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Species Richness of Lepidoptera in Bega Watershed, Prosperidad, Agusan del Sur, Philippines

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ABSTRACT
The Philippines is a megadiverse country as well as a global biodiversity hotspot with high diversity of butterflies. This study aimed to determine the species richness of butterflies and moths (Lepidoptera) in Bega Watershed, Prosperidad, Agusan del Sur, Philippines. A survey using the sweep netting method was conducted on May 8-14, 2014. Three sampling sites were established. Seventeen species of Lepidoptera of which 13 species are butterflies and four species are moths under eight families were documented. Family Nymphalidae was the most dominant in the study area. Among the three sites, Site 1, the riparian area, had the highest abundance (63.77%), species richness (S=13), and species diversity (H'=2.31) of Lepidoptera. The two species, Eurema hecabe and Anthene sp. were present in all the three sites. Results showed that Bega Watershed had moderate to high species diversity with a relatively even distribution which may be attributed to micro-habitats within the study area. However, continuing conversion of forest land for agriculture may affect the species richness and diversity of Lepidoptera.
Keywords: *butterflies, diversity, moths, Nymphalidae, riparian.*

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INTRODUCTION

Order Lepidoptera which consists of butterflies and moths is the second largest and more diverse order of the class Insecta [1, 2] comprising more than 150,000 described species [3]. Lepidopterans are more commonly associated with flowering plants [4] and thus butterflies are the diurnal pollinators of flowers just as moths are the major nocturnal pollinators of flowers [5].

Aslam [6] documented 774 moth specimens belonging to six families. Bharamal [7]; Chandra and Sambath [8] recorded 56 species of moths from 14 families and 102 moths belonging to 12 families in India, respectively. Vu and Vu [9] in the tropical rain forest of Southern Vietnam recorded 112 butterfly species and observed that the rare species tends to decline from the natural forest to the stream sides while the proportion of common species tends to increase from the natural forest to the stream sides. Kumar [2] documented 58 butterfly species in Gujarat and concludes that butterflies are almost always associated with higher plants especially angiosperms. In spite of these studies, biodiversity research and survey of Lepidopterans in tropical regions are still very few [10] despite having a high species diversity compared to the temperate region due to the diverse vegetation [11]. Habitat fragmentation particularly in tropical regions is well exhibited [12] which is one of the threats to Lepidoptera [13].

The Philippines, a tropical country, has a high species diversity and endemism of butterflies and moths [14] which could be due to the country's patchwork of isolated islands, its tropical location, and its once extensive areas of rainforest [15]. Recently, a new species of moth which is most probably seen in primary forests of low mountains and middle elevations from 1650 and 2100 meters above sea level (masl) was discovered in Banaue, Mountain Province of the Philippines. The new species, *Cleora aimeelynnae* Tautel was named after Dr. Aimee Lynn B. Dupo [16]. New records of two moth species, *C. decisaria* and *C. determinata* from Mt. Makiling of Luzon were also discovered [17]. Hence, continuous biological survey could lead to the discovery of new species and is needed since rapid destruction of the

Philippine forest, especially in Mindanao, the second largest island in the country, is seen as one of the major threats not just to Lepidopterans but to many faunal species [18].

Mindanao is home to a diverse and high number of endemic Lepidopterans consisting of 528 species with 219 (41.5%) endemic [18]. However, studies on Philippine butterflies and moths particularly in Mindanao are woefully lacking. The only published studies on Lepidopterans were by Mohagan and Treadaway [18] on the diversity and status of butterflies across vegetation types of Mt. Hamiguitan in Davao Oriental, Cahatian and Butardo [19] on the insect fauna in Mt. Apo, Toledo and Mohagan [14] on the diversity and status of butterflies in Mt. Timpoong and Mt. Hibok-hibok of Camiguin Island, Mohagan *et al.* [20] on the diversity of butterflies in the selected key biodiversity areas of Mindanao, and Ramirez and Mohagan [21] on the diversity and status of butterflies in Surigao del Sur. Many places in Mindanao like the Bega Watershed of Agusan del Sur are still waiting to be explored in terms of species richness of Lepidoptera. As such, there is a need to study the Lepidopterans present in Bega Watershed in order to fully appreciate the Lepidopteran diversity of the Mindanao Island.

METHODOLOGY

Study Area

The study was conducted in Bega Watershed of Barangay Mabuhay, Prosperidad, Agusan del Sur (Figure 1). Agusan del Sur is located on the island of Mindanao in the south of the Philippines with Prosperidad as its capital. Three sampling sites were established.

