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Diversity Analysis of Insect Fauna in Grassland and Woodland Community at Mbeya University of Science and Technology, Tanzania

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Abstract Insect fauna are found almost everywhere.Yet, their abundance and diversity in some terrestrial ecosystems is still undisclosed. The present study was conducted to assess and compare the abundance, species richness and diversity of insects from grassland and woodland communities at Mbeya University of Science and Technology in Mbeya, Tanzania. A total of 1574 insects belonging to 55 insect species under 9 insect orders and 38 families were collected from study area. Evenness index, Margalef index, Shannon index, Simpson index, and Sorenson similarity index are diversity parameters used to analyse the diversity of insects. Result showed that the most abundant groups of insect were Hymenoptera (36.150%), Coleoptera (30.686%) and Orthoptera (19.123%) while the least abundant were Diptera (0.889%) and Mantodae (1.271%). The grassland community was rich in terms of species (Margalef index = 6.284), abundance (69.822%) and diversity (H = 3.208) of insects, however, the abundance of insects between grassland and woodland differed significantly ($p<0.05$). On both sites, Sorensen similarity index showed 55.3% similarity. Insects in the order Mantodae showed highest value of similarity index (100%) followed by the order Hymenoptera (83.3%), Odonata (80%), Coleoptera (66.7%), and Hemiptera (50%). Moreover, it was found that the mean number of species between grassland and woodland in Blattodea, Orthoptera and Odonata differed significantly. High abundance and species diversity in grassland community suggests a stable ecosystem. There fore, this study revealed that though the grassland community has the potential to support insect diversity, but also act as refugia for some insects from woodland community.

Keywords Abundance, Diversity, Evenness, Insects, Richness, Similarity, MUST, Mbeya

Introduction

Our planet hosts more than 30 million species of animals, of which about 1.4 million have been described, among these, 750,000 are insects [1]. Insects together with other invertebrates make up more than 75% of all described global species diversity [2]. They are the largest group of animal species which represent the majority of species in both terrestrial and freshwater ecosystem [3-4]. They are diverse group that shows a big difference in their life history strategy, movement, seasonality, size, trophic level and requirements for habitats[3]. Insects occur in different ecological niches of grassland and woodland, they may be permanent and or transient inhabitants. They also visit many other habitats apart from grassland and woodland. Largely, insects have populated almost every possible type of habitat from the equator to the arctic and from sea level to the snowfield of highest mountains, on land, in air and water and almost everywhere [5].

Insects are known to be either beneficial or harmful organisms [1-5]. They play an important role in the ecology of grassland and woodland habitats [6]. For example, insects such as termites and wood borers, especially the larvae of beetles or moths that feed on dead trees or wood or other decaying organic material play a significant role in nutrient cycling. Additionally, insects form an important part of the food chain, especially for many amphibians, birds, mammals and reptiles because they are found almost in each habitat [7]. Foottit and Adler [8] explained that, in many food webs and food chain lengths insects dominate, and have a big importance due to their diversity, ecological roles and influence on the agriculture, natural resources and human health. Characteristically, insects are the dominant constituent of biodiversity in terrestrial ecosystems and play imperative roles in ecosystem processes, they cycle nutrients, pollinate plants, disperse seeds, maintain soil structure and fertility, control populations of other organisms, provide a major food source for other taxa[9]. Furthermore, they maintain the structure and composition of ecosystem [2], also they are the parasites or disease vectors for many other organisms, including human being [10].

Several studies have shown that there is a close association of insects with our lives which affect the well-being of humanity in various ways, however a large number of insect species, including those not yet known or revealed continue to become extinct from their native habitats worldwide [1, 3, 6, 10]. This is due to many reasons not limited to climate change and anthropogenic activities. Moreover, because of their small size, short life spans, and high reproductive rates, the abundances and diversities of many insect species can change by several orders of magnitude on a periodic or annual time scale, minimizing time lags between environmental changes and population adjustment to new conditions [3, 5]. These changes are detectable and make insects more useful as indicators of environmental changes or quality than larger or longer-lived organisms that respond more slowly, for instance many aquatic insects. Insects respond vastly to environmental changes, including those resulting from anthropogenic activity to agriculture. For example, response of aquatic insects to environmental changes can dramatically affect aquatic ecosystem health, structure and function [11, 12]. Despite the fact that many insects are able for long distance dispersal and capable of finding and colonizing isolated resources, other insects are flightless, and thus vulnerable to environmental alterations.

