Review Article

Assessment of Bees' Diversity within Ngel-Nyaki Forest Reserve at Taraba State, Nigeria

Abstract

A field survey was conducted in Ngel-Nyaki Forest Reserve to assess the diversity of bees within the Reserve. Two methods of sampling techniques were used to sample bee species, opportunistic sampling and systematic sweep netting. Opportunistic sampling method was applied by sweep netting bees along 100 m plot where flowering plants were blooming. Collection was conducted by a single collector using an active search by walking randomly around the plot observing flowering plants and searching for bees foraging on the flowers then a sweep net was used for capturing bees. Sweep netting was conducted, line transect established within the plots for two hours, from 6:00am to 11:00am spending 20 minutes in each plot considering when the weather is conducive for bees' activity. This was done using entomological sweep net. Bees captured were killed in a killing bottle containing 70% ethanol. Specimens were pinned on a board and unique codes were assigned to each species before identification. Bees were identified to species level by using published systematic keys, Bees field guide and use of online materials. All data were computed using Microsoft® Excel® 2016 and percentage abundance composition of bees were calculated.575 bees spreading across 3 families and 12 species were sampled. The most abundant species was the honey bee (Apismellifera)(245; 42.53%),followed by memic bee (Megachile sp.)(89;15.45%),and the least was leafcutter bee(Osmiasp.) (2;0.35%). In terms of diversity by species, Shannon Diversity Index (H) and Shannon Equitability Index (EH) were 1.694893 and 0.736083respectively while diversity by plots using Shannon Diversity Index (H) and Shannon Equitability Index (EH) were 1.750688 and 0.977078 respectively. This study therefore, brings to the fore the diversity of bees within Ngel-Nyaki Forest Reserve and underline the need for sustainable actions to be taken to conserve beneficial rare species while managing the abundant ones

Keywords : Bee, Assessment, Diversity, Forest, Ngel-Nyaki

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INTRODUCTION

Bees belong to the Order Hymenoptera, Sub-order Apocrita, Super-family Apoidae, Clade Anthophila and are of monophyletic lineage (Kayaalp, 2011; Masiga, 2017). There are about 20,900 known species of bees in eleven (11) recognized biological families (Ojwang, 2017), though many are yet to be identified. Out of the eleven (11) bee families, six (6) are found in Africa (Eardley *et al*., 2010) namely, Apidae, Megachilidae, Melitidae, Andrenidae, Colletidae and Halicatidae (Butchmann, 1987; Michener, 2000; Muli *et al.*, 2014). They are found on every continent except Antarctica, in every habitat on the planet that contains insect pollinated flowering plants (Gilgert, and Vaughan,2011; Masigà, 2017).Bees range in size from tiny stingless bee species (*Trigonaminima*) (Hymenoptera, Stenotritidae), whose workers are less

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than 2 millimeters long (Asiko, 2012), to largespecies of leafcutter bee (*Megachile pluto*) (Hymenoptera, Melitidae) (Willmer and Stone, 2004), whose females can attain a length of 39 millimeters (Michener, 2000; Ascher*et al.*,2008). Bees are among the main pollinators in most ecosystems, as they rely on flowers for proteins (Roulston *et al.*, 2000;Russo *et al.*, 2019), oils and sugar throughout their life cycle (Michener, 2000). They also exhibit the highest floral visitation rates among all the insects (Masigà, 2017).There is little study on the different species of bees in Nigeria (Abdullahi *et al.*, 2011) as most of the work conducted in Nigeria has only been on honey bees and bee keeping. Honey bees are just one out of many species of bees (Nsor, 2014). So also the Ngel-Nyaki Forest Reserve is a biodiversity hotspot zone with different species of bees but till date there is no documented work on the taxonomy and different species of bees found within the Reserve (Cheek *et al.*, 2021). The findings of the study therefore, will contribute in the field of conservation, by identifying the different species of bees within Ngel-Nyaki Forest Reserve. The work will also help to document the different types of bees within the Forest Reserve by creating a checklist for the different species of bees as well as the percentage abundance composition of bees found within Ngel-Nyaki Forest Reserve.

