Diversity And Abundance Of Arthropods At Mbeya University Of Science And Technology, Tanzania

Fredrick Ojija

Abstract: Despite the high abundance of arthropods in many terrestrial environments, our understanding of their ecological diversity and abundance remain unknown in some habitats. The aim of this study is to assess the abundance, diversity and species richness of some arthropods found in grassland and woodland habitats at Mbeya University of Science and Technology in Tanzania. A total of 1719 arthropods belonging to 63 species under 12 orders and 46 families were collected. Parameters such as Shannon index, Simpson index, Margalef index, Evenness index and Sorenson similarity index were used to analyse the diversity of arthropods. Result showed that, Hymenoptera (33.101%), Coleoptera (28.098%) and Orthoptera (17.510%) were the most dominant orders, whereas the least abundant order were Diptera (0.814%) and Scolopendromorpha (0.291%). The grassland showed high species richness, Margalef index (D = 6.930), abundance (n = 1177), Evenness (E = 0.854) and Shannon diversity (H = 3.339) of arthropods. The abundance of arthropod groups between grassland and woodland differed significantly ($p<0.05$). Sorensen similarity index in both habitats showed 53.5% similarity. Therefore, result indicates that the grassland habitat has the potential to support arthropod diversity and act as effective refugia for some arthropods from woodland.

Index Terms: Abundance, Arthropods, Diversity, Evenness, Richness, Similarity, MUST, Tanzania

1 INTRODUCTION

Arthropod is the most diverse and dominant constituent of biodiversity in terrestrial ecosystems. It is the largest animal phylum constituting about 85% of all known animals in the world [1]. It is estimated that, worldwide, arthropod species is around 1,170,000 [1, 2]. Among the arthropod groups, insect is the most diverse and abundant in our planet. Approximately, about 30 million species of insects are found worldwide, of which about 1.4 million have been described, among these, 750,000 are insects [2]. All invertebrates including insects make up more than 75% of all described global species diversity [3]. They occur in different habitats, in both terrestrial and freshwater ecosystem [4, 5]. Arthropods have adapted nearly every possible type of ecosystem [6], and play an important role in the ecology of many habitats [7]. They play a significant role as herbivores, detritivores, and carnivores for nutrient cycles as well as energy flow in the terrestrial ecosystem. Moreover, they provide numerous ecosystem services that are profitable to both human and ecosystem. These ecosystem services include but not limited to pollination, organic matter decomposition, seeds dispersal, control populations of other organisms, pest control, and maintain soil structure and fertility [8]. Arthropods such as insects especially those feed on dead trees or wood and other decaying organic materials play a major role in nutrient cycling. In addition, arthropods form an important part of the food chain because are found almost in every habitat and are consumed as food by other animals such as amphibians, birds, fish, mammals and reptiles [9]. In many food webs and food chain lengths arthropods are prevalent and have a huge significance due to their diversity, ecological roles and influence on the agriculture, natural resources and human health [10]. Furthermore, they maintain community structure and composition [3] and are the parasites or disease vectors for many other organisms, including humans [11]. Although there is association of arthropods with our lives which affect the well-being of humanity in different ways, but a huge number of arthropods including those not yet known or discovered continue to extinct from their local habitats worldwide [2, 7, 11]. This is due to some reasons such as climate change and anthropogenic activities. Moreover, because of their small size, short life spans, and high reproductive rates, the abundances and diversities of some arthropods change on a seasonal or annual time scale. These changes are noticeable and make arthropods more suitable as indicators of environmental changes or quality than larger and longer-lived organisms that respond more slowly [4, 6]. Arthropods such as species of insects respond highly to environmental changes, including those resulting from anthropogenic activity to agriculture [12]. For example, response of aquatic insects to environmental changes can vividly affect aquatic ecosystem health, structure and function [13]. The abundance, diversity and species richness of arthropods represent an equivalent variety of adaptations to variable environmental conditions. Diversity can be defined as the variability among the living organisms from different environments (terrestrial and aquatic ecosystems), this constitutes diversity within species, between species, and of ecosystems as well as their ecological complexity within the environment, and all the ecological processes [14]. Development of infrastructures affects abundance, species richness, species composition, populations, and communities, because changes in community attributes influence the structures and functions of ecosystems. Undeveloped areas of Mbeya University of Science and Technology (MUST) host high abundance of arthropods, however are continuously disturbed by human activities such as expansion of the university infrastructures and cutting of grasses. As result many habitats of arthropods are declining, fragmented or isolated. Despite MUST having large area covered by grasses and woods, little is known about the abundance, diversity, and species of arthropods inhabiting the area because no study which has been done to assess the diversity and abundance of arthropods present. The on-going human activities destroy macro-habitats and micro-habitats of arthropods. Therefore, decrease the abundance, diversity and species richness of arthropods [15] because arthropods are disturbance sensitive [16]. Therefore, this study was carried out to assess abundance, diversity and species richness of arthropods found at MUST main campus. Precisely, it was to determine whether the composition of arthropod assemblages can differ in the two habitats, grassland and woodland.

