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SURVEY OF GROUND DWELLING ARTHROPODS ASSOCIATED WITH TWO HABITAT TYPES IN THE JOS MUSEUM ZOOLOGICAL GARDEN JOS PLATEAU STATE, NORTH CENTRAL NIGERIA

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Abstract
Little is known about the species composition and ecology of ground dwelling arthropods of Zoological Gardens. Thus, this study was aimed to investigate the species abundance and diversity of ground dwelling arthropods associated with Gallery forest and Rocky outcrop of the Jos Museum Zoological Garden Jos Plateau State, North central Nigeria. Arthropods were collected using Pitfall traps during the raining season of June-July, 2013. A total of 500 arthropods belonging to 6 Classes, 11 Orders, 12 Families, 14 Genera and 14 Species were collected. Out of which 130 arthropods individuals representing 26% of the total were collected from Gallery forest, whereas 370 arthropods individual representing 74% were collected from Rocky outcrop. There is a significant difference in the mean abundance of species of ground dwelling arthropods collected from both habitats. There is no significant difference in the mean abundance of ground dwelling arthropods in relation to taxa. The diversity and distribution of arthropods taxa depicted 73% Insecta and 64.4% Hymenoptera as the most abundant taxa. The Shannon-Weiner diversity index (H) differs significantly between the two habitat types. The Gallery forest had the highest diversity index of 2.2140 and Rocky outcrop had the lowest diversity index of 0.9038. Food availability and vegetation cover were found to be critical to arthropods species abundance and diversity. This is a pointer to the usefulness of vegetation and food as key resources for ground dwelling arthropods. It is therefore recommended that adequate protection of the garden be carried out to curd anthropogenic activities.

Key Words: *Arthropods, Habitats, Gallery forest, Rocky outcrop and Zoological garden*

Introduction

Arthropod are the most successful and diverse group of animals. More than 80% of the described living animal's species are arthropods of the phylum Arthropoda which is the largest in the animal kingdom and comprise of more than one million species (Franke, 2003). They are common throughout marine, freshwater, terrestrial and even aerial environments (Thanukos, 2007). However there are several other families in the phylum Arthropoda which are important to the forest ecosystem (Basset, 2001). Entomologists have focused their attention on biodiversity of arthropods as a tool for conservation and this has received increasing attention (Noss, 1990).Arthropods are important in below ground processes through the alteration of the physical and chemical environment and

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through their effects on plants microorganisms and other soil organisms (Motohiro, 2001).Arthropods in both forest and surrounding farm lands serve as food for Birds, Predatory insect and other vertebrates, plant pollinators, diseases vectors of mammals, biological control agents, and biotic indicators of health of the forest (Basset, 2001).The continuous removal of forests for various agricultural and industrial purposes has caused the loss and degradation of the primary tropical forests, leaving only man-made ones. This destruction causes extinction or loss of richness for those species whose habitats have been altered by man (Adebayo, 1995).Studies of arthropod responses to ecological change can enhance man's understanding of the effects of human disturbance and landscape modification on the terrestrial ecosystem. In addition, species diversity can be measured using the number of species present and their relative abundance (Watt *et al.*, 2002).Currently, little is known about the species composition and ecology of ground dwelling arthropods of Zoological Garden.

This study was carried out to generate a species checklist of ground dwelling arthropods of Gallery forest and Rocky outcrop of Jos Museum Zoological Garden the second oldest Museum in Nigeria where no studies have been carried out. More importantly, the species checklist will provide a template on which to overlay an examination of species diversity of ground dwelling arthropods that may be associated with similar habitats elsewhere.

