Technoscience Journal for Community Development in Africa 5:1 (2026) 59–69
ISSN 2659-0573

Research Article

Effects of land-use types on ant assemblage at Kwara state university campus: A guinea savanna region of Nigeria

Abubakar Abdullahi Adeoye[1]*, Raliat Aliyu[1], Fatimah Nyaminin Yahaya[1], Adegoke Victor Oyedokun[2]

[1]Department of Zoology, Kwara State University, Malete, Kwara State, Nigeria
[2]Cooca Research Institute of Nigeria, Idi-Ayunre, Ibadan, Oyo State.

Abstract: Ants are abundant and can be sampled easily, thereby respond to environmental changes at small spatial scales. The key functions of ants as bioindicators in the environment have promoted the classification of ants into different functional groups. Three quantitative sampling methods were employed in three land-use types: disturbed, undisturbed, and cultivated land-use types, on the Kwara State University Campus, Malete, Nigeria. Taxonomic, species, and functional group diversity of ants encountered were analyzed. A total of 1,075 ant occurrences belonging to 40 species, 20 genera and 5 subfamilies were recorded during the rainy and dry seasons. Disturbed land had the highest species richness and abundance, followed by undisturbed land and then cultivated land. Manual ant search yielded the highest richness, followed by pitfall and then baiting methods. A statistical analysis revealed that mean species richness varied significantly across the land-use types during the rainy season but no significant differences during the dry season. Similarly, six of the functional groups were encountered, of which Generalized Myrmicinae was the most frequent in disturbed land-use while Subdominant Camponotini was the most frequent in undisturbed and cultivated land-use types. Ants are confirmed as useful bioindicators for proper management of the environment and human impacts.

Key words: Ant functional group, Disturbed land, Formicidae, High diversity, Land-use types.

1. Introduction

Ants occur in all terrestrial ecosystems and are of high ecological importance (Guenard, 2013). They are considered good bioindicators as they are sensitive to environmental changes. Ants are abundant and can be sampled easily, thereby they respond to environmental changes at small spatial scales. The key functions of ants as bioindicators in the environment promoted the classification of ants into different functional groups as described by Anderson (1995) and Brown (2000), to analyze general responses of ant communities to environmental stress and disturbance. Different habitat types have been reported to influence the assemblage of various and functional groups. Typical example is the research conducted by King et al. (1998) which investigated the ant community differences between primary and secondary tropical rainforests in Australia. It was observed from the study that Opportunist ants dominated the young secondary forests while generalized myrmicinae ants were the most abundant in primary forests.

Nigeria is part of the Afrotropical region with unique geographical, climatic, and ecological diversity, but with few myrmecological studies. Although insect biodiversity research has not been thoroughly explored in Nigeria, few studies have been conducted on butterflies in 3 varying habitats (Kemabonta et al., 2015) and insect abundance in many university campuses (Chima et al., 2013; Yager et al., 2016; Abah et al., 2017; Thomas & Gijo, 2022). Comprehensive research in Nigerian ants was carried out more than four decades ago (Taylor, 1976; 1977; 1979; 1980a,b), but few publications related to Nigerian ant biodiversity have been published recently (Jimoh et al., 2024, Adeoye, 2025). Many

* Corresponding author:
Email: abubakar.adeoye@kwasu. edu.ng

KWASU PRESS AND PUBLISHING

ants remain to be discovered, and their diversity and distribution patterns still require further study. It was reported that there are 317 species of ants in 64 genera and 10 subfamilies in Nigeria (Jimoh et al., 2024).

Kwara State is located in north central Nigeria and has been categorised as a derived guinea savanna, covered by a mosaic of vegetation types with enormous grasses and few trees. Myrmecology studies in the region are relatively scarce. The known existing reports were on the nesting behaviours and control of *Messor galla* in the University of Ilorin (Fasoranti, 1997), a non-mosquito arthropods study which included *Camponotus* sp (Obembe, 2021) and arthropods associated with telecommunication mast in Ilorin, which included *Tetramorium caespitum* (Adelaja et al., 2021).

Anthropogenic activities drive land-use changes, which are the primary drivers of biodiversity loss and also alter the ecosystem function, especially in tropical biomes (Srivastava et al., 2019). The vegetation on the Kwara State University campus has been fragmented and modified due to advancements in building constructions and other anthropogenic activities. This has led to generation of different land-use types. Little research was conducted on insect composition in the campus, and this was basically on termites' diversity (Adeoye et al., 2024) and mound activity (Ajao et al., 2018), thereby leaving out ants and other arthropods that are also important in the proper functioning of the ecosystem. The present study was conducted to provide information on how different land-use types at the Kwara State University campus influence the abundance and diversity of ants during the rainy and dry seasons on the campus and to test the efficiency of the three sampling methods used in ant sampling.

This study aims to enhance knowledge and assemblage in the Kwara State University campus across different land-use types. Furthermore, the findings will provide useful and relevant information for biodiversity monitoring and conservation planning.

2. Material and Methods

Study area

This research work was carried out in three different land use types in the Kwara State University campus (Fig. 1), a derived savanna from the Guinea Savanna belt of Nigeria. The area is marked by two climatic seasons: the dry and wet seasons, with an intervening cold and dry Harmattan from December to January. The temperature ranges from 33°C to 37°C, and annual rainfall ranges between 990 mm and 1318 mm, while the relative humidity ranges from 75% to 88% during rainy season and 35% to 80% during dry season (Ajadi et al., 2016). The grass commonly found in the region are: *Panicum capillare*, *Eragrostis pectinacea*, *Hyptis spicigera*, *Hyptis suaveolens*, *Axonopus compressus*, *Pennisetum purpureum*, *Tithonia diversifolia*, *Digitaria abyssinica*, *Digitaria ciliaris*, *Laportea canadensis*, *Cynodon dactylon*, *Stenotaphrum secundatum*, *Cyperus rotundus* and *Eleusine indica*. And the dominant trees are *Daniella oliveri*, *Azadirachta indica*, *Parkia biglobosa* and *Eucalyptus citriodora*.