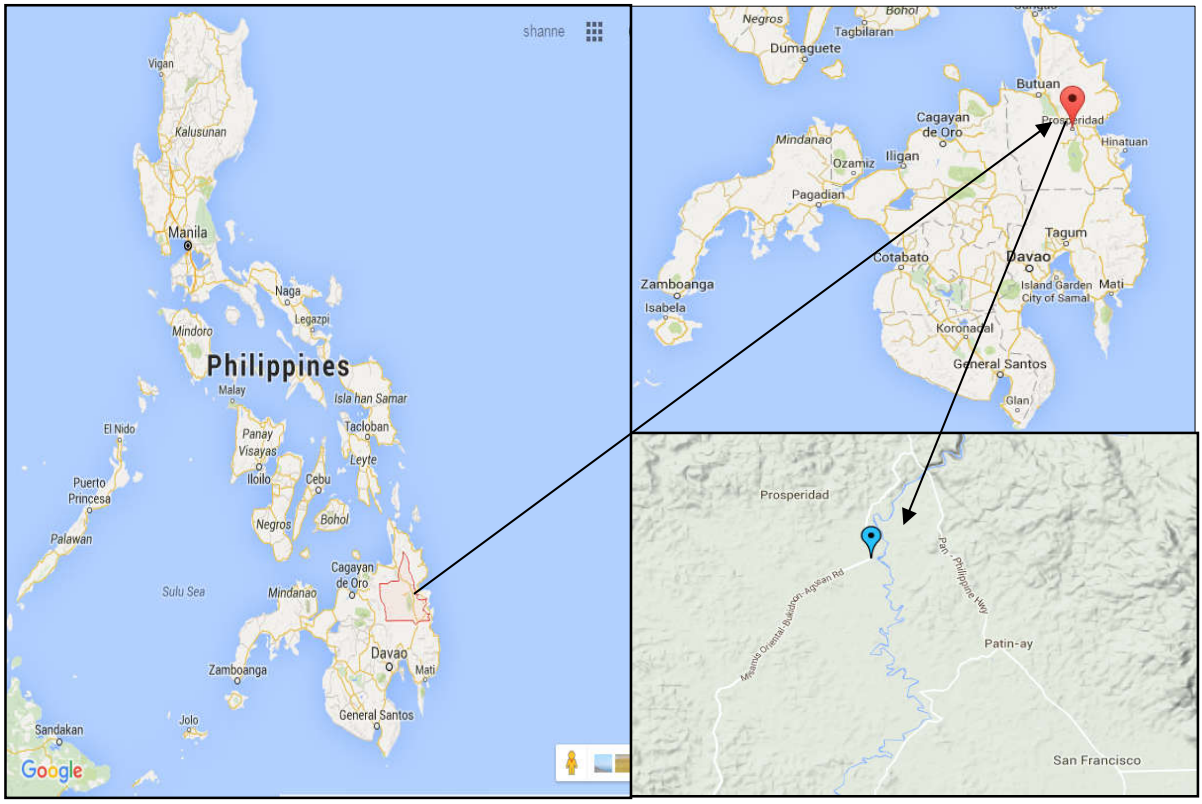

Figure 1: Map of the world and the Philippines showing the location of Bega Watershed in Prosperidad, Agusan del Sur [22].

Sampling Sites

Site 1 (8°69'95.6"N, 125°97'40.9"E) is the riparian area of Bega Watershed. The site has diverse secondary vegetation assumed to be due to few disturbances. Site 2 (08° 42'01.8"N 125°58'45.2"E) is the highly disturbed area of Bega watershed. The site includes the slash-and-burn area. The area is bare of trees with only ground cover plants such as grasses present. Site 3 (8°70'41.8"N 125°98'38.2"E) is the forested area of Bega Watershed. The site has a flat slope with secondary vegetation.

Collection, Identification, and Processing of Samples

Opportunistic sampling was conducted for seven field days on May 8-14, 2014. Sampling sites were randomly selected. Samples were collected using a sweep net. Samples were then placed in glassine paper and in clear plastic bags as soon as they were captured. The live specimens collected in glassine paper

were placed in a closed plastic container with a cotton ball soaked in ethyl acetate to suffocate them. Photographs of the specimens were taken in the field or immediately after capture. Initial identification was done through the use of published references. The identification was verified by the third author.

Statistical analysis

The biodiversity indices were computed using Paleontological Statistics Software Package (PAST) 3.10. Seriation analysis was also done using the same software.