2 Materials and Methods

2.1 Study area.

Mbeya University of Science and Technology (MUST) is located in Mbeya region (altitude 1718m) at latitude 8°56′30″S and longitude 33°24′58″E on the higher altitude of unplanned settlement of Ikuti areas [17]. The University is 10km away from the city centre. The University encompasses an area of more than 2000 ha. Large part of this area is covered by grasses and woods. Insects were sampled from grassland and woodland habitats. Woodland area is dominated by planted eucalyptus tree, fewer short grasses and few shrubs while the grassland is dominated by Cynodon spp, Panicum maximum and Urochloa mosambicensis. The rainy season usually occurs from October to May and the dry season occurs from June to September. The area receives rainfall around 1400mm-1600mm per year [18]. The climate of Mbeya region is influenced by physiology and altitude. The temperatures in the region vary according to altitude but generally range from about 16oC in the highlands to 30^{o}C in the lowland areas [17, 19].

2.1.1 Arthropod collection methods

Arthropods were collection from March 2016 to June 2016. They were collected using pitfall traps, sweep nets, beating sheets and manually using hands. Collected arthropods were brought back to the laboratory and sorted with the help of keys and guides to species level [21]. Trapped arthropods were killed using ethyl acetate in the killing bottle 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). Techniques used to collect arthropod are similar to those described in Balakrishnan et al., [2], Adjaloo et al., [3], Nazir et al., [4], Belamkar and Jadesh [6], Khadijah et al., [11] and Nyundo and Yaro [20].

Pitfall trapping (PT): A plastic cup (diameter 8 cm, depth 10 cm) was used to make a trap without using any bait for the collection of arthropods (Fig.1a). A total of 23 pitfall traps were permanently installed at an interval of 5m. In each habitat only one line transect was established with pitfall traps being allocated within the transect line by systematic random sampling technique. Pitfall traps were sunken in the ground in such a way that the top was flush with the ground surface and they were visited every morning (8am), afternoon (2pm) and evening (5 pm) to collect any captured arthropods. Pitfall traps were continuously exposed from March 2016 to June 2016. Traps were half-filled with soapy fluid to avoid escape by captured arthropods. No roof was used to avoid microclimate change and trap loss was negligible. These kinds of traps have been widely used for sampling arthropod group especially insects in biodiversity inventories [20].

Beating sheets (BS): This technique was used to arthropods that feed and or rest on trees, bushes, and other plants. These kinds of arthropods are 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 centre (Fig.1b).

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 sampling habitats. Sweep sampling was done to trap flying arthropods (Fig.1c). This method is suited for sampling insects from ground layer vegetation [6]. Collected arthropods in the sweeping were temporarily transferred in polythene bags and plastic bottles before taken to the laboratory for identification and preservation.

Hand collection (HC): Manual collection of arthropods using hands was done three times every week for 3h during the day time. Collecting involved actively searching for the arthropods on the ground, in leaf litters and grasses, under logs, tree barks and other substrates. They were directly collected by hand.

Fig. 1. *Arthropod collection methods: (a) Setting of pitfall traps, (b) Beating sheet and (c) sweep nets*

2.1.2 Diversity analysis

Biodiversity indices were calculated using the standard formulas. Diversity of arthropod species in both habitats was calculated using Shannon-Weaver diversity index (H) [22, 23].

The Shannon index is given by the formula

$$H = -p_i \ln p_i$$

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 arthropods was calculated using the Margalef index (D) [24]. 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). Evenness or equitability was calculated using the Pielou's evenness index [25]. 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 determine information about rarity (diversity) of species present on the sites [26]. 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. 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 [27-29] 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. Comparison between grassland and woodland habitats based on the mean number of insect species was done using independent sample t-test [4] whereas Mann-Whitney U-test was used to compare the arthropod abundance between grassland and woodland habitats. For all data, normality was tested using, STATISTICA Ver. 8 [30]. Significance was assessed at α = 0.05.