Due to anthropogenic activities, three different land-use types were chosen for sampling: disturbed, undisturbed and cultivated lands. Disturbed land was characterized as an area with frequent visits by humans

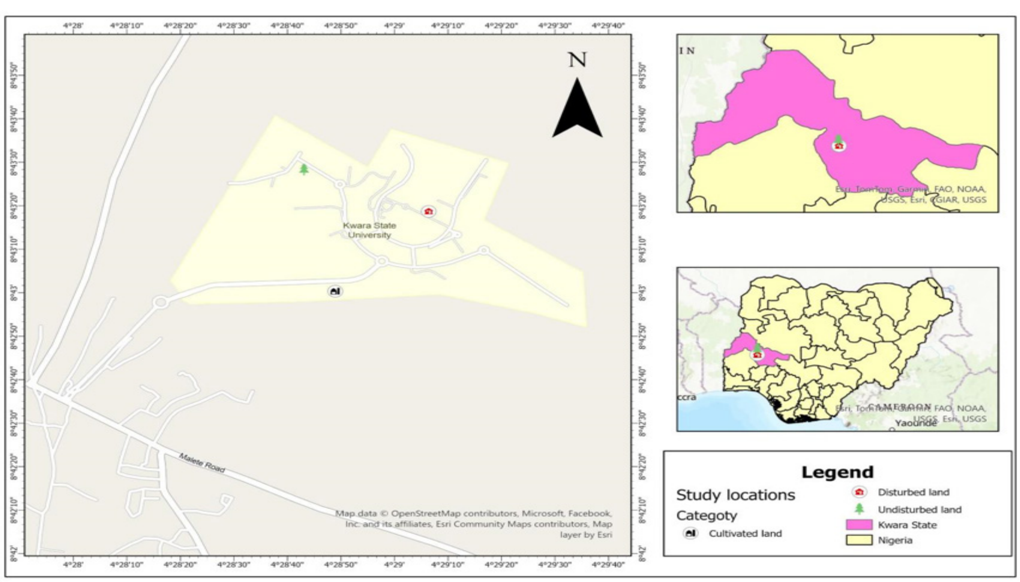

Figure 1: Ants sampling locations at the Kwara State University, Malete campus.

and several human activities. The area is vast and *2.3. Data analysis*

Each instance of a species detected during sampling was recorded as a single occurrence, rather than counting individual ants. Data from the three sampling methods were combined to determine the total ant species richness and abundance in the three selected land-use types and analysis was conducted utilizing PAST 4.03 Software and Microsoft Excel (2013) to compute species abundance, richness and diversity indices. Analysis of variance (ANOVA), followed by Tukey's post hoc tests were performed to assess the variation of relative species abundance and richness across the three land-use types using PAST 4.03 software (Hammer et al. 2001). Individual-based rarefactions and extrapolation curves were used to measure sampling effort. Individual-based rarefaction curves were computed in iNEXT online (Chao & Hsieh, 2016).

Interpolation and extrapolation of ant incidences were based on Hill's numbers that integrate species richness and species abundance (Chao et al. 2014). The 95% confidence intervals were obtained by bootstrap method based on 200 replications (Chao & Hsieh, 2016). This helps in determining if the sampling effort was sufficient and if all the species were sampled.

The ant diversity examined in this study pertains to *α*-diversity, which encompasses the diversity of species within a specific community or habitat. To assess diversity, the Shannon–Wiener diversity index and Simpson's diversity index were employed (Adeoye et al., 2024). Species richness was quantified using Chao-1, while the Evenness index was determined using the formula: e^H/S. Canonical correspondence analysis was used to compare differences in species composition among the three land use types in PAST 4.03 software.

3. Results

A total of 1,075 occurrences from 40 species in 5 subfamilies and 20 genera were recorded in the three different land-use types. Subfamily Myrmecinae was the dominant with 20 species, followed by Formicinae with 11 species while Dorylinae was the least subfamily with only one species. The most species-rich genus was *Camponotus* (7 species), followed by *Tetramorium* and *Monomorium* (5 species each) (Table 1).

Myrmecinae was the most encountered subfamily during rainy and dry seasons (295 and 175 occurrences respectively), followed by Formicinae (240 and 174 occurrences in the rainy and dry seasons respectively) and Ponerinae (109 and 70 occurrences in the rainy and dry seasons respectively) while Dorylinae was the least encountered subfamily (1 and 4 occurrences in the rainy and dry seasons) (Fig. 2 & 3).

Comparing the overall species that were encountered in the two seasons, *Camponotus sericeus* was most encountered both in the rainy and dry seasons, followed by *C. acvapimensis*, then *Brachyponera sennaarensis* while the least encountered species was *Tapinolepis pernix* which was encountered once in the dry season. However, there are three species found only in disturbed land use namely, *Tapinolepis pernix*, *Dorylus fimbriatus* and *Monomorium pharaoenis*, while 37 species were shared within the three land use types.

Among the three land-use types, disturbed land has the highest number of species richness and occurrences while undisturbed land has the lowest species richness and occurrences (Table 2). *Crematogaster* cf. *depressa* (23 encounters) was the most encountered species in disturbed land during the rainy season, followed by C. *sericeus*. In the undisturbed land, *Camponotus sericeus* was most encountered (24 occurrences), followed by *Camponotus acvapimensis* while *Brachyponera sennaarensis* (23 encounters) was most encountered in the cultivated land in the rainy season. In the dry season, distributed land had *C. sericeus* (14 occurrences) to be the most encountered species while *Tapinolepis pernix* is the least encountered, undisturbed land had *C. acvapimensis* (18 occurrences) as the most encountered species and *Brachyponera sennaarensis* (19 occurrences) was the most encountered species in the cultivated land. The mean number of species varied significantly across the land use types during the rainy season (One-way ANOVA: $F = 3.28$, $df= 2$, $P< 0.05$) but did not vary significantly during dry season (One-way ANOVA: $F = 0.46$, $df = 2$, $P> 0.05$). In general, the diversity index calculated in the three land use types were higher during the rainy season than dry season, and disturbed land use had the overall highest diversity indices (Table 2).

