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Species richness and composition of butterfly with reference to anthropogenic activities in the wildlife management areas, Southern Tanzania

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Abstract
The objectives of this study were to assess butterfly communities, and to determine the influence of disturbance on individual butterflies, species richness and composition within five Wildlife Management Areas (Mbarang'andu, Kimbanda, Kisungule in Namtumbo District; Nalika and Chingoli in Tunduru Didistict) located in Ruvuma landscape. The survey was conducted between September and November 2014 using sweep nets and visual observations. A total of 545 butterflies from 90 species that belong to 6 families, were recorded. Butterfly species richness was highest in Mbarang'andu (28.7±0.81) and lowest in Kimbanda (2.2±0.29). Mean number of individual butterfly was higher (3.1±0.26) in miombo woodlands compared to riverine forest (2.9±0.37). Further destruction of vegetation could affect species richness and abundance, hence; we recommend that more resources and effort such as human resource be in place to safe guard these Wildlife Management Areas from any environmental degradation for the benefit of present and future generation.

Keywords: Butterfly, richness, disturbance, conservation, Ruvuma wildlife management areas

1. Introduction
One of the most important aspects of any conservation strategy is the identification of high-value sites on the basis of their biodiversity content [1]. In recent years, there has been an escalating increase in human pressure on the biodiversity which causes conservation challenges to biologists due to anthropogenic disturbances [2]. Insects being a major taxonomic group of animal species are mostly affected and represent a good example of these challenges [3], however are remained undiscovered and less prioritized group for conservation assessments [4]. Butterflies among other insects, are typically considered as a good example, that can be sampled and identified within a short period of time and give indication of habitat conservation priority [5]. Quite few studies have advocated that butterflies are key taxa for biodiversity monitoring because they reflect changes of climatic environments [6] along with seasonal and other ecological changes [7] and they are good indicators of anthropogenic disturbance and habitat quality [8]. Collection of baseline information on animal biodiversity is a reference point for ecological risk valuation and management but this remain far from being realized [9].

Among the 19,238 globally described butterfly species [10], Tanzania hosts 1,699 species [11] which also need conservation priority. However, a few studies have been conducted to investigate butterfly species diversity and geographical distribution in disturbed habitats in Tanzania. They include [12, 13] who examined butterflies habitats diversity in Katavi National Park and distribution in areas disturbed by elephants (*Loxodonta africana*) in Kilombero Valley, southern Tanzania respectively and concluded that butterfly abundance and richness were low in disturbed when compared to undisturbed habitats.

In the Wildlife Management Areas (WMAs) of the Ruvuma landscape, human pressure is rapidly increasing which may lead to management problems, which after a long run may affect diversity, abundance and distribution of butterfly species in the area. However, information on the diversity and distribution of many species including butterflies is often incomplete and data are lacking.

The main objective of this study was to assess butterfly species and to understand whether the existing anthropogenic activities may have influenced diversity and distribution of butterfly communities with the following specific objectives: First, to determine species richness and abundance of butterfly in miombo woodland and riverine forest, second, to determine the species richness and abundance of butterfly in each of the five WMA of Ruvuma landscape in relation to anthropogenic disturbance. We predicted that butterfly species richness and abundance should be higher in low grazed and cultivation than in intensively grazed.

2. Methods and materials

2.1 Study area

This study was conducted in the Ruvuma landscape which encompasses five WMAs namely; Mbarang'andu, Kimbanda, Kisungule in Namtumbo District; Nalika and Chingoli in Tunduru District. The Ruvuma landscape is an extensive trans-frontier area of approximately 278,950 km^2, flanking the Ruvuma River, spanning Tanzania's southern regions (Coast, Lindi, Mtwara, Morogoro and Ruvuma) to Mozambique's northern provinces of Niassa and Cabo Delgado, forming the largest wilderness area of unfragmented miombo woodland, coastal forests and associated ecosystems remaining in Africa. The study area comprises 10 villages located between latitude -9° 52' 8" to -11° 45' 36" South and longitude 35° 41' 42" to 37° 19' 43" East (Figure 1). The Ruvuma landscape borders with Selous Game Reserve in the north and Niassa Game Reserve (Mozambique) to the south.