Methodology

Study Area

The Jos Museum was founded in December, 1955 and was approved in June 1960 when the Zoological Society of Nigeria was formed to manage it. Jos Museum is the second oldest museum in Nigeria, after the small museum at Esie, near Ilorin, which was opened in 1945. For many years Jos was the headquarters of the Federal Department of Antiquities until this was eventually transferred to Lagos. It is the second largest museum in the country offering a wide range of exhibits and facilities for visitors. It is also the principal research station for the Department. The study was conducted within the Gallery forest and Rocky outcrop of the museum. It is located in the heart of the cityof Jos, Plateau State, North-Central Nigeria and found on longitude 9°54' 51"North and latitude 8° 53' 9"East (Figure 1).Though situated in the tropical zone, a higher altitude means that Jos has a near temperate climate with an average temperature of between 18 and 22°C. Harmattan winds cause the coldest weather between December and February. The warmest temperatures usually occur in the dry season months of March and April. The mean annual rainfall varies from 131.75 cm (52 in) in the southern part to 146 cm (57 in) on the Plateau. The highest rainfall is recorded during the wet season months of July and August. The Jos Plateau is the source of many rivers in northern Nigeria including the Kaduna, Gongola, Hadejia and Yobe rivers (Ajakpo and Okonkwo, 1984).In line with the rainfall distribution, Plateau State falls largely within the northern guinea savannah zone which consists mainly of short trees, grasses and the Plateau type of mosaic vegetation. Fringing woodlands or gallery forests can be found along some river valleys. The unique physical features of Plateau State are its high relief, especially in the north, and its geological history. The high relief, or more appropriately, the Jos Plateau, provides a hydrological Centre for many rivers in northern Nigeria and confers on the northern part of the state a cool climate suitable for livestock rearing and growing of exotic crops. The process of formation of its high relief makes Plateau State one of the mineral rich states in the country (Ajakpo and Okonkwo, 1984).

Sampling Techniques

The pit fall traps were used to sample arthropods within the Gallery forest and Rocky outcrop of the Museum Zoological Garden during the raining season of June-July 2013. In each habitat, a total of twenty pit fall traps were randomly placed. The sampling design involved placing a trap at a distance of 50meters away from each other for a period of twenty four (24) hours along a transect in each habitat type (Van den Bergh, 1992). The objective is to give all arthropods an equal chance of being trapped. Arthropods were harvested after 24hours. Plants debris was removed and arthropods collected were preserved in 70% alcohol, 10% glycerin and 20% distilled water (Sutherland, 1997)

Identification and Quantification of Arthropods

Each labelled sample bottle was emptied into a Petri- dish, observed, screened out and quantified. The arthropods were then identified, grouped and classified into classes, order, families, genus and species using coloured atlas and identification keys provided by Castner (2000), Shattuck (2000) and Skaife *et al.* (1979).

Statistical Analysis

The data was analyzed using R-Console Software version 2.9.2. The Welch Two Sample t-test was used to compare the mean abundance of ground dwelling arthropods between Gallery forest and Rocky outcrop habitats. One-way analysis of variance (ANOVA) was used to compare the mean abundance of ground dwelling arthropods in relation to the classes, orders, and families respectively. Significant level was achieved if $P<0.05$.