Individual- based species rarefaction and extrapolation curves for sampling methods in the three land-use types indicated that manual search sampling had highest species richness and abundance. Among the three sites, disturbed land-use attained the highest species richness peak while undisturbed and cultivated land-use types had significantly lower species richness. Based on the predicted species richness of the manual search sampling methods, the extrapolation curves suggest an increase in species richness with increasing individuals. In disturbed land-use types, the extrapolation curves suggest a considerable increase in species richness with increasing number of individuals for the 3 sampling methods, which is also applied to the 2 remaining sites

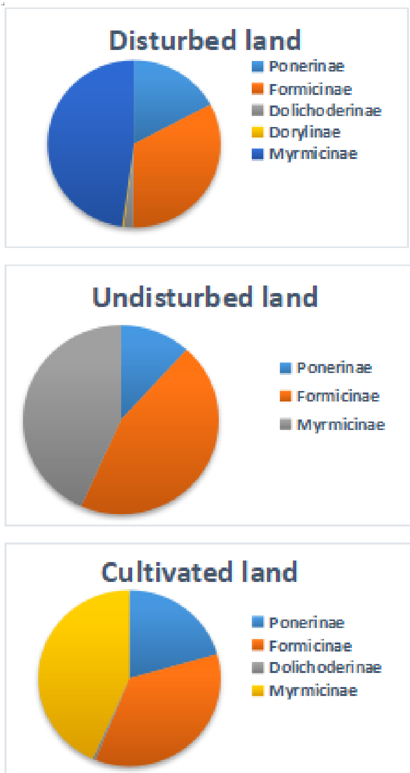

Figure 2: Percentage of ant subfamilies encountered in the three land use types in Kwara State University during the rainy season

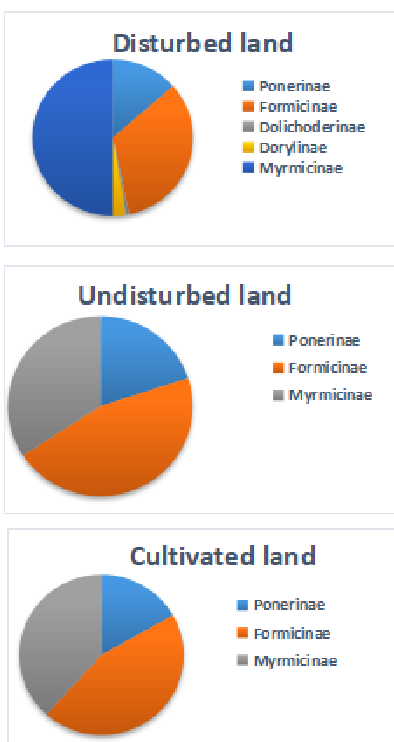

Figure 3: Percentage of ant subfamilies encountered in the three land use types in Kwara State University during the dry season

(Fig. 4). In all the sites, wet season had increased species richness than dry season.

Overall, six of Andersen's functional groups were found in the three land-use types. The most diverse functional group was Opportunist (14 species; 35.0%), followed by General Myrmicinae (11 species; 27.5%), Subdominant Camponotini (7 species; 17.5%), Specialist predators (5 species; 12.5%), Tropical climate specialists (2 species; 5.0%) and Hot climate specialist (1 species; 2.5%). In the two seasons, General Myrmicinae was the most frequent functional group in the disturbed land-use while Subdominant Camponotini was the most frequent functional group in the undisturbed and cultivated lands (Fig. 5 & 6).

The correspondence analysis between the species with >650 occurrence (40 species) is presented in Fig. 7. From the first dimension we can observe during the rainy season that *Pheidole* sp1, *Cardiocondyla emeryi*, *Pheidole leingmei*, *Paratrechina longicornis*,*Crematogaster* cf. *depressa*, *Mesoponera caffraria*, *Messor galla*, *Tapinoma melanocephalum* are close to the disturbed land-use type, while *Camponotus vestitus*, *Camponotus sericeus*, *Monomorium bicolor*, *Pheidole rugaticeps*, *Paltothyreus tarsatus*, *Camponotus maculatus*, *Tetramorium* cf. *cristatum* are to the undisturbed land. *Tetramorium sericieventre*, *Lepisiota canescense*, *Brachyponera sennaarensis*, *Odontomachus troglodytes*, *Crematogaster gambiensis*, *Oecophylla longinoda*, *Pheidole decarinata*, *Trichomyrmex destructor*, *Camponotus perrissii*, *Camponotus flavomarginatus* are close to the cultivated land. In the dry season, the correspondence analysis between the species with >400 occurrence (40 species), it was observed that *Paratrechina longicornis*, *Crematogaster* cf. *depressa*, *Tetramorium caldarium*, *Mesoponera caffraria*, *Messor galla*, *Tapinolepis pernix*, *Pheidole* sp1 are close to the disturbed landuse type, while *Camponotus vestitus*, *Camponotus sericeus*, *Pheidole rugaticeps*, *Odontomachus troglodytes*, *Pheidole leingmei*, *Paltothyreus tarsatus*, *Camponotus maculatus* are to the undisturbed land. *Tetramorium sericieventre*, *Oecophylla longinoda*, *Camponotus perrissii*, *Camponotus flavomarginatus*, *Lepisiota canescense*, *Brachyponera sennaarensis*, *Monomorium bicolor* are close to the cultivated land (Fig. 8).

4. Discussion

The present study indicated that the region is rich in pecies composition and abundance. Some invasive species reported from this study and other regions of Guinea savannah region were recently reported (Adeoye,