Fig 1: Map of Ruvuma WMAs showing location of sampling sites

The landscape forms the largest unfragmented miombo woodlands, dominated by *Brachystegia* spp, *Julbernardia* spp, *Isoberlinia* spp, *Afzelia quanzensis*, *Pterocarpus angolensis*, and the rare and threatened species of plant such as *Dalbergia melanoxylon*. Other vegetation types include wooded grasslands, open savannahs, granite inselbergs, seasonal and permanent wetlands and riverine forests along numerous perennial and seasonal streams [14]. The area is dominated by small hills, whereas the southern part towards the greater Ruvuma River is dominated by slightly undulated to flat isolated hills [14]. The rainfall pattern is unimodal spanning from late November to April and May with a mean annual rainfall of 800-1200 mm in a north-south gradient, and the mean annual temperature is about 21 °C following the Köppen system [15].

2.2 Butterfly sampling design

A total of 10 different sites covering an area of approximately 10,000 m^2 each were established in the five WMAs, one site in each habitat/vegetation type. We selected two main habitat/vegetation types (miombo woodland and riverine forest) due to its large coverage in the area. A minimum of two sampling sites were selected in each habitat/vegetation type. Anthropogenic activities such as livestock grazing, burning, cultivation and tree felling were recorded. Burnt areas were categorized into (i) low, when traces or no disturbance were observed, and (ii) high when the whole sampled plot was burned. Each site was sampled for three consecutive days, totaling 65 sampling days (September to November 2014).

Each site was sampled using two complementary methods. First, butterflies were collected using a hand-held butterfly net (35 cm in diameter). Random searches covering a site area of approximately 40,000 m^2 were conducted by four to five collectors for a minimum of 4.5 hours for each trap day from morning (09:00 hrs to 11:30 hrs) and from 15:00 hrs to 17.00 hrs to sample butterflies in the miombo, forest under-story/scrub/thicket and around ground herbs and grasses. Timed sweep netting was conducted within each vegetation plot. Data on species type, disturbance and associated vegetation types were recorded on standardized data sheets. Unidentified individuals were kept in special envelopes and later identified to species level by the aid of field guide book [16, 17].

Secondly, transect method was used to sample butterflies, by visual observation of flying butterflies along the transect [18-20]. The visual observation method was conducted in the same plot before a hand-held butterfly net was used. The method was used to record butterfly species that are common and easy to identify to avoid over collection. The method involved counting the number of flying butterflies that crossed a strip of known length (somewhere between 30 and 60m) and 20m wide for 10 minutes. Time lapsed was recorded by Casio hand-held stopwatch.

2.3 Statistical analysis

Data on the sampled butterflies were tested for normality using the Shapiro-Wilk (W) Test and the Kolmogorov-Smirnov (KS) test. The data were found not to be normally distributed even after data transformation. Therefore a non-parametric Kruskal-Wallis (KW) test was used to examine differences in multiple independent samples among WMAs [21]. The differences in species richness and numbers between disturbances levels (i.e. levels of cultivation and grazing) in the different habitat types were tested using Wilcoxon test.

Species richness estimates were obtained following [22]. This index uses two biodiversity indices including, richness and abundance to determine which WMA had the greatest biodiversity for the butterfly community. Butterfly species richness is described as the number of different species in each area, while butterfly abundance is represented by the number of individuals counted in an area per unit time. We used Kruskal-Wallis and Wilcoxon tests to test the significance of the variations across WMAs.

