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Abundance and Diversity of Beetles at Ikuti Area in Mbeya: Influence of Sampling Efficiency of Collecting Method

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ABSTRACT

The present study is the first to be conducted to examine the community structure and diversity of beetles occupying areas of Ikuti ward in Mbeya, Tanzania, as well as to investigate the efficiency of different trapping methods in capturing different beetles using habitats of Mbeya University of Science and Technology as study sites. The survey was carried out for two months from April 2016 to June 2016. Beetles were sampled using pitfall traps, sweep nets, beating sheets and hands. A total of 483 individuals of beetles were collected, consisting of 9 families and 16 species. The dominant family was Tenebrionidae (41%) and Elateridae (16%). Highest species diversity was recorded in family Tenebrionidae (H' = 1.38). The family Carabidae and Tenebrionidae indicated high species richness. Family Tenebrionidae and Carabidae, on the other hand, showed high evenness, E' = 0.99 and E' = 0.92 respectively. Furthermore, Pitfall trap was the most efficient collecting methods of beetle in terms of number of individuals and species. Thus, this study showed that pitfall traps are the most efficient collecting methods for beetles at MUST areas, especially the ground beetles.

INTRODUCTION

Coleoptera commonly known as beetles is the largest and most diverse order of insects on our planet [1]. Nearly 350,000 species of beetles have been described around the world [2] and have a high diversity, representing about 30% of all insects [3]. Beetles can be found almost in all available habitats in Tanzania [4]. Beetles living in terrestrial environments are usually found in soil, leaf litters and humus; in dung, carrion and the fruiting bodies of various types of fungi [5]. They are also found beneath the bark of living and dead trees or in decomposing wood as well as under stones and logs. Certain species of beetles live exclusively in caves whereas others live in the nests of vertebrates and or social insects such as termites or in man-made environments such as grain store [5, 6]. They have ability to inhabit various habitat types and are easily sampled. Beetles differ in shapes and colors, but are characterized by the forewings having evolved into hardened wing-cases (elytra) and the possession of mouth-parts adapted to chewing and crushing their food. They are holometabolous, with a larval stage that may be predatory, detritus-feeding or herbivorous, and pupate for a period of days or longer before enclosing as adults to reproduce. Many species are known to be herbivores, scavengers or predator as adults; however, certain adult beetles do not feed at all. Some beetle species are predatory when in the larval stage and plant-feeders when adults [7]. They are important in ecological functioning of most ecosystems, due to their wide range of feeding mechanisms and being very abundant. In addition to the roles (herbivore, predator and detritivores) played by beetles in ecosystem food web, they are pollinators [7, 8], also used as food for amphibians, birds, mammals and reptiles. Like other insects, beetles also play roles in decomposition and nutrient cycling in forest ecosystems. Furthermore, beetles are used as biological indicator species of environmental change and forest health and management [8]. Species diversity of beetles, especially Carabidae (ground beetles), is frequently used as a proxy for overall ecosystem health, and thus as a rapid metric for assessment of land management effectiveness. The diversity of beetles in an area can be measured by comparing data from inventory studies. The inventories can be carried out by different methods suitable for sampling groups of beetles occurring in a study area. In this current study, investigation of the efficiency of different trapping methods in capturing different beetles was examined in southern highland, Tanzania, in and around a university campus, with particular emphasis on ground-dwelling species and arboreal species. The main objective of this research study was to collect, identify and analyze the diversity, species richness and evenness of beetle species, and assess the sampling efficiency of collecting methods.

MATERIALS AND METHODS

Study area

Mbeya University of Science and Technology (MUST) is located in Mbeya region at latitude 8°56′30″S and longitude 33°24′58″E (Fig.1) on the higher altitude 1718m of unplanned settlement of Inyala and Ikuti wards [9] .The University is 10km away from the city center. The University encompasses an area of more than 2000 ha. The study area comprises primarily amenity provision of managed grassland, dominated by eucalyptus trees, *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. The climate of Mbeya region is greatly 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 [10].

