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Assessment of the relationship and variability of flying arthropods inside the JOS wildlife park, plateau state, north central Nigeria

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Abstract
Arthropods have a significant impact on our ecosystem because they play a crucial role in food chains and pollination. Consequently, research was carried out to determine the variety and distribution of species of flying insects in the gallery forest and savanna woodland of Jos Wildlife Park between June and September, 2021. The flying insects were collected using sweep netting technique. A total of 617 flying insects distributed into 45 Families, 90 Species and 8 Orders were gathered from the two environments. The composition of flying insect species differed significantly ($p< 0.05$). *Musca domestica* was the main species found in the collection. Additionally, the distribution of flying insects in respect to their Orders and Families showed a significant difference ($p< 0.05$). The savannah woodland had the largest distribution of flying insects compared to the gallery forest, and there was a significant difference ($p<0.05$) in the mean distribution of flying insects between the two habitats. Although the species distribution of flying insects in the gallery forest was low, there was a higher species diversity (H´ = 2.83) compared to savannah woodland with a lower H´ = 2.21. The similarity index value of 0.46 showed that the species composition of flying insects in the two habitats are not similar, indicating that the Jos Wildlife Park is a healthy ecosystem that support varieties of flying insects. Thus it is recommended that dumping of trash, defecating, bush burning and logging should be discouraged to further improve the variety and distribution of species among flying insects.

Keywords: Species composition, species diversity, species abundance, insects and entomology

Introduction
Insects are omnipresent in the natural world and play significant roles in preserving the stability of ecosystems by contributing to the food chain, facilitating the decomposition of organic matter, and participating in a variety of ecological interactions like pollination, predation, and herbivory. Large-scale human activities, such as clearing forests, exterminate insect species and alter long-standing ecological dynamics and interactions Insects are therefore distinctive in their own right and perform a crucial ecological role in ensuring the continuation of life on Earth; their diversity is in fact an essential component of the planet's ecology [1]. The term "biodiversity" is frequently used to refer broadly to the variety of plants, animals, and microorganisms that exist, the levels at which they occur (such as species, populations, and ecosystems), and the various ways that organisms, climate, and geology interact to create healthy ecosystems. One million of the 1.8 million extant species that have been named and characterized are insects [2]. Additionally, it has been calculated that of the planet's approximately 10 million animal species, invertebrates make up more than 90% of them [3, 4]. The evaluation of an area's insect diversity is currently of worldwide interest since it will help in the creation of conservation plans, although it will be more successful if it is focused at local or regional scales [5]. By doing this, the uncertainty that could arise from conservation efforts being undertaken on a global scale without adequate consideration for small scale processes that influence insect diversity and conservation needs might be removed [6]. Understanding how insect species composition and relative abundance fluctuate between various places is also important [7]. The goal of the current study is to catalog the variety and abundance of airborne insects in Jos Wildlife Park, Nigeria Plateau State. In addition to being helpful for medicinal, veterinary, and agricultural applications, this information will likely provide insight into the diversity of insect species in Jos Wildlife Park, which is crucial for management and conservation efforts.

Materials and Methods

Area of Study

The study was carried out in the Jos Wildlife Park in Plateau state, North Central Nigeria. The park is situated in the Northern region of the State on longitude 9°53′8″ N and latitude 8°50′57″ E encompassing an area of about 8 km2 and distinguished by mild hills, rocky (rock outcrop) topography, seasonal streams, typical savanna woods, gallery forests, and some exotic flora. *Jacaranda mimosaefolia, Parkia clappertoniana, Ficus* species, *Delonix regia*, and *Acacia* species make up the majority of the vegetation. Introduced tree species like *Pinus* and *Eucalyptus* are widespread. There are also several herbs and shrubs, including *Sida acuta*, Bohemia species, and *Emilia sonchiofolia*. One of the relatively untouched natural vegetation types of the Jos Plateau is the forest [8]. The Jos Plateau's vegetation has been severely damaged by tin mining operations, large-scale deforestation has continued due to a high human population, grasslands and scrub have been turned into farmland, and the few remaining patches of forest and woodland are being rapidly depleted due to unsustainable fuel wood collection [9]. On the Jos Plateau, only a small number of natural grasslands, savanna-woodlands, and forests still exist. One of these is the Jos Wildlife Park. The area hosts various kinds of animals ranging from herbivores to carnivores, reptiles, birds and primates. Some herbivorous there include elephant, eland's cattle and gazelles. The carnivorous animals there are hyenas, lions, honey badgers, desert tortoise, crocodile, jackals, rock pythons among others. The various habitats in the park are the savanna woodlands, rocky outcrop and gallery forest.

