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Eluyeba Olumayowa
Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria

Kehinde Temitope
Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria

Correspondence
Eluyeba Olumayowa
Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria

Taxa-dependent response of flower-visiting insects to local and landscape disturbance in tropical grassland habitats in Ile-Ife, Nigeria

Eluyeba Olumayowa and Kehinde Temitope

Abstract
This study examined the effect of local and landscape scale disturbances on different flower-visiting insect taxa in grassland habitats in Ile-Ife, Nigeria. Four replicates of disturbed and less disturbed grassland habitat were sampled. Flower-visiting insects were sampled with coloured pan traps and observation along transects. A total of 969 flower-visiting insects belonging to five taxa (true flies, butterflies, bees, wasps and beetles) were collected. True flies had the highest percentage composition and abundance followed by butterflies and bees. The landscape variable had a significant effect on the mean abundance of flower-visiting insects, abundance of bees, true flies and wasps. Only the mean abundance of true flies was significantly higher in less disturbed than disturbed grassland. This indicates that the insect taxa respond differently to disturbances at local and landscape scale. This underscores the need to pay attention to ecological sensitivity of the different taxa in conservation planning.

Keywords: biodiversity, conservation, flower-visiting insects, grassland, pollinators

1. Introduction

Biodiversity is fundamental to the health of ecosystems and provision of ecosystem services on which all organisms including humans depend for vital benefits such as climate regulation, pollination and food [1]. Flower-visiting insects are a key component of the organismal diversity of terrestrial ecosystems, which are closely linked with the provision of pollination services in both agricultural and natural vegetation [2, 3]. Bees, butterflies and some fly species are among the most dominant insect taxa responsible for much of the flower visitation activities and the consequent ecosystem services [4]. Tropical ecosystems rely largely on these and other insect groups for critical ecosystem services such as pollination and regulation of pest populations [5].

Deforestation, land use intensification as well as habitat loss and fragmentation are some of the most critical environmental stressors on tropical ecosystems with documented threats to biodiversity generally and to insect diversity [6]. Within fragmented, human dominated landscapes in these ecosystems, native vegetation cover continues to decline and land use intensity and anthropogenic activities continue to increase with attendant threats to terrestrial biodiversity such as flower-visiting insects and their associated ecosystems services [7, 8]. Common land use practices have aided the removal of the natural habitat of important groups as well as the removal of food sources through habitat fragmentation and degradation [9]. Although, flower-visiting insects have a wide range of diversification in life traits and functional groups, they all share a common reliance on floral resources as a food source. Consequently, regardless of the direction of the land use change, flower-visiting insects are very sensitive to changes in the availability of flowers which is a major food source in their environment [3]. Anthropogenic activities have aided the global decline of flower-visiting insects through processes like development and agricultural intensification which has led to the loss of flora resources in the environment [10, 11, 12].

The ability to predict the responses of ecological communities and species to human-induced environmental change remains a key issue for ecologists and conservation managers [13]. For flower-visiting insects, the diversity of life traits and variation in ecological adaptation and sensitivity among the various insect taxa suggests the possibility of taxa-dependent response to land use change. However, there is paucity of information on the response of some flower-visiting insect taxa to land use change.

Hence this study examines the response of various flower-visiting insect taxa in the same study area to local and landscape changes in land use.