3. Results

3.1 Butterfly composition, vegetation types and disturbance

Overall, 545 butterfly individuals belonging to 6 families, 41 genera and 90 species were recorded in the study area. Of the six butterfly families, only four families were observed from both habitat types, thus the comparisons presented here excluded the two families, Papilionidae and Acraeidae which were not observed in miombo (Figure 2). A total of 49% of species were recorded in the miombo woodland, 31% in riverine forest and 20% were found in both vegetation types. Species richness of the four families (Nymphalidae, Hesperiidae, Lycaenidae and Pieridae) was always higher in the miombo vegetation than in the riverine forest (Figure 2A). The overall mean species richness (mean±SE) was higher in miombo 23±0.9 than in riverine forest 14.4±0.4. These results were similar in terms of abundance for three families (Nymphalidae, Hesperiidae and Lycaenidae), with overall mean number of 3.1±0.2 and 2.9±0.4. Butterfly abundance in the Pieridae family was higher in riverine forest (Figure 2B). The highest species richness values were observed in the miombo vegetation in Mbarang'andu, where also the riverine vegetation had the highest species richness. In terms of butterfly abundance, Kisungule riverine forest and Nalika miombo vegetation had the highest values (Figure 3).

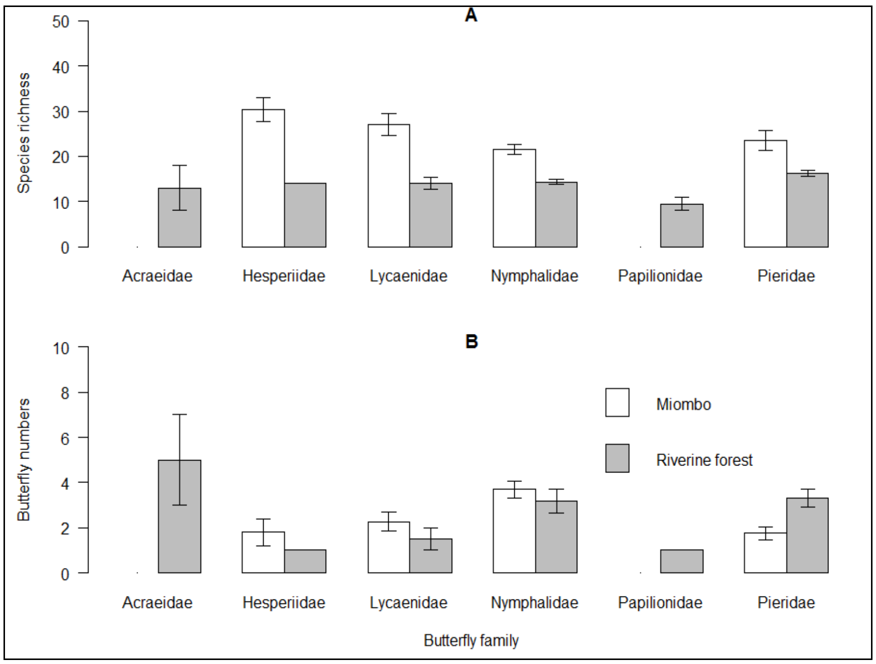

Fig 2: Butterfly species richness (A) (mean±SE) and abundance (B) distribution across different families as were recorded between Miombo woodland and riverine forest in WMAs of the Ruvuma landscape.