Sampling Sites

Two habitat types were used for the sampling. They are Savanna woodland and Gallery-forest.

Sampling Period

The flying insects were collected between June and July 2021, when it rained. For a period of four weeks, the insects were gathered every 72 hours between 7am and 12pm.

Techniques for Collecting and Preserving Insects

The fly sweep-net, which had a diameter of 25 cm and a thickness of 2.7 cm and was made of muslin material, had a wooden handle that measured 32 inches long and was used to catch flying insects. Three belt transect points (edge, mid, and interior) were measured at each sampling site. The length of each transect point is 50 meters. At the two sampling sites, the sweep-net was utilized to catch insects from every angle. The sweep-net was flung in a full 180° arc from side-to-side while being gripped at the wooden handle closest to the ground. Each transect point received a total of 20 sweeps. The captured insects were thoroughly immobilized with ethyl-acetate before being transferred to sample bottles with 70% ethanol and glycerol. All captured insects were taken to the lab for identifying, counting, and classifying.

Species identification for insects

Each sample bottle's contents were emptied into a petri plate, sorted, and identified using Castner photographic atlas of Entomology and guide to insect identification [10] in addition to the Picture Insect and Google Lens android applications. In the systematic and taxonomic laboratory of the Department of Science Laboratory Technology, University of Jos, Nigeria, the majority of general and precise identifications were accomplished utilizing insects.

Statistical Analysis

The R-console software version 4.0.2 was used to analyze the data. The parameters of the abundance of orders, families as well as species was measured using simple percentages. The Shapiro-Wilk test was used to determine whether the distribution of the response variable (the abundance of insects) was normal. In order to compare proportions in respect to insect orders and families, the Pearson's chi-square test was employed. The mean abundance of flying insects in relation to the two habitat categories was compared using a two-sample t-test. The significance threshold was established at $P < 0.05$.

Species index for biological diversity

The Shannon-Wiener diversity index (H') was used to determine how many different species of flying insects there are [11].

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

Where

$\mathbf{H}'$ is the diversity index

P_i is the proportion of individual species

S is the total number of species in the habitat

i is the proportion of species.

Similarity or differences in the makeup of flying insect species according to their habitat To assess the compositional similarity and/or habitat-specific variation of insect species, Sorensen's similarity index [12] was utilized. The formula used to measure it was:

$$\text{Sorenson's Coefficient} = \frac{2c}{a+b}$$

Where

CS=coefficient of similarity

a = species diversity at the two sites under consideration

b = number of species found in Savannah woodland but missing from Gallery-forest

c = the number of species found in Gallery-forest but missing from Savannah woodland

Results

A total of 617 insects were collected from the two habitats which spread across 8 orders, 45 families and 90 species as shown in Table 1, there was significant difference (χ^2 = 1199.5, df = 7, p< 0.0001) in the species abundance of flying insects in the two habitats. The dominant species of aerial insects collected from the savannah wood land were *Musca domestica*, *Tenebrio molitor* as well as *Sibovia occatoria*, while the least dominant species of flying were *Chilocorus bipustulatus*, *Oryctes nasicornis*, *Tomarus gibbosus*, *Thermonectus basillaris*, *Sanderlus niger*, *Episyrphus balteatus, Trogus pennator, Polistes*

