Open Journal of Ecology, 2024, 14, 274-291
https://www.scirp.org/journal/oje
ISSN Online: 2162-1993
ISSN Print: 2162-1985

Impacts of Human Activities and Season on Species Diversity and Abundance of Butterflies in Mpanga Kipengere Game Reserve and Surrounding Farmlands, Tanzania

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How to cite this paper: Kasisi, P.M., Mbije, N. and Lyimo, P. (2024) Impacts of Human Activities and Season on Species Diversity and Abundance of Butterflies in Mpanga Kipengere Game Reserve and Surrounding Farmlands, Tanzania. *Open Journal of Ecology*, **14**, 274-291.
https://doi.org/10.4236/oje.2024.144017

Received: October 10, 2023
Accepted: April 14, 2024
Published: April 17, 2024

Abstract

Maintaining natural habitats is crucial for the preservation of insects and other species that indicate environmental changes. However, the Mpanga/Kipengere Game Reserve and its surrounding farmlands are facing disturbance due to human activities, which is putting many wildlife species, particularly larger mammals, at risk. To determine the impact of human activities on butterfly species diversity and abundance in the reserve and its surrounding areas, we conducted a study from November 2021 to October 2023. We collected butterfly data using transect walks and baited traps in two habitat types. Our study yielded 2799 butterfly Individuals ranging in 124 species divided into five families habitat, season, and anthropogenic factors are significant environmental variables influencing species diversity and abundance of butterflies. Therefore, it's important to protect habitat and dry-season water for the conservation of invertebrates such as butterflies. Our study findings provide essential information for ecological monitoring and future assessment of the Mpanga/Kipengere Game Reserve ecosystem health.

Keywords

Mpanga Kipengere Game Reserve, Species Diversity, Habitat, Butterflies, Season, Human Activities

1. Introduction

Identifying high-value sites based on their biodiversity content is a crucial aspect of any conservation strategy [1]. Unfortunately, in recent years, human activity has put increasing pressure on biodiversity, posing challenges for biologists dealing with anthropogenic disturbances [2] [3]. Human activities are known to cause environmental changes that have adverse effects on plants and animal species in protected areas [4] [5]. Human activities that cause disturbances in natural areas can have a direct impact on important species' needs, such as food, cover, and nesting sites, according to [6]. Among these species, butterflies are known to be particularly sensitive to environmental changes, as noted by [2] [7]. Natural habitats play a crucial role in the conservation of insects and other arthropods, providing them with essential elements like food, shelter, and nectar [8] [9] [10]. When natural ecosystems are disrupted, it can have negative consequences for plants and animal species [11]. Insects, as a major taxonomic group, have been particularly impacted, exemplifying these challenges [12] [13].

The Mpanga Kipengere Game Reserve (MPKGR) is known for its rich biodiversity and high levels of endemism in both flora and fauna [14]. To effectively conserve this biodiversity, it is necessary to have a broad understanding of the classification, distribution, and biogeography of various indicator species [11] [15]. Among these, butterflies are considered a prime group for such assessments [16] as they can provide valuable information on environmental changes and help monitor and assess ecosystem health [13] [17] [18] However, the only available information on the butterflies in MPKGR is from a biodiversity survey conducted by Frontier Tanzania in collaboration with the University of Dar es Salaam and WWF back in 2003. Previous research has mostly focused on vertebrate species in the area, with little attention given to invertebrates beyond the game reserve where human activities take place.

To gain a better understanding of the diversity patterns of invertebrate species in different areas with varying conservation designations, it is essential to gather more data on a wider range of taxa [19] [20]. This will provide valuable insight into effective biodiversity management on a larger scale. By establishing a baseline for future monitoring, we can work towards preserving the biodiversity in this ecosystem, which has been impacted by human activities. Therefore, this study was conducted to provide valuable information to MPKGR Management regarding butterfly conservation, ecological monitoring, and ecosystem health assessment. Its objectives were to:

1) Evaluate the impact of human activities on butterfly species diversity and abundance in both MPKGR and adjacent farmlands.

2) Analyze the occurrence and seasonal variations of butterflies in MPKGR and compare them to those in adjacent Farmlands.

The study's hypothesis is that butterfly species composition and diversity will differ between natural and disturbed habitats during various seasons.

2. Material and Method

2.1. Study Area

The Mpanga Kipengere Game Reserve (MPKGR) is situated in the Southern

Highlands within Wanging'ombe and Makete districts of the Njombe Region, as well as the Mbarali District in the Mbeya Region. Its latitude ranges from 8˚50' to 9˚10' South, while its longitude ranges from 34˚00' to 34˚30' East. The reserve is surrounded by 24 villages, which are divided into five divisions: Wanging'ombe (7 villages), Imalinyi (3 villages), Ikuwo (9 villages), Lupalilo (1 village), and Rujewa (4 villages). To reach the reserve, one can use road, railway, or air transportation as it is located near Mbeya (135 km) to the southwest, Njombe (80 km) to the southeast, and Iringa (195 km) to the northeast. Other towns such as Makambako, Ilembula, Igawa, and Chimala are also nearby and are experiencing rapid growth. The rainfall distribution in MPKGR is greatest at higher altitudes and is peaking between March and May [21]. Rainfall is greatest in the southeast of the mountains, increasing from 1200 mm annually in the foothills to over 2300 mm at higher altitudes [21]. The dry season occurs from June to August and the wet season starts from November to May. The vegetation of these forests' ranges includes lowland forests at 300 m on the Eastern side, sub-montane forests, and montane forests (**Figure 1**).