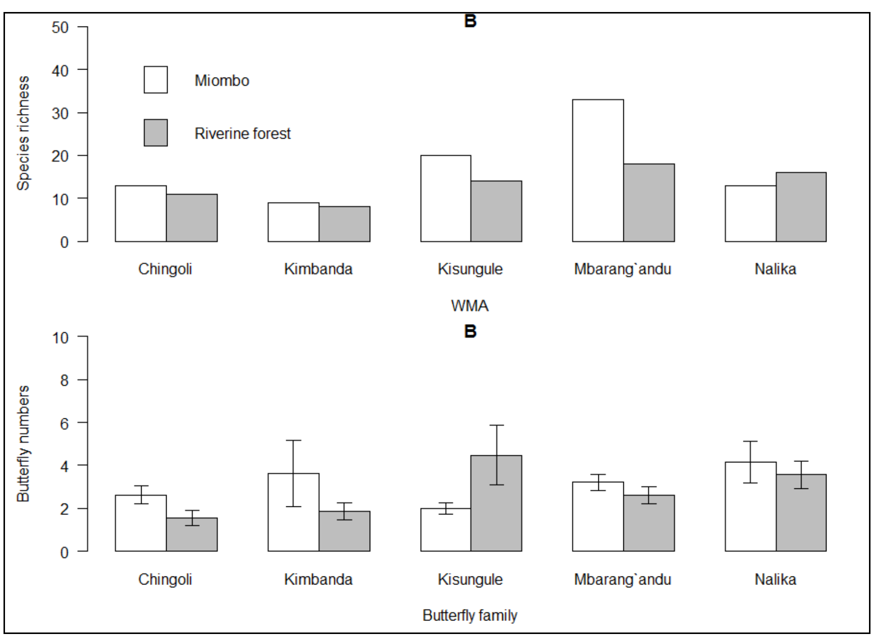

Fig 3: Butterfly species richness (A) and abundance (B) (mean±SE) distribution across different WMAs as were recorded between Miombo woodland and riverine forest in the Ruvuma landscape.

The overall species richness differed significantly across the WMAs using Kruskal-Wallis rank sum test, ($\chi^2 = 147.9$, df = 4, $P < 0.0001$), with the highest mean±SE being in Mbarang'andu WMA (28.7±0.27) and lowest in Kimbanda WMA (8.5±0.12). Similarly in terms of abundance of butterfly calculated differed significantly ($\chi^2 = 9.9$, df = 4, $P < 0.05$). The highest abundance of butterfly was recorded in Nalika WMA (3.8±0.5) and the lowest was in Chingoli WMA (2.2±0.3).

3.2 Butterfly richness and abundance across grazing and cultivation gradients

Both butterfly species richness and abundance differentially varied with gradients of cultivation and grazing. Using Wilcoxon rank sum test, the overall species richness was significantly lower in areas with high grazing than in those with relatively low grazing (W = 990, $P < 0.0001$). Similarly, there was significantly lower butterfly species richness in areas of high cultivation than those with relatively low cultivation (W = 1226, $P < 0.0001$). In contrast, abundance of butterfly did not differ across the grazing area (W = 2287, $P > 0.05$) as well as cultivation (W = 3473, $P > 0.05$) gradients.

A further analysis involved testing the influence of cultivation and grazing on species richness and abundance of butterfly within each vegetation type. The results revealed that, within the miombo vegetation, butterfly species richness was significantly lower in areas with high cultivation (W = 392, $P < 0.0001$) and were similar for butterfly abundance (W = 1151, $P < 0.05$). Similarly in the reverine forest, butterfly richness was higher in areas with low grazing intensity than areas with high grazing intensity (W = 240, $P < 0.0001$). Interestingly, butterfly richness was significantly higher in areas with high cultivation than those with high cultivation in the riverine forest (W = 0, $P < 0.0001$). However, the number of butterfly did not differ with cultivation gradient (W = 506.5, $P > 0.05$).

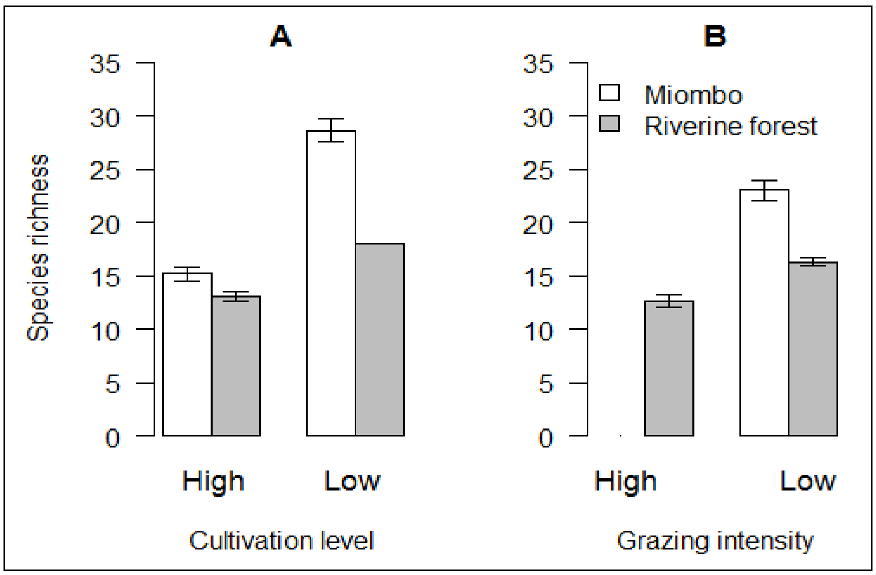

Fig 4: Butterfly Species Richness (mean ±SE) in low and high cultivation and grazing intensity respectively as were recorded in the Miombo and Riverine forest vegetation in the Ruvuma WMAs.

