected specimens were identified to species taxon at the Biology Laboratory of Universitas Mataram. The naming of the Rhopalochera species was done with the help of the identification books by Peggie and Amir (2006) and Wahyuni (2015). Other references included articles resulting from research, especially those conducted on Lombok Island, and published in reputable international journals (Matsumoto et al. 2012; Ilhamdi et al. 2018; Ilhamdi et al. 2023a).

Data analysis

The data were analyzed based on species richness and species dispersion patterns. Species richness analysis employs the equation of the Margalef richness index (Koneri et al. 2019). The mathematical equation is as follows:

$$R = (S\text{-}1)/(\ln N)$$

Where:
R = species richness index
S = number of species
N = the number of individuals of all species

Species distribution patterns in populations were measured using the Morisita dispersion index (Koneri et al. 2020). Mathematically, the equation of this index is:

$$Id = n[(\sum x^2 - \sum x)/((\sum x)^2 - \sum x)].$$

Where:
Id = Morisita dispersion index
n = number of sampling locations
x = number of individuals per sampling location

If the Id value <1, then the species is evenly dispersed. If Id = 1, then the species are randomly dispersed. If Id>1, the species is dispersed in groups.

RESULTS AND DISCUSSION

Species richness

Forty-seven Rhopalocera species were identified, which represented the families Hesperiidae, Licaenidae, Papilionidae, Pieridae, and Nymphalidae (Table 2). Amongst them, three species included members of the Hesperiidae and Lycaenidae families, five species belonged to the Papilionidae family, nine species were from the Pieridae family, and 27 species originated from the Nymphalidae family. The list of species recorded in this study is larger than previous records. A total of 16 species and four families were previously observed in the Sesaot forest waterway (Hapsari et al. 2022), whereas 42 species and five families were found in the Nuraksa waterway, middle forest and forest edge habitat types (Ilhamdi et al. 2023a). However, in this study, there is an addition to the list of five species from the Rhopalocera suborder. These species include *Junonia atlites* Linnaeus, 1763, *Junonia almanac* Linnaeus, 1758, *Danaus genutia* Cramer, 1779, *Hypolimnas misippus* Linnaeus, 1764, *and Amathusia phidippus* Linnaeus, 1763 (Figure 3).

The number of species listed in Table 2 are 47 species. This number is maximum based on the von Bertalanffy curve (Figure 2). The number of species is greater than the number found in TWA Suranadi, Joben East Lombok, and several other areas on Lombok Island, Indonesia. In Suranadi TWA, Rhopalocera consists of 40 species (Ilhamdi et al. 2018). On the other hand, in Joben, East Lombok, 29 species were found (Yuniartin et al. 2023). The Kembang Kuning Protected Forest area has been observed to have 30 species (Sumiati et al. 2018). However, simultaneous survey results in several locations, namely Sekaroh, Suranadi, Senaru, and Pusuk, only recorded ten species (Matsumoto et al. 2012). In another study conducted in the Aik Bukak area, only 23 species were recorded (Ashari et al. 2022). Moreover, in Kerandangan TWA, 41 species were recorded from the Rhopalocera suborder (Wahyuni 2015). This means that the biological, physical, and chemical environmental conditions in Tahura Forest Park are better in supporting the life of the Rhopalocera community compared to several of the listed locations.

Table 2. Species richness of the Rhopalocera suborder in Nuraksa Forest Park, West Lombok District, West Nusa Tenggara, Indonesia