The abundance, diversity and species richness of insects represent an equivalent variety of adaptations to variable environmental conditions. Balakrishnan *et al*., [1] defined biological diversity as the variability among the living things from different habitats such as terrestrial, marine, and other aquatic ecosystems. This comprises diversity within species, between species, and of ecosystems or habitats. Biological diversity refers to the entire body of organisms, their ecological complexity within the environment, and all the ecological processes in relation to these systems [3, 13]. Despite MUST having large areas of grassland and woodland, little is known about the diversity and type of insect species living in these habitats. This is because no any study which has been done to analyse insect diversity, abundance and even establish different species of insects present in the study area. However many human activities including burning and cutting of grasses seem to disturb the ecology, both macrohabitats and microhabitats of insects within the area. These activities are with no doubts that decrease the abundance, diversity and species richness of insects [14]. An insect survey was carried out with the aim to understanding the ecological significance of the grassland and woodland community in relation to insect abundance, diversity and species richness. Specifically, it was to determine whether the composition of insect assemblages can differ in the two communities. The objectives of this study were to determine and establish different insect fauna present at MUST main campus, to compare and analyse the diversity, abundance and species richness of the two sampling communities.

Materials and methods

Study location

Mbeya University of Science and Technology (MUST) is a public university in Tanzania. It is located in Mbeya city at latitude 8°56′30″S and longitude 33°24′58″E (Fig.1) on the higher altitude of unplanned settlement of Inyala and Ikuti areas [15]. The University is 10km away from the city centre. The University comprises an area of more than 2000 ha and only a very small portion of this area has been developed. Part of the undeveloped area is used for agricultural activities; and the remaining area is occupied by grasses and woods. Grassland and woodland areas were selected for insect sampling in this study because are never studied (Fig.1). Woodland areas are dominated by eucalyptus tree, fewer short grasses and few shrubs while the grassland is dominated by *Cynodon spp, Panicum maximum* and *Urochloa mosambicensis*. The rainy season is longer which starts from October to May and the short dry season starts from June to September. The study area receives rainfall approximately 1400mm-1600mm per year [16]. The climate of Mbeya region (altitude 1718m) is greatly influenced by physiology and altitude. It is generally tropical with marked seasonal and altitudinal temperature variations. The temperatures in the region vary according to altitude but generally range from about 16^{o}C in the highlands to 30^{o}C in the lowland areas [15, 17].

Insect collection methods

This study was carried out between March 2016 and June 2016. Two sampling sites, the grassland and woodland found at MUST were selected. Sampling sites covered approximately a quota of the total MUST area. Insects were collected using pitfall traps, sweep nets, beating sheets and manually using hands. Insect collection techniques used in this study are similar to those described in Balakrishnan *et al*., [1], Adjaloo *et al*.,[2], Nazir *et al*.,[3], Belamkar and Jadesh [5], Khadijah *et al*.,[10] and Nyundo and Yaro [18].

Pitfall trapping (PT): For the collection of ground insects, a total of 23 pitfall traps, plastic containers, were permanently installed at an interval of 5m. In each habitat one line transect was established with pitfall traps being allocated within the transect line by systematic random sampling technique. Pitfall traps (top diameter = 8 cm, height = 10 cm) were sunken in the ground in such a way that the top was flush with the ground surface.

The traps were not baited, however were half-filled with soapy fluid to avoid escape by captured insects. They were regularly visited every morning (8am), afternoon (2pm) and evening (5 pm) to collect any captured insects. Pitfall traps were continuously exposed from March 2016 to June 2016. No roof was used to avoid microclimate change and trap loss was negligible. These kinds of traps have been widely used for sampling insects in biodiversity inventories [18].

