

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

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**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 16°C in the highlands to 30°C in the lowland areas [17, 19].

#### 2.1.1 Arthropod collection methods

Arthropods were collected 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

$$H = - \sum p_i \ln p_i$$

Where  $p_i = S/N$ , 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 ( $p_i$ ) was calculated, and multiplied by natural logarithm of this proportion ( $\ln p_i$ ). 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 ( $\lambda$  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 measure 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  $\alpha = 0.05$ .

### 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 ( $\lambda = 1.000$ ) 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 Sorenson similarity index, both sites showed 53.5% similarity, and arthropods in the order Mantodea 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 woodland habitats differed significantly ( $p < 0.05$ ) (Figure 2, Table 4). 3). However, the abundance of arthropods between grassland

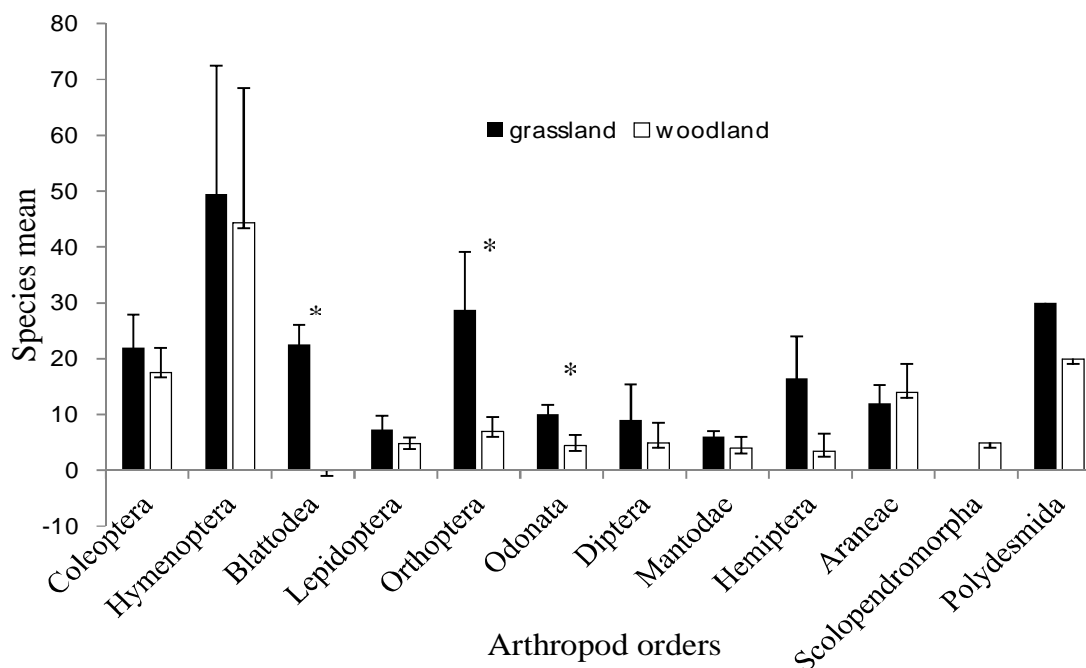
**Table 1:** The number of arthropod species and individuals within taxonomic order and family recorded from grassland and woodland habitats