Family	Species Name	Block						N
		B1	B2	B3	B4	B5	B6	
Hesperiidae	*Erionota torus*	2	1	9	3	2	11	28
Hesperiidae	*Udaspes folus*	1	1	6	3	3	7	21
Hesperiidae	*Pseudocoladenia dan*	2	1	10	3	4	11	31
Lycaenidae	*Jamides celeno*	0	1	11	6	2	21	41
Lycaenidae	*Doleschallia bisaltide*	2	2	18	7	0	20	49
Lycaenidae	*Lampides boeticus*	0	0	7	1	0	5	13
Papilionidae	*Papilio memnon*	1	1	11	4	2	13	32
Papilionidae	*Papilio polites*	0	0	11	4	2	10	27
Papilionidae	*Graphium doson*	0	0	9	0	1	8	18
Papilionidae	*Graphium agamemnon*	0	0	6	2	3	12	23
Papilionidae	*Graphium sarpedon*	0	0	7	1	1	9	18
Pieridae	*Catopsila pamona*	0	0	18	3	5	18	44
Pieridae	*Delias belisama*	0	0	2	0	0	4	6
Pieridae	*Eurema hecabe*	0	1	12	0	2	15	30
Pieridae	*Eurema blanda*	0	0	19	9	2	17	47
Pieridae	*Leptosia nina*	2	2	21	11	9	19	64
Pieridae	*Cepora iudith*	0	0	15	7	2	17	41
Pieridae	*Lebadea Martha*	0	0	3	10	2	12	27
Pieridae	*Parnara ganga*	0	0	9	3	2	11	25
Pieridae	*Polyura hebe*	0	1	6	1	3	9	17
Nymphalidae	*Euploea dimena*	0	1	5	2	1	6	20
Nymphalidae	*Euploea tuliolus*	0	0	15	6	3	19	15
Nymphalidae	*Euploea mulciber*	0	0	6	2	2	7	43
Nymphalidae	*Elymnias hypermnestra*	2	3	11	2	3	15	36
Nymphalidae	*Euploea eunice*	0	4	6	3	2	11	26
Nymphalidae	*Euploea climena*	0	0	6	2	2	10	20
Nymphalidae	*Junonia iphita*	1	4	12	4	2	15	38
Nymphalidae	*Junonia hedonia*	4	4	14	6	4	25	57
Nymphalidae	*Junonia erigone*	2	1	5	1	1	15	25
Nymphalidae	*Junonia atlites*	0	0	7	2	0	12	21
Nymphalidae	*Junonia almana*	0	0	7	1	0	14	22
Nymphalidae	*Melanitis leda*	4	5	19	6	5	22	61
Nymphalidae	*Mycalesis horsfieldii*	4	5	21	6	7	28	71
Nymphalidae	*Tagiades gana*	1	2	11	5	2	12	33
Nymphalidae	*Tanaecia pelea*	0	0	7	3	2	15	27
Nymphalidae	*Neptishylas*	0	0	19	7	6	25	57
Nymphalidae	*Parantica pseudomelaneus*	0	1	17	7	5	14	44
Nymphalidae	*Idiopsis juventa*	0	0	18	7	6	29	60
Nymphalidae	*Danaus chrysippus*	0	0	19	6	5	27	57
Nymphalidae	*Danaus genutia*	0	0	15	5	2	23	45
Nymphalidae	*Pantoporia hordonia*	0	0	8	2	0	9	19
Nymphalidae	*Elymnias casiphone*	2	1	6	4	4	8	25
Nymphalidae	*Hypolimnas bolina*	0	1	8	3	2	12	26
Nymphalidae	*Tirumala hamata*	0	0	17	4	2	19	42
Nymphalidae	*Hypolimnas misippus*	0	0	5	0	0	11	16
Nymphalidae	*Ypthima baldus*	0	2	16	4	2	17	41
Nymphalidae	*Amathusia phidippus*	2	0	0	0	0	3	5