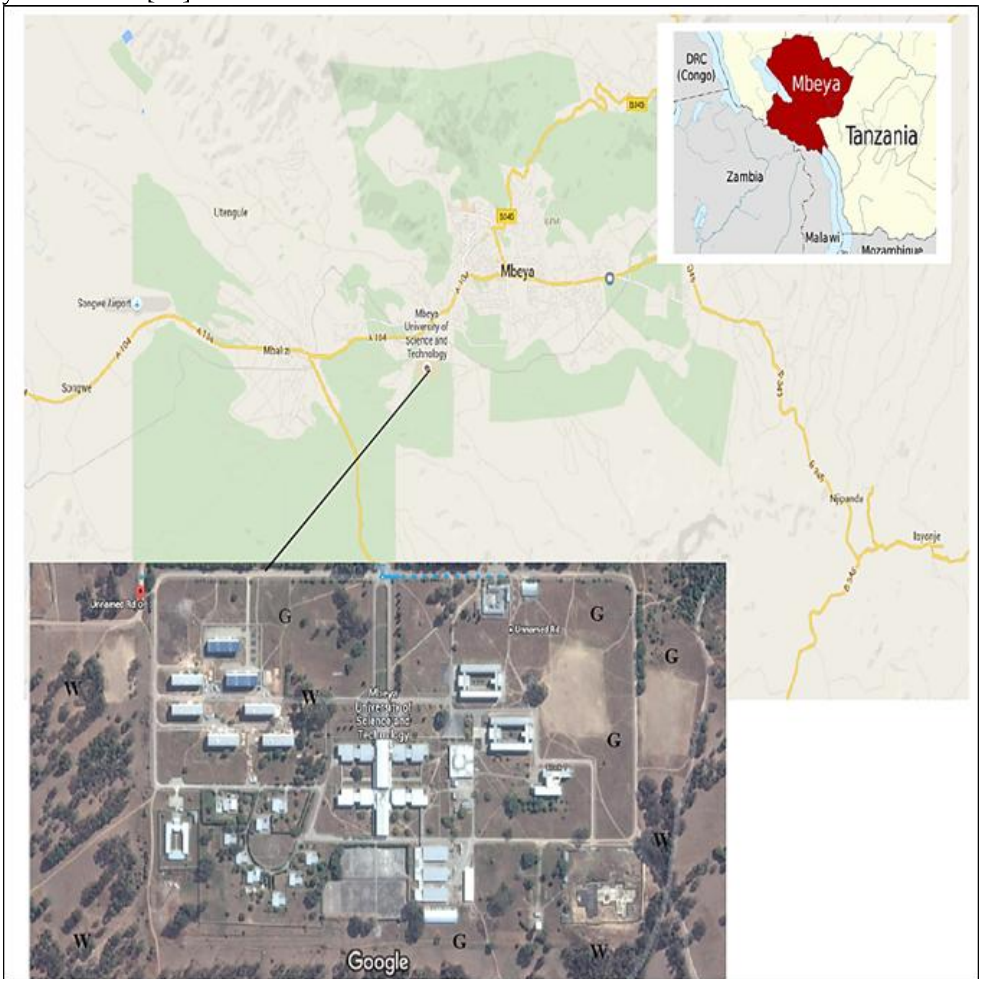

Figure 1: Site map of MUST showing insects sampling sites (G= grassland and W = woodland) and location of Mbeya region in Tanzania. (Source Google map)

Sweeping nets (SN): Sweep nets (32cm diameter) were swept three times every week from 10.00 am to 1.00 pm while walking within the study areas. Sweep sampling was done from herb and shrub layers of the vegetation to trap flying insects. The insects collected in the sweeping were temporarily transferred in polythene bags and plastic bottles before taken to the laboratory for identification and preservation. This method is suited for sampling insects from ground layer vegetation [5]

Beating sheets (BS): This technique was used to collect arboreal insects. These are insects that feed and or rest on trees, bushes, and other plants. These kinds of insects are often difficult to spot by casual observation, but can be easily collected by beating the plants with some sort of stick or net handle while holding a beating sheet under the area being beaten. A beating sheet is basically just a piece of heavy duty cloth stretched across two diagonal pieces of wood joined at the center.

Hand collection (HC): Manual collection of insects was done three times every week for 3h during the day time. Collecting involved actively searching for the insects on the ground, in leaf litters and grasses, under logs, tree barks and other substrates. Insects were directly collected by hand and transferred in killing bottles. The insects were processed for pinning and preserved in dry condition.

All collected insect specimens were brought back to the laboratory and sorted with the help of available literature such as Martins [19] and the keys to species level. Trapped insects were killed using ethyl acetate in the killing jar before being identified and preserved. The specimens were stretched, dried, dry pinned (for hard bodied insects) and preserved in the 70% ethyl alcohol (for soft bodied insects) in the multipurpose containers.

Diversity analysis

Biodiversity indices were calculated using the standard formulas. Diversity of insect species at both sites was calculated using Shannon-Weaver diversity index (H) [20, 21]. The Shannon index is given by the formula below;-

$$H = -\Sigma p_i \, lnpi$$

Where pi = S/N, S is the total number of individuals of one species, N is the total number of all individuals in the sample and ln = logarithm to base e. The proportion of species relative to total number of species (pi) was calculated, and multiplied by natural logarithm of this proportion (ln pi). The results were summed across the species, and multiplied by -1.

Species richness of insect was calculated using the Margalef index (D) [22]. The index is given by the following formula

$$D = \frac{(S-1)}{\ln N}$$

Where S is the total number of species, N is the total number of individuals in the sample and ln is the natural logarithm (logarithm to base e).