2. Materials and Methods

2.1 Study Area

The study was carried out in Ile-Ife, which is located between Latitudes 6º 57' 05"N and 7º 35' 19"N and Longitudes 4º 20' 41"E to 4º 46' 21"E, Osun State, Nigeria (Figure 1). This area is located in the rainforest region of Nigeria. The weather of the area is characterized by wet and dry season which last from March to October and November to February respectively. Grasslands within the study area are constantly being influenced by human activities such as mowing and cattle grazing at the local scale as well as fragmentation and isolation of habitats at the landscape scale. This study was carried out in two grassland habitat types, which were distinguished based on the intensity of anthropogenic disturbances both at the local and landscape scales. The first grassland type was made up of four replicates of intensively disturbed grassland habitats which were within urban settlement (referred to as disturbed grassland in this study). These study sites had the following flowering plants: *Tridax procumbens* L., *Commelina congesta* C.B. Clarke, *Synedrella nodiflora* (L.), *Sidaacuta* Burm. F., *Talinum triangulare* (Jacq) and *Vernonia cinerea* (L.). The main anthropogenic disturbances on this grassland type were constant mowing and trampling of the plants from human movement which limited the growth of the grasses and flowering plants on these sites. The second grassland type includes four replicates of less intensively disturbed grassland habitats which were within suburban settlement (referred to as less disturbed grassland in this study). These study sites had the following flowering plants during the period of study: *T. procumbens*, *S. acuta*, *Corchorus* sp. L., *Mimosa pudica* L., *T. triangulare*, *Aspilia Africana* (Pers) C.D. Adams, *Indigofera* sp. L., *Chromolaena odorata* (L.), *Stachytarpheta cayennensis* (Rich.), *Ageratum conyzoides* L., *Ipomoea* sp. (L.), and *V. cinerea*. The grasslands in these study sites were sparingly grazed by a few cattle which resulted in minimal level of disturbances to the grasses and flowering plants on the sites.

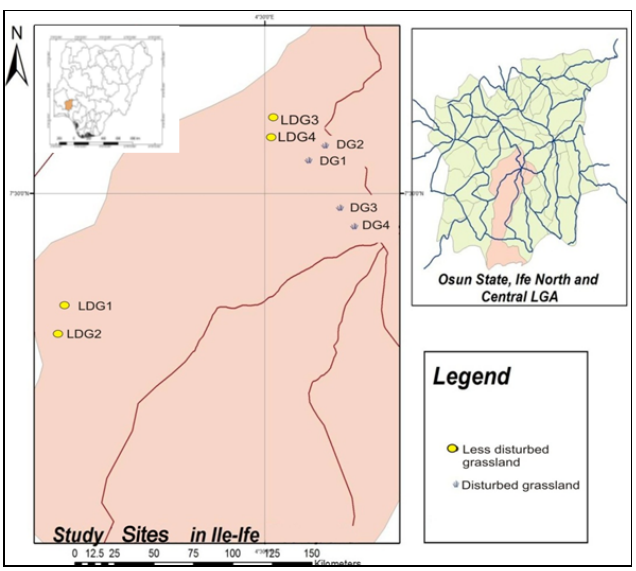

Fig 1: Study sites and land use types in Ile-Ife.DGI= Sport complex, DG2= Health Sciences car park, DG3= Adventist Secondary School, DG4= St. Mulumber College, LDG1= Akinlalu 1, LDG2= Akinlalu 2, LDG3= OAU Commercial farm1, LDG4= OAU Commercial farm 2

2.2 Sampling, sorting and identification of flower-visiting insects and flowering plants

Flower-visiting insects and flowering plants were sampled across the study sites on a monthly basis for a period of eight months between July 2016 and February 2017 covering parts of the rainy and dry seasons. Sampling was conducted on days with more favourable weather conditions (i.e. days without rainfall and with little or no cloud cover). The sampling of flower-visiting insects was carried out using nine bowls of 1.5 L capacity of colour yellow, blue and white as pan traps. Each pan trap was half filled with water and a few drops of liquid detergent were added to reduce the surface tension of the water and enhance insect trapping. The bowls were arranged randomly on each study site and left for a period of 48 hours after which insects collected were removed and stored in 70% alcohol until sorting and identification. Furthermore, aerial netting and observation along transects of dimension 100m x 5m was used for additional insect sampling. Flower-visiting insects observed on the floral parts of flowering plants along the transectsin the study sites during the sampling period were recorded. The flower visitors were collected with aerial net for further identification. Furthermore, flowering plants were also sampled on each study site using 2 m x 2 m quadrat placed at 25 m interval along each 100 m transect where insects were sampled. The flowering plant specimens were identified at Ife Herbarium, Ile-Ife. Insects collected were sorted under a dissecting microscope (Model- ZEISS Steimi, 2000) and identified with the assistance of expert taxonomists and with the use of the following keys; Bees of the world [14], Common Butterflies of IITA [15], Butterfly of West Africa [16]. Reference collection in Entomology Laboratory of Zoology Department and Museum of Natural History, ObafemiAwolowo University, Ile-Ifewere also used.