Canadensis, Sceliphron Caementarium, Trypoxylon politum, Atta Mexicana, Sphictostethus nitidus, Junonia lemonias, Mesoligia furuncula, Hagenomyia tristris, Vella fallax, Ululodes macleayanus, Dissosteira Carolina, Acanthacris ruficornis, *Neoxabea bipunctata*, *Sympetrum rubicundulum*, *Zyxomma petiolatum* and *Pantala flavescens*. Conversely, the dominant species of flying insects collected from the Gallery forest are *Musca domestica, Lasioderma sericone, Conoderus exsul*, *Capohilus lugubris, Hermitia illucens* as well as *Chlorion aerarium,* while the least dominant species of flying insects are *Phymatodes testaceus*, *Prionus californicus*, *Harmonia axyridis*, *Halmus chalybeus*, *Attagenus pellio*, *Serica brunea*, *Chrysomya megacephala*, *Cylindromyia bicolor*, *Melanophora roralis*, *Fieberiella florii* , *Menecles insertus*, *Reduvius personata*, *Acrotaphus wilti, Enicospilus purgatus, Isodontia auripes*, *Acraea andomacha*, *Cyligramma latona*, *Noctua pronuba* and *Dictyophorus spumans*. Therefore, there was significant difference (χ^2 = 1199.5, df = 7, p< 0.0001) in abundance in relation to flying insect orders. Also, the most dominant family was Muscidae having 315 insects representing 51.05%, while the least abundant were families with only one 1 individuals representing 0.16%. Thus, the abundance of flying insects in relation families shows high significant difference (χ^2 = 7050.6, df = 44, p< 0.0001). There was a significant difference (χ^2 = 1199.5, df = 7, p< 0.0001) in abundance of flying insects in relation to insect orders with regards to the two habitats (Table 1). The most dominant insect order in the Savannah woodland is Diptera having 258 insects representing 53.53% while the least dominant order is the Odonata having 3 insects representing 0.62%. Also, the gallery forest has Diptera 90 (46.15%) as the most dominant order, while Lepidoptera 3 (1.54%) was found to be the least dominant order. There was significant difference (χ^2 = 7050.6, df = 44, p< 0.0001) in abundance of insect Families in the two habitats (Table 1). The most dominant Families recorded in the Savannah woodland is Muscidae 241 (58.21) while Dermestidae 1 (0.24%), Dytiscidae 1 (0.24%), Rhipiceridae 1 (0.24%), Stratiomyidae 1 (0.24%), Rhopalidae 1 (0.24%), Lygaeidae 1 (0.24%), Crabronidae 1 (0.24%), Apidae 1 (0.24%), Vespidae 1 (0.24%), Pompilidae 1 (0.24%), Ascalaphidae 1 (0.24%) and Gryllidae 1 (0.24%) where arguably the least dominant families. Also, in the Gallery forest, Muscidae 74 (41.11%) found to be the most dominant family, while Dermestidae 1 (0.56%), Melolonthidae 1 (0.56%), Tachinidae 1 (0.56%), Rhinophoridae 1 (0.56%), Lygaeidae 1 (0.56%), Vespidae 1 (0.56%), Nymphalidae 1 (0.56%) and Pyrgomorphidae 1 (0.56%) are the least dominant families in the gallery forest. There was a significant difference (t = -6.2632, df = 14, P = 0.0000208) in the mean distribution of flying insects between the savannah woodland and gallery forest as shown in Figure 3. The savannah woodland had higher distribution of aerial insects of 422 representing a percentage of 68.40% while the gallery forest had lower distribution of 195 individuals of flying insects representing percentage of 31.60%.