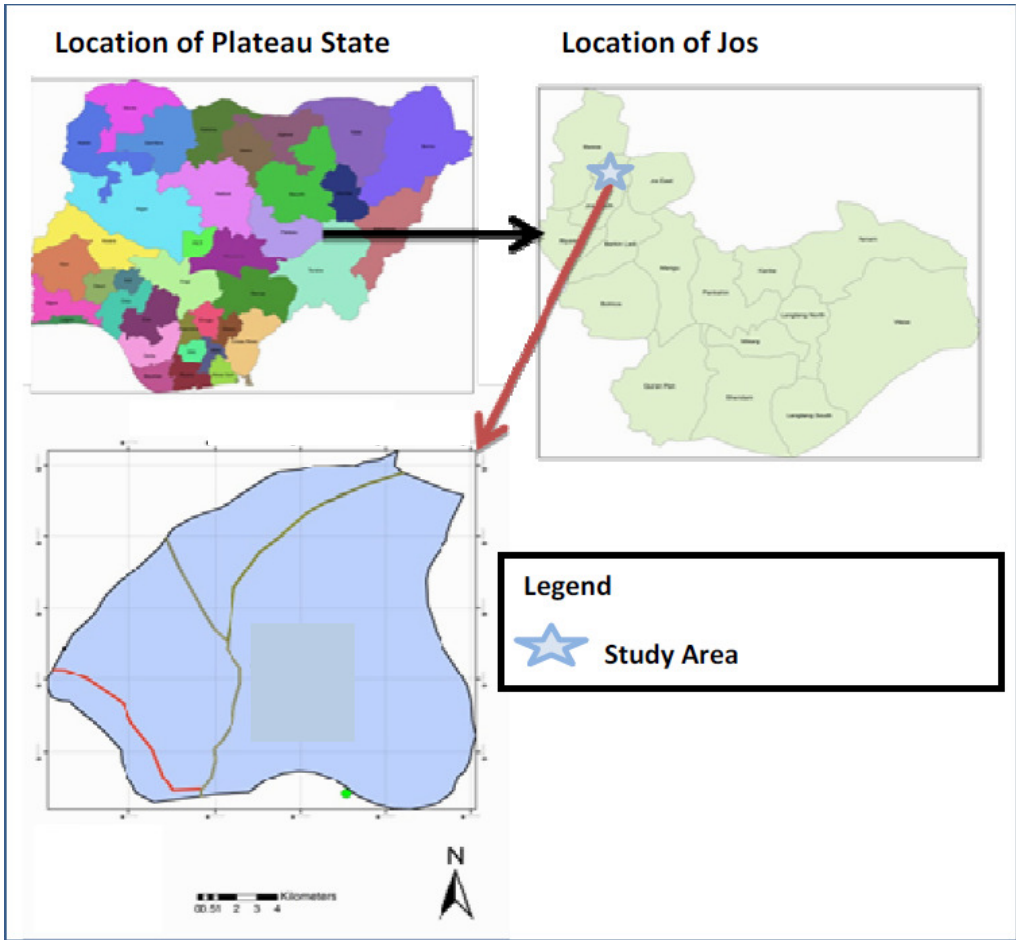


Figure 3: Map of Plateau State, Nigeria showing location of the study area

Species Diversity Index

Arthropod species diversity was calculated using the Shannon-Weiner diversity index (H) (Shannon and Weiner, 1963):

$$H = -\sum_{i=1}^{S} P_i \ln P_i$$

Where:
H is the diversity index
Pi is the proportion of individual species
S is the total number of species in the habitat and
i is the proportion of *S* species

Results

Species Checklist of Ground Dwelling Arthropods

Species checklist of ground dwelling arthropods generated at the end of the study is shown in Table 1. A total of 500 arthropods belonging to 6 Classes, 11 Orders, 12 Families, 14 Genera and 14 Species were collected and identified (Table 1). There is a significant difference (F_{27} = 1. 252, Adjusted R- Squared = 0.0679, P= 0.3031) in the mean abundance of species of arthropods (Figure1). *Solenopsis invicta* (Coleoptera: Formicidea), *Archispirostreptu sgigas* (Spirostreptida: Spirostreptidae) and *Cicindela ocellata* (Coleoptera: Carabidae) were the most abundant species of arthropods identified. Conversely, the least abundant species were *Calosoma scrutator* (Coleoptera: Carabidae), *Paederus* species (Coleoptera: Staphylindae) and *Gryllus campestrus* (Orthoptera: Gryllidae) (Figure 1).

There is a significant difference in the mean abundance of ground dwelling arthropods between the Gallery Forest and Rocky outcrop of the Jos Museum Zoological Garden (Welch Two Sample t-test: t = -2.053, df = 27.605, P = 0.04966) as shown in Figure 2. Whereas 130 individuals representing 26.00% of the total were collected from Gallery forest, 370 representing 74.00% were collected from Rocky outcrop as shown in (Table 1).