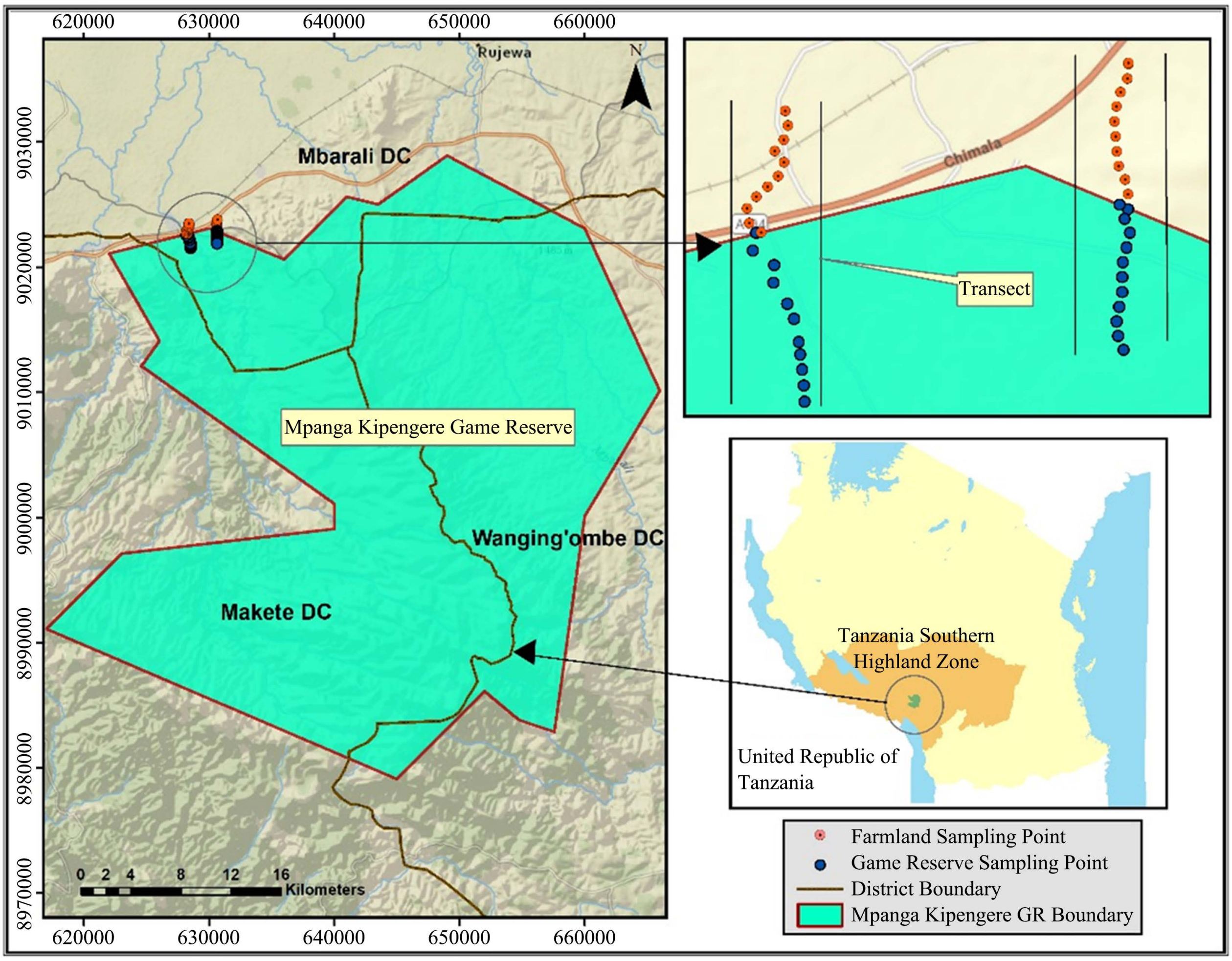

Figure 1. Map of Mpanga Kipengere Game Reserve showing location, districts, transects, and sampling points along MPKGR and adjacent Farmlands.

2.2. Sampling Design and Data Collection

For the study, two transects measuring 1000 m each were created. One-half of each transect spanned 500 m inside the MPKGR while the other half extended 500 m into adjacent farmlands. Within each transect, 20 sampling points with 50-meter distance from one point to another were established, and the study period lasted for 12 consecutive months, from November 2021 to October 2022. During this time, butterflies were sampled for 10 days each month, during two time slots: 9:00-11:00 am and 3:00-5:00 pm. The sampling methodology outlined by [14] was followed, and two methods were employed to collect butterfly samples: baited traps and sweep nets.

2.3. Data Collection

Field data sampling

To catch butterflies attracted to fermenting fruit, we used traps baited with fermented bananas. We followed the process described by [22] [23] and constructed the traps from local materials based on the Van Someren-Raydon Trap design [24]. The bait was made by mashing ripe bananas and pineapples and then allowing them to ferment for three days. We placed traps at the center of each sampling point, 100 meters apart. Regular checks were performed, and the number of butterflies caught was recorded as individuals per trap per day.

To collect butterflies from areas where traps couldn't be placed easily, we used sweep nets based on the methodology outlined by [25]. We spotted flying butterflies along the transect or around the traps and caught them using the nets. Once collected, we identified each butterfly species using the key described by [17] and counted them. For harder-to-identify individuals, we took photos since we couldn't remove them from the Game reserve. These photos were then shared with butterfly taxonomists to confirm their identification.

Environmental data

To comprehend the impact of environmental factors on species richness, abundance, and community composition, we obtained data on annual temperature, mean annual precipitation, and solar radiation from (https://weatherandclimate.com/tanzania/njombe/kipengere#t3). Furthermore, we recorded the type of habitat at all sampling points. Topographic factors including elevation, slope, and aspect were extracted from the raster layer derived from the SRTM 30 m-based DEM-USGS Earth Explorer (https://earthexplorer.usgs.gov/).

