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SPECIES COMPOSITION OF LEAF LITTER ARTHROPODS IN THE GALLERY FOREST OF THE JOS WILD LIFE PARK, JOS PLATEAU STATE

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ABSTRACT

Arthropods play a major role in the function and stability of terrestrial ecosystems. Thus, a study was designed to document the diversity and abundance of leaf litter arthropods in relation to some physiochemical parameters in the Jos Wildlife Park. Two sites (Edge and Interior Points) reflecting different levels of disturbances and land use were selected within the gallery forest for arthropods collection. Arthropods were collected between the months of June and July 2021 using the pitfall trap method. A total of 681 leaf litter arthropods distributed into 3 Classes, 12 Orders, 31 Families and 38 Species were collected and identified. There was a significant difference in the abundance of Species of leaf litter arthropods. Loxosceles reclusa was the most abundant species of leaf litter arthropods. There was also a significant difference in the abundance of leaf litter arthropods in relation to Classes, Orders and Families. The Class Insecta, Order Araneae and Family Sicaridae were the most abundant taxa of leaf litter arthropods identified. There was a significant difference in the mean abundance of leaf litter arthropods in relation to the Edge and Interior Points of the Gallery Forest. The abundance of leaf litter arthropods was significantly influenced by soil pH and marginally influenced by soil temperature and organic matter respectively. The overall diversity Index values of H´ = 2.69 in the forest edge and H´ = 2.56 in the interior point. It is therefore recommended that adequate protection of the gallery forest be ensured to curtail anthropogenic activities.

Keywords: Leaf, Litter, Arthropods Gallery, Forest Wild Life Park

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INTRODUCTION

In most habitats and ecosystems, the major components of animal diversity are the arthropods (Ananthaselvi *et al.*, 2009). They are adjudged the most diverse and largest group of organisms and constitutes more than half of the world known animal species (Aslam, 2009). Amidst others, their success is attributable to the diverse flowering plants that provide shelter and food. Some arthropods species can tolerate varying environmental conditions while others are very sensitive to vagaries of weather (Sheikh *et al.*, 2017). Arthropods perform very important roles in the functioning of terrestrial ecosystems as such are referred to as important 'natural capitals' (Collados and Duane, 1999). The ecosystem goods and services they provide includes; pollination, natural/biological pest control, decomposition, nutrient release, ecosystem engineering, maintenance of wildlife species and food for man. They are also a major prey for a lot of vertebrates and invertebrates, including other insects (Chelse *et al.*, 2013). The high diversity of plants and animals in the tropical

forests creates a variety of biotic and abiotic interactions and processes which lead to high levels of productivity. For example, bacteria, fungus, and micro invertebrates living in the leaf litter and subsoil of the forest floor contribute to the health of the soil itself (Wolters, 2000). As decomposers, they convert the detritus on the ground to organic soil. Their presence in the soil can add to or take away from the stability and richness of the soil in which plants take root. (Njila and Hadi, 2015). Additional invertebrates are the predators of the lower trophic levels which participate in such processes. The maintenance of the population of these decomposers is essential to the health of the soil. The growing awareness on the need to understand and conserve bio-diversity has triggered the interest in evaluating arthropods richness and diversity in various habitats and ecosystems (Njila and Hadi, 2015). Generally, studies on litter arthropods composition are relatively few. Therefore, this study is to give a preliminary inventory on the species composition of leaf litter arthropods in the Gallery forest of the Jos Wildlife Park which will provide a checklist of arthropods for more extensive studies in the park.

MATERIALS AND METHODS

Study Area

The study was carried out in the Jos Wildlife Park, Jos, Plateau state, north central Nigeria (Figure 3). The park is located in the northern part of the state with map coordinates of 9º53'8"N 8º50'57" E covering approximately 8 km^2 and characterized by gentle hills and rocky (rocky outcrop) topography with seasonal streams, a typical savanna woodlands and gallery forests and also consists of some exotic plants (Mannok, 2006).

Sample Period

The research was conducted during the raining season of June-July 2021. The arthropods were harvested after every 72hours for a period of four weeks.