Equitability or evenness was calculated using the Pielou's evenness index [23]. Pielou's evenness index is given by the formula

$$E = \frac{H}{\ln S}$$

Where H is the Shannon – Wiener diversity index and S is the total number of species in the sample.

Simpson index (λ or D) was used to determinerarity (diversity) information of species present on the sites. The Simpson's index is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. In essence it measures the probability that two individuals randomly selected from an area will belong to the same species[24]. The index is given by the formula below

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i is the total number of organisms of each individual species; and N is the total number of organisms of all species.

Sørensen similarity index [25-28] was used to measures similarity in species composition for two sites, grassland and woodland, by the equation

$$C_S = \frac{2ab}{a+b}$$

Where C_S explains the coefficient of similarity, 'a' is the number of species found in site A; 'b' is the number of species present in site B and 'ab' is the number of species shared by the two sites.

Statistical tests

Comparison between grassland and woodland communities based on the mean number of insect species was done using independent sample t-test [3] while Mann-Whitney U-test was used to compare the insect abundance of the two sites. Normality was checked before analysis using STATISTICA Ver. 8 [29]. Significance was assessed at $\alpha = 0.05$

Results

A total of 55 insect species, 9 insect orders and 38 insect families of about 1574 insects were collected from grassland and woodland communities (Table 1). A total of 1099 insects belonging to 45 insect species under 9 insect orders and 33 insect families were captured from grassland whereas 475 insects belonging to 31 insect species under 9 insect orders and 25 families were collected from woodland (Table 1). The most abundant group of insects in grassland community were hymenoptera (347 insects), Coleoptera (307 insects) and Orthoptera (287 insects) while in woodland were hymenoptera (222 insects) and Coleoptera (176 insects). Moreover, the least abundant insect order in grassland were Diptera (9 insects) and Mantodae (12 insects) whereas in the woodland were Diptera (5 insects) and Hemiptera (7 insects) (Table 2). The grassland community revealed the highest Shannon-Wiener diversity index (H=3.208) and Margalef index (D = 6.284) (Table 2). In terms of species number, Coleoptera, Orthoptera, and Hymenoptera had more number of insect species in grassland while Coleoptera, Lepidoptera and Hymenoptera had more insect species in woodland (Table 2). Coleopterans showed the highest Shannon-Wiener index diversity and Margalef index in both communities (Table 2). On the basis of Sorensen similarity index, both communities showed 55.3% similarity (Table 2). Insects in the order Mantodae showed highest value of similarity index (100%) followed by the orders Hymenoptera (83.3%), Odonata (80%), Coleoptera (66.7%), and Hemiptera (50%) (Table 2). Furthermore, it was found that there was a significant difference in the mean number of species between grassland and woodland only in three insect orders, Blattodea ($p<0.05$), Orthoptera ($p<0.05$) and Odonata ($p<0.05$) (Fig.2 and Table 3). It was observed that the insect abundance differed significantly between grassland and woodland ($p < 0.05$) (Fig. 3). It was further observed that the most abundant insect orders in terms of insect abundance were Hymenoptera, Coleoptera and Orthoptera. The orders with respect to the number of individuals in the two communities shown in figure 4 were as follows; Hymenoptera (36.150%), Coleoptera (30.686%), Orthoptera (19.123%), Lepidoptera (4%), Hemiptera and Blattodea (3%), Odonata (2%), Diptera and Mantodae (1%). The most dominant family was Apidae with 330 individuals of Apis mellifera in the order Hymenoptera and family Acrididae with 90 species of Aeoloplides turnbulli in the order Orthoptera.

Table 1: Checklist of taxon, species and abundance of insects recorded from grassland and woodland at MUST