Collection and identification of beetles

Beetles were collected from April 2016 to June 2016 in both grassland and wooded habitats. They were collected using, beat sheets, hands, sweep nets and pitfall traps. Specimens of beetles were taken to the laboratory and identified with the help of guides and keys [11] .Beetles was killed using ethyl acetate in the killing jar before being identified and preserved. After identification to morphospecies level, they were dried, dry pinned and preserved in the 70% ethyl alcohol. Collection techniques used are similar to those described in described in Rainio and Niemelä [1], Gullan and Cranston [2], Nyundo and Yarro [4], Lak An [5], Albuquerquea et al., [6] and Kra et al., [12, 13].

Hand searching on the ground (GS)**:** Manual collection of beetles using hands was done three times every week for 3h during the day time, 1.5 h in each habitat type. Collecting involved actively searching for the beetles on the ground, in leaf litters and grasses, under logs, tree barks and other substrates.

Pitfall trapping (PT): This involved using plastic containers with diameter 8 cm, depth 10 cm (Fig. 1). A total of 26 pitfall traps were set up permanently at an interval of 5m (13 traps in each sub-plot). In each habitat, one line transect was established with pitfall traps being allocated within the transect line by systematic random sampling technique. 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 until the end of the study. Traps were half-filled with preservative liquid (formaldehyde). No roof was used to avoid microclimate change and trap loss was negligible. This method is suitable for collecting ground-dwelling beetles.

Beating sheets (BS): A beating sheet is basically just a piece of heavy duty cloth stretched across two diagonal pieces of wood joined at the center (Fig. 2). Collections of beetles were done by shaking or hitting the tree or its branch while holding the beating sheet (Fig. 2).

Sweeping nets (SN): Sweep nets (32cm diameter) were swept three times every week between 10.00 am and 1.00 pm (Fig. 3). Beetles sampled in the sweeping were temporarily transferred in polythene bags and plastic bottles before taken to the laboratory for identification and preservation.

Community structure analysis

Collected beetles were counted for the number of individuals (N) and species (S). Diversity of beetles was analyzed using Shannon-Wiener diversity index (H'), Simpson index (λ) and evenness (E). Species richness was calculated using Margalef index (D).

$$(H) = -\varepsilon\left(\frac{n}{N}\right)\log_2\left(\frac{n}{N}\right)$$

Where, n = is the total number of individuals of one species and N is the total number of all individuals in the sample [14].

Species richness of beetles was calculated using the Margalef index (D). 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 [15].

Evenness or equitability was calculated using the Pielou's evenness index. 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 [16].

Simpson index (λ) was used to determine information about rarity (diversity) 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 [17]. 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.

Figure 3: Collection of beetles using sweep nets

RESULTS AND DISCUSSION

A total of 16 species belonging to nine families were identified from 483 collected beetles (Table 1). Highest species diversity was recorded in Tenebrionidae (H' = 1.38) and Carabidae (H' = 0.64). The family Carabidae and Tenebrionidae indicated high species richness (Table 2). Scarabaeidae, Dermestidae, Elateridae, Cleridae and Coccinellidae showed high Simpson index (λ =1.000) (Table 2). Moreover, family Tenebrionidae and Carabidae showed high equitability or evenness, E' = 0.99 and E' = 0.92 respectively (Table 2). Family Tenebrionidae had the most number of individuals (41%), followed by Elateridae (16%), Curculionidae (12%) and Chrysomelidae (10%) (Fig.4). Among the identified species, the following species were abundant, *Arturium tenuieostatum, Curculio spp, Chrysochus auratus, Pimelia bipunctata, Pedinini Platynotina, Hippodamia convergens* and Checkered beetles *spp*. Pitfall trap was the most efficiency method for collecting beetles species (n = 398, 45.85%) followed by Sweeping net (n =187, 21.54%) compared with hand collection (n = 184, 21.20%) and Beating sheet (n = 99, 11.41%) (Fig.5). In terms of number of species, Pitfall traps collected many species of beetles (s = 11), followed by hand collection (s = 7) and sweep net (s = 4). Examples of beetle species collected are shown in fig 6. The abundance and diversity of beetles and the effectiveness of traps in collecting beetles were assessed. Although the phenology of beetles in Mbeya region is poorly understood, and no study of beetles which has been done in Southern highland, result indicated a very low biological diversity of beetles. This may due to frequent disturbances such human activities including grass cutting which interfere with ecological niches of beetles, that influences the low diversity and abundance of beetle species [18]. Nevertheless, the diversity index, species richness and evenness of beetles at MUST are primarily due to the rich vegetation in the area. This is because vegetation is known to supports the existence of many insect fauna in several habitats as it provides macro and microhabitats in addition to the main source for food for beetle and other insects. Moreover, differences in abundance and species richness between and within families of collected Coleoptera could be due to their difference in adaptation, food preferences and habitats selection [19, 20].