2.4. Data Analysis

To compute variations between habitats (MPKGR and Farmlands) and seasons (Dry and Wet) we calculate their butterfly species abundance, diversity, richness, and evenness. In determining the species richness and abundance of butterflies, a species checklist was created. This checklist consisted of four variables: the name of the butterfly species, its family, the number of individuals counted, and its habitat and season of occurrence. Jaccard's Similarity Index was used to measure similarities of butterfly species diversity between MPKGR and Farmlands. The formula for Jaccard's Index was $J(A, B) = |A \cap B|/|A \cup B|$ where the Jaccard's Similarity Index value is 1 indicates that two datasets share the same members, and if there are no common members then the Jaccard Similarity Index will be 0.

Computer software Palaontological Analysis (PAST) was used to compute the Shannon Wiener Diversity Index (H) and to plot rarefaction interpolation and extrapolation curves to ensure that the sample size we use is enough and Pielou's evenness index to compare butterfly species distribution between MPKGR and Farmlands. The formula for the Shannon index $H = -\Sigma [(pi)*\log(pi)]$ (Shannon-Wiener, 1949) was used where; Pi is a proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of calculations and s is the number of species while Pielou's Index formula was $J = H'/\ln(S)$ where H' is Shannon Weiner diversity and S is the total number of species in a sample, across all samples in a dataset. Indicator species analysis was performed to identify significant dominant species of the butterflies' communities, using the computer software PAST.

3. Results

3.1. Butterflies' Community Composition Diversity, Richness, and Abundance

In our study, we documented 124 butterfly species from five Lepidoptera families (Nymphalidae, Pieridae, Lycaenidae, Hesperiidae, and Papilionidae), with a total of 2799 individuals observed. *Neptis morosa* was observed to be the most dominant of all species with a total abundance of 0.03358 whereas *Pseudacraea lucretia expansa* were the most dominant species of all individuals recorded in farmlands (**Appendix**). Shannon wiener diversity index indicates that MPKGR is more diverse (H = 4.49) compared to Farmlands (**Figure 2**). Butterfly species in MPKGR and Farmlands have even distribution according to Pielou's evenness index, with values of 0.947 and 0.91 respectively. Additionally, the results reveal that both habitats share most of the same species, as the Jaccard's Index value calculated was 0.629.

3.2. Species Found in Specific Habitat

A total of 124 butterfly species (MPKGR-110 and Farmland-92) were observed, whereby 78 butterfly species, which account for 62.9% of all recorded species, were observed in both MPKGR and Farmlands. Out of these, 32 species (25.8%) were only seen in MPKGR, while 14 species (11.29%) were exclusive to Farmlands. The family Nymphalidae accounted for the majority of species observed in both locations. Most of the butterfly species observed to be specific in either MPKGR or Farmlands belong to the families Lycaenidae, Pieridae and Nympharidae (**Appendix**). We believe that our butterfly sampling was thorough enough for the time and season of our survey, as the rarefaction extrapolation curves almost reached asymptotes in both MPKGR and farmlands (**Figure 3**).

Additionally, the rarefaction and extrapolation curves based on coverage percentage suggested that the diversity in our study region was well-represented with a sample coverage percentage above 95% as shown in (**Figure 4**).

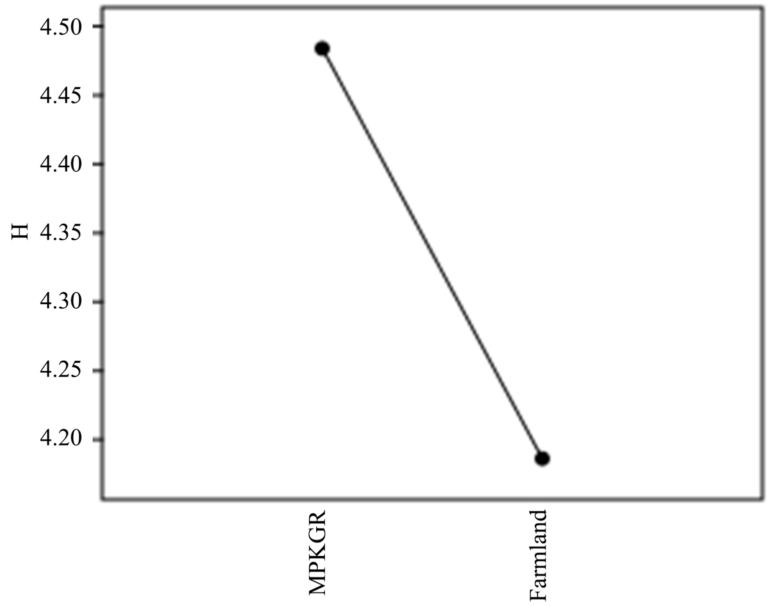

Figure 2. Shannon wiener diversity index (H) computed from Computer software Palaontological Analysis (PAST). The result indicates the diversity is higher in MPKGR compared with Farmlands.