3. Results

A total of 1719 arthropods individuals belonging to 63 species under 12 orders and 46 families were collected from grassland and woodland habitats (Table 1 and 2). A total of 1177 arthropods belonging to 50 arthropod species under 11 arthropod orders and 38 arthropod families were captured from grassland while 542 arthropods belonging to 36 arthropod species under 12 arthropod orders and 30 families were collected from woodland (Table 1). Different diversity parameters such as Shannon index, Simpson index, Margalef index, Evenness index and Sorenson similarity index were used to explain the diversity of arthropods in both habitats (Table 2 and 3). Grassland habitat showed high species richness (Margalef index = 6.930), abundance (n = 1177), Evenness (E = 0.854) and Shannon diversity (H = 3.339) of arthropods (Table 3). Order Scolopendromorpha and Polydesmida had no species richness, and indicated zero Margalef and Shannon index (Table 2). Only order Polydesmida indicated high Simpson index (λ =1.000) in both habitats (Table 3) A maximum number of arthropod species recorded was that belonged to Coleoptera, Hymenoptera and Orthoptera (Table 2). Total abundance of each order with respect to the number of arthropods in both habitats is shown table 2. The most abundant orders of arthropod were Hymenoptera (33.101%), Coleoptera (28.098%) and Orthoptera (17.510%), constituting 78.709% of the total, whereas the least abundant were Diptera (0.814%) and Scolopendromorpha (0.291%) (Table 2). On the other hand, 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). On the basis of Sorensen similarity index, both sites showed 53.5% similarity, and arthropods in the order Mantodae and Polydesmida showed highest value of similarity index (100%) followed by the order Hymenoptera (83.3%), Odonata (80%), Coleoptera (66.7%), and Hemiptera (50%) while Blattodea, Diptera and Scolopendromorpha showed no similarity (Table 3). Furthermore, it was found that the mean number of arthropod species between grassland and woodland habitats in Blattodea ($p<0.05$), Orthoptera ($p<0.05$) and Odonata ($p<0.05$) differed significantly (Figure 2, Table 4). However, the abundance of arthropods between grassland and woodland habitats differed significantly ($p<0.05$) (Figure 3).

Table 1: *The number of arthropod species and individuals within taxonomic order and family recorded from grassland and woodland habitats*

Arthropod taxon			Habitats	
Order	Family	Species	Grassland	Woodland
Coleoptera	Curculionidae	*Polydrusus formosus*	4	0
		Sitophilus zeamais	1	0
		Curculio spp	24	29

	Chrysomelidae	*Chrysochus auratus*	0	47
		Glyptoscelis pubescens	1	1
	Scarabaedae	*Macrodactylus subspinosus*	15	0
	Carabidae	*Pterostichus melanarius*	0	2
		Promeces spp	1	0
	Tenebrionidae	*Unidentified beetle spp*	41	11
		Pimelia bipunctata	34	11
		Pedinini Platynotina	41	0
		Arturium tenuieostatum	37	21
	Dermestidae	*Unidentified beetle spp*	10	12
	Elateridae	*Unideintified bettele spp*	79	0
	Cleridae	*Checkered beetles spp*	11	19
	Coccinellidae	*Hippodamia convergens*	8	23
Hymenoptera	Formicidae	*Pchycondyla spp*	6	6
	Apidae	*Apis mellifera*	179	151
	Syrphidae	*Eristalis tenax*	50	30
	Vespidae	*Polistes*	30	20
	Pompilidae	*Auplopus mellipes*	10	15
	Sphecidae	*Sceliphron caementarium*	12	0
	Margarodidae	*Unidentified ants spp*	60	0
Blattodea	Blattidae	*Blatta orientalis*	25	0
	Blattellidae	*Loboptera decipiens*	20	0
Lepidoptera	Papilionidae	*Papilio constantinus*	0	5
	Erebidae	*Achaea spp*	0	4
	Danaidae	*Danaus plexippus*	7	6
	Nymphalidae	*Acraea encedon*	6	0
		Junonia oenone	0	4
		Pseudacraea boisduvali	0	7
	Pieridae	*Eurema hecabe*	15	0
	Lasiocampidae	*Malacocoma spp*	0	5
	Hesperiidae	*Asbolis capucinus*	1	0
	Sphingidae	*Hippotion celerio*	0	3
Orthoptera	Acrididae	*Aeoloplides turnbulli*	90	0
		Aeropedellus clavatu	30	0
		Phlibostroma quadrimaculata	70	0
		Sphingonotus balteatus	60	0
		Acanthacris ruficornis	1	0
	Diapheromeridae	*Diapheromera femorata*	20	11
	Tettigoniidae	*Pterophylla camellifolia*	5	0
		Tettigonia viridissima	3	0
	Pyrgomorphidae	*Phymateus viridipes*	4	3
	Gryllidae	*Acheta domestica*	4	0
Odonata	Calopterygidae	*Phaon iridipennis*	13	5
	Libellulidae	*Brachythemis spp*	10	4
		Crocothemis erythraea	7	0
Diptera	Calliphoridae	*Lucilia sericata*	9	0
	Asilidae	*Fly spp*	0	5
Mantodae	Mantidae	*Stagmomantis carolina*	5	6
		Parasphendale affinis	7	2
Hemiptera	Pentatomidae	*Proxys punctulatus*	21	4
		Unidentified sp	0	3
	Cercopidae	*Tomaspis cf. biolleyi*	12	0
Araneae	Tetranathidae	*Leucauge venusta*	0	20
	Agelenidae	*Eratigena agrestis*	10	0
	Araneidae	*Gasteracantha cancriformis*	0	7
	Salticidae	*Salticus scenicus*	10	0
	Miturgidae	*Chiracanthium inclusum*	15	0
	Pholcidae	*Pholcus phalangioides*	13	15

