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Butterfly Diversity and Distribution of Southwestern Ethiopia. In Case of Chebera Churchura National Park and Its Surrounding Farmlands

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Abstract

A total of 79 butterfly species from 3801 individuals were recorded. The riverine forest had the greatest diversity, with 54 species and 1611 individuals, and the least, the mosaic habitat, with 23 species and 659 individuals. The Shannon and Simpson indices were highest in the riverine, followed by wooded grassland and the mosaic habitat. There was a significant difference across land use types with Kruskal-Wallis of H=19.89 and p=1.274 E-05. The butterfly diversity varied with the month of sampling, such that January had the highest, followed by February, and the lowest was recorded in June. In riverine forest, the highest was recorded in January and the least was in June, while wooded grassland had the highest in January and the least was in March. In the mosaic habitat, January was the most abundant month, and May was the least abundant. Jaccard's index of similarity indicated the lowest similarity was found between the riverine forest and the mosaic habitat. The number of butterflies showed a strong positive correlation with minimum and maximum temperatures and a strong negative correlation with average precipitation. The recent study found an important habitat for butterflies, but additional research is needed to find new species.

Keywords: Butterfly diversity • Chebera churchura • Conservation • Diversity • Land use

Introduction

Butterflies are grouped in order Lepidoptera together with moths and they are the most studied and well-known insects [1]. There are approximately 46 superfamilies, 128 families, and 180,000 species of described Lepidopterans (moths and butterflies) around the world and only less than 10% are butterflies. So far, 2,438 species of lepidoptera comprising 48 families listed in Ethiopia of this 426 species with in ive families are butterflies [2]. They are the most successful insects and found in all parts and habitats of the world except Antarctica [3]. Butterflies are respectable indicators of environmental impacts on biodiversity in different land uses and play important role in the regular functioning of healthy ecosystem [4,5]. The presence of butterflies indicates the presence of other invertebrates such that habitats rich in butterflies are supposed to be rich in other invertebrates. Pollination is the process of transferring pollen grains from one plant to another plant and butterflies play substantial role in natural and agricultural pollination as they feed on nectars of plants. Like other insects' butterflies are important component of the feeding chain in the ecosystem and are important food source for birds, bats, and other invertebrates. Butterflies have been used as model organisms to study the impact of habitat losses, and fragmentation and climate change by ecologists [6]. Nevertheless, of the above functions, insects' biodiversity is decreasing at a speedy rate, butterflies are at the frontline of decline, and the most common causes of species decline are habitat loss, degradation, and fragmentation [7]. Different land use types support different species of insects [8-10]. Thus, understanding and discovering butterfly diversity in different land areas use types plays an important ecological role in conserving biodiversity conservation to enhance policy decisions about our environment.

According to literature searches on butterfly's diversity in Ethiopia, about 87 butterfly species were identified in Belete-Gera forest, Ethiopia, 46 species from the Menagesha-Suba State Forest, Ethiopia, while 43 butterfly species were identified from the Gura-Ferda forest, Gura-Ferda woreda, Ethiopia. Similarly about 19 butterfly species were identified from west Shewa while 64 species of butterflies from Jimma Highlands were observed and document described [11-14]. However, no publication on the diversity of butterflies from different land use types in and around Chebera Churchura National park, Southwestern, Ethiopia. Thus, the study focused on the identification, abundance and biodiversity of butterflies on three different land-use types in and around Chebera Churchura National park, Southwestern, Ethiopia and their impacts.

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Materials and Methods

Study area description

The study area was situated at 6º53′14″N and 36º38′11″E and it is 480 km away from Addis Ababa. The park's elevation ranges from 700 to 2450 meters above sea level, with an average yearly temperature of 10 to 29 degrees Celsius. The annual rainfall averages between 1200 mm and 2300 mm. The park has an area of 1119 km^2 and have four vegetation zones, namely wooded grassland, riverine forest, mountain woodland, and woodland (Figure 1) [15].