The breakdown of this result shows that a total of 13 species of ground dwelling arthropods were collected from Gallery forest (Table 1). The comparison in the mean abundance of species of arthropods shows a significant difference (F_{27} =1.252, Adjusted R- Squared = 0.0679, P = 0.3031) in the mean abundance of species of arthropods in the Gallery forest. *S. gigantea*, *A. gigas* and *L. reclusa* are the most abundant species of ground dwelling arthropods collected from the Gallery forest. Conversely, the least abundant species were *Paedarus* species*, G. campestrus and Blatella lituricollis* (Table 1).

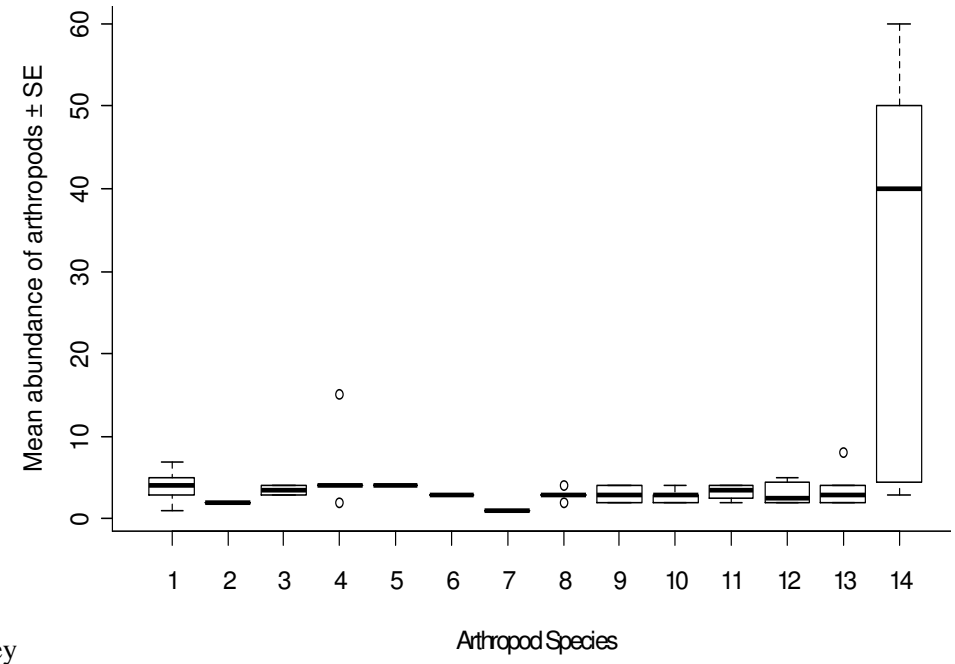
A total of 10 Species of ground dwelling arthropods were collected from Rocky outcrop (Table 1). The comparison of mean abundance of species of ground dwelling arthropods shows significant difference (F_{17} = 1.745, Adjusted R-Squared = 0.2051, P= 0.1543), in the mean abundance of species in the Rocky outcrop. *S. invicta, A. gigas* and *I. purpureus* were the most abundant species collected from Rocky outcrop.

Conversely, *B. lituricollis (Blattodae: Blatella), Solenopsis molesta*(Hymenoptera: Formicidae) and *Calosoma scrutator* (Coleoptera: Carabidae) were the least abundant species of ground dwelling arthropods collected from Rocky outcrop (Table 1).

Table 1: Species Checklist of Ground Dwelling Arthropods Collected from Gallery Forest and Rocky Outcrop of the Jos Museum Zoological Garden