Scolopendromorpha	Crptyopidae	*Theatops californiensis*	0	5
Polydesmida	Eurymerodesmidae	*Eurymerodesmus spp*	30	20
		Total arthropods	1177	542
		Total species	50	36

Table 2: Shows abundance, diversity, evenness and species richness of arthropod orders collected from MUST

Group of arthropods (order)	Number of family	Number of Species	Number of insects	Percentage (%)	Diversity index (H')	Margalef index	Evenness index	Simpson index
Coleoptera	9	16	483	28.098	2.398	2.427	0.865	0.099
Hymenoptera	7	7	569	33.101	1.343	0.946	0.690	0.377
Blattodea	2	2	45	2.618	0.687	0.263	0.991	0.495
Lepidoptera	8	10	63	3.665	2.098	2.172	0.911	0.130
Orthoptera	5	10	301	17.510	1.763	1.577	0.766	0.202
Odonata	2	3	39	2.269	1.033	0.546	0.940	0.358
Diptera	2	2	14	0.814	0.652	0.379	0.940	0.505
Mantodae	1	2	20	1.163	0.688	0.334	0.993	0.479
Hemiptera	2	3	40	2.327	0.849	0.542	0.773	0.473
Araneae	6	6	90	5.236	1.683	1.111	0.939	0.196
Scolopendromorpha	1	1	5	0.291	0.000	0.000		1.000
Polydesmida	1	1	50	2.909	0.000	0.000		1.000
Total	46	63	1719	100.000				

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

Table 3: Comparison of arthropod diversity from grassland and woodland habitats based on different diversity parameters

Arthropod group (order)	Community	Number of species	Abundance	Shannon index	Margalef index	Evenness index	Simpson index	Sorensen similarity index
Overall	Grassland	50	1177	3.339	6.930	0.854	0.053	0.535
	Woodland	36	542	2.666	5.560	0.744	0.103	
Coleoptera	Grassland	14	307	2.171	2.270	0.698	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	
Araneae	Grassland	4	48	1.371	0.775	0.989	0.242	0.286
	Woodland	3	42	0.283	0.535	0.257	0.367	
Scolopendromorpha	Grassland	0	0	0.000	0.000	0.000	0.000	0.000
	Woodland	1	5	0.000	0.000	-	1.000	
Polydesmida	Grassland	1	30	0.000	0.000	-	1.000	1.000
	Woodland	1	20	0.000	0.000	-	1.000	