Three land-use types namely wooded grassland, riverine forest, and mosaic habitat were selected based on information from literatures and based on the accessibility of the habitats. The geographical coordinates of all the sampling sites were measured with a Global Positioning System (GPS) device. Each of the land use types are described below as follows. Riverine Forest (RF): It was located at 36°41" 00.60"E and 07°00' 36"N and at 1176 m.a.s.a. It was characterized by di erent plant species and lowing water. The main plant species of this land use types were *Cordia africana, Terminalia laxiflora, Combretum collinum, Clerodendrum alatum, Satureja montana, Ficus sycomorus, Syzygium guineense, Sida rhombifolia,* and *Grewia mollis*.

Wooded Grassland Habitat (WGL): It was positioned at 36°37" 47.88"E and 06°54' 00" N and 1587 m.a.s.l. and covers 62% of the park is an area covered by herbaceous plants with less tree and herb coverage such as *Acanthus mollis, Eseveria abyssinica, Crinum ornatum, Ocimum gratissimum,* and *Clerodendrum alatum*. Mosaic environment: It was found at 36º40"17.04"E and 07º01'12"N and elevation 1444 mal found in Seri kebele outside of the national park. It was mainly its high level of interaction with wildlife, and lepidopterans do not appear to be immune to the efects of human interaction *Mangifera indica, Colocasia esculenta, Terminalia laxifelera, Combretum mole, Combretum collinum, Entada africana, Prunus africana* and *Harrisonia abyssinica* were some representatives.

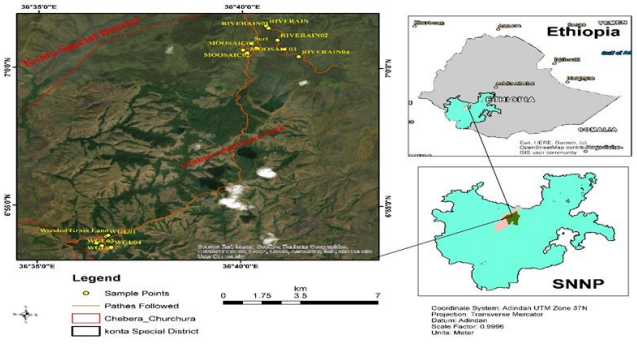

Figure 1. Map of Chebera Churchura national park.

Butterfly collection and identification

Purposive sampling was used to collect samples of butterflies according to pollard line transect method [16]. Surveys were conducted once a month for each site from January 25 to June 25, and sampling was done from 9:00 am to 12:00 am and 2:00 pm to 4:00 pm each site was sampled once every month and six times throughout the sampling period. All the voucher specimens were stored and identified at Ethiopian biodiversity institute. The identification of the specimens was done using all available publications/keys such as [17-19]. Climate trend analysis was also done using Microsoft Excel version 2016 by taking the climate data for the five years from 2013 to 2017 from the world climate database to analyze the effect on the population's distribution [20].

Data analysis

Diversity indices: Selected diversity indices namely Shannon diversity index, Simpson diversity index, species richness, evenness, and abundance. Shannon diversity index: is the measure of species richness and abundance using the following formula. $H=-\sum[(pi) \times \log (pi)]W$ here: H-Shannon diversity index; pi-Proportion of individuals of ith species in a whole community; n-individuals of a given species; N-total number of individuals in a community; ∑-Sum symbol and log-Usually the natural logarithm. Simpson's diversity indices: Is the value of Simpson's index reflects how many different types of species are in a community and how evenly distributed the population of each species is. It is the probability that any two individuals randomly selected from an in initely large community will belong to the same species, given by the following formula: $D=\Sigma pi^2$ where D is the dominance index, 1-D is Simpson's diversity index; pi is the proportion of individuals in the ith species.

Evenness: Pielou's measure of species evenness given by the formula J=H'/ln(S) where H' is Shannon Weiner diversity and S is the total number of species in a sample, across all samples in dataset. Abundance of species: is the actual number of individuals in a population. Species richness: S is the total number of species in a sample, across all samples in dataset. Jaccard's index (Cj)=j/(A+B-j) was used to determine the similarity of lepidopterans in different habitats. Where j is the number of species that are similar to both sites, and A is the number of species that are unique to each site 1 B=the total number of species at site 2.

Statistical analysis: SPSS version 26 was used to calculate the significance habitat association using *chi-square* test regarding to moth species diversity and abundance. Pearson's Correlation of butterfly species with climatic data was also calculated. PAST 4.10 were also used to calculate the diversity indices and species refraction curves.