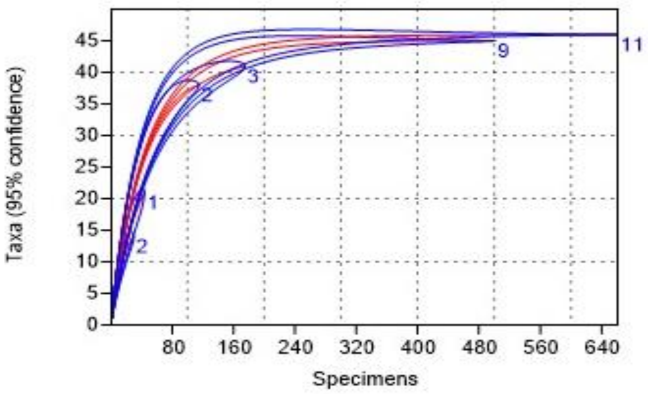

Figure 2. Kurva von Bartalanffy

The number of species found in Nuraksa is also higher than in several locations in the Wallacea region and the Lesser Sunda Islands. In the Talaud Islands, 23 species were found, where the highest species richness was the forest-edge habitat type (Koneri et al. 2019). In the Sangihe Islands, 39 species from five different families have been previously reported, and the highest diversity was found in the forest edge habitat type (Koneri and Nangoy 2019). In North Minahasa, more species than the current study have been found. In that area, a total of 52 species, with details of 30 species from the Nymphalidae family, 10 species from the Papilionidae family, five species from Pieridae, nine species from Lycanidae, and two species from Hesperiidae have been found (Koneri et al. 2020). This means that in terms of the environmental carrying capacity in several urban forests, North Minahasa is better than Nuraksa, Lombok.

Generally, differences in the number of species found in certain habitats are caused by differences in location as well as the time period or season. Other factors include altitude, habitat type, and the complexity of the vegetation structure at each location. Furthermore, time periods, such as the dry season and rainy season, greatly influence the microhabitat of butterflies. In addition, various environmental disturbances in each habitat are also strongly suspected to have a significant effect on the number of butterfly species in each habitat (Koneri et al. 2019). With respect to environmental conditions, external factors that influence differences in the number of Rhopalocera species include humidity, temperature, altitude, canopy, light intensity, and human disturbance, such as trails that divide the habitat (Liao et al. 2017; Gupta et al. 2019; Gueratto et al. 2020; Grundel et al. 2020; Sridhar et al. 2021). In the habitat, these external factors function as limiting factors, as each species of the Rhopalocera taxon can only survive in a certain range of conditions.

The five species that are newly recorded in Nuraksa (Figure 3) are not included in the new list in Indonesia as they have previously been reported by several studies (Matsumoto et al. 2012; Ilhamdi et al. 2018; Ilhamdi et al. 2023b). The species *A. phidippus*, *J. atlites*, and *Junonia iphita* Cramer, 1782 have been found in Jember, which geographically belongs to the oriental region (Kurnianto et al. 2023). *A. phidippus* is also reported to survive in oil palm plantation areas in West Kalimantan, Indonesia (Kwatrina and Santosa 2020). In the Southeast Asia Region, *A. phidippus* is reported in Johor, Sabah, and Sarawak in Malaysia (Ismail et al. 2020; Amil et al. 2021; Suraya et al. 2022). However, the new *A. phidippus* species was first reported to be present on Lombok Island. On the other hand, *D. genutia* is distributed in Yuanjiang, Yunan in China (Zhen et al. 2017), the Indian Himalayan geographic region (Verma and Arya 2023), Queensland and Australia (Meyer et al. 2013). This species can also be found in several locations in India (Arya and Chaudhary 2014; Ankola et al. 2015; Khan and Rastogi 2015), and in mangrove forests in Bangladesh (Hossain 2014). *H. misippus* has been recorded based on the results of a study in West Java, Indonesia (Shahroni et al. 2022). Outside Indonesia, this species is distributed in Europe, namely Madeira, Portugal, and Latin America, namely Venezuela (Eugenia and Anillo 2013; Tennent et al. 2013).