Insect taxon			Community	
Order	**Family**	**Species**	**Grassland**	**Woodland**
Coleoptera	Curculionidae	*Polydrususformosus*	4	0
		Sitophiluszeamais	1	0
		Curculio spp	24	29
	Chrysomelidae	*Chrysochusauratus*	0	47
		Glyptoscelispubescens	1	1
	Scarabaedae	*Macrodactylussubspinosus*	15	0
	Carabidae	*Pterostichusmelanarius*	0	2
		Promeces spp	1	0
	Tenebrionidae	*Unidentified beetle spp*	41	11
		Pimeliabipunctata	34	11
		PedininiPlatynotina	41	0
		Arturiumtenuieostatum	37	21
	Dermestidae	*Unidentified beetle spp*	10	12
	Elateridae	*Unideintifiedbettele spp*	79	0
	Cleridae	*Checkered beetles spp*	11	19
	Coccinellidae	*Hippodamiaconvergens*	8	23
Hymenoptera	Formicidae	*Pchycondyla spp*	6	6
	Apidae	*Apis mellifera*	179	151
	Syrphidae	*Eristalistenax*	50	30
	Vespidae	*Polistes*	30	20
	Pompilidae	*Auplopusmellipes*	10	15
	Sphecidae	*Sceliphroncaementarium*	12	0
	Margarodidae	*Unidentified ants spp*	60	0
Blattodea	Blattidae	*Blattaorientalis*	25	0
	Blattellidae	*Lobopteradecipiens*	20	0
Lepidoptera	Papilionidae	*Papilioconstantinus*	0	5
	Erebidae	*Achaea spp*	0	4
	Danaidae	*Danausplexippus*	7	6
	Nymphalidae	*Acraeaencedon*	6	0
		Junoniaoenone	0	4
		Pseudacraeaboisduvali	0	7
	Pieridae	*Euremahecabe*	15	0
	Lasiocampidae	*Malacocoma spp*	0	5
	Hesperiidae	*Asboliscapucinus*	1	0
	Sphingidae	*Hippotion celerio*	0	3
Orthoptera	Acrididae	*Aeoloplides turnbulli*	90	0
		Aeropedellusclavatu	30	0
		Phlibostromaquadrimaculata	70	0
		Sphingonotusbalteatus	60	0
		Acanthacrisruficornis	1	0
	Diapheromeridae	*Diapheromerafemorata*	20	11
	Tettigoniidae	*Pterophyllacamellifolia*	5	0
		Tettigoniaviridissima	3	0
	Pyrgomorphidae	*Phymateusviridipes*	4	3
	Gryllidae	*Achetadomestica*	4	0

Odonata	Calopterygidae	*Phaoniridipennis*	13	5
	Libellulidae	*Brachythemis spp*	10	4
		Crocothemiserythraea	7	0
Diptera	Calliphoridae	*Luciliasericata*	9	0
	Asilidae	*Fly spp*	0	5
Mantodae	Mantidae	*Stagmomantiscarolina*	5	6
		Parasphendaleaffinis	7	2
Hemiptera	Pentatomidae	*Proxyspunctulatus*	21	4
		Unidentified sp	0	3
	Cercopidae	*Tomaspis cf. biolleyi*	12	0
		Total number of insect individuals	1099	475
		Total number of insect species	45	31

Table 2: Comparison of insect diversity from grassland and woodland communities based on different diversity parameters

Insect order	Community	Species richness	Abundance	Shannon index	Margalef index	Evenness index	Simpson index	Sorensen similarity index
Overall	Grassland	45	1099	3.208	6.284	0.843	0.060	0.553
	Woodland	31	475	2.671	4.868	0.778	0.129	
Coleoptera	Grassland	14	307	2.171	2.270	0.823	0.138	0.667
	Woodland	10	176	2.020	1.741	0.877	0.149	
Hymenoptera	Grassland	7	347	1.424	1.026	0.732	0.325	0.833
	Woodland	5	222	1.029	0.740	0.639	0.492	
Blattodea	Grassland	2	45	0.687	0.000	0.991	0.495	0.000
	Woodland	0	0	0.000	0.000	0.000	0.000	
Lepidoptera	Grassland	4	29	1.126	0.891	0.812	0.347	0.182
	Woodland	7	34	1.911	1.701	0.983	0.127	
Orthoptera	Grassland	10	287	1.714	1.590	0.744	0.215	0.333
	Woodland	2	14	0.520	0.379	0.750	0.637	
Odonata	Grassland	3	30	1.068	0.588	0.972	0.331	0.800
	Woodland	2	9	0.687	0.455	0.991	0.444	
Diptera	Grassland	1	9	0.000	0.000	-	1.000	0.000
	Woodland	1	5	0.000	0.000	-	1.000	
Mantodae	Grassland	2	12	0.679	0.402	0.980	0.470	1.000
	Woodland	2	8	0.562	0.481	0.811	0.571	
Hemiptera	Grassland	2	33	0.655	0.286	0.946	0.523	0.500
	Woodland	2	7	0.683	0.514	0.985	0.429	