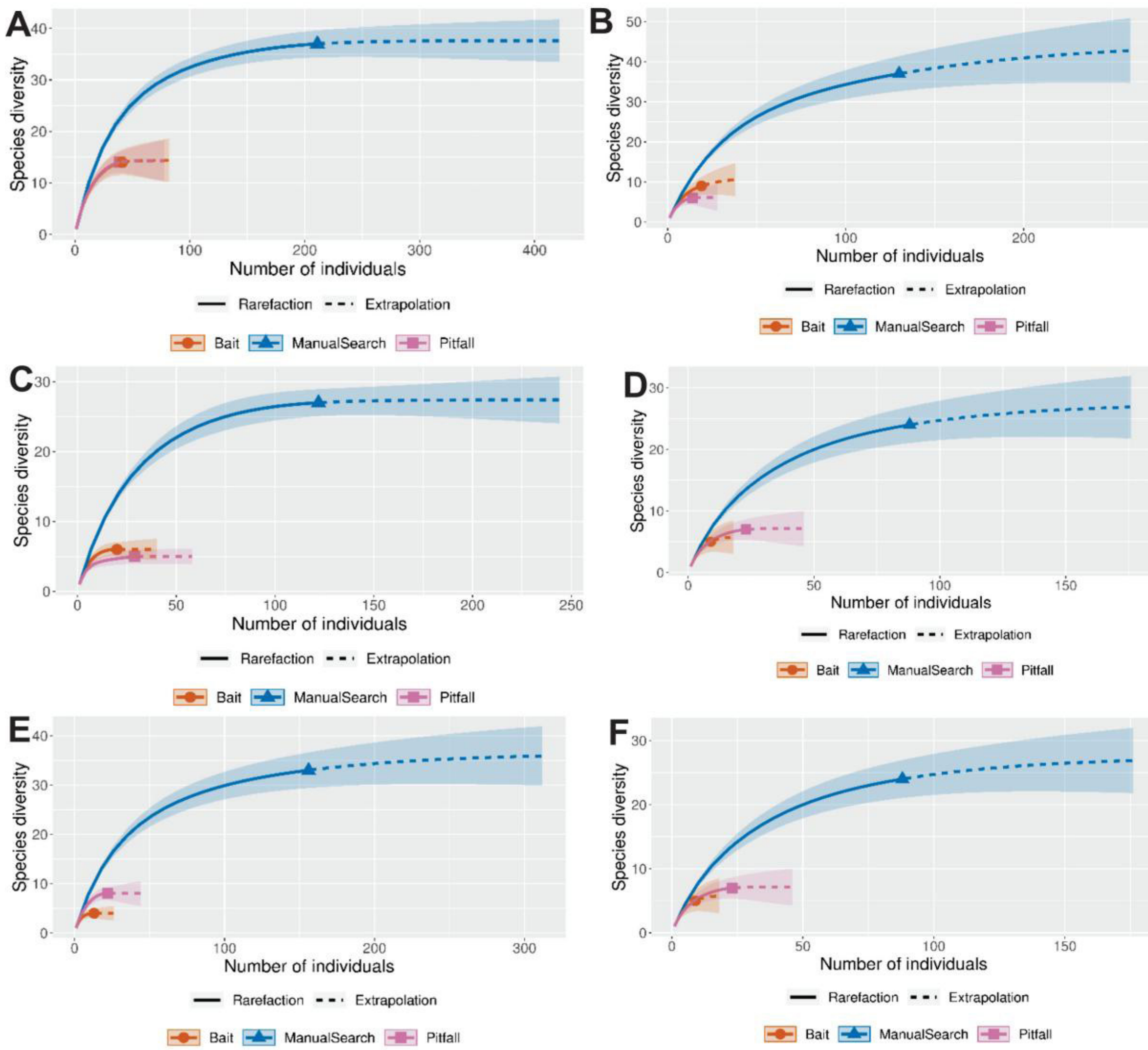

Figure 4: Accumulation curves for the observed and estimated number of ant species in three land-use types: Disturbed land during rainy season (A) dry season (B) Undisturbed land during rainy season (C) dry season (D) Cultivated land during rainy season (E) dry season (F) at the Kwara State University Campus, Malete.

2025). This study represents the first comprehensive inventory of ant fauna in guinea savannah region of Nigeria. Most of the comprehensive research were conducted in rainforest zones of Nigeria (Taylor, 1976; 1977; 1979; 1980a,b; Jimoh et al., 2024). Species richness of the study represents almost 13% of the total ant fauna recorded in Nigeria (Table 1). The significantly higher species richness in disturbed land compared to undisturbed and cultivated lands as observed in this study could be due to differences in ecological conditions and human activities between these areas. This aligns with previous research by Abah et al. (2017), which highlighted higher diversity and abundance in botanical garden, a disturbed region than dam area and farmland. The ant communities in disturbed land were more diverse and abundant than undisturbed and cultivated lands. A recent study on survey of ants across the Tapia woodland of Madagascar (Ravelomanana et al., 2025) also reached a similar conclusion of unequal diversity between different sites. These variations can be attributed to different levels of human disturbance across the three land use types (Zephirin et al., 2022).

Human activities have both negative and positive impacts on the environment. Urbanization has been previously reported to negatively impact environment, thereby reducing biodiversity (Haddad et al., 2015), while recent reports have negated the notion, thereby revealing that some certain urban habitats support high insect diversity and richness (Diamond et al., 2023; Ombugadu et al., 2023). The low species richness in cultivated land could be attributed to constant tilling of the soil and sometimes, use of insecticides and herbicides by some farmers, thereby leading to destruction of ant's habitat and killing of ants which consequently

Table 1. List of ant species sampled and their occurrence in three land-use types at the Kwara State University Campus, Malete.

Subfamily	Species	Disturbed land			Undisturbed land			Cultivated land		
		Pitfall	Manual search	Bait	Pitfall	Manual search	Bait	Pitfall	Manual search	Bait
Ponerinae	*Brachponera sennaarensis*	*	*		*	*		*	*	
	Bothroponera silvestri	*	*						*	
	Leptogenys longiceps	*	*					*	*	
	Mesoponera caffraria	*	*			*			*	
	Odontomachus triglodytes	*	*		*	*		*	*	
	Paltothyrus tarsatus	*	*						*	
Formicinae	*Camponotus acvapimensis*	*	*	*	*	*	*	*	*	
	Camponotus flavomarginatus	*	*			*		*	*	
	Camponotus maculatus		*			*		*	*	
	Camponotus perrisii		*			*			*	
	Camponotus sericeus	*	*	*	*	*		*	*	*
	Camponotus schoutedeni		*						*	
	Camponotus vestitus	*	*		*	*		*	*	
	Lepisiota canescens		*	*		*	*		*	*
	Oecophylla longinoda					*			*	
	Paratrechina longicornis		*	*		*	*		*	
	Tapinolepis pernix		*							
Dolichoderinae	*Tapinoma melanocephalum*		*	*						
	Tapinoma crinonitum		*						*	
Dorylinae	*Dorylus fimbriatus*		*							
Myrmicinae	*Cardiocondyla emeryi*		*			*			*	
	Crematogaster cf. *depressa*	*	*	*		*	*		*	
	Crematogaster gambiensis		*			*			*	
	Messor galla	*	*	*	*	*	*		*	
	Monomorium afrum					*				
	Monomorium bicolor	*	*	*	*	*	*		*	*
	Monomorium exiguum		*						*	
	Monomorium pharoenis		*	*						
	Pheidole decarinata		*	*		*			*	*
	Pheidole leingmei		*	*		*	*			

Pheidole rugaticeps		*	*	*	*	*		*	
Pheidole sp1		*			*		*	*	
Pheidole sp2		*			*			*	
Tetramorium caldarium		*						*	
Tetramorium calinum		*			*			*	
Tetramorium cf. *cristatum*					*			*	
Tetramorium sericieventri	*	*			*			*	
Tetramorium uelense		*							
Trichomyrmex abyssinicus		*						*	
Trichomyrmex destructor		*	*		*			*	*