Techniques for Collection of Arthropods

In the Gallery forest, two belts transect points (edge and interior) were measured. The distance between each of the transect points was 50m long and a total of twenty (20) pit fall traps were randomly placed in the two belts transect points. The sampling design involved placing a trap at a distance of 50meters from each other for a period of forty-eight (72) hours along the transect points. The objective is to give all arthropods an equal chance of being trapped. Arthropods were harvested after 48hours. Plant debris were removed and the arthropods were preserved in 70% alcohol. Each labelled sample bottle was emptied into a Petri- dish, observed, screened out and quantified. The arthropods were then be identified, grouped and classified into classes, order, families, genus and species using coloured atlas and identification keys provided by Castner, 2000) and Shattuck, (2000).

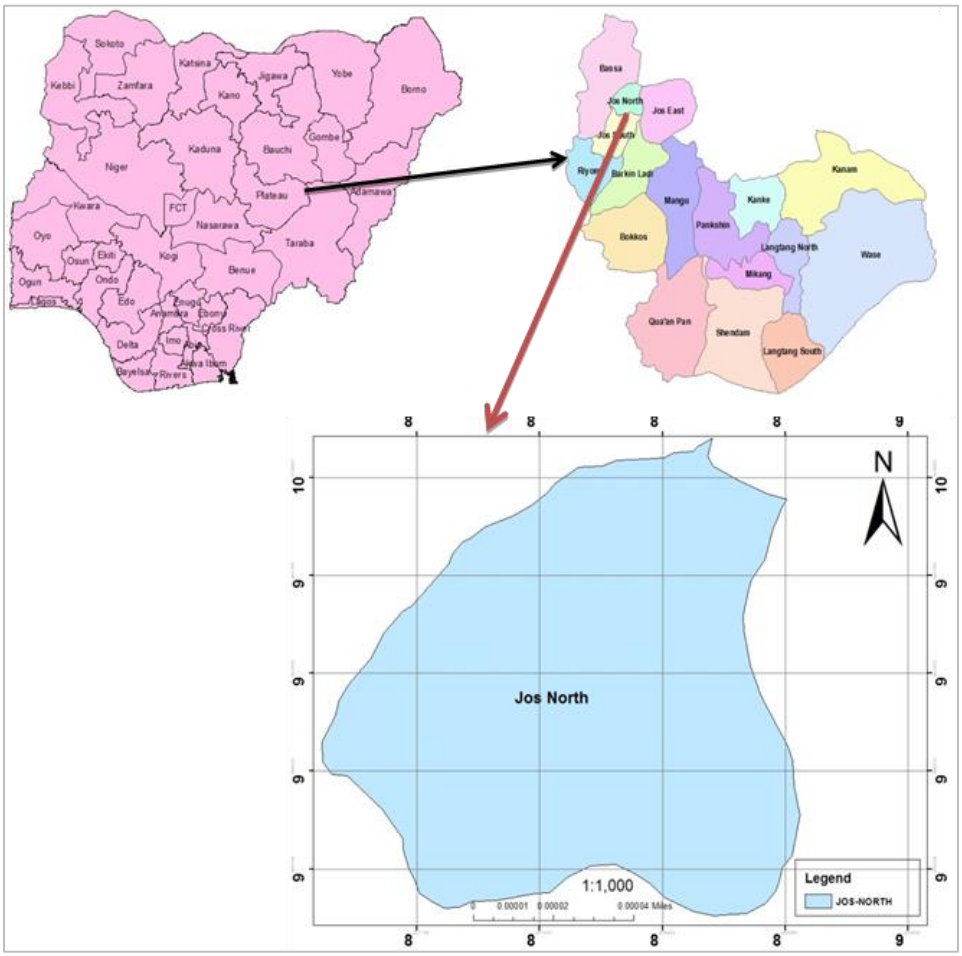

Figure 3: Map Nigeria showing the Location of Plateau State and Jos Wildlife Park Quantification and Identification of Arthropods

Techniques for Determination of Soil Physicochemical Parameters

Determination of Soil Temperature: The soil temperature was determined by digging the soil (about 5cm) and thermometer inserted and left for 5mimutes, then the readings were taken.