2.3 Disturbance at the Landscape Scale

Effect of disturbance at the landscape scale was considered using the distance of each study site to the nearest forest habitat as the index of disturbance. It has been reported that distance of a site to the nearest forest or natural habitat is an indication of degree of fragmentation or habitat loss at the landscape level [17, 18]. Distance of each study site to forest was determined using Geographic Information System (ArcGIS 10.3).

2.4 Statistical Analyses

Data collected were analysed using Analysis of variance (ANOVA), generalized linear model (GLM, Poisson error distribution), and t-test in R (version 3.3.3, R development core team 2015) [19] and SPSS version 17.

3. Results

A total of 969 flower-visiting insects belonging to five taxa (true flies, butterflies, bees, wasps and beetles), 25 families and 61 species were collected during this study (Table 1). True flies had the highest percentage composition and abundance followed by butterflies while the least percentage composition and abundance was recorded for beetles (Table 2). The result of the GLM analysis showed that the mean abundance of flower-visiting insects was not significantly different between the two grassland types ($z = -0.179$, $p > 0.05$). However, distance of the sites to forest had a significant effect on the mean abundance of flower-visiting insects ($z = -4.606$, $p < 0.05$). The mean abundance of flower-visiting insects reduced with increasing distance of the study sites to forest (Figure 2). Furthermore, mean species richness of flower-visiting insects was not significantly different between the two grassland types ($z = 0.298$, $p > 0.05$) and distance of the sites to forest had no significant effect on the mean species richness of flower-visiting insects.

Mean abundance and species richness of bees, beetles, butterflies and wasps as well as the mean species richness of true flies were not significantly different between the two grassland types but the mean abundance of true flies was significantly higher in less disturbed than disturbed grassland (Table 3). Mean abundance of bees (Figure 3), wasps (Figure 4) and true flies (Figure 5) decreased with increasing distance of the sites to forest. However, mean abundance and species richness of beetles and butterflies as well as the species richness of bees, true flies and wasps did not vary with increasing distance of the sites to forest (Table 3).

4. Discussion

This study assessed the abundance and species richness of the flower-visiting insect community in the study area. Flower-visitors were found to compromise members of important taxa such as bees, true flies and butterflies which dominate tropical ecosystems [20]. Bees, true flies and butterflies have been identified as the most important flower-visiting insects collecting floral rewards and contributing significantly to the pollination of crops and native vegetation globally [21]. True flies, butterflies and bees which are the flower-visiting insects with high abundance and composition of this study are mostly obligate florivores that could outcompete other facultative flower-visitors in foraging for flower resources hence becoming the dominant flower-visitors in flower rich habitats [22]. Although several reports have identified bees as the most important flower-visiting insects providing the most effective pollination service in both natural and agricultural ecosystems [23], however, true flies have been reported to outnumber the abundance of bees and other flower-visiting insects visiting flowers for floral resources [24].