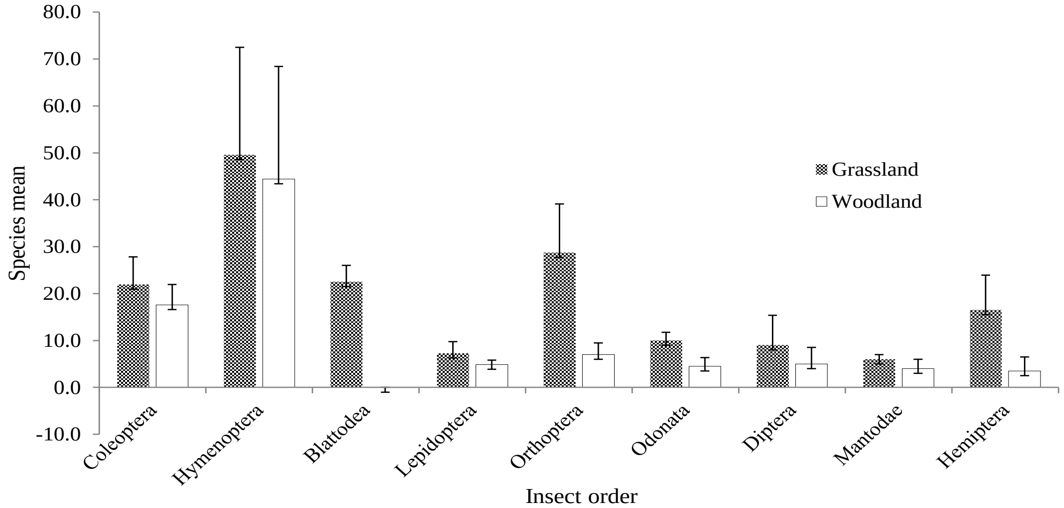

*Figure 2: Comparison of insect mean number of species (mean ± SE) between grassland and woodland within insect order: There is significant difference in species mean number between grassland and woodland communities in Blattodea, Orthoptera and Odonata. *significant difference ($p < 0.05$).*

Table 3: Comparison between grassland and woodland communities based on the mean number of insect species

Insect order	Community	Species richness	Mean	Standard deviation	Standard error	t-value	p-value
Coleoptera	Grassland	14	21.93	22.12	5.91	1.50	0.07^{NS}
	Woodland	10	17.60	13.75	4.35		
Hymenoptera	Grassland	7	49.57	60.72	22.95	0.58	0.29^{NS}
	Woodland	5	44.40	53.73	24.03		
Blattodea	Grassland	2	22.50	3.54	3.54	9.00	0.01*
	Woodland	0	0.00	0.00	-		
Lepidoptera	Grassland	4	7.25	5.02	2.51	0.28	0.39^{NS}
	Woodland	7	4.86	2.59	0.98		
Orthoptera	Grassland	10	28.70	32.88	10.40	2.61	0.01*
	Woodland	2	7.00	3.50	2.48		
Odonata	Grassland	3	10.00	3.00	1.73	3.03	0.02*
	Woodland	2	4.50	2.65	1.87		
Diptera	Grassland	1	9.00	6.36	6.36	0.39	0.37^{NS}
	Woodland	1	5.00	3.54	3.54		
Mantodae	Grassland	2	6.00	1.41	1.00	0.89	0.23^{NS}
	Woodland	2	4.00	2.83	2.00		
Hemiptera	Grassland	2	16.50	10.54	7.45	0.95	0.21^{NS}
	Woodland	2	3.50	2.08	3.00		

NS: Not significant, * significant difference ($p < 0.05$).

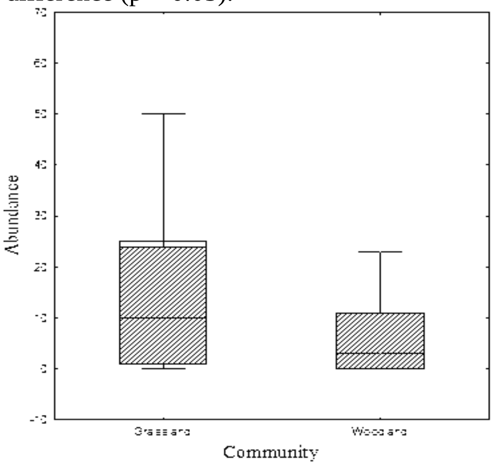

*Figure 3: Box plot of insect abundance collected from grassland (a) and woodland (b) communities. There is a significant difference in abundance of insects between grassland and woodland (Mann-Whitney U: p = 0.0009, p<0.05, $n_{grassland}$ = 1099, $n_{woodland}$ = 475). *significant difference (p < 0.05).*