4 Discussion

A total of 1719 arthropods which belonged to 63 arthropod species, 12 arthropod orders and 46 families were collected during study on the diversity and structure of arthropod groups in grassland and woodland habitats at MUST (Table 1 and Table 2). The grassland showed high arthropod abundance (1177), species (50) and families (38) compared to woodland. The grassland indicated high value of Shannon-Wiener index (H = 3.339) which suggested this habitat had high diversity than the woodland (H = 2.666). Similarly, the grassland showed high species richness which is indicated by high value of Margalef index (D = 6.930) compared to woodland (D = 5.560) (Table 3). A comparison of arthropod mean number of species between grassland and woodland habitats within arthropod orders indicated that the two habitats differed significantly in Blattodea, Orthoptera and Odonata (Fig. 2). Additionally, the abundance of arthropods between grassland and woodland indicated a significant difference (Fig.3). The unlikeness in abundance and mean number of arthropod species between the two habitats could be due to differences in availability of food resources and ecosystem stability as explained by Adjaloo et al., [3] and Jaganmohan et al., [31]. Although this study was carried out during dry seasons, the grassland habitat had young green grasses. Additionally, the grassland was less disturbed compared to woodland habitat. The woodland habitat was dominated by Eucalyptus trees with poor canopies and ground cover, neither grasses nor young 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 could be the reason for the less abundance and diversity of arthropod species in this habitat. Furthermore, Crane and Baker [32] described that, ground cover and woody debris and organic matter provide habitats for many arthropods and are food for the foragers. Therefore due to presence of less organic matter, less ground cover and less woody debris in the woodland habitat there were less arthropod species, diversity and abundance. The difference in abundance and number of species shows that there are differences between these habitats in the factors that affect arthropods growth. Ranio and Niemela [15] underlined that, changes in species abundance such as a decrease or increase is often due to environmental disturbances. Grassland habitat showed a low value of Simpson index (λ =0.053) as compared to woodland (λ =0.103). This indicates that overall grassland consisted less rare species because of high diversity in grassland habitat [26]. Due to presence of less rare species in grassland, 85.4% arthropod species were evenly distributed in grassland while only 74.4% arthropod species showed even distribution in the woodland habitats [4]. Moreover, the similarity index showed that both habitats were 53.5% similar in the distribution of arthropods and 46.5% dissimilarity was left between both habitats. Mantodae and Polydesmida showed highest similarity index (100%) between both habitats whereas Blattodea, Diptera and Scolopendromorpha showed no similarity (Table 3). Arthropod orders, Hymenoptera and Coleoptera showed high abundance in both habitats. However, Orthoptera showed high arthropod abundance in grassland (Table 3). The high abundance of Hymenoptera and Coleoptera in both sites may possibly be due to their ability to inhabit different habitats [33]. A maximum number of arthropod species recorded was that belonged to

Coleoptera, Hymenoptera and Orthoptera. Nevertheless, the order Coleoptera recorded the highest number of arthropod species in both habitats compared to Hymenoptera. High species richness of Coleoptera is indicated by Margalef index (D = 2.270) in grassland and (D = 1.741) in woodland (Table 3). The high richness of Coleopterans has been also shown in many studies around the world [2, 4, 6, 11, 15, 21]. Coleoptera commonly known as beetles is the most widespread order of arthropods. It is the largest and most diverse order of arthropods on our planet [15]. They are generally herbivores, scavengers or predators [34, 35]. Coleoptera showed high abundance in both habitats because of their ability to respond to factors such as conditions in the soil and litter layer, vegetation complexity and microclimate [36]. Both larvae and adults have strong mouthparts and different life styles that make them able to feed on a wide variety of foods and live in all types of habitat niche [34, 37]. The present study had shown the presence of 24 species belonging to 9 families from the study area (Table 2). According to total number of individuals it is second dominated order (Fig.2). Hymenoptera is a group of pollinators found in many habitat types [33]. Nevertheless, it was found to be less abundant in woodland compared to grassland community (Table 4). The current study indicated the presence of 12 species of Hymenoptera belonging to 7 families from the study areas. According to total number of individuals it is the first dominated order (Table 4). It has been indicated 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 3). The reason of being less abundant in woodland habitat may be limited by floral display and availability of nectar in the woodland which is dominated by Eucalyptus trees with no flowers during this study. According to Winfree [38], the availability of nest and forage sites are essential for pollinating insects and low floral diversity reduces the pollinators' 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 3). This may be due to other reasons such as insects sampling techniques, habitat preference during sampling hours and effects of local habitat characteristics [39].