Results

Composition of total butterfly species

A total of 79 butterfly species with five families, 3801 individuals and 33 genera were recorded in the study area (Table 1). Family Nymphalidae with 42 species (57.6% of total population of sampled butterflies), has the highest abundance while family Pieridae with 17 species (22%) and 7 genera was ranked the second diversified followed by family papilonidae, Lycanidae, abd Heaspariidae.

No	Family name	Species number (%)	Number of individuals (%)	Genera number
1	Nymphalidae	42 (53%)	2191 (58%)	17
2	Pieridae	17 (22%)	1173 (30%)	7
3	Lycanidae	8 (10%)	278 (7%)	6
4	Papilonidae	10 (13%)	145 (4%)	2
5	Hesparidae	2 (2%)	14 (1%)	1
	Total		3801	33

Table 1. Butterfly's abundance in the study area.

Butterfly species composition across land use types

Riverine forest had the greatest diversity and abundance with 54 species and 1611 individuals, and the least species composition was recorded in mosaic habitat with 23 species and 659 individuals (Table 2). Kruskal-Wallis test was used to test the significance and reveled that (H (chi^2))=19.89, p=1.274E-05) there was significant difference between sample medians across land use types. Table 3 showed that species composition and abundance in the three different land use types. In the riverine forest *Acraea acara* and *Belenois aurota* were the most frequently occurring species while the least frequent species was *Graphium angolanus*. The most abundant species in wooded grassland were *Leptosia alcesta* and the least abundant were *Cacyreus lingeus* and *Deudorix antalus*. The highest abundant butterfly species in the mosaic habitat was *Anthene opalina* while the least abundant was *Dixeia orbona*. Butterfly species of members of the families Nymphalidae, Pieridae, Papilionidae and Lycaenidae were common across the three land use types with exception of members of the family Hesparidae absent in mosaic habitat.

Diversity indices	Riverine forest	Wooded grass land	Mosaic habitat
Taxa_S	54	44	23
Individuals	1611	1531	659
Simpson_1 - D	0.9707	0.969	0.9238
Shannon_H	3.712	3.584	2.808
Evenness_e^H/S	0.7581	0.8189	0.7207

Table 2. Diversity of butterfly communities in the three land-use types.

Family name	Species name	Habitat type		
		Rf	WGL	Mo
Nymphalidae	*Acraaea acara*	100	60	57
	Acraea caecilia	0	56	0
	Acraea chilo	50	45	0
	Acraea egina	0	0	0
	Acraea pseudegin	21	70	0
	Acreeaea braesia	0	61	0
	Acreeaea cerasa	40	56	46
	Amauris albimaculata	32	34	30
	Amauris echeria	23	0	0
	Amauris niavius	55	0	0
	Bematistes aganice	34	0	0
	Bicyclus angulate	64	0	0

	Bicyclus anynanaa	0	0	0
	Bicyclus campus	0	0	0
	Bicyclus vulgaris	20	0	0
	Byblia anvatara	39	75	0
	Charaxes candiope	10	47	0
	Charaxes eurinome	10	40	0
	Charaxes jahlusa	12	20	80
	Charaxes numenes	8	0	0
	Charaxes tiridates	9	0	0
	Cyrestis camillus	8	0	0
	Euphaedra medon	9	0	0
	Eurytela dryope	0	0	0
	Hamanumida daedalus	21	0	0
	Hypolimnas anthedon	10	30	26
	Hypolimnas misippus	0	0	0
	Junnonia chroimene	40	0	0
	Junnonia hierta	25	0	0
	Junonia oenone	30	30	0
	Junonia Sophia	0	30	0
	Junonia terea	30	45	40
	Neptis agouale	0	34	45
	Neptis laeta	0	40	61
	Neptis serena	20	30	0
	Phalaanta eurytis	42	30	0
	Phlantat phlanta	50	0	0
	Precis antilope	0	25	0
	Protogoniomorpha parhassus	10	0	0
	Pseudacraea boisduvali	23	0	0
	Pseudacraea lucretia	43	0	10
	Ypthima asterope	50	0	0
Pieridae	*Belenois aurota*	100	45	12
	Belenois creona	50	34	17
	Belenois gidica	0	34	7
	Belenois raffrayi	0	0	11
	Belenois thysa	0	60	17
	Belenois zochalia	22	0	25
	Catopsilia florella	0	80	0
	Catopsilia scylla	60	54	0
	Dixeia orbona	0	70	20