Study Area

Ngel-Nyaki is located towards the western escarpment of the Mambilla Plateau. The Forest Reserve forms part of the Guinean forest biodiversity hotspot which extends from Sierra Leone to Cameroon Mountains. The reserve is situated between longitude 07° 05'N and latitudes 011° 05'E at an altitude of 1,450m–1,600m above sea level (Figure 1). The Reserve occupies about 46km^2 of land, montane grassland, forest fragments, woodland forests and lowlands with about 7.2km^2 of submontane to mid-altitude forest (Korndoerfer, 2010; Borokini*et al.*, 2012). The Forest Reserve can be reached on foot 40 minutes from Yelwa village (Chapman and Chapman, 2001). Ngel-Nyaki Forest Reserve is one of the most diverse sub-montane forests in Nigeria. It contains many plants which are endemic to the Afro- montane region. There are more than 146 vascular plants out of which 75 are in IUCN Red List (Borokini *et al.*, 2012); 4 endangered species and 8 new species. The forest is an Important Bird Area (IBA)(Ihuma *et al.*, 2010) and has been classified as an Important Bird Area by Bird Life International and a critical site for biodiversity conservation (Ezealor, 2002). The forests fall within the Cameroon Highlands Eco region, which are exceptionally rich in endemic taxa. Ngel-Nyaki forest, a 46 km^2 forest reserve, is the most species rich forest on the Plateau and is the location of the Nigerian Montane Forest Project field station. Ngel-Nyaki forest harbours 9 IUCN Red Data Listed tree species with at least another 2other species in the genera *Warneckia* and *Deinbollia*, new to science. It is rich in primate species, including the IUCN Endangered/Nigeria-Cameroon chimpanzee *Pan troglogytes ellioti*. There are Africangolden cats *Caracal aurata*, 3 new species of frogs that the Nigerian Montane Forest Project have identified so far. However, Ngel-Nyaki and other Mambilla Plateau forests and the animal species are threatened because of increased human and cattle populations, poverty and climate change. Fulani pastoralists are increasingly moving their

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cattle into the forests and burning forest for grazing, farmers are felling trees and planting crops and poachers are hunting wildlife (Chapman and Chapman, 2001).

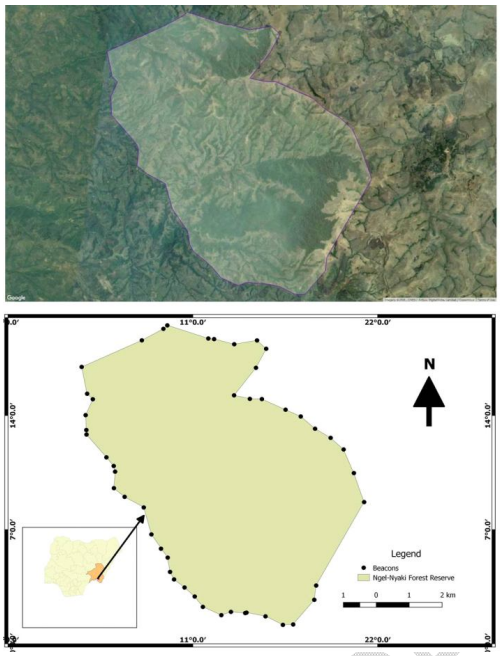

Figure 1. Map of Ngel-Nyaki Forest Reserve, Taraba State, Nigeria [**Source**: Nigerian Montane Forest Project (NMFP)].

MATERIALS AND METHODS

Sampling Method

Six (6) plots were established randomly where flowering plants were found within the Forest Reserve after a pilot survey.

Bee Sampling

Two (2) methods of sampling techniques were used to sample bee species. These were Opportunistic sampling and Systematic sweep netting. Opportunistic sampling method was applied by sweep netting bees along 100 m plot where flowering plants were blooming. Collection was conducted by a single collector using an active search by walking randomly around the plot observing flowering plants and searching for bees foraging on the flowers then a sweep net was used for capturing bees (Nielsen *et al.*, 2011). Sweep netting was conducted, line transect established within the plots for 2 hours, from 6:00am to 11:00am spending 20 minutes in

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each plot considering when the weather is conducive for bees' activity. This was done using entomological sweep net. Bees captured from flowers were killed in a killing bottle containing 70% ethanol. Specimens were pinned on a board and unique codes were assigned to each species before identification (McGavin, 1997; Brosi *et al*., 2008; Westphal *et al*., 2008, Prendergast *et al*., 2020).