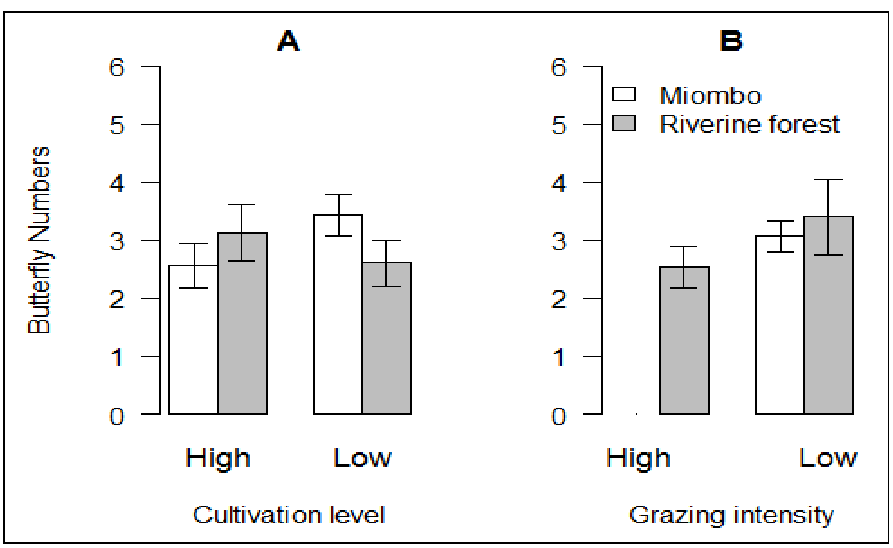

Fig 5: Butterfly abundance (mean±SE) in low and high cultivation and grazing intensity respectively as were recorded in the Miombo and Riverine forest vegetation in the Ruvuma WMAs.

4. Discussion

4.1 Butterfly composition, vegetation types and disturbance

We will now compare the results with the prediction from the hypothesis laid out in the introduction. The overall aim of this work was to document butterfly species composition and to understand the role of human pressure on butterfly species richness and abundance in the study area. We hypothesized that the distribution of butterfly species in the WMAs in Ruvuma landscape was influenced by the level of anthropogenic disturbance. We predicted that butterfly species richness and abundance should be higher in low grazing and cultivated areas than in intensively grazed and cultivated. Our results show that the Ruvuma landscape was highly rich in terms of butterfly species and included *Pentila rondo* (Lycaenidae) which is endemic to Tanzania. Our survey has also revealed existence of the known as forest dependent butterfly species *Protogoniomorpha parhassus* (Nymphalidae) in the riverine area. However, although the results have suggested that the Ruvuma landscape was rich in butterfly species, the richness was being significantly influenced by anthropogenic disturbances.

Both the increase in cultivation and intensive grazing lowered the richness of butterfly species in the miombo vegetation, which is in agreement with hypothesis we laid down in the introduction. There is increasing evidence that disturbance has an impact on biodiversity. Many studies including [23]; [24]; [25]; [26] and [27] have shown that different types and scales of disturbance have different effects and that different groups of insects including butterfly respond to the same form of disturbance in different ways.

Higher species richness of butterflies was found to be associated with miombo woodlands than in riverine forest. A possible explanation is that butterflies visit miombo woodland for possibly supplemental nectar resources not found in the adjacent small patches of forested areas outside the miombo woodland. However, the extensive removal of forest cover due to anthropogenic activities like bush burning and agriculture may be responsible for the low record of forest dependent species (31%) only 51 butterfly individuals being recorded. Unfortunately, much of the forest has been converted to farmland, so drastically reducing the habitat for butterflies.