During the survey, these species were only found in certain habitat types. *Euplea Eunice* Godart, 1819, *J. atlites*, and *J. almana* were only found in habitat types B3, B4, and B6. *H. misippus* and *A. phidippus* were found to be only distributed in habitat types B3 and B6. However, *D. genutia* has the widest distribution as it is found in habitat types B3, B4, B5, and B6. This indicates that such species can only survive in certain environmental conditions in Nuraksa. Table 1 shows that the species *E. eunice*, *J. atlites*, and *J. almana* can survive in temperature conditions of 21-27°C, light intensity range of 2100-2400 Cd, air humidity of 70-73%, canopy 80-83%, and an altitude range of 352-360 asl. *H. miceppus* and *A. phidippus* can survive in temperature conditions of 26-27°C, light intensity range of 2300-2400 Cd, air humidity of 70%, canopy of 80-83%, and altitude range of 351-352 asl. However, *D. genutia* can survive in temperature conditions of 20-27°C, light intensity range of 1200-2400 Cd, air humidity of 70-73%, canopy 80-95%, and altitude range of 351-360 masl.

Based on the habitat type, the blocks with the highest number of species are the utilization block and the traditional block (S = 47). Meanwhile, the habitat type with the lowest species richness is the special block (S = 15). Other habitat types have a number of species ranging from 21 to 43 (Figure 4A). Nymphalidae is the family with the highest number of species (S = 47), whereas the families with the lowest number of species are Hesperidae and Lycanidae, each consisting of only three species (Figure 4B). These data show that (i) the utilization block and the traditional block are the habitat types whose environmental conditions are most suitable for the survival of Rhopalocera in Nuraksa, and (ii) Nymphalidae is the dominant and most surviving family in the habitat in Nuraksa.

Figure 3. Photograph of five newly-recorded species in Nuraksa Forest Park, West Lombok District, West Nusa Tenggara Province, Indonesia

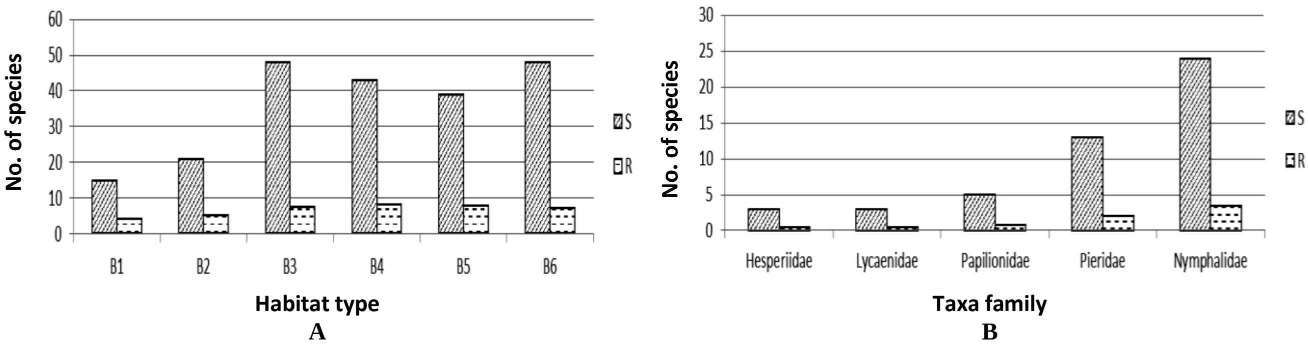

Figure 4. Comparison of the number of species and the Margalef index in terms of: A. Habitat type; and B. Family taxa present in Nuraksa, West Lombok District, West Nusa Tenggara Province, Indonesia

Based on Figure 4A, it can be seen that the habitat types with the highest number of species are B3 and B6. However, this habitat type has lower species richness compared to habitat types B4 and B5. Respectively, the Margalef indices of B4 and B5 are 8.09 and 7.98. However, the Margalef index values of B3 and B6 are 7.52 and 7.20, respectively. This means that habitats with environmental conditions suitable for more species do not necessarily have higher species richness compared to habitat types with environmental conditions that support the survival of fewer species. With respect to the Margalef index equation, the number of species is directly proportional, but inversely proportional to the number of individuals of all species (Koneri et al. 2019).