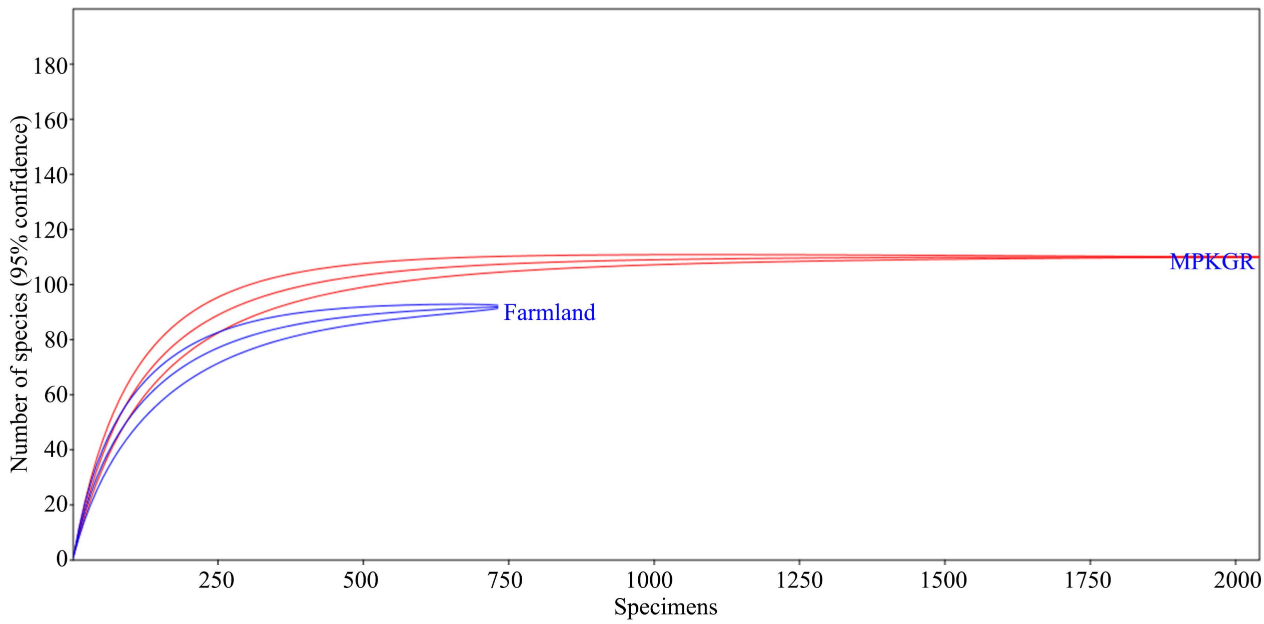

Figure 3. The size-based rarefaction and extrapolation curves show the species richness at MPKGR and adjacent Farmlands, with the inner line representing interpolation and the outer line representing the 95% confidence intervals.

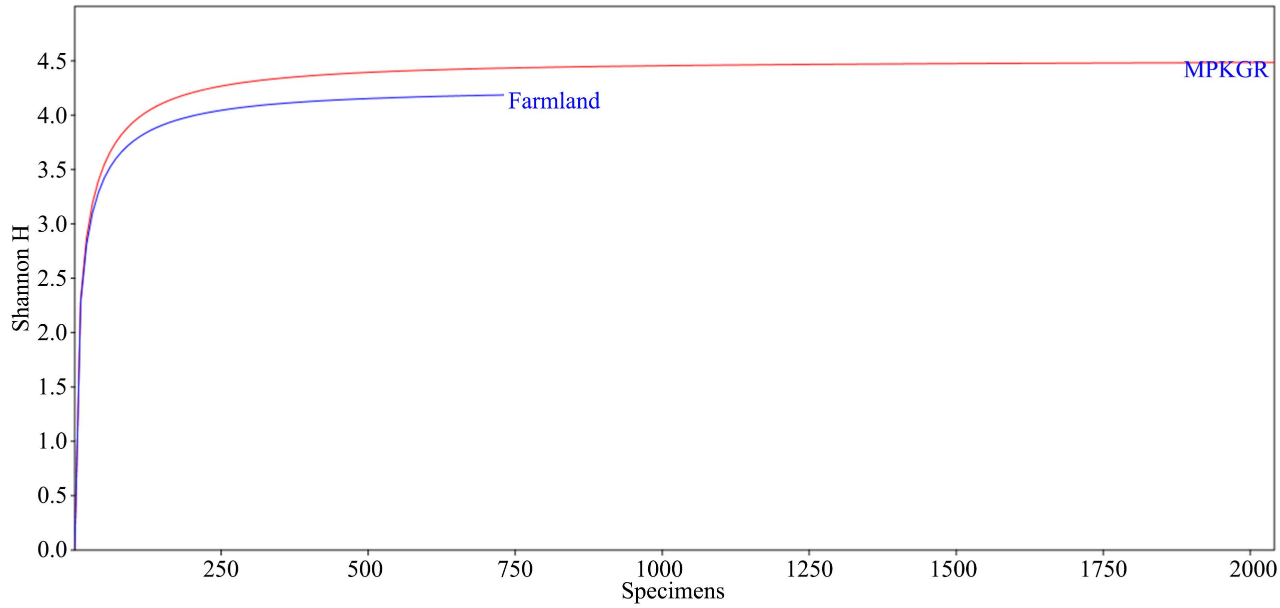

Figure 4. The rarefaction and extrapolation curves based on size display butterfly diversity and sample representation at MPKGR and adjacent Farmlands with 95% confidence intervals.

3.3. Seasonal Variations and Monthly Occurrences of Butterflies

According to the results, the month of April during the rainy season had the highest number of species (96) with a total of 524 individuals making up 77% and 18%, respectively of all species and individuals collected. The average temperature and rainfall were recorded at 26.44˚C and 6.7 mm. On the other hand, during the dry season in September, the number of species dropped to 39 (31.45%) with only 146 individuals (5.22%). The average temperature and rainfall were reported at 24.94˚C and 0.02 mm, respectively (**Table 1**).

3.4. Indicator Species and Endemic Species

We have identified a total of 9 butterfly species that serve as indicators for both MPKGR and Farmland. Of these 9, 6 species (*Neptis morosa*, *Neptis serena serena*, *Colotis antevipe zera*, *Colotis auxo incretus*, *Azanus ubaldus*, *Graphium antheus*) are considered generalists as they can be found throughout the year in both habitats. The remaining 3 species are specific to their respective habitats and can only be found during the wet season. These species are *Acraea servona*, *Pseudacraea lucretia expansa*, and *Acraea pudorina*. This study also observes the presence of two endemic species, *Charaxes congdoni* and *Harpendyreus juno* which are endemic to the southern highlands, including the MPKGR area.

4. Discussion

Species diversity and abundance

Our findings indicate that MPKGR recorded a significantly larger diversity and abundance of butterflies than the adjacent Farmlands. The reason behind the high number of individual and species of butterflies observed in Mpanga

Table 1. Monthly occurrence of butterfly species in relation to the influence of temperature and rainfall.