Class	Order	Family	Common Name	Species	GF	RO	Total	Percent (%)
Arachnida	Araneae	Pholcidae	Daddy long leg	*Pholcus phalangoides*	15	4	19	3.80
		Sicariidae	Brown recluse spider	*Loxosceles reclusa*	17	7	24	4.80
Insecta	Coleoptera	Carabidae	Tiger beetle	*Cicindela ocellata*	15	11	26	5.20
			Ground beetle	*Calosoma scrutator*	-	2	2	0.40
		Staphylinidae	Rove beetle	*Paederus species*	2	-	2	0.40
	Orthoptera	Gryllidae	Field cricket	*Gryllus campestrus*	1	-	1	0.20
	Thysanura	Nicoletidae	Silver fish	*Grassiella wheeleri*	3	-	3	0.60
	Blattodea	Blatellidae	False German cockroach	*Blatella lituricollis*	1	4	5	1.00
	Dermaptera	Forficulidae	Earwig	*Corixa puntata*	4	-	4	0.80
	Hymenoptera	Formicidae	Fire ant	*Solenopsis invicta*	-	286	286	57.20
			Black carpenter ant	*Camponotus pennsylvanicus*	3	5	8	1.60
			Thief ant	*Solenopsis molesta*	-	3	3	0.60
Chilopoda	Geophilomorpha	Scolopendridae	Giant centipede	*Scolopendra gigantean*	25	-	25	5.00
Diplopoda	Spirostreptida	Spirostreptidae	Millipede	*Archispirostreptus gigas*	23	32	55	11.00
Oligochaeta	Megadrilacea	Acanthodrilidae	Earthworm	*Lumbricus terrestris*	11	-	11	2.20
			Unidentified	Unidentified	-	1	1	0.20
				Total	130	370	500	
				Percent (%)	26.00	74.00		100

GF= Gallery Forest
RO = Rocky Outcrop



Key
1.*Archispirostreptus gigas* 2.*Calosoma scrutator* 3.*Camponotus pennsylvanicus* 4.*Cicindela ocellata* 5.*Corixa punctata* 6.*Grassiella wheeleri* 7.*Gryllus campestrus* 8.*Iridomyrmex purpureus* 9.*Paederus* species 10.*Loxosceles recluse* 11.*Lumbricus terrestris* 12. *Pholcus phalangoides* 13.*Scolopendra gigantean* 14.*Solenopsis invicta*

Figure 1: Mean Species Abundance of Ground Dwelling Arthropods in the Jos Museum Zoological Garden

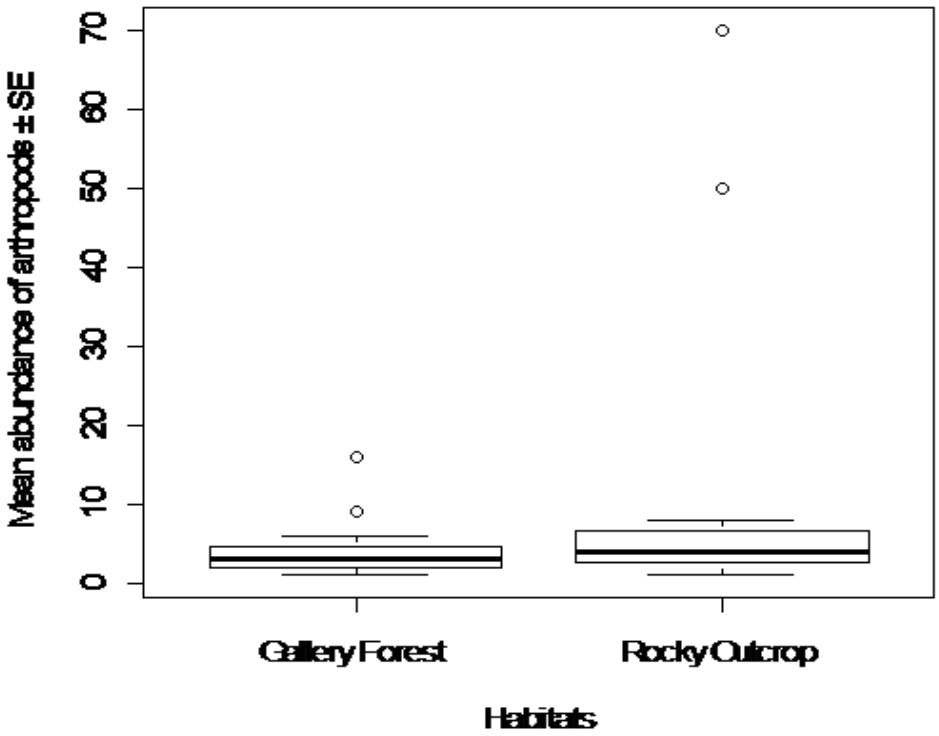


Figure 2: Comparison in Mean Abundance of Ground Dwelling Arthropods in Two Habitat Types of Jos Museum Zoological Garden