This study showed no significant difference in the mean total abundance and species richness of flower-visiting insects between the two grassland types. While some studies have reported that abundance and species richness of flower-visiting insects decreases with increasing land use intensification [25, 26] others have reported no effect of land use change [27]. Moreover in this study, no significant difference was observed in the mean abundance and species richness of bees, beetles, butterflies and wasps as well as the species richness of true flies between the two grassland types. Flower-visiting insects are sometimes insensitive to only local scale anthropogenic disturbances especially in tropical ecosystems with long tropical flowering season [28]. Other important indices of anthropogenic disturbance at the landscape level may contribute as key drivers of variation in the abundance and species richness of flower-visiting insects [17, 29]. Some of the important landscape indices include; distance of the sites to the nearest forest and proportion of natural habitat in the landscape. These indices indicate the extent of habitat loss and fragmentation at the landscape level which explains how close the sites are to natural and reservoir habitats of flower-visiting insects. It has been emphasized that biological diversity and ecological functions within flower-visiting insects' community are not only affected by local habitat factors but also by landscape characteristics such as forest [18].

This study shows that the mean abundance of flower-visiting insect reduced with increasing distance of sites to forest. Furthermore the mean abundance of bees, true flies and wasps decreased with increasing distance of sites to forest underscoring the sensitivity of these taxa to disturbances at the landscape scale. Effects of disturbance at the landscape scale on the abundance of key ecosystem service providers such as bees have been reported [30]. However, there has been a paucity of information on other important flower-visiting insects taxa such as true flies and wasps as shown in this study. Ecological processes may interact at the local and landscape levels to influence biodiversity of flower-visiting insects [31] which further underscores the need for local and landscape considerations in conservation planning [3]. Furthermore, more attention should be paid to the ecological adaptations and sensitivity of different flower-visiting insect taxa to delineate possible taxa dependent response to local and landscape disturbances as shown in this study. On the local scale, wildlife-friendly practices that promote flower rich vegetation should be encouraged and anthropogenic disturbances should be minimal to promote the diversity of flower-visiting insects in grassland communities [3, 32]. Moreover, habitat fragmentation and habitat loss which contribute to increased isolation between grasslands and forest should be reduced especially in tropical ecosystems where forests are important reservoir habitat for these insects and other components of biodiversity.

Table 1: List of flower-visiting insects sampled

Common name	Family	Species
Bee	Apidae	*Apismellifera* *Xylocopa*sp.1 *Xylocopa*sp.2 *Tetralonia penicillata* *Amegilla kaimosica*
	Megachilidae	*Lithurguspullatus* *Megachile*sp. *Pseudoanthidium*sp.1
	Halictidae	*Pseudapis*sp.1 *Lasioglossum*sp.1
Beetle	Chrysomelidae	*Cryptocephalussexpunctatus* *Cucujuscolonarius* *Meroscalcisselecta* *Apteropedaglobosa*
	Scarabaeidae	*Xylotrupesgideon*
	Cerambycidae	*Saperdapopulnea*
	Limnichidae	*Limnichusaustralis*
Butterfly	Nymphalidae	*Acraea*sp.1 *Acraea*sp.2

		*Acraea*sp.3 *Acraeaeponina* *Acraealycoa* *Junoniaoenone* *Hypolimnassalmacis* *Junoniasophia* *Acraeaalciope* *Acraeaserena* *Ladoga camilla*
	Pieridae	*Nepheronia*sp. *Leptidaesinapsis Pierisnapi*
	Papilionidae	*Papilioanchisiades*
	Danainae	*Danauschrysippus*
True fly	Oestridae	*Hypodermalineatum*
	Muscidae	*Muscadomestica* *Muscinastabulans*
	Tachinidae	*Bombyliopsisabrupta* *Spoggosiaclaripennis*
	Rhagionidae	*Rhagioscolopaceus*
	Sarcophagidae	*Sarcophagaargyrostoma* *Sarcophagahaemorhoidalis*
	Calliphoridae	*Chrysomya*sp.
	Fanniidae	*Fanniascalaris*
Wasp	Sphecidae	sp.1 sp.2 sp.3 sp.4 sp.5 sp.6
	Scoliidae	sp.1 sp.2
	Pompolidae	sp.1 sp.2 sp.3 sp.4 sp.5 sp.6
	Eumenidae	Eumenidae sp.
	Mutillidae	Mutillidae sp.
	Formicidae	Formicidae sp.
	Vespidae	Vespidae Vespidae sp.