Determination of Soil Moisture Content: 20 g of soil samples taken was placed in an oven for 24 hours at 100^{o}c after which it was weighed and the moisture content was calculated as follows:

% of soil moisture content = $(w_1-w_2)/w_1 \times 100$

Where:
W_1-W_2 is loss in weight
W_1 - initial weight
W_2 - final weight

Determination of Soil pH: 20g of processed soil samples was poured into a 500ml beaker. 40ml of deionized water was added to it and stirred; then allowed to stand for 30min. It was occasionally stirred with a glass rod. The electrode of a calibrated pH meter was inserted into the partly settled mixture and pH was read on the meter.

Determination of Soil Organic Matter: The soil organic matter was determined using modified (Walkley- Black, 1934) method.

Statistical Analyses

The data was analyzed using R-Console Software version 4.0.2. The proportions of the abundance of classes, orders, families as well as species was measured using simple percentages. Pearson's chi-square test was used to compare the proportions of leaf litter arthropods abundance in

relation to their classes, orders, families and species respectively. The distribution of the response variable (arthropods abundance) was tested for normality using shapiro-wilk test. Two sample t-test was used to compare the mean abundance of arthropods abundance in relation to the two gallery forest points. General Linear Model (GLM) was used to check the effects of physiochemical parameters (temperature (°C), moisture (%), organic matter (%), and pH) on arthropods abundance. Level of significance was set at $P<0.05$.

Species Diversity Index: Species diversity was calculated using the Shannon-Wiener diversity index (H´):

$H' = -\sum_{i=1}^{S}(Pi)\ (\ln Pi)$……. (2)

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/

RESULT

Species Checklist of Leaf Litter Arthropods in Gallery Forest of Jos Wildlife Park

Species checklist of leaf litter arthropods generated at the end of the study is shown in Table 1. A total of 681 leaf litter arthropods were collected from the gallery forest area of the Jos Wildlife Park representing 3 classes, 12 orders, 31 families and 38 species were collected and identified (Table 1). There was a significant difference ($\chi^2 = 2378.7$, df = 37, $P < 2.2 \times 10^{-16}$) in the abundance of Species of litter arthropods collected and identified *Loxosceles reclusa* with 196 individuals was the most abundant species of arthropods identified (Table 1).

Abundance of Leaf Litter Arthropods in Relation Classes, Orders and Families

The most dominant Class was Insecta 310 (45.5%) followed by Arachnida 294 (43.2) and the least was Diplopoda 77 (11.3%) as shown in Table 1. Therefore, there was a significant difference ($\chi^2 = 21.925$, df = 2, P = 0.00001734) in the abundance of leaf litter arthropods in relation to the 3 classes recorded (Figure 4). There was a significant difference ($\chi^2 = 1397.6$, df = 11, $P < 0.0001$) in the abundance of leaf litter arthropods in relation to orders (Figure 4). The order Araneae was the highest with 261 individuals representing 38.33% (Table 1). There was a significant difference ($\chi^2 = 1895.9$, df = 30, $P < 0.0001$) in the abundance of leaf litter arthropods arthropods in relation to Families (Figure 4). The Family Sicaridae was the most abundant with 196 individuals representing 28.78% (Table 1).

Abundance of Leaf litter Arthropods in Relation to the Edge and Interior Points

There was a significant difference (t = -7.2239, df = 18, P = 0.000001015) in the mean abundance of leaf litter arthropods in relation to the Edge and Interior Points of the Gallery Forest (Figure 4).The interior had the highest abundance of leaf litter arthropods of 470 representing 69.02%, while the edge had the lowest of 211 (30.98%) as shown in Table 1. The dominant species of litter arthropods collected in the Edge and interior of the forest was *Loxosceles reclusa* (Table 1).

Effects of Physiochemical Parameters on the Abundance of Leaf Litter Arthropods

Table 2 shows that with the exception of soil moisture content, the abundance of leaf litter arthropods was highly significantly ($P < 0.0001$) influenced by soil pH and then marginally influenced by soil temperature and organic matter (P = 0.03) respectively.