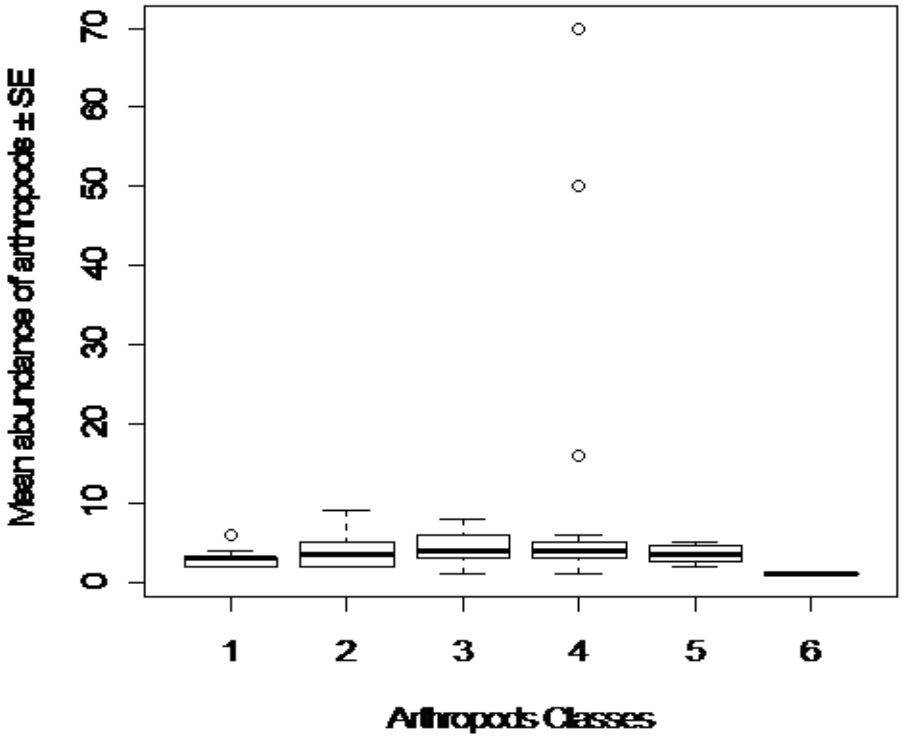
Abundance of Ground Dwelling Arthropods in Relation to Taxa

There is no significant difference(F_{61} = 1.039, Adjusted R-squared = 0.003, P = 0.4032) in the mean abundance of ground dwelling arthropods in relation to arthropod Classes in the Jos Museum Zoological Garden as shown in Figure 3.Arthropods collected in both habitats were identified as belonging to five (5) Classes of the phylum Arthropoda, Arachnida, Insecta, Chilopoda, Diplopoda and Oligochaeta. The Insecta recorded the highest abundance of 286 individuals representing 77.29%, while *Blatella lituricollis* had the lowest abundance of 1 individual representing 0.77% (Figure 3).

There is no significant difference (F_{56} = 1. 527, Adjusted R-squared = 0.074, P = 0.1542) in the mean abundance of ground dwelling arthropods in relation to arthropod Orders (Figure 4). The dominant orders identified in both habitats are Hymenoptera (5.00%), Coleoptera (5.20%) and Spirostreptida (11.00%). While the least dominant orders are Thysanura (2.31%), Orthoptera (0.77%) and Blattodea (0.77%) as shown in Figure 4.