The opposite phenomenon occurs in the comparison between S and R based on the taxon family. Although the abundance of the Nymphalidae family is the highest, its R-value is also the highest. The abundance (N) of this family was found to be 874 individuals, while other taxon families only range from 80 individuals to 401 individuals. The highest number of species from the Nymphalidae family also occurs in several regions in Indonesia as well as other parts of the world. In Suranadi TWA, 45% of the total species found belonged to the Nymphalidae family, while other families only ranged from 2% to 25% (Ilhamdi et al. 2018). On Sangihe Island, North Sulawesi, 19 species from the Nymphalidae family were recorded, whereas other families were represented by species with numbers ranging from two to eight species (Koneri and Nangoy 2019). In many urban forests in Minahasa, North Sulawesi, 30 species of Nymphalidae have been documented, while other species are represented by species ranging from two to ten species (Koneri et al. 2020). In one area in Gujarat, India, the Nymphalidae family covers 39% of the species found, while species from other families account for 3-25% of the total species (Gohel and Raval 2019).

There are several reasons behind this family has a high species richness in its habitat. One of them is the synergistic factor between climate and vegetation, especially flowering plants. A previous study has found that butterfly species richness and diversity are mainly influenced by the synergism between climate and vegetation. This shows that the availability and diversity of vegetation in the Nymphalidae habitat can contribute to the high species richness. Habitat Diversity. Another study found that butterfly diversity and abundance were influenced not only by increasing altitude but also by environmental factors that synergized with changes in vegetation (Ahmad et al. 2022). This suggests that the diversity of habitats in which Nymphalidae can thrive may contribute to their high species richness.

Another factor is habitat loss and fragmentation. Habitat loss and fragmentation are considered the biggest cause of insect extinction. However, the Nymphalidae may have adapted well to various habitats, which may have contributed to their high species richness. Host and habitat specificity. The high species richness of Nymphalidae may also be due to its adaptability to various host plants and habitats (Subedi et al. 2021). This adaptability presumably allows them to utilize a wide variety of habitats and host plants, thereby contributing to high species richness. Seasonal structure and habitat. A study found that the altitudinal distribution of butterfly species richness and abundance was influenced by seasonality and habitat structure (Mtui et al. 2022). This depicts that environmental factors in the Nymphalidae habitat also lead to their high species richness. Overall, the high species richness of Nymphalidae may be due to a combination of factors, including the availability and diversity of vegetation, adaptability to various habitats and host plants, and environmental factors, such as season and habitat structure.

Species distribution patterns

Most of the Rhopaclocera found in Nuraksa are unevenly distributed, whereas a few are evenly distributed as they are found in all types of habitats. In addition, many of the Rhopaclocera are only found in a few habitat types. All species from the Hesperiidae family are present in all habitat types from B1 to B6. From the Paplionidae family, only a single species was recorded to be present, namely *Papilio memnon* Linnaeus, 1758, which is widely distributed and has a distribution area that reaches all types of habitat. Among the Pieridae family, only *Leptosia nina* (Fabricius, 1793) was evenly distributed in all habitat types. With respect to the Nymphalidae family, eight species were found to be distributed in all types of habitats, including *Elymnias hypermnestra* Linnaeus, 1763, *J. iphita*, *Junonia hedonia* Linnaeus, 1764, *Junonia erigone* Cramer

1775, *Melanitis leda* Linnaeus, 1758, *Mycalesis horsfieldii* Moore 1892, *Tagiades gana* Moore 1866, and *Elymnias casiphone* Hübner, 1824. On the other hand, the Lycanidae family has three species that are not distributed in all habitat types. The *Jamides celeno* species is found in B2 to B6; however, it is not present in habitat type B1. Moreover, the *Doleschallia bisaltide* species can survive in all habitats except B5. The *Lampides boeticus* Linnaeus, 1767 species is only distributed in habitat types B3, B4, and B6. However, all species depict a clustered dispersion pattern since the Motricity Index is observed to be more than 1 (Table 3).