	Eurema brigitta	60	34	0
	Eurema desjardinsiii	50	50	0
	Eurema hecabe	43	0	10
	Eurema regularis	70	0	15
	Leptosia alcesta	0	56	11
	Mylothris agathina	0	30	0
	Mylothris rueppellii	0	22	0
	Nepheronia buquetii	0	0	4
Papilonidae	*Graphium almansor*	9	0	0
	Graphium angolanus	4	0	0
	Graphium leonidas	6	0	0
	Papilio dardanus	18	8	0
	Papilio demodocus	15	16	9
	Papilio echerioides	5	0	0
	Papilio microps	5	8	0
	Papilio nireus	13	10	7
	Papilio rex	7	0	0
	Papilio wilsoni	5	0	0
Lycaenidae	*Anthene amarah*	35	9	0
	Anthene definita	45	6	99
	Anthene opalina	35	10	0
	Cacyreus lingeus	0	4	0
	Deudorix antalus	0	12	0
	Eicochrysops hippocrates	0	4	0
	Lachnocnema emperamus	10	9	0
	Zizula hylax	0	0	0
Hespariidae	*Coeliades forestan*	6	0	0
	Coeliades pisistratusb	0	8	0

Note: RF: Riverine Forest; WGL: Wooded Grass Land; Mo: Mosaic habitat

Table 3. Species list and abundance of butterflies in different habitats.

According to the diversity indices (both Shannon and Simpson indices), results demonstrated that the riverine forest has the highest species diversity followed by wooded grassland and the least diverse was the Moosic habitat. The evenness index was highest in wooded grassland followed by riverine forest and the least was recorded in Moosic habitat. Jaccard index of similarity of butterflies by habitat type was calculated and results showed that the highest similarity was found between wooded grassland and mosaic habitats, followed by riverine forest and wooded grassland, and the least was between riverine forest and mosaic habitat (Table 4).

Comparison	**Jacarda index of similarity (j)**			
	J	**A**	**b**	**j/a+b-j**
Riverine *vs*. wooded	22	54	43	0.29
Riverine *vs*. mosaic	16	54	23	0.26

Wooded *vs.* mosaic	17	43	23	0.34

Note: (j=the number of species found in both sites a=the number of species in site Ab=the number of species in site B)

Table 4. Jaccard index of similarity by habitat.

Monthly abundance of butterfly species across land use types

Based on month of sampling January had the highest number of butterflies, with 940 individuals accounting for 25%, followed by February, with 749 individuals accounting for 20%. The lowest number of butterflies was recorded in the month of June with 460 individuals accounting for 12% (Figure 1). Out of 1,611 butterflies recorded from the riverine forest, 420 butterflies (highest) was recorded in January and the least recorded in June 169. Wooded grassland had about 1,531 butterflies with 300 (highest) butterflies in January and the least was 170 in March. From the total of 659 butterflies recorded in mosaic habitat, the highest abundance was recorded in January with 220 butterflies and the less abundant month was in May with 65 individuals (Figure 2).

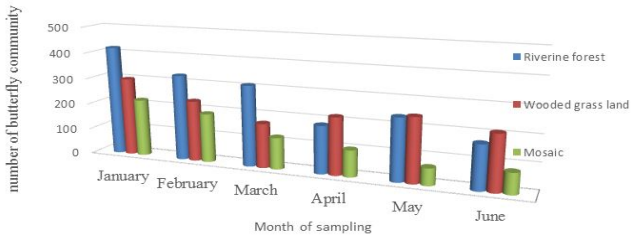

Figure 2. Monthly abundance of butterfly species across land use types.

Generally, the average monthly rainfall showed increasing trend and decreasing trend of maximum and minimum temperature from January to June (Figure 3). Pearson's correlation coefficient analysis result showed that number of butterflies showed strong positive correlation with minimum and maximum temperature and strong negative correlation with average precipitation (Table 5).