Month	Number of species	% of Species	Number of counts	% of count	Average temperature (˚C)	Average Rainfall (mm)
January	45	36.29	163	5.82	26.73	17.94
February	56	45.16	209	7.47	26.19	17.72
March	71	57.26	473	16.90	25.59	20.13
April	96	77.42	524	18.72	26.44	6.7
May	68	54.84	286	10.22	25.87	1.23
June	53	42.74	198	7.07	16.51	0.51
July	49	39.52	172	6.15	15.63	0.37
August	47	37.90	164	5.86	17.22	0.02
September	39	31.45	146	5.22	24.94	0.02
October	41	33.06	147	5.25	27.49	0.23
November	43	34.68	151	5.39	28.22	0.65
December	39	31.45	166	5.93	26.69	10.66

Kipengere Game Reserve could be due to the miombo woodland present there, as opposed to the cultivated areas in the Farmlands. This suggests that woodland and wooded grassland habitats may provide a better quality of life for butterflies as explained by [26] [27]. These qualities include the availability of larval host plants and food resources in these habitats [28] [29]. Additionally, the low abundance and species richness recorded in the Farmlands could be attributed to the habitat disturbance caused by human activities like tree cutting [30] [31] [32]. Such habitat disturbances directly remove the required conditions for butterfly breeding, thus affecting their overall abundance and richness [33] [34].

Species found in specific habitat

A total of 78 butterfly species, which account for 62.9% of all recorded species, were observed in both MPKGR and Farmlands. Out of these, 32 species (25.8%) were only seen in MPKGR, while 14 species (11.29%) were exclusive to Farmlands. The family Nymphalidae accounted for the majority of species observed in both locations. Most of the butterfly species observed to be specific in either MPKGR or Farmlands belong to the families Lycaenidae, Pieridae and Nympharidae (**Appendix**) This suggests that the environmental and climatic conditions in both habitats are favorable for some species. Vegetation is also a factor that affects butterfly composition across habitats. Conversely, butterfly species that are only observed at specific locations indicate that they have specific requirements for survival at that particular location [17] [29].

Seasonal variation and Temporal occurrence of butterfly

During the wet season (January to June), there is a significant increase in butterfly species diversity compared to the dry season. In MPKGR, there is a small number of species recorded during the dry season (July to December) which may be due to environmental conditions. During this season, most of the plants are dry and affected by the dry conditions. Although trees and shrubs are present, many of them cannot be used by butterflies due to their deciduous phenology.

The study noticed a seasonal population fluctuation as there were more butterflies during February, March, April, and May, but fewer during June to December. Research has indicated that seasons play a role in influencing the quantity and variety of insects present. It is also revealed that during the transition from short to long rains (January to March), we observed a higher number of butterfly species and a greater abundance of them than during the long to short rains transition that is April to June (**Figure 5**) These findings align with previous research conducted on Kihansi gorge, which found that butterfly species richness and abundance were higher during the dry season compared to other seasons [23].

The months of June and July are the coldest in Mpanga Kipengere and adjacent farmlands, with maximum temperatures around 16˚C (**Table 1** and **Figure 6**). Additionally, from June to mid or late October, a dry season occurs in the reserve which can result in scarce butterfly food. These cold conditions and low food availability may have contributed to poor detection or resulted in lower numbers of Hesperiids, Lycaenids, and Pierids in the reserve and surrounding farmlands. The Nymphalidae is currently the largest butterfly family in Tanzania, with 657 species [24] [25] and therefore has the highest occurrence throughout the year compared to other butterfly families (**Appendix**).

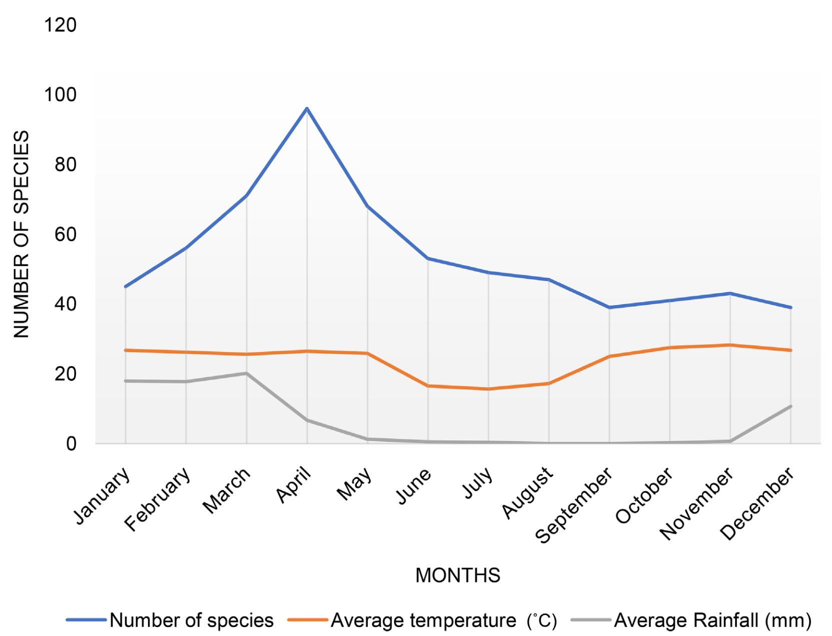

Figure 5. Butterfly species observed each month in MPKGR and adjacent Farmlands during the wet season (January-June) and dry season (July-December).