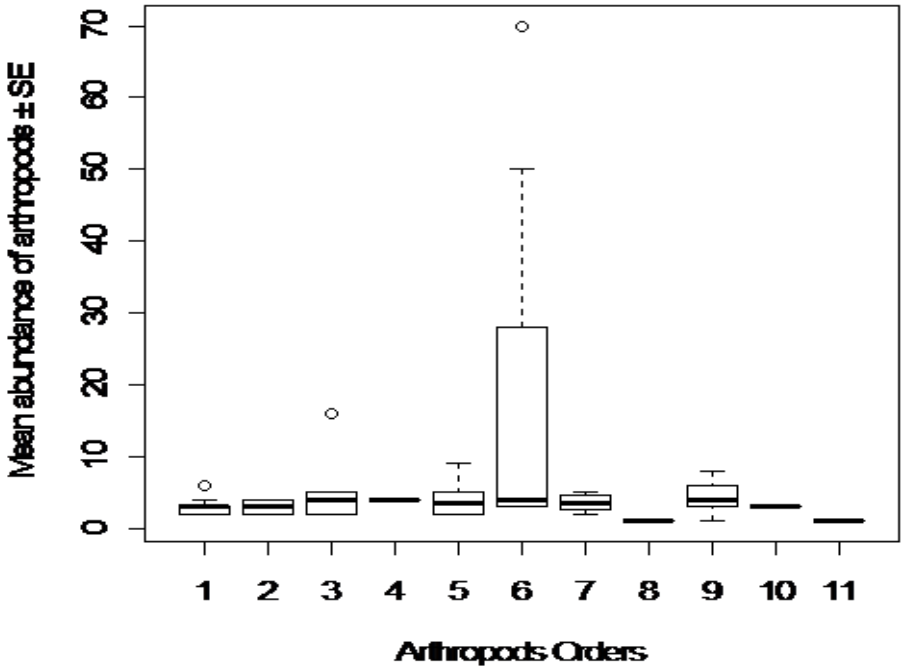
Species Diversity Index

The species diversity, calculated as Shannon-Weiner Diversity Index (H) differs significantly between different species in the two habitats investigated (Tables 2 and 3). The breakdown of the result revealed that the Gallery forest had the highest diversity index of 2.2140 and Rocky outcrop had the lowest diversity index of 0.9038.



Key
1.Arachnida 2.Chilopoda 3.Diplopoda 4.Insecta 5. Oligochaeta 6. Unidentified

Figure 2: Mean Abundance of Ground Dwelling Arthropods in Relation to Classes



Key
1.Araneae 2.Blattodea 3.Coleoptera 4.Dermaptera 5.Geophilomorpha 6.Hymenoptera 7.Megadrilacea 8.Orthoptera 9.Spirostreptida10.Thysanura11.Unidentified

Figure 3: Mean Abundance of Ground Dwelling Arthropods In Relation to Orders

Table 2: Shannon- Weiner Diversity Index (H) of Ground Dwelling Arthropods Trapped in Gallery Forest Jos Museum Zoological Garden

Species	Abundance	H
Phalcus phalangoides	15	0.2492
Loxosceles reclusa	17	0.2660
Cicindella ocellata	15	0.2492
Iridomyrmex purpureus	16	0.1974
Camponotus pennsylvanicus	3	0.0869
Blatella lituricollis	1	0.0374
Corixa punctata	4	0.1071
Paederus species	2	0.0642
Gryllus campestus	1	0.0374
Grassiella wheerleri	3	0.0869
Scolopendra gigantea	25	0.3170
Archispirostreptus gigas	23	0.3064
Lumbricus terrestris	11	0.2089
Total	130	2.2140

Table 3: Shannon- Weiner Diversity Index (H) of Ground Dwelling Arthropods Trapped in Rocky Outcrop of Jos Museum Zoological Garden

Species	Abundance	H
Phalcus phalangoides	4	0.0490
Loxosceles reclusa	7	0.0752
Iridomyrmex purpureus	15	0.1301
Solenopsis invicta	286	0.1974
Solenopsis molesta	3	0.0391
Blatella lituricollis	4	0.0490
Cicindella ocellata	11	0.1047
Calosoma scrutator	2	0.0282
Camponotus pennsylvanicus	5	0.0582
Archispirostreptus gigas	23	0.1729
unidentified	1	-
Total	370	0.9038