All species of the Rhopalocera taxon demonstrate a clustered distribution pattern. The factors that cause butterflies to spread in clustered patterns include biotic and abiotic factors, which, when combined, can influence butterfly distribution. These factors include temperature, relative humidity, and the presence and abundance of host plants, all of which can create certain microclimatic conditions that attract certain butterfly species, causing their distribution to cluster (Meléndez-Jaramillo et al. 2019). Other factors include altitude and habitat. A study in Gunung Ledang National Park, Malaysia, found that butterfly richness decreased with increasing altitude due to environmental factors and habitat variables (Ismail et al. 2018). This suggests that the availability of suitable habitats at various altitudes may contribute to the clustering distribution of butterflies. Additionally, butterfly fauna has been shown to respond strongly to temperature, even when other environmental factors are taken into account (Comay et al. 2021). This means that temperature can play a vital role in the group distribution of butterflies.

Table 3. Distribution of Rhopalocera in Nuraksa, West Lombok District, West Nusa Tenggara Province, Indonesia

Rhopalocera species	Habitat type						Id	Dispersion pattern
	B1	B2	B3	B4	B5	B6		
Erionota torus	+	+	+	+	+	+	1,5	Grouped
Udaspes folus	+	+	+	+	+	+	1,2	Grouped
Pseudo coladenia dan	+	+	+	+	+	+	1,4	Grouped
Jamides celeno	-	+	+	+	+	+	2,1	Grouped
Doleschallia bisaltide	+	+	+	+	-	+	1,9	Grouped
Lampides boeticus	-	-	+	+		+	2,4	Grouped
Papilio memnon	-	-	+	+	+	+	1,7	Grouped
Papilio polites	-	-	+	+	+	+	1,8	Grouped
Graphium doson	-	-	+	-	+	+	2,5	Grouped
Graphium agamemnon	-	-	+	+	+	+	2	Grouped
Graphium sarpedon	-	-	+	+	+	+	2,2	Grouped
Catopsila pamona	-	-	+	+	+	+	2	Grouped
Delias belisama	-	-	+	-	-	+	2,8	Grouped
Eurema hecabe	-	+	+	-	+	+	2,4	Grouped
Eurema blanda	-	-	+	+	+	+	1,9	Grouped
Leptosia nina	+	+	+	+	+	+	1,4	Grouped
Cepora iudith	-	-	+	+	+	+	1,9	Grouped
Lebadea Martha	-	-	+	+	+	+	1,9	Grouped
Parnara ganga	-	-	+	+	+	+	1,9	Grouped
Euplea dimena	-	+	+	+	+	+	1,7	Grouped
Euplea tuliolus	-	+	+	+	+	+	1,5	Grouped
Euploea mulciber	-	-	+	+	+	+	1,9	Grouped
Polyura hebe	-	-	+	+	+	+	1,7	Grouped
Elymnias hypermnestra	+	+	+	+	+	+	1,6	Grouped
Euploea eunice	-	+	+	+	+	+	1,5	Grouped
Euploea climena	-	-	+	+	+	+	1,9	Grouped
Junonia iphita	+	+	+	+	+	+	1,6	Grouped
Junonia hedonia	+	+	+	+	+	+	1,6	Grouped
Junonia erigone	+	+	+	+	+	+	2,3	Grouped
Junonia atlites	-	-	+	+	-	+	2,5	Grouped
Junonia almana	-	-	+	+	-	+	2,9	Grouped
Melanitis leda	+	+	+	+	+	+	1,4	Grouped
Mycalesis horsfieldii	+	+	+	+	+	+	1,5	Grouped
Tagiades gana	+	+	+	+	+	+	1,5	Grouped
Tanaecia pelea	-	-	+	+	+	+	2,2	Grouped
Neptis hylas	-	-	+	+	+	+	1,9	Grouped
Parantica pseudomelaneus)	-	+	+	+	+	+	1,6	Grouped
Idiopsis juventa	-	-	+	+	+	+	2	Grouped
Danaus chrysippus	-	-	+	+	+	+	2,1	Grouped
Danaus genutia	-	-	+	+	+	+	2,2	Grouped
Pantoporia hordonia	-	-	+	+	-	+	2,3	Grouped
Elymnias casiphone	+	+	+	+	+	+	1,1	Grouped
Hypolimnas bolina	-	+	+	-	-	+	1,8	Grouped
Tirumala hamata	-	-	+	+	+	+	2,2	Grouped
Hypolimnas misippus	-	-	+	+	+	+	3,2	Grouped
Ypthima baldus	-	+	+	+	+	+	1,9	Grouped
Amathusia phidippus	+	-	-	-	-	+	2,4	Grouped