Table 1: Species Checklist of leaf litter arthropods in gallery forest of Jos Wildlife Park

Class	Order	Family	Common Name	Species	Edge	Interior	Total	%
Arachnida	Araneae	Gnophosidae	Mouse spider	*Scotophaeus blackwalli*	0	26	26	3.82
		Sicaridae	Brown recluse spider	*Loxosceles reclusa*	49	147	196	28.78
		Trachelidae	Broad faced sac spider	*Trachelas pacificus*	23	16	39	5.73
	Opiliones	Phalangidae	European harvestman	*Phalangium opilio*	7	26	33	4.86
Diplopoda	Polydesmida	Xystodesmidae	Yellow spotted millipede	*Harpaphe haydeniana*	4	10	14	2.06
		Paradoxosomatidae	Green house millipede	*Oxydus gracilis*	5	5	10	1.47
	Julida	Paeromopodidae	Brown millipede	*Paeromopus augusticeps*	5	21	26	3.82
		Julidae	Portuguese millipede	*Ommatoiulus moreleti*	6	21	27	3.96
Insecta	Coleoptera	Carabidae	Tule beetle	*Tanystoma maculicolle*	16	67	83	12.19
			Amara beetle	*Carabus vulgaris*	2	2	4	0.59
			Scarite ground beetle	*Scarites subterraneous*	2	2	4	0.59
		Dystscidae	Predaceous diving beetle	*Thermonectus basillaris*	4	42	46	6.75
		Staphylinidae	Large rove beetle	*Quedius cinctus*	10	13	23	3.38
		Elateridae	Lined click beetle	*Agriotes lineatus*	3	3	6	0.88
		Melolonthidae	Brown chafer	*Serica brunea*	1	2	3	0.44
		Scarabaecidae	Beetle larvae (grub)	*Holotrichia reynaudi*	0	6	6	0.88
		Tenebrionide	Yellow mealworm	*Tenebrio molitor*	0	2	2	0.29
		Dynastidae	Rhinoceros beetle	*phyllognathus excavatus*	0	2	2	0.29
		Dermestidae	Fur beetle	*Attagenus pellio*	5	0	5	0.73
			African black beetle	*Heteronychus arator*	21	2	23	3.38
		Elmidae	Riffle beetle moth	*Heterelmis stephani*	0	1	1	0.15
	Blattodea	Ectobidae	Darkwood cockroach	*Ishnoptera deropeltiformis*	0	1	1	0.15
			western wood cockroach	*Parcoblatta americana*	0	4	4	0.59
			German cockroach	*Blattela germanica*	8	4	12	1.76
		Archotermopisidae	Dampwood termite	*Zootermopsis angusticollis*	0	2	2	0.29
		Kalotermitidae	Western drywood termite	*Incisitermes minor*	2	0	2	0.29
	Hymenoptera	Formicidae	Bullet ant	*Paraponera clavata*	0	2	2	0.29
			Black carpenter ant	*Camponotus pennsylvanicus*	6	3	9	1.32
			Western carpenter ant	*Camponotus modoc*	0	1	1	0.15
	Lepidoptera	Lymentridae	Gypsy moth	*Lymantria dispar*	2	11	13	1.91
		Noctuidae	Cutworm moth larvae	*Noctua pronuba*	0	2	2	0.29
		Notodontidae	Walnut caterpillar	*Datana imtegerrima*	16	0	16	2.35
	Orthoptera	Trigonididae	Carolina ground cricket	*Eunomobius carolinus*	8	12	20	2.94
	Hemiptera	Cicadidae	Brown bunip	*Tamasa tristigma*	0	2	2	0.29
		Nepidae	Water scorpion	*Nepa cinerea*	0	3	3	0.44
		Coreidae	Western conifer seed bug	*Leptoglossus occidentalis*	0	1	1	0.15
	Zygentoma	Lepsimatidae	Silver fish	*Lepsima saccharina*	0	1	1	0.15
	Dermaptera	Forficulidae	Ear wig nymph	*Forficula auricularia*	6	5	11	1.62
Total (%)					**211 (30.98)**	**470 (69.02)**	**681**	**100**