Absent= ; Present= *

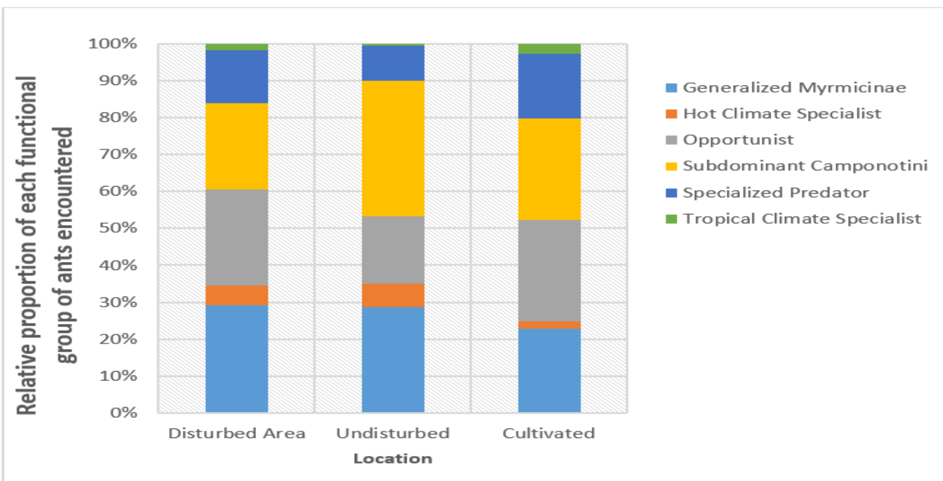

Figure 5: Percentage of functional group of ants encountered during rainy season in three land-use types at the Kwara State University Campus, Malete

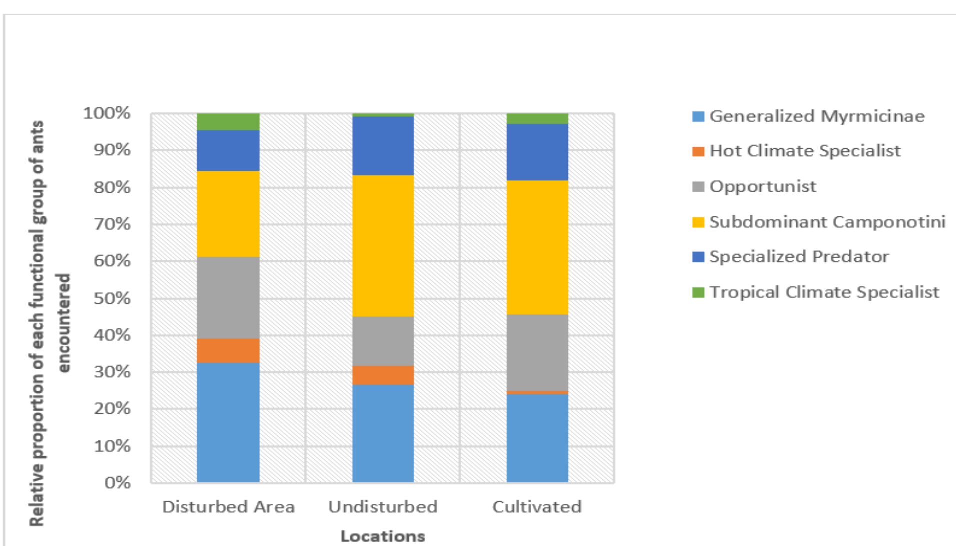

Figure 6: Percentage of functional group of ants encountered during dry season in three land-use types at the Kwara State University Campus, Malete.

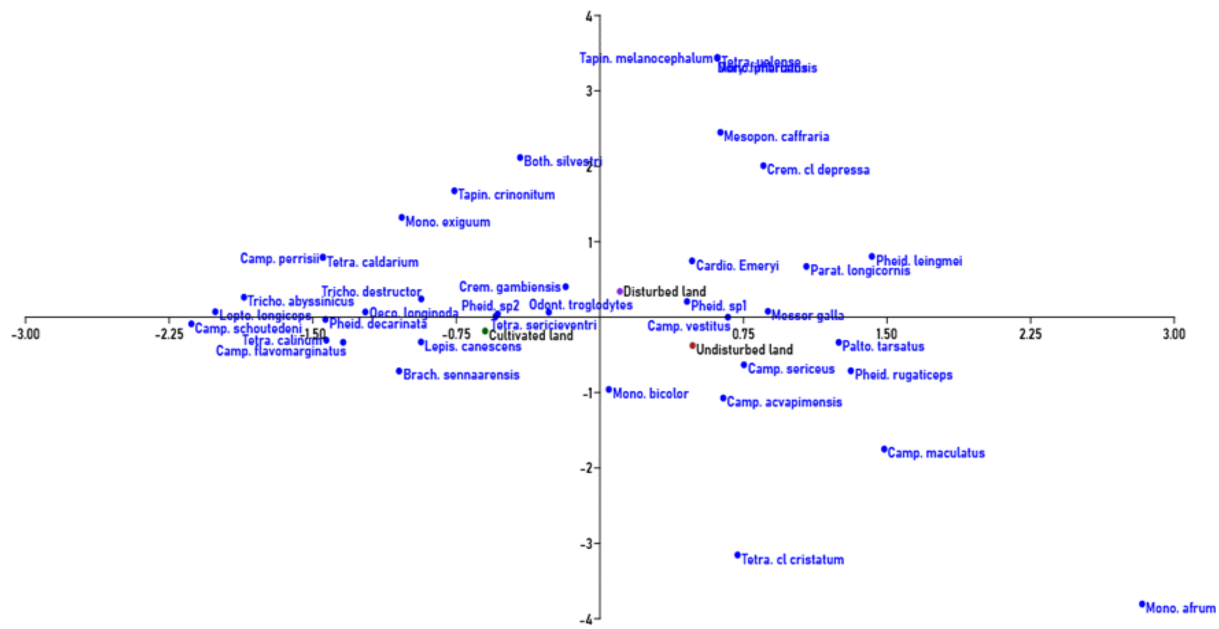

Figure 7: Simple correspondence analysis of land-use type and their ant assemblage during the rainy season at the Kwara State University Campus, Malete