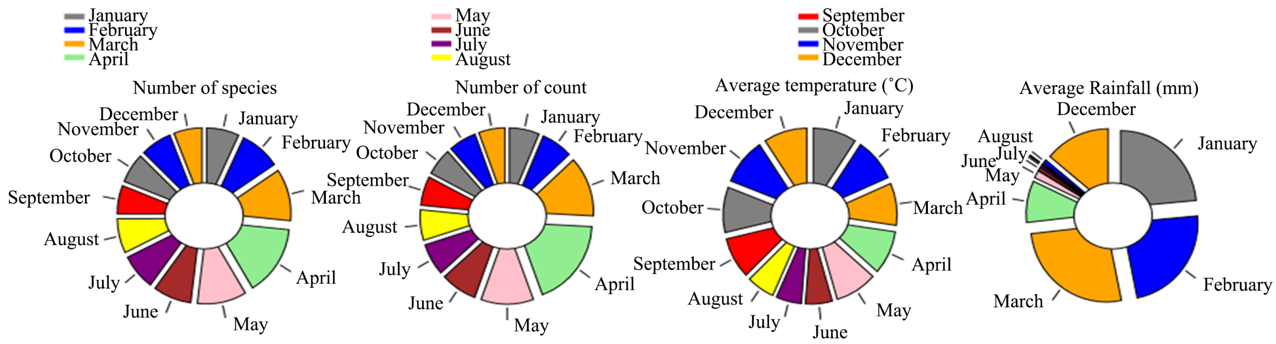

Figure 6. Show the butterfly species and individual counts in relation to climatic variables (temperature and rainfall).

Indicator Species and endemic species

It is crucial to identify a set of indicator species for long-term environmental monitoring in conservation and biodiversity management [35] [36] [37]. We have discovered 9 indicator butterfly species that are associated with different habitat quality in the ecologically sensitive areas. These species can be helpful for future monitoring and assessment of biodiversity in the area. The majority of these indicator species are habitat generalists and polyphagous, while a few are habitat specialists, monophagous, and have a small wingspan, such as *Euryphula concordia*, *Colotis danae*, and *Neptis jordani.* This suggests that they have limited dispersal ability and are highly dependent on specific habitats that may only occur in certain environmental conditions, as observed in previous studies [38] [39]. Furthermore, studies have shown that the plant-abundance relationship is strongest for butterfly species that are habitat specialists, monophagous, and less mobile, as reported by [40] [41]. This study highlights the presence of two endemic species, *Charaxes congdoni* and *Harpendyreus juno*, in the Livingstone mountains and southern highlands, including the MPKGR area as previously reported by [21] [42]. Their existence in this region underscores the significance of MPKGR as a crucial area for biodiversity preservation.

5. Conclusion

Understanding the impacts of human activities and seasonal variations on species diversity and the abundance of butterflies in an ecosystem is important to inform the conservation of existing Game Reserves. Our findings suggest that there is a significant difference in butterfly diversity and abundance between MPKGR and adjacent farmlands with higher diversity in MPKGR where the land is free from anthropogenic disturbance. The large and significant variation in butterfly diversity and species community explained by anthropogenic and environmental factors suggests a need for conservation plans for the natural habitats of MPKGR which is under threat from anthropogenic disturbance from adjacent farmlands. The butterfly species that were specific to certain locations may serve as ecological indicators because they appear to be favored by the environmental conditions of those locations. Future studies looking into how various individual butterfly species are influenced by the available qualities of the habitats will be necessary in generating information that will be useful in identifying species-specific needs for improving the conservation of the butterfly community in MPKGR. This study reveals that Southern Highlands, including the MPKGR area, is home to two unique species, *Charaxes congdoni* and *Harpendyreus juno*. Their presence in this region emphasizes the importance of MPKGR as a critical area for conserving biodiversity. We need further research to determine how the anthropogenic activities on the farmlands could be affecting the diversity and abundance of these indicator species in MPKGR which has already recorded the extinction of large mammals in the recent decade due to human development activities.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

Table A1. Abundance, species richness, and species occurrence in specific habitat *i.e.*, in MPKGR, Farmlands, or both. The abbreviation GR-Represent species recorded from MPKGR only, FL-Represent species recorded from farmlands only, and GR + FL-Represent species found in both MPKGR and Farmlands.

Species	Family	MPKGR Count	Abundance MPKGR	Farmland Count	Abundance Farmland	Total Count	Total Abundance	Uniqueness
Graphium colonna	Papilionidae	2	0.00097	0	0.00000	2	0.00071	GR
Lepidochrysops polydialecta	Lycaenidae	4	0.00194	0	0.00000	4	0.00143	GR
Bicyclus compus	Nymphalidae	0	0.00000	4	0.00540	4	0.00143	FL
Charaxes congdoni	Nymphalidae	0	0.00000	5	0.00675	5	0.00179	FL
Vanessa cardui cardui	Nymphalidae	5	0.00243	0	0.00000	5	0.00179	GR
Harpendyreus juno	Lycaenidae	6	0.00292	0	0.00000	6	0.00214	GR
Harpendyreus major	Lycaenidae	3	0.00146	3	0.00405	6	0.00214	GR + FL
Lepidochrysops desmond	Lycaenidae	6	0.00292	0	0.00000	6	0.00214	GR
Eurema upembana	Pieridae	6	0.00292	0	0.00000	6	0.00214	GR
Acraea leocopyga	Nymphalidae	5	0.00243	2	0.00270	7	0.00250	GR + FL
Charaxes berkeyi	Nymphalidae	4	0.00194	3	0.00405	7	0.00250	GR + FL
Neptis kiriakoff	Nymphalidae	3	0.00146	4	0.00540	7	0.00250	GR + FL
Anthene lunulata	Lycaenidae	8	0.00389	0	0.00000	8	0.00286	GR
Charaxes paphianus	Nymphalidae	4	0.00194	4	0.00540	8	0.00286	GR + FL
Charaxes pollux pollux	Nymphalidae	8	0.00389	0	0.00000	8	0.00286	GR
Neocoenyra heckmanni	Nymphalidae	8	0.00389	0	0.00000	8	0.00286	GR
Precis octavia sesamus	Nymphalidae	8	0.00389	0	0.00000	8	0.00286	GR
Calleagris jamesoni	Hesperiidae	9	0.00437	0	0.00000	9	0.00322	GR
Belenois zochalia agrippinides	Pieridae	0	0.00000	9	0.01215	9	0.00322	FL
Spialia spio spio	Hesperiidae	10	0.00486	0	0.00000	10	0.00357	GR
Bicyclus safitza safitza	Nymphalidae	7	0.00340	3	0.00405	10	0.00357	GR + FL
Papilio bromius chrapkowskii	Papilionidae	8	0.00389	2	0.00270	10	0.00357	GR + FL
Bicyclus cottrelli	Nymphalidae	6	0.00292	5	0.00675	11	0.00393	GR + FL
Precis tugela	Nymphalidae	11	0.00534	0	0.00000	11	0.00393	GR
Colotis regina	Pieridae	8	0.00389	3	0.00405	11	0.00393	GR + FL
Lolaus crawshayi	Lycaenidae	12	0.00583	0	0.00000	12	0.00429	GR
Acraea alicia	Nymphalidae	12	0.00583	0	0.00000	12	0.00429	GR
Acraea esebria	Nymphalidae	11	0.00534	1	0.00135	12	0.00429	GR + FL
Acraea pharsalus	Nymphalidae	9	0.00437	3	0.00405	12	0.00429	GR + FL
Byblia anvatara acheloia	Nymphalidae	12	0.00583	0	0.00000	12	0.00429	GR