RESULTS AND DISCUSSION

Seventeen species of Lepidoptera (13 butterflies and 4 moths) with 69 individuals under eight families and 16 genera were recorded in the three established sampling sites of Bega Watershed (Table 1). The same number of butterfly species was recorded in Šćedro Island of Croatia [23] and in Amboli Reserve Forest of India [7]. However, the result was lower than the recorded number of butterfly species in Mt. Hamiguitan [18], Mt. Timpoong and Mt. Hibok-hibok of Camiguin Island [14], selected key biodiversity areas of Mindanao [20], Tandag, Surigao del Sur [21] and in La union botanical garden of Northern Luzon [24]. The number of moth fauna in Šćedro Island of Croatia [23] is higher than the species richness of the moth fauna in Bega watershed.

Table 1: Species richness, relative abundance, and distribution of Lepidoptera in Bega Watershed, Agusan del Sur, Philippines.

Species Name	Sampling Sites in Bega Watershed			Total
	Site 1 (Riparian area)	**Site 2** (Slash-and-burn area)	**Site 3** (Forested area)	
BUTTERFLIES				
Family Lycaenidae				
Anthene sp.	3 (4.35)	2 (2.90)	5 (7.25)	10 (14.49)
Rachana cf. *jalindra*	2 (2.90)	0(0)	0(0)	2 (2.90)
Family Nymphalidae				
Hypolimnas sp.	1 (1.45)	0(0)	0(0)	1 (1.45)
Danaus melanippus edmondii Bougainville, 1837	0(0)	1 (1.45)	3 (4.35)	4 (5.80)
Charaxes sp.	0(0)	1 (1.45)	0(0)	1 (1.45)
Symbrenthia hypatia (Wallace, 1869)	3 (4.35)	0(0)	0(0)	3 (4.35)
Acrophtalmia artemis C. & R. Felder, 1861	4 (5.80)	0(0)	2 (2.90)	6 (8.70)
Junonia hedonia (Linnaeus, 1764)	3 (4.35)	0(0)	1 (1.45)	4 (5.80)
Family Papilionidae				
Papilio polytes ledebouria Eschscholtz, 1821	9 (13.04)	0(0)	0(0)	9 (13.04)
Lamproptera meges decius C. & R. Felder, 1862	9 (13.04)	0(0)	0(0)	9 (13.04)
Papilio rumanzovia Eschscholtz, 1821	0(0)	1 (1.45)	0(0)	1 (1.45)
Papilio helenus hystaspes C. & R. Felder, 1862	4 (5.80)	0(0)	1 (1.45)	5 (7.25)
Family Pieridae				
Eurema hecabe Linnaeus, 1758	2 (2.90)	4 (5.80)	2 (2.90)	8 (11.60)
MOTHS				
Family Noctuidae				
Ercheia sp.	1 (1.45)	1 (1.45)	0(0)	2 (2.90)
Family Saturniidae				
Antheraea diehli Lemaire, 1979	1 (1.45)	0(0)	0(0)	1 (1.45)
Family Sphingidae				
Daphnis hypothous (Cramer, 1780)	0(0)	1 (1.45)	0(0)	1 (1.45)
Family Uraniidae				
Micronia aculeata Guenée, 1857	2 (2.90)	0(0)	0(0)	2 (2.90)
Total number of individuals	**44 (63.77)**	**11 (15.94)**	**14 (20.29)**	**69**
Total number of species	**13**	**7**	**6**	**17**

Legend: () - Relative Abundance in Percentage

The 13 species of butterflies collected belong to four families: Lycaenidae, Nymphalidae, Papilionidae, and Pieridae. The four species of moth are from four different families: Noctuidae, Saturniidae, Sphingidae, and Uraniidae. All the four butterfly families documented in this study were also observed in Kolkata, India [25, 26], in Plummers Island, Maryland [27], and Rema-Kalenga Wildlife Sanctuary of Bangladesh [28] while the moth families were also recorded in Sunderban Biosphere Reserve, India [29], in Khao Nan National Park, Thailand [30], and in northern Maharashtra [31].