Notes: (+) is found, and (-) is not found

Internal factors include wingspan and deployment capability. Butterfly characteristics, such as wingspan and larval host plant specificity, can also influence their dispersal ability and impact their distribution patterns (Sekar 2012). Butterflies with limited dispersal ability are more likely to show clumped distributions. Other biotic factors that contribute to butterfly clustering include nectar plants, and their availability and diversity can attract butterflies to certain areas, leading to their cluster distribution. Moreover, the tree perch factor implies that the availability of suitable roosting trees may also contribute to butterfly clustering (Kass et al. 2020). Biotic factors, such as egg clustering, can also directly influence clumped distribution patterns. Egg clustering itself can increase the reproductive success of female butterflies, especially when the number of host plants is limited (Griese et al. 2017).

The clustered dispersion pattern of Rhopalocera can impact its survival and reproduction through grouping eggs. Egg clustering has been known to function as an adaptive behavior for plant defense and has been shown to increase the reproductive success of female butterflies, especially when host plants are scarce (Griese et al. 2017). However, it can also lead to increased competition for resources and higher levels of predation. Furthermore, habitat loss and degradation can have a negative impact on butterfly populations, including their survival and reproduction (WWF 2023). Reduced breeding habitat due to herbicide use and land use changes, as well as forest degradation at wintering sites, can lead to a decline in butterfly populations. In addition, environmental stressors, such as dietary stress and extreme weather conditions, can also affect the energy, reproduction, and lifespan of Rhopalocera. This is proven by research that found that flying stress increased the reproductive output of the Melitaea cinxia butterfly (Niitepõld 2019).

Moreover, keeping butterflies in captivity has been shown to result in lower fitness and lower survival rates compared to wild butterflies (Pelton 2023). This suggests that butterfly retention may not be an effective way to help butterfly populations. Hence, it can be said that the overall clustered distribution pattern of Rhopalocera can have both positive and negative impacts on its survival and reproduction. Although egg clustering can increase reproductive success, habitat loss and degradation, environmental stress, and captivity can negatively impact butterfly populations. Understanding these factors can help in better conservation and management of butterfly populations and their habitats.

In conclusion, the results of a survey conducted from January to July 2023 found 48 species spread across six habitat types, namely special blocks, collection blocks, utilization blocks, protection blocks, historical and cultural blocks, and traditional blocks. The Margalef Index depicted that the species richness in this area is 6.38. The blocks with the highest number of species were the utilization block and the traditional block. However, the habitat type with the highest species richness was the refuge block, which had a Margalef index of 8.09. If compared by taxon, the family with the highest number and species richness was found to be Nymphalidae. Although each species found in Nuraksa was distributed unevenly across all habitat types, their distribution patterns were equally grouped. The results of this research can contribute to conservation efforts.

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