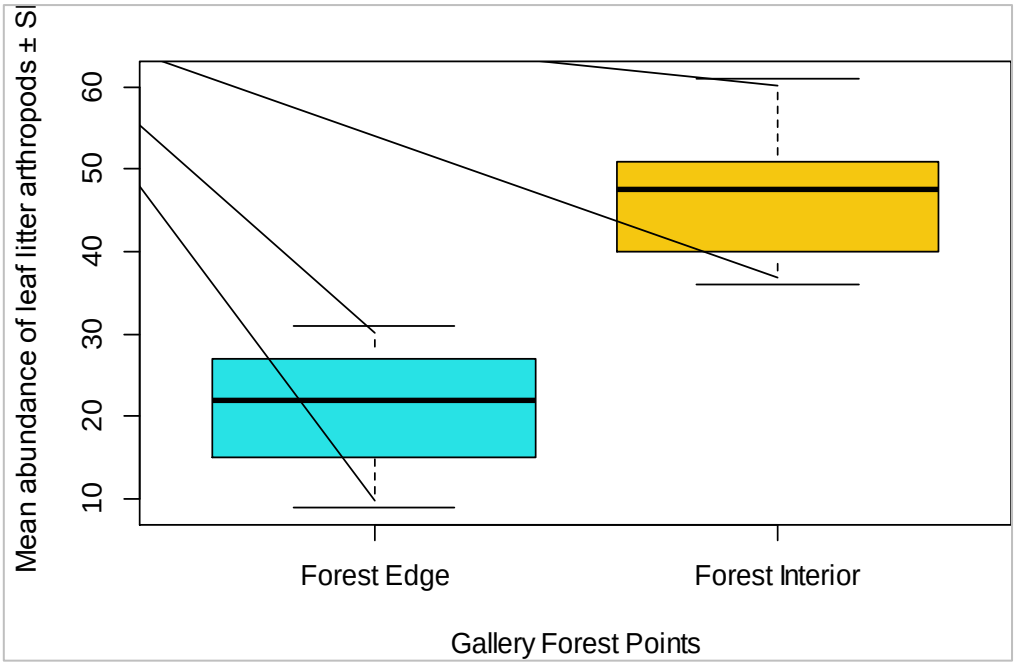

Figure 4: Mean abundance of leaf litter arthropods in relation to the two points in the gallery forest of Jos Wildlife Park

Table 2: Generalized Linear Models (GLM) showing the association of arthropods abundance in relation to soil physiochemical parameters

Parameter	Estimate	Std. Error	z value	Pr(>|z|)
Intercept (No. of arthropods)	32.00338	6.50022	4.923	8.50e-07 ***
Temperature	0.1134	0.05226	2.17	0.0300 *
pH	-4.1664	0.96127	-4.334	1.46e-05 ***
Moisture content	0.07556	0.04617	1.637	0.1017
Organic Matter	-1.28143	0.59105	-2.168	0.0302 *

****: Very highly significant; *: Significant*

Species Diversity of Leaf Litter Arthropods in Relation to the Two Points in Gallery Forest

There was no significant difference (χ^2 = 0.003219, df = 1, P = 0.9548) in the level of diversity index of leaf litter arthropods in relation to the two gallery forest points. The overall diversity status of the gallery forest was high due to the Shannon-Wiener index (H´) value recorded in the two points, which depicted H´ = 2.69 in the forest edge and H'=2.56 in the Interior points as shown in Table 3.

Table 3: Transient-Specific Shannon-Weiner Diversity Index (H) of Leaf Litter arthropods in the Gallery Forest of Jos Wildlife Park

Transient type	Arthropod abundance	Major contributing species	Diversity Index (H)
Forest edge	211	*Loxosceles reclusa* *Trachelas pacificus* *Heteronychus arator* *Tanystoma maculicolle* *Datana imtegerrima*	2.69
Forest interior	470	*Loxosceles reclusa* *Tanystoma maculicolle* *Thermonectus basillaris* *Phalangium opilio* *Scotophaeus blackwalli*	2.56

(χ^2 = 0.003219, df = 1, P = 0.9548)