Table 1: Checklist of Flying Insects in the two Habitats of Jos Wildlife Park

Order	Family	Common Name	Species	Savannah woodland	Gallery forest	Total	Percent (%)
Coleoptera	Anobiidae	Common furniture beetle	*Anobium punctatum*	4	0	4	0.64
		Cigarette beetle	*Lasioderma sericone*	1	6	7	1.13
	Buprestidae	Metallic wood boring beetle	*Agrilus cyanescens*	0	2	2	0.32
	Cerambycidae	Tanbark borer	*Phymatodes testaceus*	1	1	2	0.32
		The tanner	*Prionus coriarus*	1	2	3	0.49
		Califonia roof borer	*Prionus californicus*	0	1	1	0.16
		Flat faced horned beetle	*Aegemorpus modestus*	0	1	1	0.16
	Chrysomelidae	Alder leaf beetle	*Agelastica alni*	1	0	1	0.16
		Viburnum leaf beetle	*Pyrrhalta viburni*	1	0	1	0.16
	Coccinelidae	Asian lady bird (Harlequin)	*Harmonia axyridis*	6	1	7	1.13
		Heather lady bird	*Chilocorus bipustulatus*	1	0	1	0.16
		Steel blue lady bird	*Halmus chalybeus*	0	1	1	0.16
		Large spotted lady bird	*Harmonia conformis*	0	2	2	0.32
	Dermestidae	Fur beetle	*Attagenus pellio*	1	1	2	0.32
	Dynastidae	European rhinoceros beetle	*Oryctes nasicornis*	1	0	1	0.16
		Carrot beetle	*Tomarus gibbosus*	1	0	1	0.16
	Dytiscidae	Predaceous diving beetle	*Thermonectus basillaris*	1	0	1	0.16
	Elateridae	Pasture wireworm	*Conoderus exsul*	0	8	8	1.30
	Lycidae	End band net wing	*Calopteron terminale*	3	2	5	0.81
		Banded net winged beetle	*Calopteron descripans*	0	2	2	0.32
	Melolonthidae	Brown chafer	*Serica brunea*	0	1	1	0.16
	Nitidulidae	Sap beetle	*Capohilus lugubris*	0	7	7	1.13
	Rhipiceridae	Cedar beetle	*Sanderlus niger*	1	0	1	0.16
	Tenebrionidae	Yellow mealworm	*Tenebrio molitor*	39	8	47	7.62
Diptera	Calliphoridae	Blue blow fly	*Calliphora vicina*	0	2	2	0.32
	Muscidae	Neomyia spp	*Neomyia cornicin*	5	0	5	0.81
		House fly	*Musca domestica*	236	73	309	50.08
		Oriental latrine fly	*Chrysomya megacephala*	0	1	1	0.16
	Tachinidae	Fire tailed mud wasp	*Cylindromyia bicolor*	2	1	3	0.49
	Syrphidae	Syrphid fly	*Ornidia obesa*	3	0	3	0.49
		Marmalade hover fly	*Episyrphus balteatus*	1	0	1	0.16
		Mexican cactus fly	*Copestylum mexicanum*	4	4	8	1.30

		Band eyed drone fly	*Eristalinus taeniops*	4	2	6	0.97
	Mydidae	Clubbed mydas fly	*Mydas clavatas*	2	0	2	0.32
	Rhinophoride	Smokey winged woodhouse fly	*Melanophora roralis*	0	1	1	0.16
	Stratiomyidae	Black soldier fly	*Hermitia illucens*	1	6	7	1.13
Hemiptera	Cicadellidae	Privet leaf hopper	*Fieberiella florii*	9	1	10	1.62
		Yellow stripped leaf hopper	*Sibovia occatoria*	14	17	31	5.02
	Cercopidae	Black/red frog hopper	*Cercopis vulnerata*	9	3	12	1.94
	Pentatomidae	African cluster bug	*Agonoscelis puberula*	1	0	1	0.16
		Elf shoe stink bug	*Menecles insertus*	4	1	5	0.81
		Harlequin bug	*Murgantia histrionica*	0	1	1	0.16
	Reduviidae	Masked hunter	*Reduvius personata*	0	1	1	0.16
		Kissing bug	Triatoma gerstaeckeri	0	2	2	0.32