Table 2: Percentage composition and abundance of insect taxa sampled

Insect order	Insect common names	Abundance	Percentage composition (%)
Diptera	True flies	408	42.11
Hymenoptera	Bees	136	14.04
	Wasps	115	11.87
Coleoptera	Beetles	64	6.60
Lepidoptera	Butterflies	246	25.39

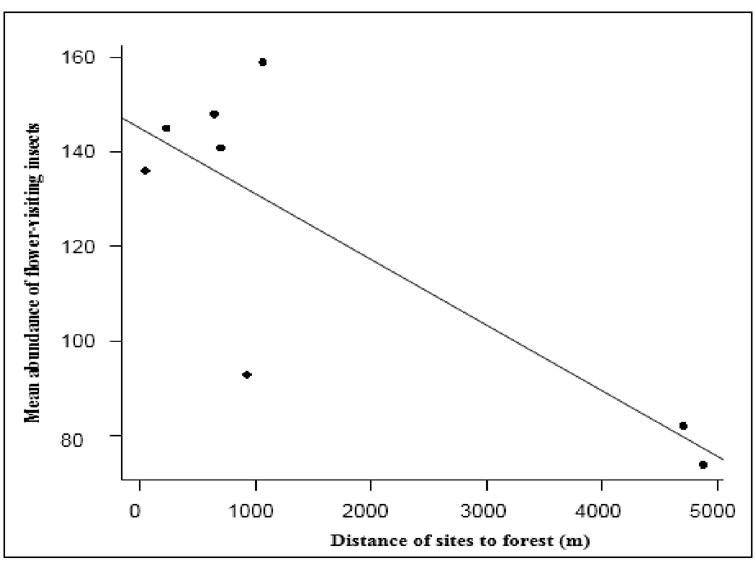

Fig 2: Mean (± SE) abundance of flower-visiting insects with distance of study sites to forest

Table 3: Mean (±) abundance and species richness of different insect taxa on disturbed and less disturbed grasslands

Insect Common Names	Land use types		P-value for Land use types(local variable)	P-value for landscape variable (distance to forest)
	Disturbed grasslands	Less disturbed grasslands		
Bees Abundance	12.00±4.690	22.00±3.651	Z= 1.441, p>0.05	Z= -2.720, p<0.05*
Bees species richness	3.25±0.750	7.25±0.250	Z= 0.554, p>0.05	Z= -1.339, p>0.05
Beetles Abundance	8.75±2.287	7.25±1.931	Z= -1.305, p>0.05	Z= -1.557, p>0.05
Beetles species richness	3.50±0.645	4.75±1.031	Z= 0.486, p>0.05	Z= -0.537, p>0.05
Butterfly Abundance	29.50±3.797	32.00±3.56	Z= 0.629, p>0.05	Z= -0.340, p>0.05
Butterfly Species richness	8.50±1.756	8.75±0.479	Z= -0.195, p>0.05	Z= -0.259, p>0.05
True flies Abundance	40.25±9.105	61.75±8.797	Z= -2.297, p<0.05*	Z= -3.949, p<0.05*
True flies species richness	9.25±0.750	12.75±1.315	Z= 0.554, p>0.05	Z= -0.161, p>0.05
Wasps Abundance	9.75±3.198	19.00±1.354	Z= 0.680, p>0.05	Z= -2.579, p<0.05*
Wasps Species richness	6.75±1.548	11.75±0.854	Z= 0.106, p>0.05	Z= -1.662, p>0.05