Identification

Bees were identified to species level using published systematic keys, Bee's field guide and use of online materials (Francoy *et al*., 2009; Buschbacher *et al*., 2020; Trianto and Purwanto, 2020).

Data Analysis

All data were computed using Microsoft® Excel® 2016 and percentage abundance composition of bees were calculated using the formula below by Potts *et al*. (2003) and LeFeon *et al*. (2013):

$$\% \text{ abundance Composition} = \frac{ns}{Ns} X \ 100$$

Where **ns** is the number of individual species.
Ns is the total number of species captured during the survey.

RESULTS

At the end of the survey, 575 bees were captured comprising 12 species namely; Leafcutter Bee(*Ammobatodes scriptus*), Mining Bee (*Andrena cineraria*), Honey Bee (*Apis mellifera*),Bumble Bee(*Bombus sp.*),Memic Bee(*Megachile spp.*), Stingless Bee (*Meliponula beccarii*), Manson Bee (*Osmia caerulescens*), Leafcutter Bee (*Osmia sp.*), Carpenter Bee (*Xylocopa augusti*), Carpenter Bee(*Xylocopa caffra*),Violet Bee(*Xylocopa violacea*)and Squash Bee (*Penonapis sp*). They were captured in the six (6) plots within the Reserve and identified. The most abundant species was the Honey Bee (*Apis mellifera*) with 245 individuals followed by Memic Bee with 89 individuals then Stingless Bee with 70 individuals while the least was *Osmia sp.* with 2 individuals captured during the survey. Plot 3 (144) captured the highest number of bees, followed by Plot 1 (112), then Plot 2 (104) and the least was Plot 4 recording 65 bees.

In terms of diversity by species, Shannon Diversity Index (H) and Shannon Equitability Index (E_H) were1.694893 and 0.736083 respectively while diversity by plots using Shannon Diversity Index (H) was 1.750688 and Shannon Equitability Index (E_H) was 0.977078. This information is shown on Table 1.

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Table 1: Number of bees captured in six (6) plots during the survey

S/N	Common Name	Scientific name	Plot1	Plot2	Plot3	Plot4	Plot5	Plot6	Total
1	Leafcutter Bee	*Ammobatodes scriptus*	3	-	5	5	-	-	13
2	Mining Bee	*Andrena cineraria*	6	4	-	3	-	-	13
3	Honey Bee	*Apis mellifera*	40	70	65	15	15	40	245
4	Bumble Bee	*Bombus sp.*	7	-	13	9	-	3	32
5	Memic Bee	*Megachile sp.*	9	10	30	19	13	8	89
6	Stingless Bee	*Meliponula beccarii*	16	-	4	-	45	5	70
7	Manson Bee	*Osmia caerulescens*	-	-	12	4	-	-	16
8	Leafcutter Bee	*Osmia sp.*	2					0	2
9	Carpenter Bee	*Xylocopa augusti*	-	9	5	-	11	-	25
10	Carpenter Bee	*Xylocopa caffra*	7	-	10	-	-	10	27
11	Violet Bee	*Xylocopa violacea*	19	11	-	10	-	-	40
12	Squash Bee	*Penonapis sp.*	3	-	-	-	-	-	3
	Total		**112**	**104**	**144**	**65**	**84**	**66**	**575**

Diversity by species
Shannon Diversity Index (H) = **1.694893**
Shannon Equitability Index (E_H) = **0.736083**

Diversity by plots
Shannon Diversity Index (H) = **1.750688**
Shannon Equitability Index (E_H) = **0.977078**

Table 2 represents the number of bee species according to their families. All the bees sampled were members of three (3) families' namely; Andrenidae, Apidae and Megachilidae. Apidae (443) took the lead, followed by Megachilidae (120) and the least was Andrenidae (13).