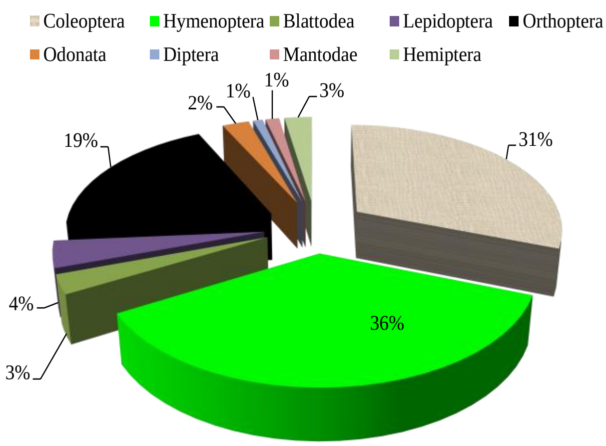

Figure 4: Abundance of insect in each order collected from grassland and woodland communities at MUST

Discussion

Study on the diversity of insect fauna in grassland and woodland community at MUST indicated a total of 1574 insects which belonged to 55 insect species, 9 insect orders and 38 families (Table 1). However, the grassland had high insect abundance (1099), species (45) and families (33) compared to woodland (Table 2). The grassland showed high value of Shannon-Wiener index (H = 3.208) which suggested that grassland had high diversity than the woodland (H = 2.671). Likewise, the grassland showed high species richness which is indicated by high value of Margalef index (D = 6.284) compared to woodland (D = 4.868). A comparison of insect mean number of species between grassland and woodland within insect orders indicated that the two communities differed significantly in some orders (Fig. 2, Table 3).Similarly, the abundance of insect between grassland and woodland revealed a significant difference (Fig.3). The difference in abundance and insect mean number of species between the two communities may be due to availability of food resources and ecosystem stability [2, 30]. For example, in grassland there were plentiful young green grasses and fewer disturbances compared to woodland community. The woodland part was dominated only by Eucalyptus trees with poor canopies and ground cover, neither young green grasses nor trees were established, and hence less food resources, poor ecological niches and microhabitats to support many insect species. It was further observed that the woodland community experienced regular human disturbances such as firewood collection. Therefore, the presence of disturbances, less food resources and shelter in the woodland community could be the motives for the less abundance and diversity of insect species in this community. Additionally, Crane and Baker [31] described that, ground cover, organic matter, and woody debris provide habitats for many insects and are food for the scavengers such as beetles. Therefore due to presence of less organic matter, less ground cover and less woody debris in the woodland community declined the abundance and diversity of insect species. The difference in abundance and number of species shows that there are differences between these communities in the factors that affect insect availability. Ranio and Niemela [14] also emphasised that, changes in species abundance such as a decrease or increase is often due to environmental disturbances.

A low value of Simpson index in grassland (λ =0.060) as compared to woodland community (λ =0.129) showed that overall grassland consisted of less rare species because of high diversity in grassland community [24]. Due to presence of less rare species in grassland, 84.3% insect species were equally distributed in grassland whereas only 77.8% insect species showed even distribution in the woodland community [3]. Moreover, the similarity index indicated that both the communities were 55.3% similar in the distribution of insect fauna and 44.7% dissimilarity was left between both communities (Table 2). Mantodae showed highest similarity index (100%) between both communities while Blattodea and Diptera showed no similarity (Table 2). The orders with respect to the number of individuals in the two communities were as follows: Hymenoptera (36.150%), Coleoptera (30.686%), Orthoptera (19.123%), Lepidoptera (4%), Hemiptera and Blattodea (3%), Odonata (2%), Diptera and Mantodae (1%) (Fig.4). Hymenoptera and Coleoptera showed high insect abundance in both communities. However, Orthoptera showed high abundance only in grassland community (Table 2). The high abundance of Hymenopterans and Coleopterans in both sites could be due to their ability to colonize and inhabit different habitats [18, 32]. A maximum number of species recorded was that belonged to Coleoptera, Hymenoptera and Orthoptera. It has been analysed that order Coleoptera recorded the highest number of species in both communities compared to Hymenoptera. For instance, there were 14 and 10 Coleopteran species in grassland and woodland respectively. Hence order Coleoptera showed high species richness as indicated by Margalef index (D = 2.270) in grassland and (D = 1.741) in woodland (Table 2). High richness of Coleopterans has been also reported in many study areas of the world [1, 5, 10].

Coleoptera commonly known as beetles is the most widespread order of insects. It is the second largest and most diverse order of insects on our planet [14]. Generally they are herbivores, scavengers or predators [33]. The environmental impact of beetles can be seen from their effects on green plants, their role to breakdown of plant and animal remains as well as their predatory activities [34]. Coleoptera showed high abundance in both communities because of their ability to respond to factors such as vegetation complexity, microclimate and to conditions in the soil and litter layers [35]. Both larvae and adults have strong mandibulate mouthparts and different life styles that make them able to feed on a wide variety of foods and dwell in all types of habitat niche [14, 33, 34, 36]. The present study revealed the presence of 24 species belonging to 9 families from the study areas. According to total number of individuals it is the second dominated order (30.686%).