Table 4: Comparison between grassland and woodland communities based on the mean number of arthropod species

Arthropod order	Community	Species richness	Mean	STDEV	SE	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	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		
Araneae	Grassland	4	12.00	6.48	3.24	0.23	0.41^{NS}
	Woodland	3	14.00	8.72	5.03		
Scolopendromorpha	Grassland	0	-	-	-	-	-
	Woodland	1	5.00	-	-		
Polydesmida	Grassland	1	30.00	-	-	-	-
	Woodland	1	20.00	-	-		

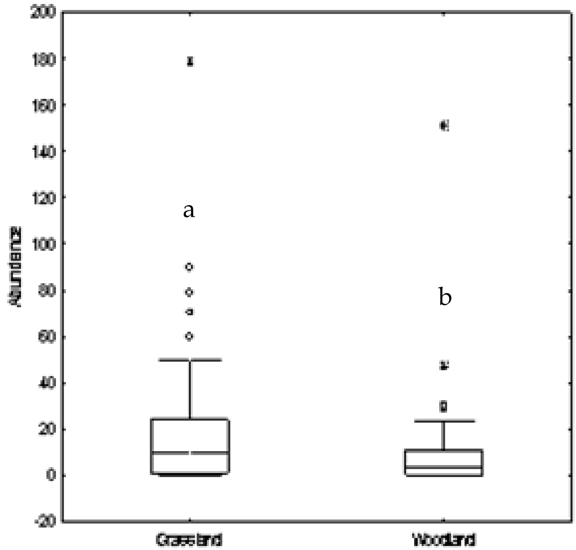

Fig. 3. Box plot of arthropods abundance collected from grassland and woodland habitats. There is a significant difference in abundance of arthropods between the two habitats (Mann-Whitney U: $p = 0.0015$, $p<0.05$, $n_{grassland} = 1177$, $n_{woodland} = 542$). Different letters on top of box plot indicate significant difference at $p < 0.05$.

The high abundance of Orthoptera was observed in grassland habitats (Table 4). This is because they are well adapted in open areas such as grassland and savannas [40-42]. Like other many arthropods, Orthoptera can also be located in many terrestrial habitats; however, a few have become semiaquatic [12, 40]. This current study presented 12 species of Orthoptera belonging to 5 families from the study habitats (Table 2). According to total number of individuals it is the third dominated order (Table 2). Moreover, the order Orthoptera shown highest Shannon-Wiener index, highest species richness and evenness in grassland compared to woodland habitat (Table 3). This study suggests that the presence of less food and shelter in the woodland may be the reason for the less diversity of this group. The other orders of arthropod such as Hemiptera, Blattodea, Odonata, Diptera, Mantodae, and Araneae although are the lowest dominated orders, showed highest arthropod abundance, highest Shannon-Wiener index, highest species richness and evenness in grassland compared to woodland community except Lepidoptera, Scolopendromorpha and Polydesmida (Table 3). Lepidoptera which commonly includes butterflies and moths, in this current study is the fourth dominated order (Table 2). This order was found to be dominant in woodland habitat in terms of arthropod abundance, highest Shannon-Wiener index, highest species richness and evenness (Table 3); most likely this group of arthropod was well adapted in woodland than the other arthropod groups. The most dominated arthropod species were Eurema hecabe (family Pieridae), Danaus plexippus (Family Danaidae), and Acraea encedon (family Nymphalidae) Order Scolopendromorpha and Polydesmida had no species richness. Additionally, arthropod species in both orders were not evenly distributed in both habitats (Table 3). Order Scolopendromorpha showed high Simpsons index (λ =1.000) in woodland compared to grassland habitat. This shows that overall woodland consisted of more rare species because of less diversity in woodland habitat. Furthermore, order Polydesmida indicated high Simpson index (λ =1.000) in both habitats (Table 3). This shows that both habitats consisted of more rare species and less diversity [26]. It was further observed that, all arthropod species present in grassland were well represented in the woodland habitat with the exception of the arthropod species belonging to order Blattodea, Orthoptera and Odonata. These three orders showed a significant difference in their mean number of arthropod species between the two habitats (Fig.2). Poor representation and colonization of these arthropod groups in woodland habitat may be due to the presence of poor distributed ecological niches, less microhabitats, many predators and less food [43]. The most dominant family of arthropod was Apidae with 330 individuals of Apis mellifera in the order Hymenoptera. The Apis mellifera are common species of hymenoptera found around the University areas, are usually seen in buildings. The second dominant family arthropod was Acrididae with 90 species of Aeoloplides turnbulli in the order Orthoptera.