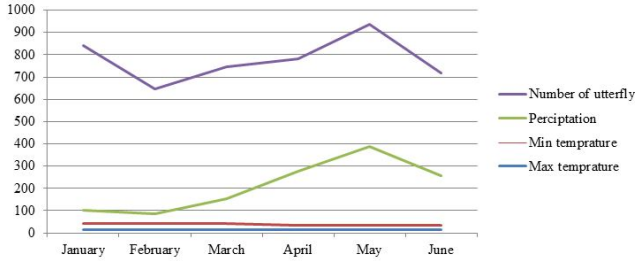

Figure 3. Month wise species abundance along with seasonal changes.

Correlation (r)	Number of butterfly	Max temperature	Min temperature	Precipitation
Number of butterfly	1			
Max temperature	0.74066	1		
Min temperature	0.70619	0.90579	1	
Precipitation	-0.6	-0.92582	-0.79446	1

Table 5. Pearson correlation coefficient analysis of total butterfly species with temperatures and precipitation.

Discussion

The diversity of butterflies was studied in and around Chebera Churchura national park on three different land use types. Based on calculated diversity indices, the diversity of butterflies in and around Chebera Churchura national park is very high. Because the area was distant, devoid of human settlement and agricultural activities, and no considerable deforestation has occurred. As mentioned in different literatures the diversity of butterflies grows in tandem with the diversity of plants. Five families of butterflies have been reported from Ethiopia and all the five families were reported in the current study.

In this study, 79 species of butterflies were identified, which is more than the 64 species of butterflies identified in a previous study done in the Jimma highlands of Ethiopia, 43 from Menagesha-Suba state forest, 43 from Gura-Ferda forest. Some authors confirmed higher numbers of identified butterfly species, such as 87 species from Ethiopia's Belete-Gera forest. In the current study family Nymphalidae was the most abundant due to the reason that they inhabit a variety of habitats, they need open habitat, and feed on a variety of plant species. This result agrees with the results. Butterfly species from the family Hespariidae have been recorded with lower abundance and diversity due to most species have limited host plants.

Comparing the three habitats based on butterfly diversity riverine forest was highly diversified habitat followed by wooded grassland and mosaic habitat was documented with lower diversity of butterflies. The possible reasons could be riverine forest was found inside the national park that is relatively free of human and animal interaction, has a relatively highest diverse plant and provided with river. Due to heavy human and animal disturbance, the mosaic ecosystem has reduced butterfly and plant variety. This shows that protected habitats support more diversity of butterfly species and unprotected and degraded habitats supports less diversity of butterflies. Investigated the diversity of butterflies in and around

Manembo-Nembo wildlife reserve in North Sulawesi, Indonesia, and found that diversity out of the wild life reserve were less than inside of the wildlife reserve.

The three habitats' types were compared by butterfly diversity and the highest similarity index of butterfly communities was found between the wooded grassland and mosaic habitat. This could be the reason that the ecological environment of the two habitats could be similar type and the distance between the habitats were not far from each other.

The number of butterflies varies depending on weather conditions because butterflies are ectothermic and weather affects adult light needed for oviposition, affects the survival of the immature stages and it affects the fecundity rate of butterflies. In the current study area, the sampling month affected the abundance of the butterfly individuals. The number of butterflies decreased from January to June, such that the highest number was recorded in January and the lowest number was in June. The weather data trend analysis revealed that the average monthly rainfall increased from January to June, while the average monthly maximum and minimum temperatures decreased. In this case, the results of the current study agree with the above conclusions. However, the lowest abundance of individuals in June does not necessarily represent the whole population abundance of butterflies in the study area. Butterflies may be present in the study area but undetected because of diapause as adults. The number of pray and predators may contribute the population difference in the study area. In general, the diversity of butterflies in and around Chebera Churchura national park was found suitable for butterflies' diversity.

Conclusion

The current study focused on the diversity of butterflies in three different land use types. The study region was generally found to be rich in the diversity and abundance of butterflies in all three forms of land use and in all the months of sampling. However, the study area is currently becoming an investment hub, and many road development projects are being planned and ongoing human activities will devastate and harm the richness, abundance, and diversity of butterfly species. As a result, such human induced activities need to be carefully studied to protect biodiversity loss in the current study area and particular attention should be paid to the conservation of biodiversity in general.

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