	Rhopalidae	Gold rain tree bug	*Leptocoris vicinus*	1	0	1	0.16
	Lygaeidae	Elm seed bug	*Arocatus melanocephalus*	1	1	2	0.32
Hymenoptera	Ichneumonidae	Ichneumonid wasp	*Netelia ephippiata*	1	1	2	0.32
		Ichneumonid wasp	*Acrotaphus wilti*	1	1	2	0.32
		Jungle dragon	*Enicospilus purgatus*	0	1	1	0.16
		Pennator ichneumon wasp	*Trogus pennator*	1	0	1	0.16
	Eumenidae	Northern paper wasp	*Polistes fuscatus*	1	1	2	0.32
		Red paper wasp	*Polistes Canadensis*	1	0	1	0.16
		Potter wasp	*Euodynerus foraminatus*	0	1	1	0.16
	Sphecidae	Blue mud dauber	*Chalybion californicum*	2	0	2	0.32
		Black and yellow mud dauber	*Sceliphron Caementarium*	1	0	1	0.16
		Brown legged grass carrier	*Isodontia auripes*	3	1	4	0.65
		Steel blue cricket hunter	*Chlorion aerarium*	0	9	9	1.46
	Crambronidae	Organ pipe mud dauber	*Trypoxylon politum*	1	0	1	0.16
	Apidae	Giant honey bee	*Apis dorsata*	1	1	2	0.32
		Honey bee	*Xylocopa tbaniformis parkinsoniae*	0	1	1	0.16
	Vespidae	Common wasp	*Vespula vulgaris*	1	1	2	0.32
	Formicidae	Black carpenter ant	*Camponotus pennsylvanicus*	1	3	4	0.65
		Mexican leaf cutting ant	*Atta Mexicana*	1	0	1	0.16
	Pompilidea	Golden hunter wasp	*Sphictostethus nitidus*	1	0	1	0.16
Lepidoptera	Nymphalidae	Danaid egg fly	*Hypolimnas missip*	2	0	2	0.32
		Blue spotted crow	*Euploea midamus*	2	0	2	0.32
		Glass wing	*Acraea andomacha*	9	1	10	1.62
		Blue pansy	*Junonia oenone*	3	0	3	0.49
		Lemon pansy	*Junonia lemonias*	1	0	1	0.16
	Noctuidae	Old lady (Black under wig)	*Mormo maura*	3	0	3	0.49
		Cloaked minor	*Mesoligia furuncula*	1	0	1	0.16
		Cream stripped owl	*Cyligramma latona*	0	1	1	0.16
		Large yellow underwig	*Noctua pronuba*	0	1	1	0.16
	Geometridae	White spring moth	*Lomographa vestaliata*	6	0	6	0.97
		March moth	*Alsophila aescularia*	3	0	3	0.49
Neuroptera	Myrmeleontidae	Greganous ant lion	*Hagenomyia tristris*	1	0	1	0.16
		Ant lion	*Vella fallax*	1	0	1	0.16
	Ascalaphidae	Owl fly	*Ululodes macleayanus*	1	0	1	0.16
Orthoptera	Acrididae	Mash meadow grasshopper	*Pseudochothippus curtipennis*	1	1	2	0.32
		Red legged grasshopper	*Melanopus feermurrubrum*	3	2	5	0.81
		Carolina grasshopper	*Dissosteira Carolina*	1	0	1	0.16
		Black short horned grasshopper	*Boopedon nubilum*	2	0	2	0.32
		Weta grass hopper	*Acanthacris ruficornis*	1	0	1	0.16
	Gryllidae	Two spotted tree crickets	*Neoxabea bipunctata*	1	0	1	0.16
	Pyrogomorphidae	Koppie foam grass hopper	*Dictyophorus spumans*	0	1	1	0.16
Odonata	Libelludae	Ruby meadow hawk	*Sympetrum rubicundulum*	1	0	1	0.16
		Brown dusk hawk	*Zyxomma petiolatum*	1	0	1	0.16
		Wandering glide	*Pantala flavescens*	1	0	1	0.16
		Coral tailed cloud wing	*Tholymis tillarga*	0	2	2	0.32
	Lestidae	Amber winged spread wing	*Lestes eurinus*	0	2	2	0.32
Total (%)				422 (68.40)	195 (31.60)	617	100