The highest species richness was recorded under family Nymphalidae comprising six species (35.29%), followed by Papilionidae (4 species, 23.53%), Lycaenidae (2 species, 11.76%), and there was only one species (5.88%) for each of the remaining five families. The biotic and abiotic factors in the sampling sites could be the reason for the abundance and distribution of the Lepidoptera families and species in each family because according to Mukherjee *et al.* [25], the relative differences in family species distribution can be attributed to variations in habitat conditions in the sites sampled which could affect their existence. Similar trend of families in terms of species was also recorded by Sethy *et al.* [32] in India. In the Philippines, the study of Toledo and Mohagan [14] and Ramirez and Mohagan [21] found that Nymphalidae was the most dominant family consisting of 25 species in the area of Mt. Timpoong and Mt. Hibok-hibok and 43 species in Surigao del Sur. Other studies also found that Nymphalidae is the most abundant and dominant family in terms of species [10, 28, 33, 34, 35, 36]. According to Bora *et al.* [37] Nymphalid butterflies are dominant in tropical regions because most of the members of this family can feed on different types of food which make them able to live in all types of habitat. In addition, Nymphalidae is the largest family of butterflies in the world representing nearly one-third of the known species [38] and the polyphagous habits of butterflies in this family probably help them to exist in a variety of habitats [35].

In terms of sampling sites, the highest species richness and abundance was recorded in Site 1, the riparian area (S=13; 63.77%) followed by Site 3 (S=7; 20.29%), the forest area, and Site 2 (S=6; 15.94%), the highly disturbed area. The high species richness of both moth and butterflies (Lepidoptera) in riparian area (Site 1) was observed to be due to its secondary vegetation where varied food plants and flowering plants in an open canopy are present. According to Fjellstad [39] and Wangdi [40] butterfly species are associated and are more attracted to flowering plants and host plants as well as sunlight which is in the case of the habitat characteristics of Site 1. As for day-flying moths, they occur typically in open and sun-lit habitats while nocturnal moths require more open habitat conditions [41]. The study of Nacua *et al.* [24] somehow concurs with the finding of this study in which they found that high abundance and richness of butterflies is found in an open canopy forest where varied food plants are present and light penetrates the area for plant growth. In addition, the presence of more varied food plants and the open canopy in site 1 are the factors that cause the butterflies to thrive. Vu and Vu [9] also found that stream sides of the forest support greatest abundance of butterflies due to the diversified vegetation, rocks, sand, mud, and water that attract more butterflies. Ober and Hayes [42] found that riparian areas are expected to have high level of moth abundance given the greater plant species richness near streams. Munyuli [43] also found that sites associated with riparian forest could harbor high species richness and abundance of butterflies. Other studies found that riparian forests consist of moderate to high species richness and abundance of moths [42, 44). This suggests that riparian area of this study is important for Lepidopteran species richness. Forest area (site 3) had only six species which could be due to its close canopy where light penetration is less. Few flowering plants were observed. According to Gilbert and Singer [45] and Anbalagan *et al.* [38], the availability of food, access to sunlight to regulate body temperature, and open space for flight are some of the factors that determine the site selection of butterflies, thus less sunlight penetration as well as food plant in an area affect the existence of Lepidopterans. The slash-and-burn area (Site 2) had only seven species which could be due to the presence of on-site anthropogenic disturbance such as slash-and-burn that is characterized by very low plant density as well as vegetation cover. According to Cornell [46] and Sundufu and Dumbuya [47] slash-and-burn includes cutting down of many trees and woody plants which resulted in a mosaic of forest and disturbed habitats and thus affect the presence of Lepidoptera in an area. This concurs with the study of Cleary and Genner [48]; Cleary *et al.* [49] who found low species richness of butterflies in slash-and-burn area. Furthermore, degradation of forest could lead to the decline of unique plant diversity and vegetation complexity [50] which affects diversity of butterflies. Forested habitats have a tendency to have a higher Lepidoptera species richness than in highly disturbed areas [24]. In addition species richness of butterfly and moth communities significantly decreased in human-induced habitat gradient and fire-degraded sites [51]. However, in this study the slash-and-burn area (site 2) has slightly higher species richness than the forested area due to the large open space and the edge effect.

Table 2 is the seriation analysis showing the presence and absence of Lepidopteran species in the three sampling sites. More Lepidopteran species are exclusively found in riparian areas than forested and