*= Significant at P < 0.05

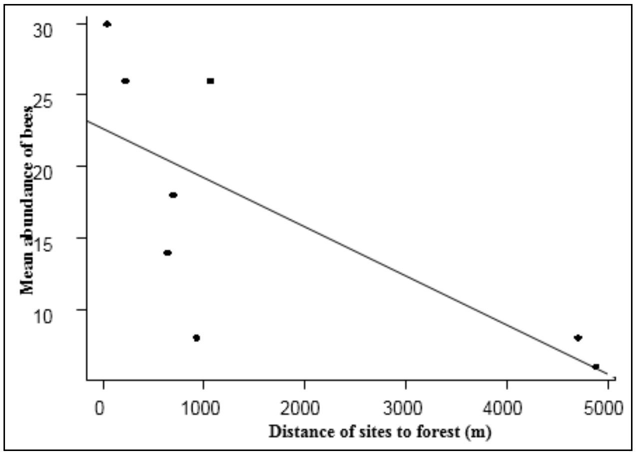

Fig 3: Mean (± SE) abundance of bees with distance of study sites to forest

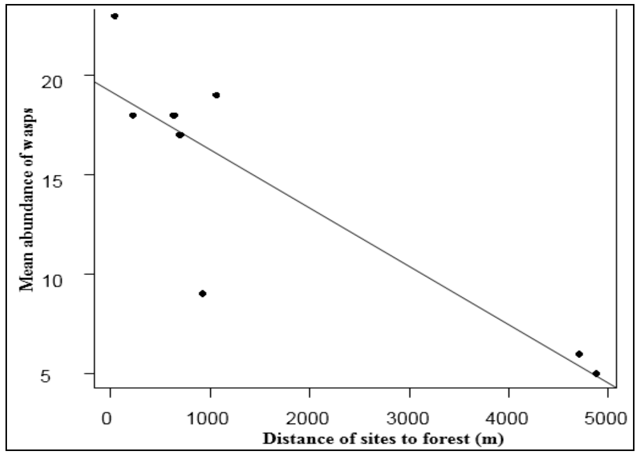

Fig 4: Mean (± SE) abundance of wasps with distance of study sites to forest

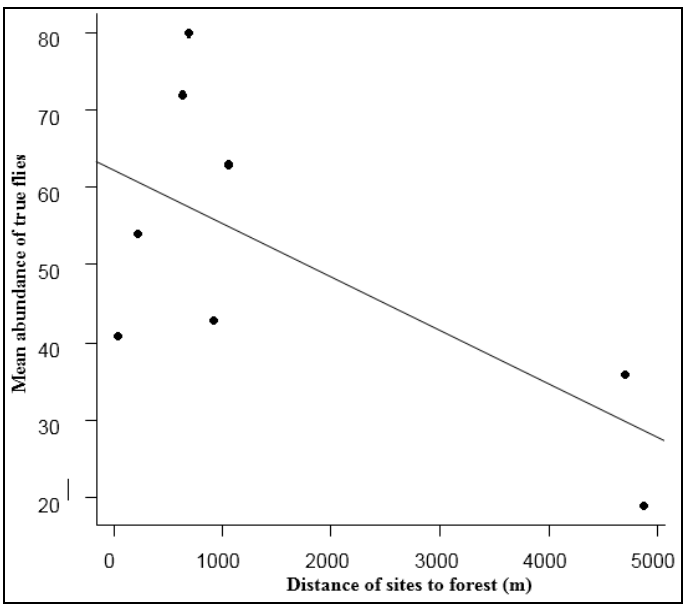

Fig 5: Mean (± SE) abundance of true flies with distance of study sites to forest

5. Conclusion

This study showed the effect of anthropogenic disturbance on the local scale (disturbed versus less disturbed grassland) on one of the groups of flower-visiting insects. It also reports the effect of disturbance on the landscape level (distance of grasslands to the nearest forest) on three of the flower-visiting insect taxa studied. This demonstrates the need for local and landscape scale considerations in conservation planning.

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