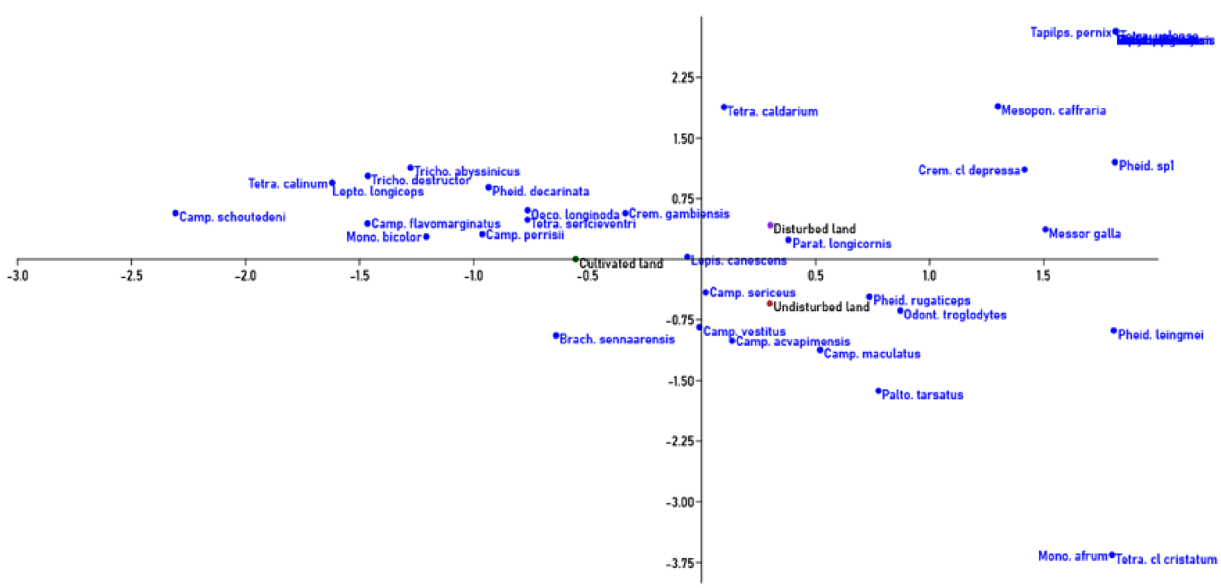

Figure 8: Simple correspondence analysis of land-use type and their ant assemblage during the dry season at the Kwara State University Campus, Malete

reduce the ant assemblages. The rich diversity of ants documented in the disturbed land use type may be because of adequate nesting sites, availability of variety of food substrates from human food remnants and light sources at night which attract nocturnal flight of alates of different insects. The light-attracted alates will de-alate and nest in the surrounding areas, thereby increasing the number of ant assemblage and diversity.

Five subfamilies were encountered in all the three land use types, of which Myrmecinae was the most abundant, then Formicinae, Ponerinae and Dorylinae being the least encountered. Similar findings have been reported by Ashigar & Ab Majid (2020) in various habitats in Nassarawa State, Nigeria where Myrmecinae was the most abundant, followed by Formicinae, then Ponerinae. Jimoh et al. (2024) who also conducted ant survey in urbanized region recorded high diversity of Myrmecinae, followed by Formicinae while Dolichoderinae was encountered once. Seasonally, the most abundant species across the

Table 2. Specific and average richness, Shannon-Weaver diversity index and Evenness distribution of ants recorded in three land-use types at the Kwara State University Campus, Malete

Stations	Rainy Season			Dry season		
STATIONS	Disturbed	Undisturbed	Cultivated land	Disturbed	Undisturbed	Cultivated land
Specific richness	37	27	33	37	24	26
Total encounters	291	171	189	155	120	149
Chao-1	37.00	27.17	37.20	48.00	27.00	29.75
Shannon_H	3.35	2.94	3.16	3.33	2.78	2.91
Simpson_1-D	0.96	0.93	0.95	0.96	0.92	0.93
Evenness_e^H/S	0.77	0.70	0.71	0.75	0.69	0.71

three sites were *Camponotus sericeus*, *Camponotus acvapimensis*, *Brachyponera sennaarensis* while the least encountered species was *Tapinolepis pernix* which was encountered only in the dry season. Eight species of ants were encountered in ancient Benin Moat (Egbon & Osabuohien, 2022), of which 5 have also been reported in the present study: *Camponotus acvapimensis*, *Paratrechina longicornis*, *Brachyponera sennaarensis*, *Odontomachus troglodytes* and *Palthothyreus tarsatus*.

Disturbed land use had the highest species diversity in rainy season (H'= 3.36) and dry season (H'= 3.31), while cultivated land use had the lowest diversity during rainy season (H'= 3.2) and dry season (H'= 2.91). Disturbed land use showed the most even distribution of species (e^H/S = 0.77) in the rainy season. Our results indicated differences in species diversity in the three land use types corroborates a study on impacts of land use types on ant communities in a tropical forest margin (Oumé – Côte d'Ivoire) (Yeo et al. 2019).

The results obtained from this study using a combination of manual search, pitfall trap and baiting methods yielded varying ant capture. In the two seasons, it was observed that manual search had the highest species diversity and abundance while baiting method yielded the lowest diversity and abundance in all the three land use types. Some of these methods have been implemented by other researchers and had also yielded varying results. Atchison & Lucky (2022) used three sampling methods, of which transect method yielded higher species richness than baiting method. Houadria & Menzel (2021) also compared 4 sampling methods, it was reported that pitfall had higher species richness than above ground and below ground baiting methods in two neotropical and two paleotropical sites.

Most studies involving ant functional groups have been carried out in areas with different human disturbance levels (García-Martínez *et al*. 2015; Narendra *et al*. 2011; Bharti *et al*. 2013; Groc *et al*. 2014). Among the most abundant species rich functional groups in this study were Generalized Myrmicinae, then Subdominant Camponotini and Opportunist while Hot climate specialist was the least abundant (Fig. 2). Marathe *et al*. (2021) and King *et al*. (1998) reported similar patterns in variation in ant functional group composition from Australian tropical forests.

Four of the 40 encountered species were invasive species, and it was observed that two species *Tapinoma melanocephalum* and *Monomorium pharaonis* were encountered only in the disturbed land. Others were mostly encountered in the disturbed land while a few were recorded in the other two study sites. This result corroborates with the result of Bharti *et al*., (2013) who reported that presence of invasive species demonstrates the anthropogenic disturbance of ant collection sites. *Tetramorium sericeiventre* was identified as an indicator of anthropogenic impacts (Yeo *et al*., 2019) and was encountered in the regions with anthropogenic activity in the present study.