Discussions

The health of an ecosystem is often measured by the biodiversity it holds, which is synonymous to its species abundance and diversity (Njila *et al*., 2013).The degree of species abundance and diversity of ground dwelling insects belonging to 6 Classes, 11 Orders, 12 Families, 14 Genera and 14 Species collected and identified in this study (Table 1) can be attributed to food availability and vegetation cover, which is consistent with the findings of Seastedt and Crossley (2004) working on the influence of arthropods on ecosystems reported that in the presence of abundant resources, arthropods population can grow at geometric or exponential rates and as the resources are depleted, the population growth rate slows and reproductive output by adults reduced.

The high abundance of *Solenopsis invicta*, *Archispirostreptus gigas* and *Cicindella ocellata* in this study is in agreement with the finding of Hickman *et al*. (2001) who reported high number of ants of the family Formicidae in a study carried out in Aldabra rain forest of India, where their dominance was linked to their Foraging and feeding habits. The ants (*Solenopsis invicta*) in this study are an important finding, these ants are known as important components of ecosystems because they act as ecosystem engineers (Folgarait, 1998).

The significant difference in the mean abundance of ground dwelling arthropods between the Gallery forest and Rocky outcrop of Jos Museum Zoological Garden (Figure 1) was attributed to differences in their habitat characterization. Though the abundance in the two habitats was high, it was significantly higher in the Rocky outcrop compared to the Gallery forest which was attributed to the presences of *Ficus* plant in the Rocky outcrop which attract so many insects that feed on its fruits example of insect order found within the plant is Hymenoptera. However low abundance in the Gallery forest was attributed to anthropogenic disturbances such as logging, livestock grazing and uncontrolled burning which may have contributed to the migration of arthropods from the Gallery forest to the Rocky outcrop. Such disturbances often produce a new set of challenges on the survival and reproduction of arthropods species that relay on vegetation to determine their foraging and breeding sites. This confirms the findings of Donald and Evans (2006) who worked on habitat connectivity and matrix were they revealed that arthropods generally preferred upslope area such as

the Rocky outcrop due to disturbances by humans and other animals in the Gallery forest.

The diversity and distribution of the major taxa of arthropods in this study (Figures 3 and 4) depicted 73.00% Insecta and 64.40% Hymenoptera is consistent with the results of Molta *et al*. (1998) who also found Insecta and Hymenoptera as the most abundant taxa of insects on *Acacia senegalensis* in Hadejia-Nguru wetlands of north-eastern Nigeria.

The Gallery forest had the highest calculated Shannon-Weiner Index of 2.2140 and Rocky outcrop the least diversity Index of 0.9038 (Tables 2 and 3) thus confirming the report of Hughes *et al*. (2000), that species abundance and diversity differs with habitat types. The Shannon-Weiner Index in the Gallery forest and Rocky outcrop is a reflection of a relatively stable ecosystem in the Jos Museum Zoological garden which calls for intensification of conservation efforts.

Conclusion

The Jos Museum Zoological garden is highly rich in arthropods fauna considering the species diversity encountered in this study. The Garden is also unique as it is cited in a city surrounded by human settlement, a Phenomena uncommon to Nigeria cities. Food availability and vegetation cover was found to be critical for ground dwelling arthropods abundance and diversity in this study. This is a pointer to the usefulness of vegetation and food as key resources for ground dwelling arthropods.

Recommendation

It is widely accepted that the conservation of terrestrial biodiversity requires nature resources, which must be protected from unsustainable human activities. During this study one major problem observed in the Jos Museum Zoological Garden are anthropogenic activities such as refuse dump, logging, grazing and bush burning. It is therefore recommended that adequate protection of the Garden should be carried out to curb these unsustainable human activities thereby allowing the arthropods to occupy their niche in the ecosystem.

Acknowledgment

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