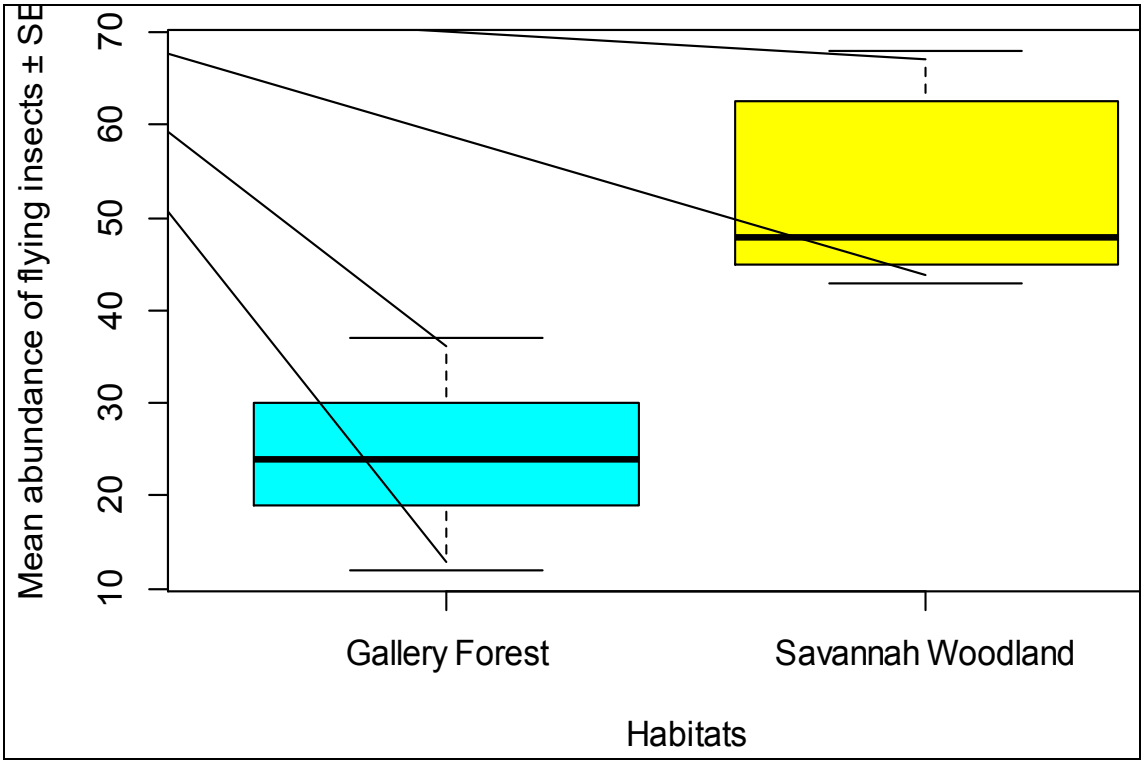

Fig 3: Mean abundance of flying insects at Jos Wildlife Park in proportion to the two habitat types

Table 2: Habitat-Specific Shannon-Wiener Diversity Index (H) of flying insects of Jos Wildlife Park

Transient type	Insects abundance	Major contributing species	Diversity Index (H´)
Gallery forest	195	*Musca domestica Sibovia occatoria Chlorion aerarium Conoderus exsul Tenebrio molitor*	2.83
Savannah woodland	422	*Musca domestica Tenebrio molitor Sibovia occatoria Fieberiella florii Cercopis vulnerata, Acraea andomacha*	2.21

Although abundance of flying insects in gallery forest was low, however, higher species diversity index of H´ = 2.83 ensued (Table 2), while savannah woodland habitat had low species diversity index of H´ = 2.21 (Table 2). The result both in the savannah woodland and the gallery forest revealed that *Musca domestica* is the major contributing species.

Sorensen's similarity index [12] was employed to gauge how well different ecosystems' flying insect species compositions matched. It was calculated using the formula.

Sorenson's Coefficient (**CS**) = $\frac{2c}{a+b}$

Where

CS=coefficient of similarity

a = species diversity at the two sites under consideration

b = number of species found in Savannah woodland but missing from Gallery forest

c = the number of species found in Gallery forest but missing from Savannah woodland

$CS = \frac{2\,(27)}{51+66}$

$CS = \frac{54}{117}$

CS = 0.4615

CS ≈ 0.46 (46%)

The similarity status between flying insects in relation to the two habitats was 0.4614 (46%) which indicated that the two habitats studied do not have much similarity in species composition of insects but revealed a complete difference in the species makeup of flying insects.

Discussion

In the two habitats of the Jos wildlife park, 617 flying insects were collected, and as shown in Table 1, 8 Orders with 45 families and 90 species were found there. Savannah woodland had the highest species abundance but with a lower diversity compared to the gallery forest and vice versa as shown in Tables 2 and 3. The abundance of different tree species (ornamental plants/seedlings) and vegetation cover in this ecosystem, which resembles a forest, may be the primary reason for the abundance of species there. This result is in par with 'habitat heterogeneity hypothesis' which assumed that ecosystems with complex structural features might offer more niches and a variety of methods to use the resources of the environment, increasing the variety of species. Plant communities typically dictate the physical structure of the habitat, and as a result, have a significant impact on the distributions and interactions of animal species [13]. Since landscape heterogeneity is undoubtedly a key element in the diversity of species of flying insects, the findings of these studies further support the hypothesis that