5 Conclusion and Recommendation

Low arthropod species diversity and abundance in woodland suggests that there are relatively few successful species in this habitat. This ecosystem is probably have few ecological niches and microhabitats, thus only few arthropod species are adapted. Food webs on the other hand seem to be relatively simple in the habitat, possibly have serious effects on the abundance and diversity of arthropods. Whereas, high abundance and species diversity in grassland habitat suggests a larger number of successful arthropod species, stable ecosystem, enough ecological niches and microhabitats likely to be less disturbed. Therefore, result indicates that the grassland habitat has the potential to support arthropod diversity and act as effective refugia for some arthropods from woodland and other habitats. Additionally, this study recommends that more studies should be done in order to establish the abundance and different types of arthropods inhabiting MUST main campus.

ACKNOWLEDGEMENT
I would like to express my heartiest gratitude to the following students for collection and identification of arthropods, that is, Evomia Kimaro, Ally Hashim Kanjoka, Asha Ngoloka, and Jafari Mtoro.

REFERENCES
[1] Ødegaard, F. (2000) How many species of arthropods? Erwin' estimate revised. Biol. J.linn.Soc. 71:583-597

[2] Balakrishnan, S., Srinivasan, M., and Mohanraj, J. (2014) Diversity of some insect fauna in different coastal habitats of Tamil Nadu, southeast coast of India. J. of Asia-Pacific Biod. 7:408-414

[3] Adjaloo, M.K., Oduro, W., and Mochiah, M. B. (2012) Spatial distribution of insect assemblage in cocoa farms in relation to natural forest. J. Appl. Biosc. 54: 3870–3879.

[4] Nazir, S., Sharif, F., Arshad, M., and Khan, A. (2014) Diversity Analysis of Insects of the Thorn Forest Community at Harappa Archaeological Site, Pakistan. Pak. J. Zool. 46(4): 1091-1099.

[5] Gullan, P.J., and Cranston, P.S. (2005) The insects: an outline of entomology (3rd ed.). Wiley-Blackwell. p.505. ISBN 978-1-4051-1113-3.

[6] Belamkar, N.V., and Jadesh, M. (2012) A Preliminary Study on Abundance and Diversity of Insect Fauna in Gulbarga District, Karnataka, India. Int. J. Sci. and Res.

[7] Balasubramanian, K., Srinivasan, M., and Kathiresan, K. (2005) Insects. In: Proceedings of coastal biodiversity in mangrove ecosystems: UNU-INWEH-UNESCO, International Training Course. 359-363.

[8] Babin-fenske, J. and Anand, M. (2010) Terrestrial insect communities and the restoration of an industrially perturbed landscape: Assessing Success and Surrogacy. J. Restor. Ecol. 18: 73-84.

[9] Contreras, M.S. and Vlisidou, I. (2008) The diversity of insect-bacteria interactions and its applications for disease control. Biotech. Genet. Engin. Rev. 25: 203-244.

[10] Foottit, R.G. and Adler, P..H. (2009) Insect biodiversity science and society. Wiley-Blackwell, Oxford, UK:

[11] Khadijah A. R., Azidah A. A. and Meor S. R. (2013) Diversity and abundance of insect species at Kota Damansara Community Forest Reserve, Selangor.

[12] Ojija, F., and Laizer, H. (2016) Macroinvertebrates as bioindicators of water quality in Nzovwe stream, in Mbeya, Tanzania. IJSTR. 5(6): 211-222.

[13] Ojija, F., and Kavishe, R. (2016) A Preliminary Study on Abundance and Diversity of Aquatic Macro Invertebrates of Nzovwe Stream, in Mbeya, Tanzania. Int. J. Life Sci. Res. 4(1): 29-38.

[14] Aslam, M. (2009) Diversity, species richness and evenness of moth fauna of Peshawar. Pak. Entomol. 31:2

[15] Rainio, J., and Niemelä, J. (2003) Ground beetles (Coleoptera: Carabidae) as bioindicators. Biod. and Cons. 12: 487–506.

[16] Magurran, A. (2004) Measuring biological diversity. Oxford, UK: Blackwell Publishing

[17] Katambara, Z. (2013) Quantifying Rooftop Rainwater Harvest Potential: Case of Mbeya University of Science and Technology in Mbeya Tanzania. Eng. 5: 816-818..

[18] Ojija, F. (2015a) Assessment Of Current State And Impact Of REDD+ On Livelihood Of Local People In Rungwe District, Tanzania. IJSTR. 4(11): 288-293.

[19] Ojija, F. (2015b) Analysis of water quality parameters and ecosystem services of Nzovwe stream. IJBLS. 7(1):1-10.