Hymenoptera is a group of pollinators found in many habitat types [32]. Nevertheless, it was found to be less abundant in woodland compared to grassland community (Table 2). The current study indicated the presence of 12 species of Hymenoptera belonging to 7 families from the study sites. According to total number of individuals it is the first dominated order (36.150%).It has been analysed that order Hymenoptera recorded highest Shannon-Wiener index (1.424), highest species richness (1.026) and evenness (0.732) in grassland compared in woodland (Table 2). The abundance of Hymenoptera in woodland may be limited by floral display and availability of nectar in the woodland community which is only dominated by Eucalyptus trees with no flowers during study period. According to Winfree[37] the availability of nest and forage sites are essential for pollinating insects and low floral diversity reduces the pollinators' abundance and diversity. Although the abundance of insects in the order Lepidoptera (also pollinators) did not differ much, but were found to be less in grassland (Table 2). This may be caused by other factors such as insects sampling techniques, habitat preference during sampling hours and effects of local habitat characteristics [38].

The order Orthoptera consisted of common insects like grasshoppers, locusts, crickets, mole crickets and grouse locusts. The high abundance of Orthoptera in grassland is because they are well adapted in open areas such as grassland and savannas [39, 40]. That is why they are also considered inhabitants of these open habitats [41]. This is supported by the number of species collected in grassland being high compared to woodland (Table 2 and 3). In theory, Orthopterans have colonised all available terrestrial habitats and a few have become truly semiaquatic [39, 11]. For instance, Orthopterans such as *Hippotioncelerio, Aeoloplides turnbulli, Aeropedellusclavatu, Phlibostromaquadrimaculata, and Sphingonotusbalteatus*are found in all terrestrial habitats. This study showed the presence of 12 species of Orthoptera belonging to 5 families from the study communities. According to total number of individuals it is the third dominated order (19%).Diversity analysis indicated that order Orthoptera revealed highest Shannon-Wiener index (1.714), highest species richness (1.590) and evenness (0.744) in grassland compared to woodland (Table 2). This study suggests the presence of less food and shelter in the woodland community may perhaps be the reason for the less diversity of these insect species.

The orders, Hemiptera, Blattodea, Odonata, Diptera and Mantodae although are the lowest dominated orders, also showed highest insect abundance, highest Shannon-Wiener index, highest species richness and evenness in grassland compared to woodland community except Lepidoptera (Table 2). Lepidoptera which commonly included butterflies and moths, in this current study is the fourth dominated order (4%). The order belongs to 8 families and 11 species. The order was found to be dominant in woodland in terms of insect abundance, highest Shannon-Wiener index (1.911), highest species richness (1.701) and evenness (0.983) (Table 2). This shows that Lepidoptera in woodland were well adapted than the other insect orders. The most dominated species were *Euremahecabe* (family Pieridae), *Danausplexippus*(Family Danaidae), and*Acraeaencedon (*family Nymphalidae).

All the insect species present in grassland were well represented in the woodland community with the exception of the species belonging to the order Blattodea, Orthoptera and Odonata. These three orders showed a significant difference in their mean number of insect species between the two communities (Table 3, Fig.2). Poor representation and colonization of these insect groups in woodland community can be due to the presence of poor distributed ecological niches, less microhabitats, many predators and less food as compared to grassland community [42]. The most dominant family was Apidae with 330 individuals of *Apis mellifera* in the order Hymenoptera. *Apis mellifera* are commonly species of hymenoptera found around areas of MUST, they can be seen in many buildings, also on trees. The second dominant family was Acrididae with 90 species of *Aeoloplides turnbulli* in the order Orthoptera.

Conclusion and recommendation

Low insect species diversity and abundance in woodland suggests that there are relatively few successful species in the community, the environment is probably quite stressful with fairly few ecological niches, microhabitats and only a few insect species are adapted in that community. Food webs also seem to be relatively simple and change in the habitat would possibly have quite serious effects. Whereas, high abundance and species diversity in grassland community suggests a larger number of successful insect species, stable ecosystem community, availability of ecological niches and the habitat is less disturbed. Hence, the results revealed that the grassland community has the potential to support insect diversity and act as effective refugia for some insects from woodland community. Moreover, this study recommends that these habitats should be given conservation priority so that to promote biodiversity of insects.

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