| Arthropod taxon |               |                                  | Habitats                 |          |     |
|-----------------|---------------|----------------------------------|--------------------------|----------|-----|
| Order           | Family        | Species                          | Grassland                | Woodland |     |
| Coleoptera      | Curculionidae | <i>Polydrusus formosus</i>       | 4                        | 0        |     |
|                 |               | <i>Sitophilus zeamais</i>        | 1                        | 0        |     |
|                 |               | <i>Curculio spp</i>              | 24                       | 29       |     |
|                 | Chrysomelidae | <i>Chrysochus auratus</i>        | 0                        | 47       |     |
|                 |               | <i>Glyptoscelis pubescens</i>    | 1                        | 1        |     |
|                 | Scarabaedae   | <i>Macroductylus subspinosus</i> | 15                       | 0        |     |
|                 | Carabidae     | <i>Pterostichus melanarius</i>   | 0                        | 2        |     |
|                 |               | <i>Promeces spp</i>              | 1                        | 0        |     |
|                 | Tenebrionidae | <i>Unidentified beetle spp</i>   | 41                       | 11       |     |
|                 |               | <i>Pimelia bipunctata</i>        | 34                       | 11       |     |
|                 |               | <i>Pedinini Platynotina</i>      | 41                       | 0        |     |
|                 |               | <i>Arturium tenuieostatum</i>    | 37                       | 21       |     |
|                 | Dermeistidae  | <i>Unidentified beetle spp</i>   | 10                       | 12       |     |
|                 | Elateridae    | <i>Unideintified bettele spp</i> | 79                       | 0        |     |
|                 | Cleridae      | <i>Checkeded beetles spp</i>     | 11                       | 19       |     |
|                 | Coccinellidae | <i>Hippodamia convergens</i>     | 8                        | 23       |     |
|                 | Hymenoptera   | Formicidae                       | <i>Pchycondyla spp</i>   | 6        | 6   |
|                 |               | Apidae                           | <i>Apis mellifera</i>    | 179      | 151 |
|                 |               | Syrphidae                        | <i>Eristalis tenax</i>   | 50       | 30  |
| Vespidae        |               | <i>Polistes</i>                  | 30                       | 20       |     |
| Pompilidae      |               | <i>Auplopus mellipes</i>         | 10                       | 15       |     |
| Sphecidae       |               | <i>Sceliphron caementarium</i>   | 12                       | 0        |     |
| Margarodidae    |               | <i>Unidentified ants spp</i>     | 60                       | 0        |     |
| Blattodea       |               | Blattidae                        | <i>Blatta orientalis</i> | 25       | 0   |
|                 | Blattellidae  | <i>Loboptera decipiens</i>       | 20                       | 0        |     |
| Lepidoptera     | Papilionidae  | <i>Papilio constantinus</i>      | 0                        | 5        |     |
|                 | Erebidae      | <i>Achaea spp</i>                | 0                        | 4        |     |
|                 | Danaidae      | <i>Danaus plexippus</i>          | 7                        | 6        |     |
|                 | Nymphalidae   | <i>Acraea encedon</i>            | 6                        | 0        |     |
|                 |               | <i>Junonia oenone</i>            | 0                        | 4        |     |
|                 |               | <i>Pseudacraea boisduvali</i>    | 0                        | 7        |     |
|                 | Pieridae      | <i>Eurema hecabe</i>             | 15                       | 0        |     |
|                 | Lasiocampidae | <i>Malacocoma spp</i>            | 0                        | 5        |     |
|                 | Hesperiidae   | <i>Asbolis capucinus</i>         | 1                        | 0        |     |
|                 | Sphingidae    | <i>Hippotion celerio</i>         | 0                        | 3        |     |
| Orthoptera      | Acrididae     | <i>Aeoloplides turnbulli</i>     | 90                       | 0        |     |
|                 |               | <i>Aeropedellus clavatu</i>      | 30                       | 0        |     |