5. Conclusion

This study represents the most extensive ant diversity survey in a guinea savannah region of Nigeria that has been published to date. The study conducted in three different land-use types recorded 40 ant species from 20 genera and 5 subfamilies, revealing highest richness and abundance in disturbed land and lowest richness in cultivated land. Comparing the rainy and dry seasons, there is slightly higher abundance and diversity in the rainy period than dry in all the three land-use types. Higher invasive species recorded in disturbed land confirm anthropogenic impacts. A new species was also reported and described; this indicates the need to intensify the myrmecofauna study in this region so that we can uncover new discoveries. Based on this survey, we conclude that level of anthropogenic activities impacts the diversity and assemblage of ants. Ants are confirmed as useful bio-indicators for proper management of the environment and human impacts.

6. Acknowledgment

The first author sincerely thanks his undergraduate project students from the 2022/2023 and 2023/2024 academic sessions for their invaluable assistance during fieldwork. Special appreciation is extended to the myrmecology specialists, Prof Kiko Gomez and Prof Sebastian Salata, for their insightful comments and corrections on the first draft of this manuscript. We also express our gratitude to the anonymous reviewers for their constructive suggestions, which greatly improved the quality of this paper.

References

Abah, J. P., Popoola, K. O. K. & Hassan, A. A. (2017) Abundance, Distribution and Diversity of Terrestrial Insects in University of Ibadan, Ibadan, Western Nigeria. *Nigerian Journal of Entomology* 33: 129–137. https://doi.or/10.36108/NJE/7102/33 (0151)

Adelaja, O. J., Ande, A. T., Abdulraheem, G. D., Oluwakorode, I. A., Oladipo, O. A. & Oluwajobi A. O. (2021) Distribution, diversity and abundance of some insects around a telecommunication mast in Ilorin, Kwara State, Nigeria. *Bulletin of the National Research Centre* 45:222

Adeoye, A. A., Ajao, A. M. & Ojo, J. A. (2024) Species composition, relative abundance, and diversity of termites (Blattodea: Insecta: Isoptera) in the Kwara State Univerity Campus, Malete, Kwara State, Nigeria. *Agricultura Tropica et Subtropica*, 57:108–115

Adeoye, A. A. (2025) A Contribution to the Study of Invasive and Exotic Ant Species in Nigeria (Hymenoptera: Formicidae). *Belgian Journal of Entomology*, 160: 1–17.

Ajadi, B. S., Adaramola, M. A., Adeniyi, A., & Abubakar, M. I. (2016) Effect of Effluents discharge on public health in Ilorin Metropolis, Nigeria. *Ethiopian Journal of Environmental Studies and Management* 9(4): 389–404.

Ajao, A. M., Oladimeji, Y. U., Oladipo, S. O., & Adepoju, S. A. (2018) Activity of mound building *Macrotermes bellicosus* (Isoptera: Termitidae) around Kwara State University campus guinea savannah ecozone, Nigeria. *Animal Research International* 15:2918 –2925.

Andersen A. N. (1995) A classification of Australian ant communities, based on functional groups which parallel plant life forms in relation to stress and disturbance. *Journal of Biogeography* 22(1): 15. https://doi.org/10.2307/2846070.

Atchison, R. A. & Lucky, A. (2022) Diversity and Resilience of Seed-Removing Ant Species in Longleaf Sandhill to Frequent Fire. *Diversity* 14: 1012. https:// doi.org/10.3390/d14121012

AntWeb. (2024) Advance Speciemn Search. Available from:https://www.antweb.org/fieldGuide.do?countryName=Nigeria&rank=species. (Accessed 30 July, 2024)

AntWiki. (2024) Nigeria species list. Available from: https://antwiki.org/wiki/Nigeria. (Accessed 5 August, 2024).

Ashigar, M. A. & Ab Majid, A. (2020) Diversity, Abundance, and Foraging Behavior of Ants (Hymenoptera: Formicidae) Scavenging on American Cockroach in Various Habitats of Nasarawa State, Nigeria. *Tropical Agricultural Science* 43(4):503 - 521

Bharti, H., Sharma, Y. P., Bharti, M. & Pfeiffer, M. (2013) Ant species richness, endemicity and functional groups, along an elevational gradient in the Himalayas. *Asian Myrmecology* 5:79–101,

Brown, W. L. (2000) Diversity of ants. In: Agosti, D., Majer, J. D., Alonso, L. E. and Schultz, T. R. eds. *Ants: standard methods for measuring and monitoring biodiversity* pp 45-79. Smithsonian Institution Press, Washington.

Chao, A., Gotelli, N. J., Hsieh, T. C., Sander, E. L., Ma, K. H., Colwell, R. K. & Ellison, A. M. (2014) Rarefaction and extrapolation with Hill numbers: A framework for sampling and estimation in species diversity studies. *Ecological Monographs* 84:45–67. https://doi.org/10.1890/13-0133.1

Chao, A., Ma, K. H. & Hsieh, T. C. (2016) iNEXT (iNterpolation and EXTrapolation) online. Program and user's guide. (October 25, 2024). Retrieved from http://chao.stat.nthu.edu.tw/wordpress/ software_download/

Chima, U. D., Omokhua, G. E. & Iganibo-Beresibo, E. (2013) Insect species diversity in fragmented habitats of the University of Port Harcourt, Nigeria. *Asian Research Publishing Network Journal of Agricultural and Biological Science* 8(2):160–168

Diamond, S. E., Bellino, G. & Deme, G. G. (2023) Urban insect bioarks of the 21st century. *Current Opinion in Insect Science* 57, 101028.

Egbon, I. N. & Osabuohien, I. P. (2022) First checklist, species richness and diversity of leaf-litter dwelling ants (Hymenoptera: Formicidae) in ancient Benin moat, Nigeria. *Animal Research International* 19(3): 4634–4642.

Fasoranti, J. O. (1997) Studies on the Nesting Behaviour and Control of the Graminivorous ant *Messor galla* Mayr (Hymenoptera: Formicidae) in Ilorin area of Nigeria. *Nigerian Journal of Entomology* 14:44-50. https://doi.org/10.36108/NJE/7991/41.0150

Fisher, B. L. & Bolton, B. (2016) Ants of Africa and Madagascar: A Guide to the Genera. First, 2. *University of California Press, Oakland, California,* 512 pp.