Continued

Charaxes Candiope candiope	Nymphalidae	12	0.00583	0	0.00000	12	0.00429	GR
Charaxes jusius	Nymphalidae	11	0.00534	1	0.00135	12	0.00429	GR + FL
Belenois gidica	Pieridae	9	0.00437	3	0.00405	12	0.00429	GR + FL
Cacyreus lingeus	Lycaenidae	9	0.00437	4	0.00540	13	0.00464	GR + FL
Bebearia cocalia orientis	Nymphalidae	13	0.00632	0	0.00000	13	0.00464	GR
Charaxes bohemani	Nymphalidae	13	0.00632	0	0.00000	13	0.00464	GR
Charaxes gudeliana rabeiensis	Nymphalidae	7	0.00340	6	0.00810	13	0.00464	GR + FL
Papilio phorcas	Papilionidae	12	0.00583	1	0.00135	13	0.00464	GR + FL
Spialia dromus	Hesperiidae	14	0.00680	0	0.00000	14	0.00500	GR
Lepidochrysops neonegus	Lycaenidae	8	0.00389	6	0.00810	14	0.00500	GR + FL
Leptotes pirthous	Lycaenidae	0	0.00000	14	0.01889	14	0.00500	FL
Acraea macarista macarista	Nymphalidae	8	0.00389	6	0.00810	14	0.00500	GR + FL
Bebearia orientis	Nymphalidae	14	0.00680	0	0.00000	14	0.00500	GR
Acraea enemosa	Nymphalidae	8	0.00389	7	0.00945	15	0.00536	GR + FL
Acraea eponia eponia	Nymphalidae	8	0.00389	7	0.00945	15	0.00536	GR + FL
Acraea perenna	Nymphalidae	9	0.00437	6	0.00810	15	0.00536	GR + FL
Belenois aurota	Pieridae	10	0.00486	5	0.00675	15	0.00536	GR + FL
Azanus isis	Lycaenidae	12	0.00583	4	0.00540	16	0.00572	GR + FL
Cacyreus palemon palemon	Lycaenidae	13	0.00632	3	0.00405	16	0.00572	GR + FL
Acraea acerata	Nymphalidae	0	0.00000	16	0.02159	16	0.00572	FL
Charaxes protoclea azota	Nymphalidae	10	0.00486	6	0.00810	16	0.00572	GR + FL
Salamis anacardii	Nymphalidae	6	0.00292	10	0.01350	16	0.00572	GR + FL
Cacyreus viritis	Lycaenidae	17	0.00826	0	0.00000	17	0.00607	GR
Lycaena phlaeas	Lycaenidae	17	0.00826	0	0.00000	17	0.00607	GR
Acraea serena	Nymphalidae	14	0.00680	3	0.00405	17	0.00607	GR + FL
Amauris eliot	Nymphalidae	0	0.00000	17	0.02294	17	0.00607	FL
Danaus chrysippus aegyptius	Nymphalidae	15	0.00729	3	0.00405	18	0.00643	GR + FL
Junonia orithya madagascariensis	Nymphalidae	15	0.00729	3	0.00405	18	0.00643	GR + FL
Antanartia dimorphica	Nymphalidae	14	0.00680	5	0.00675	19	0.00679	GR + FL
Eurytela dryope angulata	Nymphalidae	14	0.00680	5	0.00675	19	0.00679	GR + FL
Graphium leonidas leonidas	Papilionidae	10	0.00486	9	0.01215	19	0.00679	GR + FL
Graphium policene	Papilionidae	19	0.00923	0	0.00000	19	0.00679	GR