landscape characteristics are significant for both species condition and species richness. For the composition of species, both large-scale and small-scale heterogeneity are significant [5]. The presence of *Harmonia axyridis* and *Musca domestica* is related to their high requirements for habitat quality, particularly the variety and structure of the vegetation. As a result, they are frequently regarded as helpful indicators of habitat quality changes in specific terrestrial ecosystems and may be the best group for conservation planning [14]. The group of insects with the greatest population density were the Dipterans, and it occurred more in savannah woodland compared to gallery forest, this could also be because the research period coincides with the end of their breeding season. Gallery forests are characterized by grasses that are largely absent with species that are mostly fire intolerant and shade tolerant. Savannahs are characterized by mixed tree and grass systems defined by fire tolerance that are *Xerophilous* in nature and shade intolerant species. Numerous species of airborne insects depend heavily on natural habitat preservation to survive [15]. Habitat-specific Shannon-Wiener species diversity index revealed that *Musca domestica* is the major contributing species in the gallery forest and savannah woodland (Table 2). This would imply that the gallery forest and savannah woodland of the park offer a natural environment that supports their survival, reproduction, and existence. In order to protect their high genetic variety, it is crucial to encourage frequent monitoring of ecological processes along with the implementation of appropriate conservation strategies. The gallery forest had a diversity index of 2.83 and the savannah woodland had a diversity index of 2.21, with a difference of $P > 0.05$ between the two analyzed habitat types. Since the species diversity value H' for biological communities is not lower than 2.5 or higher than 5.0 [16], this shows that the Jos Wildlife Park has a healthy ecosystem. The two habitat categories under study overlap according to the value of the estimated Sorenson's coefficient. It therefore shown a full divergence in the species composition of flying insects. This is most likely caused by the structure and makeup of their habitat. The assemblage's constituent species are generalists that can adapt to most environmental factors that encourage their development and dissemination in the savannah woodland [17]. Due to the superior ecological qualities of the Savannah woodland, including microclimate, vegetation structure, co-occurrence of vegetation types at a local scale, and less habitat degradation, the Savannah woodland has a higher number of flying insects than the gallery forest. According to research by Stork *et al*. [18] on butterfly diversity and silvicultural practices in lowland rainforests of Cameroon, both insects and plants are in danger of going extinct due to pollution, poor habitat quality, unsustainable overpopulation, and climatic changes on a global scale. Anthropogenic activities like cattle herding and defecating are a significant issue seen in both habitats of the Jos Wildlife Park. These actions have a significant impact on the variety and quantity of insect species. In this study, it was discovered that there were 51 species of insects in the gallery forest, distributed across 7 orders, 33 families. Conversely, the savanna forest of the Jos wildlife park contained 8 orders, 36 families, and 66 species. Ten family (Ascaphidae, Dynastidae, Dysticidae, Gryllidae, Geometridae, Mydidae, Myrmeleonidae, Pompilidae, Rhopalidae and rhipiceridae) were only found in the savanna woodland while Buprestidae, Caliphoridae, Elateridae, Lestidae, Melolontidae, Nitidulidae, Pyrgomorphidae, Rhinophoridae were only peculiar to the gallery forest of the park (Table 1). It should be emphasized that a complex habitat would contain a greater range of insects [19]. According to Suana [20], the design of complex landscapes will allow for a variety and distribution of habitat types, resulting in an increase in the number of insects that may coexist there. Herbaceous trees and plants will result in a structure that is more and more complicated, which will affect the diversity and distribution of flying insects [21, 22]. Complex ecosystems and heterogeneous vegetation structures create niches for wildlife, which help to form food webs [19]. Because it provides a variety of substrate types that may affect the preys that are available to it and the means by which they are obtained, vegetation structure may be a significant predictor of the characteristics of insect communities. According to Kamal *et al*. [23] and Ayansola [24], species diversity and dispersion will typically rise along with the diversity of habitat structure. The findings thus suggest that habitat selection behavior, an essential but usually ignored mechanism of community and meta-community assembly, can significantly influence patterns of species distribution and landscape patterns.

Conclusion

This study clearly shows that the Jos Wildlife Park have got abundant and richly diverse flying insects of interest. The composition of flying insects significantly varied across species. The dominant species collected was *Musca domestica.* A high preponderance of flying insects in savannah woodland habitat over the gallery forest was recorded. On the other hand, flying insects were higher in the gallery forest ($H' = 2.83$) than savannah woodland ($H' = 2.21$). The species composition of flying insects in the two habitats are not similar based on the 0.46 index value recorded, this clearly shows that the Jos Wildlife Park is a healthy ecosystem that support varieties of flying insects. In order to further promote the species distribution and diversity of flying insects, it is advised that garbage dumping, defecating, logging, and bush burning within the Jos Wildlife Park should be prevented.

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None.

Conflicts of interest

All authors listed here declare no conflict of interest exists.

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