García-Martínez, M. A., Martínez-Tlapa, D. L., Pérez-Toledo, G. R., Quiroz-Robledo, L. N., Castaño-Meneses, G., Laborde, J. & Valenzuela-González, J. E. (2015) Taxonomic, species and functional group diversity of ants in a tropical anthropogenic landscape. T*ropical Conservation Science* 8(4): 1017-1032

Groc, S., Delabie, J. H. C., Fernández, F., Leponce, M., Orivel, J., Silvestre, R., Vasconcelos, H. L. & Dejean, A. (2014) Leaf–litter ant communities (Hymenoptera: Formicidae) in a pristine Guianese rain-forest stable functional structure versus high species turnover. *Myrmecological News* 19:43–51.

Guenard, B. (2013). An overview of the species and ecological diversity of ants. Available from: htpp://www.els.net. (Accessed November, 3, 2024). doi.org/10.1002/9780470015902.a0023598

Haddad, N. M., Brudvig, L. A., Clobert, J., Davies, K. F., Gonzalez, A., Holt, R. D. et al. (2015) Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances* 1(2):e1500052.

Hammer, O., Harper, D. A. T. & Ryan, P. D. (2001) Paleontological statistics software: Package for education and data analysis. *Palaeontologia Electronica* 4: 1–9.

Houadria, M. & Menzel, F. (2021) Digging Deeper into the Ecology of Subterranean Ants: Diversity and Niche Partitioning across Two Continents. Diversity 13:53. https://doi.org/10.3390/d13020053

Jimoh, B. O., Gómez, K., Kemabonta, K. A., Wakanjuola, W. A., Phiri, E. E. & Mothapo, P. N. (2024) A checklist of Nigerian ants (Hymenoptera, Formicidae): a review, new records and exotic species. *Biodiversity Data Journal* 12: e99555. https://doi.org/10.3897/BDJ.12.e99555

Kemabonta, K. A., Ebiyon, A. S. & Olaleru, F. (2015) The butterfly fauna of three varying habitats in south western Nigeria. FUTA Journal of Research in Sciences 1: 1–6

King, J. R., Andersen, A. N. & Cutter, A. D. (1998) Ants as bioindicators of habitat disturbance: validation of the functional group model for Australia's humidtropics. *Biodiversity Conservation* 7:1627–1638. https://doi.org/10.1023/A:1008857214743.

Marathe, A., Shanker, K., Krishnaswamy, J. & Priyadarsanan, D. R. (2021) Species and functional group composition of ant communities across an elevational gradient in the Eastern Himalaya. *Journal of Asia-Pacific Entomology* 24: 1244–1250. https://doi.org/10.1016/j.aspen.2021.08.009.

Microsoft Corporation. (2013) Microsoft Excel (Computer software). Narendra, A., Gibb, H. & Ali, T. M. (2011) Structure of ant assemblages in Western Ghats, India: role of habitat, disturbance and introduced species. *Insect Conservation and Diversity* 4: 132–141. DOI: 10.1111/j.1752-4598.2010.00113.x.

Obembe, A. 2021 Abundance and diversity of non-mosquito insects of importance found during mosquito surveillance in selected rural houses in kwara state, Nigeria. *Munis Entomology & Zoology* 16 (1): 209-213.

Ombugadu, A., Hassan, Z. A, Ibrahim, J. I., Atabo, L. O., Ayim, J. O., Attah, S. A. et al. (2023). Butterfly community composition within a tropical urban landscape is influenced by habitat type and temperature. *Insect Conservation and Diversity* 17(2), 324–333. Available from: https://doi.org/10.1111/icad.12705

Ravelomanana, A., Ravaomanarivo, L. H., Rakotoarimanana, V., Razafindraleva, H. A. & Fisher, B. L. (2025) Fire regime and spatial distributions of leaf litter- and ground-dwelling ants (Hymenoptera: Formicidae) across the tapia woodland of Madagascar. *Journal of Insect Science* 25(2): 16; ieaf023 https://doi.org/10.1093/jisesa/ieaf023

Srivastava, R., Mohapatra, M. & Latare, A. (2019) Impact of land use changes on soil quality and species diversity in the Vindhyan dry tropical region of India. *Journal of Tropical Ecology* https://doi.org/10.1017/S0266467419000385

Taylor, B. (1976) Ants of the Nigerian forest zone (Hymenoptera: Formicidae). I. Ponerinae, Cerapachyinae, Pseudomyrmecinae. *Cocoa Research Institute of Nigeria Technical Bulletin Series* 4: 1–41.

Taylor, B. (1977) Ant mosaic on cocoa and other tree crops in western Nigeria. *Ecological Entomology* 2: 245–255.

Taylor, B. (1979) Ants of the Nigerian forest zone (Hymenoptera: Formicidae). III. Myrmicinae (Cardiocondylini to Meranoplini). *Cocoa Research Institute of Nigeria Research Bulletin* 66:1–65.

Taylor, B. (1980a) Ants of the Nigerian Forest Zone (Hymenoptera: Formicidae). IV. Myrmicinae (Myrmecinini to Tetramoriini). *Cocoa Research Institute of Nigeria Research Bulletin* 7:1–63.

Taylor, B. (1980b) Ants of the Nigerian forest zone (Hymenoptera: Formicidae). V. Dorylinae, Leptanillinae. *Cocoa Research Institute of Nigeria Research Bulletin* 8:1–33.

Thomas, C. N. & Gijo, A. H. (2022) Species Composition and Relative Abundance of Insects in Niger Delta University and Environs of Amassoma Community in Bayelsa State, Nigeria. *IIARD International Journal of Geography and Environmental Management* 8(1): 16–24.

Yeo, K., Konate, S., Tiho, S. & Camara, S. K. (2019) Impacts of land use types on ant communities in a tropical forest margin (Oumé – Côte d'Ivoire). *Advances in Food Science and Technology* 7(6): 001–015

Yager, G. O., Agbidye, F. S. & Okoh, A. O. (2016) Diversity and abundance of butterfly species (Lepidoptera) fauna in Federal University of Agriculture, Makurdi Forestry Nursery, Benue State, Nigeria. *Journal of Research in Forestry, Wildlife & Environment* 8(3):83–89.

Zephirin, T., Jean Pierre, G., Edith Blandine, M-Y., Stephanie, E., Judicaël, F-L., Désirée, C.A. & Champlain, D-L. (2022) Relation between ground-dwelling and arboreal ant diversity in three vegetation types in the humid forest zone of southern Cameroon. *African Journal of Ecology* 00:1–14. https://doi.org/10.1111/aje.13019