|                   |                  |                                    |      |     |
|-------------------|------------------|------------------------------------|------|-----|
|                   |                  | <i>Phlibostroma quadrimaculata</i> | 70   | 0   |
|                   |                  | <i>Sphingonotus balteatus</i>      | 60   | 0   |
|                   |                  | <i>Acanthacris ruficornis</i>      | 1    | 0   |
|                   | Diapheromeridae  | <i>Diapheromera femorata</i>       | 20   | 11  |
|                   | Tettigoniidae    | <i>Pterophylla camellifolia</i>    | 5    | 0   |
|                   |                  | <i>Tettigonia viridissima</i>      | 3    | 0   |
|                   | Pyrgomorphidae   | <i>Phymateus viridipes</i>         | 4    | 3   |
|                   | Gryllidae        | <i>Acheta domestica</i>            | 4    | 0   |
| Odonata           | Calopterygidae   | <i>Phaon iridipennis</i>           | 13   | 5   |
|                   | Libellulidae     | <i>Brachythemis spp</i>            | 10   | 4   |
|                   |                  | <i>Crocothemis erythraea</i>       | 7    | 0   |
| Diptera           | Calliphoridae    | <i>Lucilia sericata</i>            | 9    | 0   |
|                   | Asilidae         | <i>Fly spp</i>                     | 0    | 5   |
| Mantodae          | Mantidae         | <i>Stagmomantis carolina</i>       | 5    | 6   |
|                   |                  | <i>Parasphendale affinis</i>       | 7    | 2   |
| Hemiptera         | Pentatomidae     | <i>Proxys punctulatus</i>          | 21   | 4   |
|                   |                  | <i>Unidentified sp</i>             | 0    | 3   |
|                   | Cercopidae       | <i>Tomaspis cf. biolleyi</i>       | 12   | 0   |
| Araneae           | Tetranychidae    | <i>Leucauge venusta</i>            | 0    | 20  |
|                   | Agelenidae       | <i>Eratigena agrestis</i>          | 10   | 0   |
|                   | Araneidae        | <i>Gasteracantha cancriformis</i>  | 0    | 7   |
|                   | Salticidae       | <i>Salticus scenicus</i>           | 10   | 0   |
|                   | Miturgidae       | <i>Chiracanthium inclusum</i>      | 15   | 0   |
|                   | Pholcidae        | <i>Pholcus phalangioides</i>       | 13   | 15  |
| Scolopendromorpha | Crptypidae       | <i>Theatops californiensis</i>     | 0    | 5   |
| Polydesmida       | Eurymerodesmidae | <i>Eurymerodesmus spp</i>          | 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  $\pm$  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 |       |

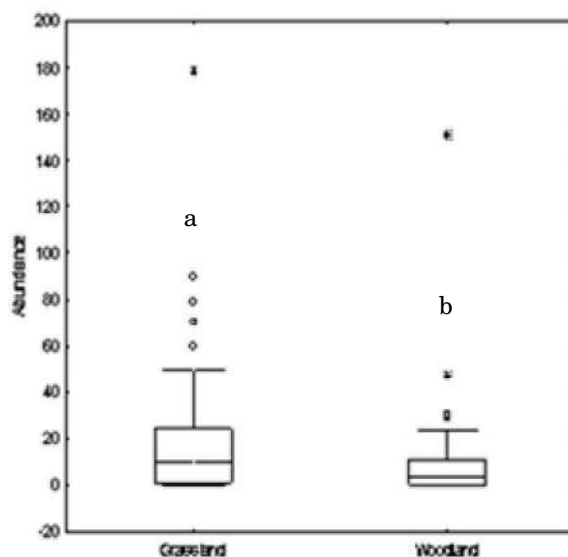
#### 4 Discussion

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 ( $\lambda = 0.053$ ) as compared to woodland ( $\lambda = 0.103$ ). 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. Mantodea 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 to 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 <sup>NS</sup> |
|                   | Woodland  | 10               | 17.60 | 13.75 | 4.35  |         |                    |
| Hymenoptera       | Grassland | 7                | 49.57 | 60.72 | 22.95 | 0.58    | 0.29 <sup>NS</sup> |
|                   | 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 <sup>NS</sup> |
|                   | 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 <sup>NS</sup> |
|                   | Woodland  | 1                | 5.00  | 3.54  | 3.54  |         |                    |
| Mantodea          | Grassland | 2                | 6.00  | 1.41  | 1.00  | 0.89    | 0.23 <sup>NS</sup> |
|                   | Woodland  | 2                | 4.00  | 2.83  | 2.00  |         |                    |
| Hemiptera         | Grassland | 2                | 16.50 | 10.54 | 7.45  | 0.95    | 0.21 <sup>NS</sup> |
|                   | Woodland  | 2                | 3.50  | 2.08  | 3.00  |         |                    |
| Araneae           | Grassland | 4                | 12.00 | 6.48  | 3.24  | 0.23    | 0.41 <sup>NS</sup> |
|                   | 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:  $p = 0.0015$ ,  $p < 0.05$ ,  $n_{\text{grassland}} = 1177$ ,  $n_{\text{woodland}} = 542$ ). 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, Mantodea, 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 ( $\lambda = 1.000$ ) 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 ( $\lambda = 1.000$ )

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.

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