Table 2: Number of bee species according to family

S/N	Family Name	Common Name	Scientific Name	Number		
1	. Andrenidae	Mining Bee	*Andrenidae cineraria*	**1**		**3**
2	. Apidae	Bumble Bee	*Bombus sp.*	3		2
		Honey Bee	*Apis mellifera*	2	4	5
		Stingless Bee	*Meliponula beccarii*	7		0
		Carpenter Bee	*Xylocopa augusti*	2		5
		Carpenter Bee	*Xylocopa caffra*	2		7
		Violet Bee	*Xylocopa violacea*	4		1
		Squash Bee	*Penonapis s.p*		3	
		Total		**4**	**4**	**3**
3	. Megachilidae	Leafcutter Bee	*Osmia sp.*		2	

Manson Bee	*Osmia caerulescens*	1		6
Leafcutter Bee	*Ammobatodes scriptus*	1		3
Memic Bee	*Megachile sp.*	8		9
Total		**1**	**2**	**0**

The percentage composition of bees varied across the three (3) families and genera. Honey Bee recorded the highest percentage composition of 42.53%, followed by Memic Bee (15.45%), then Stingless Bee (12.15%) and the least was Leafcutter Bee (*Osmia sp*) (0.35%) as shown below in Table 3.

Table 3: Percentage composition of bees' species in the study area

Common Name	Scientific Name	Percentage Composition(%)
Leafcutter Bee	*Ammobatodes scriptus*	2.00
Mining Bee	*Andrena cineraria*	2.00
Honey Bee	*Apis mellifera*	42.53
Bumble bee	*Bombus sp.*	5.56
Memic Bee	*Megachile sp.*	15.45
Stingless Bee	*Meliponula beccarii*	12.15
Manson Bee	*Osmia caerulescens*	2.78
Leafcutter Bee	*Osmia sp.*	0.35
Carpenter Bee	*Xylocopa augusti*	4.34
Carpenter Bee	*Xylocopa caffra*	4.69
Violet Bee	*Xylocopa violacea*	7.12
Squash Bee	*Penonapis sp*	0.52
Total		**100%**

DISCUSSION

Brosi *et al.* (2008) and McGavin (1997) reported that targeted sweep netting was the best method of sampling bees. This assertion is in agreement with the present study which recorded large populations of bees' species collected using the same method. In thecurrent study, only three(3)

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families of bees were found within the Reserve, this is in contrast to the six (6) families previously reported by Michener (2000) and Masigà (2017) that out of the eleven (11) bees' families, six (6) are found in Africa. The carpenter bees (*Xylocopa sp.)* were more diversified. Bees rely on flowers for protein, oils and sugar throughout their life cycle (Michener, 2000). All bees in the study area were captured on flowering plants. It was also observed during the survey that as flowering plants increased so also the number of bees increased, this agrees with the report by Kasina *et al.* (2007) who reported that bees need plants for other uses such as getting nest materials, hiding, mating or just as resting sites.

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Out of the six (6) plots created within the Reserve, plot three (3) had most of the bees' species as almost all the species were found in the plot, this was because all plants in the plot were in bloom during the survey, while plot 4 had least species because the plot was on high elevation; this agrees with the report by Lefebvre *et al.* (2018) who reported that abundance and diversity of pollinators decrease with increasing elevation. The honey bees (*Apis mellifera)* were found across all the six (6) plots making them more abundant than the other species.

Percentage abundance composition also showed that honey bee (*Apis mellifera*) is the most abundant species with about 245 (42.53%) individuals captured; this is because honey bees are social insects and live in colony with each worker visiting flowers 8-10 times daily in search of pollens (Abou-shaara, 2015) and the least was *Osmia sp.* with only 2(0.31%) individuals captured during the survey, probably because it is uncommon and rare.

CONCLUSION

In conclusion, the present survey has shown that Ngel-Nyaki Forest Reserve is rich in bees' diversity. It has also documented probably for the very first time, the bees' fauna in the Forest Reserve. At the end of the survey a total of 12 different bee species were caught belonging to three (3) bees' family. Result obtained showed that honey bee (*Apis mellifera*) was the most abundant bee species found within the Reserve while the least was the *Osmia sp.*

RECOMMENDATION

1. Further studies should be conducted using other sampling techniques.

2. There is need to expand the duration of the study as seasonal variations affect population dynamics of bees.

3. The geographical scope of the study should be expanded as the Forest is large and six (6) plots may not give the actual representation of the Reserve.

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