Table 1: Species richness, diversity, evenness and abundance of family of beetles collected using three study methods from MUST, at Ikuti ward

Family	Num. Sp./Ind.	Diversity index (H')	Margalef index(R')	Evenness index(E')	Simpson index
Curculionidae	3/58	0.34	0.49	0.31	0.84
Chrysomelidae	2/49	0.17	0.26	0.25	0.92
Scarabaedae	1/15	0.00	0.00	-	1.00
Carabidae	2/3	0.64	0.91	0.92	0.33
Tenebrionidae	4/196	1.38	0.57	0.99	0.25
Dermestidae	1/22	0.00	0.00	-	1.00
Elateridae	1/79	0.00	0.00	-	1.00
Cleridae	1/30	0.00	0.00	-	1.00
Coccinellidae	1/31	0.00	0.00	-	1.00

Sp: Number of species; Indivi: Number of individuals

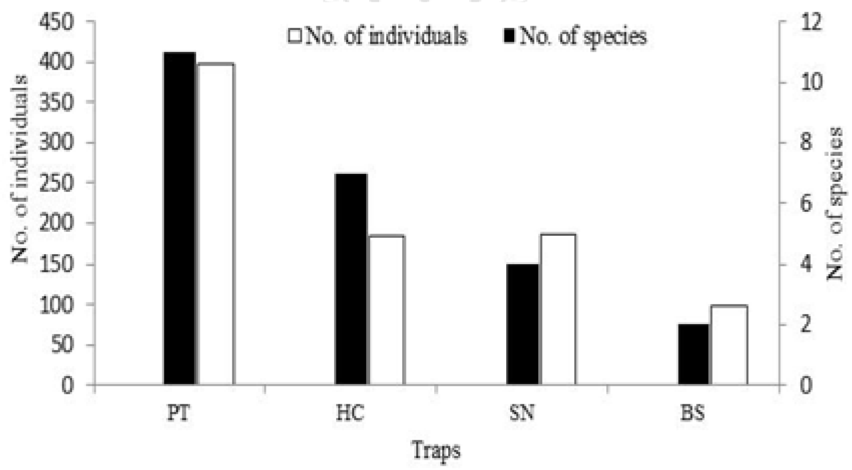

Figure 4: The number of species and individuals collected by four methods: HC; Hand collection, PT; Pitfall traps, BS; Beating sheet and SN; Sweep net.

Figure 5: Some beetle species collected from MUST campus at Ikuti area

Sampling techniques which depend on insect activity, the abundance is influenced by activity, rather than density [12]. The beating sheet, hand collection and sweeping method collected a small number of beetles (Fig.5). This indicates that the data captured were influenced by the type of trap used. The large abundance of beetle individuals collected in pitfall trap is an indication of efficiency of this method although precaution should be taken when interpreting the results than for diversity because the trap can be influenced by the site and other factors. Additionally, the effectiveness of pitfall traps might be associated with the vegetation around the trap [13]. The pitfall traps captured most beetle specimens that move on the ground, for example, *Pterostichus melanarius* (Carabidae) was captured mainly in the pitfall traps. Furthermore, it is important to understand that the best sampling of beetles needs a combination of different trapping methods [12].

CONCLUSION AND RECOMMENDATION

This piece of work was an attempt to describe community structure and diversity of beetles occupying areas of Ikuti ward in Mbeya, Tanzania. However, more work is needed and further collections of beetles in different seasons of the year are important to understand faunal diversity of beetle in southern highland of Tanzania. On the other hand, conservation of the habitats is very important for the survival of beetle and other insect species.

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