Continued

Papilio demodocus demodocus	Papilionidae	16	0.00777	3	0.00405	19	0.00679	GR + FL
Eurema senegalensis	Pieridae	19	0.00923	0	0.00000	19	0.00679	GR
Mylothris sagala	Pieridae	16	0.00777	3	0.00405	19	0.00679	GR + FL
Charaxes kirki	Nymphalidae	15	0.00729	6	0.00810	21	0.00750	GR + FL
Junonia oenone oenone	Nymphalidae	21	0.01020	0	0.00000	21	0.00750	GR
Precis ceryne ceryne	Nymphalidae	16	0.00777	5	0.00675	21	0.00750	GR + FL
Colotis amantus amantus	Pieridae	13	0.00632	8	0.01080	21	0.00750	GR + FL
Actizera lucida	Lycaenidae	19	0.00923	3	0.00405	22	0.00786	GR + FL
Euchrysops malathana	Lycaenidae	21	0.01020	1	0.00135	22	0.00786	GR + FL
Acraea jodutta jodutta	Nymphalidae	18	0.00875	4	0.00540	22	0.00786	GR + FL
Antanartia abyssinica jacksoni	Nymphalidae	0	0.00000	22	0.02969	22	0.00786	FL
Charaxes ethalion	Nymphalidae	14	0.00680	8	0.01080	22	0.00786	GR + FL
Precis pelarga actia	Nymphalidae	23	0.01118	0	0.00000	23	0.00822	GR
Leptosia hybrida	Pieridae	0	0.00000	23	0.03104	23	0.00822	FL
Euchrysops subpallida	Lycaenidae	0	0.00000	24	0.03239	24	0.00857	FL
Acraea penelope	Nymphalidae	22	0.01069	2	0.00270	24	0.00857	GR + FL
Charaxes cithaeron	Nymphalidae	22	0.01069	2	0.00270	24	0.00857	GR + FL
Belenois creona	Pieridae	0	0.00000	24	0.03239	24	0.00857	FL
Charaxes brutus	Nymphalidae	17	0.00826	8	0.01080	25	0.00893	GR + FL
Colias electo pseudohecate	Pieridae	25	0.01215	0	0.00000	25	0.00893	GR
Colotis evagore antigone	Pieridae	19	0.00923	6	0.00810	25	0.00893	GR + FL
Colotis evenina	Pieridae	16	0.00777	9	0.01215	25	0.00893	GR + FL
Eurema desjardinsii	Pieridae	21	0.01020	4	0.00540	25	0.00893	GR + FL
Papilio horniman	Papilionidae	23	0.01118	3	0.00405	26	0.00929	GR + FL
Eronia leda	Pieridae	21	0.01020	5	0.00675	26	0.00929	GR + FL
Eurema brigitta brigitta	Pieridae	23	0.01118	3	0.00405	26	0.00929	GR + FL
Mylothris agathina	Pieridae	19	0.00923	7	0.00945	26	0.00929	GR + FL
Charaxes elesipe gordoni	Nymphalidae	19	0.00923	9	0.01215	28	0.01000	GR + FL
Hamanumida daedalus	Nymphalidae	0	0.00000	28	0.03779	28	0.01000	FL
Papilio desmondi teita	Papilionidae	24	0.01166	4	0.00540	28	0.01000	GR + FL
Colotis eris eris	Pieridae	22	0.01069	6	0.00810	28	0.01000	GR + FL
Neptis pennington	Nymphalidae	16	0.00777	13	0.01754	29	0.01036	GR + FL
Phatanta phatanta aethiopica	Nymphalidae	29	0.01409	0	0.00000	29	0.01036	GR

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Papilio lormieri	Papilionidae	29	0.01409	0	0.00000	29	0.01036	GR
Precis antilope	Nymphalidae	21	0.01020	10	0.01350	31	0.01108	GR + FL
Acraea sotikensis	Nymphalidae	26	0.01263	6	0.00810	32	0.01143	GR + FL
Neptis saclava marpessa	Nymphalidae	19	0.00923	13	0.01754	32	0.01143	GR + FL
Eurema hecabe solifera	Pieridae	32	0.01555	0	0.00000	32	0.01143	GR
Nepheronia thalassina	Pieridae	0	0.00000	32	0.04318	32	0.01143	FL
Acraea pudorina	Nymphalidae	0	0.00000	33	0.04453	33	0.01179	FL
Amauris echeria	Nymphalidae	26	0.01263	7	0.00945	33	0.01179	GR + FL
Lepidochrysops persimon	Lycaenidae	30	0.01458	4	0.00540	34	0.01215	GR + FL
Papilio ophidicephalus	Papilionidae	33	0.01603	1	0.00135	34	0.01215	GR + FL
Pseudacraea lucretia expansa	Nymphalidae	0	0.00000	35	0.04723	35	0.01250	FL
Acada biceriatus	Hesperiidae	32	0.01555	4	0.00540	36	0.01286	GR + FL
Appias sabina	Papilionidae	29	0.01409	7	0.00945	36	0.01286	GR + FL
Acraea servona	Nymphalidae	38	0.01846	0	0.00000	38	0.01358	GR
Graphium antheus	Papilionidae	29	0.01409	9	0.01215	38	0.01358	GR + FL
Junonia natalica natalica	Nymphalidae	33	0.01603	8	0.01080	41	0.01465	GR + FL
Precis actia	Nymphalidae	35	0.01701	6	0.00810	41	0.01465	GR + FL
Colotis vesta	Pieridae	35	0.01701	8	0.01080	43	0.01536	GR + FL
Junonia artaxia	Nymphalidae	41	0.01992	3	0.00405	44	0.01572	GR + FL
Pseudacraea boisduvali	Nymphalidae	42	0.02041	6	0.00810	48	0.01715	GR + FL
Colotis hataera	Pieridae	39	0.01895	9	0.01215	48	0.01715	GR + FL
Eurema regularis regularis	Pieridae	42	0.02041	6	0.00810	48	0.01715	GR + FL
Eurema hepale	Pieridae	32	0.01555	17	0.02294	49	0.01751	GR + FL
Junonia hierta cebrene	Nymphalidae	46	0.02235	6	0.00810	52	0.01858	GR + FL
Azanus ubaldus	Lycaenidae	53	0.02575	1	0.00135	54	0.01929	GR + FL
Colotis auxo incretus	Pieridae	49	0.02381	9	0.01215	58	0.02072	GR + FL
Colotis antevipe zera	Pieridae	39	0.01895	20	0.02699	59	0.02108	GR + FL
Neptis serena serena	Nymphalidae	67	0.03256	19	0.02564	86	0.03073	GR + FL
Neptis morosa	Nymphalidae	76	0.03693	18	0.02429	94	0.03358	GR + FL