DISCUSSION

Litter arthropod abundance in tropical forests is patchily distributed in space and time (David and Michael, 2013). The variety of leaf litter arthropods belonging to 3 classes, 12 orders, 31 families and 38 species collected and identified in this study (Table 1) could be attributed to habitat, microclimate and availability of food in the leaf litter which offered protection from predators and harsh weather conditions. This is supported by the findings of Hamilton, 2015 who reported that the leaf litter layer is an important habitat to many arthropods since they utilize it for food and shelter from adverse environmental conditions and protection from predators thereby enhancing their abundance. The high abundance of *Loxosceles reclusa* (Table 1) in this study was probably due to their attraction to the fermented products of decaying leaf litter materials which they utilized for food. The decomposition process of leaf litter is known to bring about fermentation which causes *Loxosceles reclusa* to aggregate in that area in order to feed. They use their mouthparts to absorb the liquid food (Stehr, 1998).

The significant difference in the abundance of leaf litter arthropods in relation to the classes where the Class insecta was the dominant Class was due to their habitat structure which is consistent with the result of Njila and Hadi, (2015) who also found that Insecta was the most abundant taxa of ground dwelling arthropods associated with two habitat types in the Jos Museum Zoological Garden Jos Plateau state, North central Nigeria. The significant difference in the abundance of leaf litter arthropods in relation to orders where the order Araneae was the highest was attributed to their body size, body coloration, and net shape or pattern which was also reported by Jimenez-Valverde & Lobo (2007). The significant difference in the abundance of leaf litter arthropods in relation to Families of leaf litter arthropods where the Family Sicaridae was the most abundant was probably due to their habitat structure which provided an excellent environmental condition at high and low temperatures.

The significant difference in the mean abundance of leaf litter arthropods in relation to the Edge and Interior Points of the Gallery Forest (Figure 4), where the gallery forest interior had the highest abundance of leaf litter arthropods and the forest edge the lowest could be due to the microhabitat heterogeneity and availability of food in the interior point compared to the edge of the forest and also could be due to the canopy provided by trees covering the leaf litters in the interior point, which supports the report of Blair *et al*. (1994) and Njila and Hadi, (2015) where they revealed that mature forests with a closed canopy in the interior forest are likely to support more abundant and diverse fauna compared to the edge of the forest in an early successional stage. The dominant species of litter arthropods collected in the edge and Interior points of the forest was *Loxosceles reclusa*. This is because the two points provided favorable microhabitats for these species.

The highly significant influence of soil pH on the abundance of leaf litter arthropods was attributed to the non-tolerance nature of the arthropods to the acidic condition of the soils in the gallery forest of the park (Njila and Hadi, 2015). The marginal influence of soil temperature on the arthropod's abundance was due to the ectothermic nature of arthropods and therefore capable of regulating their internal body temperature with respect to the conditions in the park. Similarly, the marginal influence of soil organic matter was attributed to high nutrient cycling within the park as well as an increased rainfall throughout the sampling period and availability of food materials which serves as food sources for the arthropods (Savopoulous *et al*., 2012).

The conservation of natural habitat is very essential for the existence of many species of arthropods (Mathew and Rahmatullah, 1993). The significant difference in the level of diversity indices of arthropods in the two forest points where the overall diversity status of the gallery forest was higher than 2.5 suggests that the gallery forest provide natural environment that supports the existence and survival of arthropods. The Shannon-Wiener index (H´) values in the two points depicted H´ = 2.69 in the forest edge and H'=2.56 in the Interior points clearly suggests that the Jos wildlife park is a healthy ecosystem since species diversity value for biological communities is not below 2.5 and does not exceeding 5.0. (Metcalfe-Smith, 1996).

Conclusion and Recommendation

This study has provided one of the first comprehensive inventory of leaf litter arthropods of the gallery forest of the Jos wildlife park. The most abundant arthropod species for the entire survey was the *Loxosceles reclusa* (Brown recluse spider) usually found aggregating within decaying leaf litter. Their demise will therefore result in the disruption of critical ecosystem services such as source of food and decomposition. It is therefore important that frequent monitoring of ecological processes beside adoption of appropriate conservation strategy to safeguard their rich genetic diversity in the Gallery forest of the Jos Wild life park.

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