Furthermore, the results showed that although richness was being influenced by both grazing and cultivation levels, butterfly abundance did not become lower in areas with intensive cultivation or grazing, which disagree with our hypothesis in the introduction. The results further indicated that, in the riverine forest, the abundance of butterfly increased in areas with higher than low cultivation which also differs with our hypothesis. Several studies have indicated that disturbed habitats support poor communities of butterflies [12, 28, 29]. However, few studies have highlighted similar findings to those obtained in the five WMAs of southern Tanzania. For example, in Vietnam, [30] recorded a higher diversity of butterflies in disturbed habitats [19, 31]. Similar observations were recorded by [30] in Costa Rica where high species richness of butterfly was recorded in intensively cultivated areas as compared to adjacent undisturbed forest remnant fields. These previous studies show that elsewhere (out of sub-Sahara Africa) disturbed habitats can be important for butterflies comparable to undisturbed forest ecosystems as it was observed in Ruvuma landscape found in southern Tanzania.

4.2 Butterfly across grazing and cultivation gradients

Anthropogenic disturbances have different effects on butterfly species diversity. The response of butterflies to habitat disturbance depends in varying degrees on physical modification, isolation and habitat area [32, 33]. Habitat specific species including rare species are important to monitor, as they are particularly vulnerable to environmental change. With this study, it was difficult to draw convincing general conclusions about the effects of anthropogenic disturbances on butterfly species richness as such conclusions require extensive research study. It is worth noting that the data we analyzed were obtained from a short term survey conducted in one season. This could have an influence on the results we have presented and we think that long term survey data could give us more realistic results. Future research, however, should focus on quantifying the impact of the many forms of disturbance on butterfly fauna this will give us a much better understanding of the environmental health of the WMAs and so that we will be able to suggest better management decisions on land use for the good sake of both the natives and the biodiversity.

The overall results have suggested that butterfly abundance and richness was significantly influenced by human disturbance, in line with findings by [[12]] who reported that butterfly abundance and species richness were lower in disturbed habitats than in habitats that have been subjected to little human alteration, especially grazing in the Katavi ecosystem of western Tanzania. Areas with lower disturbance levels such as the Mbarang' andu WMA, which was located near the Selous Game Reserve, and which was found with the lowest level of human disturbance had the highest butterfly species richness. Kimbanda WMA rice cultivation was very intensive and had the lowest butterfly richness, indicating that land clearance for rice farms lowered the richness, because some species are prone to disturbance and could therefore have shifted to other habitats.

5. Conclusion and recommendations

Butterfly species richness in miombo woodlands of southern Tanzania in the five WMAs was much higher than expected. Indicating that butterflies could be visiting miombo woodland for possibly supplemental nectar resources not found in the adjacent small patches of forested areas outside of the miombo woodland. Finding from this study indicates that the five WMAs are under great threat due to anthropogenic activities. While recently there has been a widespread operation to convert riverine flooded forest for the cultivation of rice in turn affecting the forest-dependent butterfly species, land conversion of flooded grassland and miombo woodland will induce a marked loss in butterfly richness in areas lacking protection within the next decade. In this case, it is suggested that the adjacent community be involved in conservation of biodiversity in the WMAs. Land use planning should be encouraged and implemented among local communities in order to put aside land for biodiversity conservation. The feasibility study on butterfly farming in the area should be carried to assess its possibility and eventually the community participates in the butterfly farming, the activity that will increase the house hold income and improve the relationship between local community and the conservation authority and win their support in conservation of the biodiversity in the WMAs.

There is a need for giving conservation education to the local communities on the importance of conserving biodiversity resource, since WMAs can be used for study and training for students in terms of attachments, internships and research projects if are properly conserved. Also, WMAs can be potential tourist attractions and activities include bird watching, butterfly viewing, and landscape hiking as well as photographic. More detailed study is recommended in the area i.e. studies of butterflies in both wet and dry seasons, bigger scale, more sampling techniques ie including the use of butterfly traps in order to yield more vigor and reliable results that will help in the proper management decisions of the study area.

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