[20] Nyundo, B.A., and Yarro, J.G. (2007) An assessment of methods for sampling Carabid beetles (Coleoptera: Carabidae) in a Montane rain forest. Tanz. J. Sci. 33.

[21] Martins, D.J. (2014) Insects of East Africa; Pocket guide. Struik nature, South Africa.

[22] Shannon, C.E. and Weaver, W. (1963) The mathematical theory of communication. University of Illinois Press, Urbana.

[23] Shannon, C. E., Wiener, W. (1949) The mathematical theory of communication. Urbana, University of Illinois Press, 177 p.

[24] Margalef, R. (1958) Temporal succession and spatial heterogeneity in phytoplankton. In: Perspectives in Marine biology, Buzzati-Traverso (ed.), Univ. Calif. Press, Berkeley, 323-347.

[25] Pielou, E.C. (1966) Shannon's formula as a measure of specific diversity: its use and misuse. Am. Nat., 100: 463–465.

[26] Simpson, E.H .(1949) Measurement of diversity. Nature. 163: 688.

[27] Sorensen, T. (1948) A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. Biol. Skrif. Kong. Dans. Vidensk. Selsk. 5: 1-34.

[28] Diserud, O.H., and Ødegaard, F. (2007) A multiple-site similarity measure. Biol. Lett.3: 20–22. doi:10.1098/rsbl.2006.0553.

[29] Novotny, V. and Weiblen, G. D. (2005) From communities to continents: beta diversity of herbivorous

insects. Ann. Zool. Fennici. 42: 463–475.

[30] Stat soft. (2007) Statistica version 8. Statistical program.

[31] Jaganmohan, M., Vailshery, S.L., and Nagendra, H. (2013) Patterns of Insect Abundance and Distribution in Urban Domestic Gardens in Bangalore, India

[32] Crane, S. and Baker, C. (2011) Ants and moths: Analysis of biodiversity and abundance inrevegetated pastoral land. Nat. Sci. 10: 1-21.

[33] Sharkey, M.J. (2007) Phylogeny and Classification of Hymenoptera. Zootaxa 1668: 521–548. In: Zhang, Z.-Q. and Shear, W.A. (Eds) (2007) Linnaeus Tercentenary: Progress in Invertebrate Taxonomy. Zootaxa. 1668: 1–766.

[34] Lee, C.M., Kwon, T.S., Lee, B.W., and Sung, J.H. (2012) Beetles (Coleoptera) inhabiting deadwoods of Quercus serrate and Carpinus laxiflora in forest of Gwangneung. Research note 448. Korea Forest Research Institute.

[35] Lee, C.M., and Kwon, T.S. (2013) Community structure, species diversity of insects ants, ground beetles), and forest health in the Hongneung forest. J. Kore. Forestry. Socie. 102:97-106.

[36] Lassau, S.A., Hochuli, D.F., and Cassis, G, et al. (2005) Effects of habitat complexity on forest beetle diversity: do functional groups respond consistently? Diversity and Distribution 11:73-82.

[37] Lee, S.I., Jeong, J.K., and Choi, J.S et al. (2005) Study on community structure and seasonal variations of Coleoptera in Mt. Yeonyeop area, Korea. Kore. J. Envir. Biol. 23:71-88.

[38] Winfree, R. (2010) The conservation and restoration of wild bees. Annls N. Y. Acad. Sci. 1195:169–197.

[39] Collinge, S.K., Prudic, K.L., Oliver, J.C. (2003) Effects of local habitat characteristics and landscape context on grassland butterfly diversity. Conserv. Biol. 17: 178–187.

[40] Sultana, R., Wagan, Y.S. and Wagan, M.S. (2013) Orthopteran biodiversity of Thar desert, Sindh, Pakistan. Pakistan J. Zool. 45: 299-304.

[41] Rahman, K. M. A. (2001) Food consumption and utilisation of the grasshopper Chrotogonus lugubris Blanchard (orthoptera, acridoidea, pyrgomorphidae) and its effect on the egg deposition. J. Cent. Europ. Agric. 2: 263-270.

[42] Bidau, C.J. (2014) Patterns in Orthoptera biodiversity. I. Adaptations in ecological and evolutionary contexts. J. Insect. Biod. 2(20): 1-39.

[43] Wolters, V. (2003) Landscape structure as an indicator of biodiversity: matrix effects on species richness. Agriculture, Ecos. and Envir. 98: 321–329.