disturbed areas. The seven species found only in the riparian area are: *Papilio polytes ledebouria, Micronia aculeata, Rachana* cf. *jalindra, Antheraea diehli, Lamproptera meges decius, Symbrenthia hypatia* and *Hypolimnas* sp. *Papilio polytes ledebouria* was the only endemic species recorded. According to Kunte [52] and Revathy and Mathew [53], *Papilio polytes* is usually found in riparian forest while Muller and Tennent [54] stated that *Symbrenthia hypatia* occurs in secondary rainforest and most commonly encountered along creeks. The presence of these species in riparian areas could be due to the habitat characteristics of having an opening where light penetrates and more varied food plant availability. According to Kumar *et al.* [34] butterfly distribution depends upon the availability of their food plant thus, indicating that open areas with more varied food plants and few disturbances are the preferred habitats for these species. *Daphnis hypothous, Charaxes* sp., and *Papilio rumanzovia* were only found in the slash-and-burn area (site 2) which means that these species can tolerate a disturbed habitat while there was no species exclusively found in site 3 (forest area). The species, *Danaus melanippus edmondii* was only found in both forested and disturbed areas. *Ercheia* sp. was only found in riparian and disturbed areas while *Papilio helenus hystaspes, Junonia hedonia, Acrophtalmia artemis* and *Anthene* sp. were only found in riparian and forested sites. Among the 17 species, two species were observed in all three sites, namely, *Eurema hecabe* commonly known as the Common Grass Yellow and *Anthene* sp. Both these species are found in Asia and Africa [55, 56, 57]. This implies that the presence of Lepidopteran in an area depends on the types of species as well as habitat characteristics because as what Nidup *et al.* [58] reported, many butterflies are restricted to specific habitat types and some are highly mobile. In addition, plant typology of the micro-habitat greatly influences the presence and richness of butterfly species [32].

Table 2: Seriation Analysis of Lepidopteran species based on sampling sites.

	Site 1 (Riparian area)	**Site 2** (Slash-and-burn area)	**Site 3** (Forested area)
**Papilio polytes ledebouria*		0	0
Micronia aculeate		0	0
Rachana cf. *jalindra*		0	0
Antheraea diehli		0	0
Lamproptera meges decius		0	0
Symbrenthia hypatia		0	0
Hypolimnas sp.		0	0
Ercheia sp.			0
Daphnis hypothous	0		0
Charaxes sp.	0		0
Papilio rumanzovia	0		0
Papilio helenus hystaspes		0	
Eurema hecabe			
Junonia hedonia		0	
Acrophtalmia artemis		0	
Anthene sp.			
Danaus melanippus edmondii	0		

*Philippine endemic

Biodiversity indices of the three sampling sites are shown in Table 3. High species diversity (>2.0) was observed in Site 1 while moderate species diversity was observed in Sites 2 and 3. The distribution of Lepidoptera was relatively even in all the sampling sites. High species diversity of Lepidopterans was observed to be associated with slightly disturbed riparian area having more varied secondary vegetation and open canopy while moderate diversity is associated with slash-and-burn area with very low plant density and undisturbed forested area with a close canopy. This indicates that high diversity of vegetation leads to a higher diversity of species while lower diversity of vegetation leads to low diversity of Lepidopterans which concurs with other previous studies [59. 60]. Blair and Launer [61]; Schulze *et al.* [62]; Vu and By [60] also found that butterfly diversity is usually lower in natural forests because of a darker and thick canopy, higher in disturbed forests, and highest in moderately disturbed forests which somehow concurred with the findings and site characteristics of this study. In addition, they reported that environment along stream sides or wetland forest are especially diversified with vegetation, rocks, sand, and water which all attract butterflies as they land to take water and nutrient which could support

the riparian diversity in this study. On the other hand, the diversity of Lepidopterans is dependent on plants because caterpillars have strict dependence on specific host plants and adult nectar plants [38]. Also, butterfly communities avoid the low temperature [58] and thus open areas with natural vegetation have the greatest diversity of butterflies [63]. This also proves that habitat is the main factor which affects the differences or similarity of butterfly communities [60, 64].

Table 3: Biodiversity indices of Lepidoptera in three sampling sites.

	Site 1 (Riparian area)	**Site 2** (Slash-and-burn area)	**Site 3** (Forested area)
Taxa	13	7	6
Individuals	44	11	14
Dominance	0.1219	0.2066	0.2245
Shannon	2.314	1.768	1.631
Evenness	0.7781	0.8368	0.8513

CONCLUSION

Bega Watershed has a rich lepidopteran diversity which may be attributed to micro-habitats within the study area. Family Nymphalidae dominated the study area while *Eurema hecabe* and *Anthene* sp. were the most distributed species which indicate that these two species can inhabit and tolerate disturbed and close canopy habitats. The endemic species, Papilio polytes ledebouria was only recorded in riparian area. Among the sampled sites, riparian area had the highest species richness, abundance, and diversity making it an important habitat for Lepidopterans. Conversion of forest land for agricultural use was seen as one of the factors that could affect the species richness and diversity of Lepidoptera in Bega Watershed.

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