

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 (*Apis mellifera*) (245; 42.53%), followed by mimetic bee (*Megachile sp.*) (89; 15.45%), and the least was leafcutter bee (*Osmia sp.*) (2; 0.35%). In terms of diversity by species, Shannon Diversity Index (H) and Shannon Equitability Index (EH) were 1.694893 and 0.736083 respectively while diversity by plots using Shannon Diversity Index (H) and Shannon Equitability Index (EH) were 1.750688 and 0.977078 respectively. The bee diversity in Ngel-Nyaki Forest reserve is similar and consistent to most primary forest. 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: Assessment, Diversity, Forest, Ngel-Nyaki

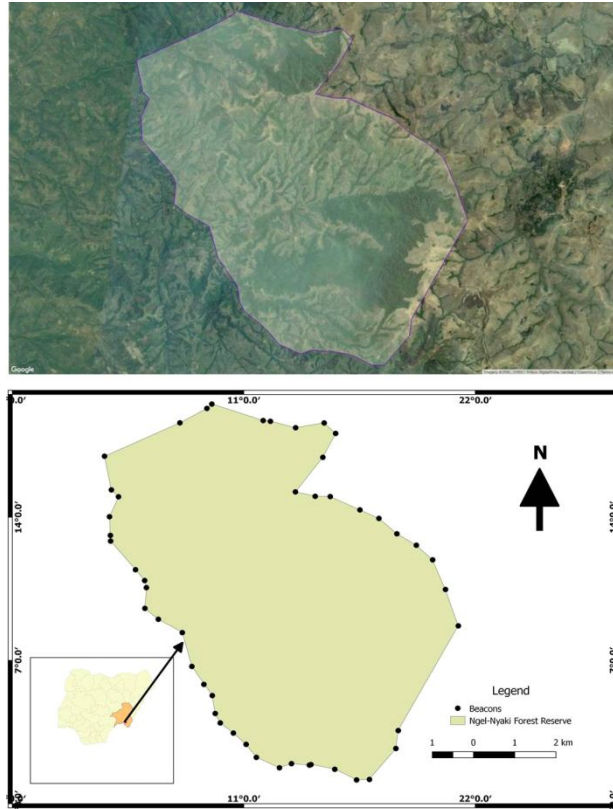
1. INTRODUCTION

Bees belong to the Order Hymenoptera, Sub-order Apocrita, Super-family Apoidea, 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 Halictidae (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 than 2 millimeters long (Asiko, 2012), to large species of leafcutter bee (*Megachilepluto*) (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

30 just one out of many species of bees (Nsor, 2014). So also, the Ngel-Nyaki Forest Reserve
31 is a biodiversity hotspot zone with different species of bees but till date there is no
32 documented work on the taxonomy and different species of bees found within the Reserve
33 (Cheek *et al.*, 2021). The findings of this study therefore, will contribute in the field of
34 conservation, by identifying the different species of bees within Ngel-Nyaki Forest Reserve.
35 The work will also help to document the different types of bees within the Forest Reserve by
36 creating a checklist for the different species of bees as well as the percentage abundance
37 composition of bees found within Ngel-Nyaki Forest Reserve.

38 39 Study Area

40
41 Ngel-Nyaki is located towards the western escarpment of the Mambilla Plateau. The Forest
42 Reserve forms part of the Guinean forest biodiversity hotspot which extends from Sierra
43 Leone to Cameroon Mountains. The reserve is situated between longitude 07° 05'N and
44 latitudes 011° 05'E at an altitude of 1,450m–1,600m above sea level (Figure 1). The
45 Reserve occupies about 46km² of land comprising of; montane grassland, forest fragments,
46 woodland forests and lowlands with about 7.2km² of submontane to mid-altitude forest
47 (Korndorfer, 2010; Borokiniet *al.*, 2012). The Forest Reserve can be reached on foot 40
48 minutes from Yelwa village (Chapman and Chapman, 2001). Ngel-Nyaki Forest Reserve is
49 one of the most diverse sub-montane forests in Nigeria. It contains many plants which are
50 endemic to the Afro-montane region. There are more than 146 vascular plants out of which
51 75 are in IUCN Red List (Borokiniet *al.*, 2012); 4 endangered species and 8 new species.
52 The forest is an Important Bird Area (IBA) (Ihumaet *al.*, 2010) and has been classified as an
53 Important Bird Area by Bird Life International and a critical site for biodiversity conservation
54 (Ezealor, 2002). The forests fall within the Cameroon Highlands Eco region, which are
55 exceptionally rich in endemic taxa. Ngel-Nyaki forest, a 46 km² forest reserve, is the most
56 species rich forest on the Plateau and is the location of the Nigerian Montane Forest Project
57 field station. Ngel-Nyaki forest harbours 9 IUCN Red Data Listed tree species with at least
58 another 20 other species in the genera *Warneckia* and *Deinbollia*, new to science. It is rich in
59 primate species, including the IUCN Endangered/Nigeria-Cameroon chimpanzee *Pan*
60 *troglogytesellioti*. There are African golden cats *Caracal aurata*, 3 new species of frogs that
61 the Nigerian Montane Forest Project have identified so far. However, Ngel-Nyaki and other
62 Mambilla Plateau forests and the animal species are threatened because of increased
63 human and cattle populations, poverty and climate change. Fulani pastoralists are
64 increasingly moving their cattle into the forests and burning forest for grazing, farmers are
65 felling trees and planting crops and poachers are hunting wildlife (Chapman and Chapman,
66 2001).



67
68 **Figure 1.** Map of Ngel-Nyaki Forest Reserve, Taraba State, Nigeria [Source: Nigerian Montane
69 Forest Project (NMFP)].
70

71 **2. MATERIAL AND METHODS**

72 **2.1 Sampling Method**

73 Six (6) plots were established randomly where flowering plants were found within the Forest
74 Reserve after a pilot survey.
75

76 **2.1.1 Bee Sampling**

77
78 Two (2) methods of sampling techniques were used to sample bee species. These were
79 Opportunistic sampling and Systematic sweep netting. Opportunistic sampling method was
80 applied by sweep netting bees along 100 m plot where flowering plants were blooming.
81 Collection was conducted by a single collector using an active search by walking randomly
82 around the plot observing flowering plants and searching for bees foraging on the flowers
83 then a sweep net was used for capturing bees (Nielsen *et al.*, 2011). Sweep netting was
84 conducted, line transect established within the plots for 2 hours, from 6:00am to 11:00am
85 spending 20 minutes in each plot considering when the weather is conducive for bees'
86 activity. This was done using entomological sweep net. Bees captured from flowers were
87 killed in a killing bottle containing 70% ethanol. Specimens were pinned on a board and
88 unique codes were assigned to each species before identification (McGavin, 1997; Brosiet
89 *al.*, 2008; Westphal *et al.*, 2008, Prendergast *et al.*, 2020).
90

91 **2.2 Identification**

92

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

96

97 **2.3 Data Analysis**

98

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

$$\% \text{ Abundance COmposition} = \frac{ns}{Ns} \times 100$$

102

103 Where 'ns' is the number of individual species.

104 'Ns' is the total number of species captured during the survey.

105

106 **3. RESULTS AND DISCUSSION**

107

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

119 In terms of diversity by species, Shannon Diversity Index (H) and Shannon Equitability Index
120 (EH) were 1.694893 and 0.736083 respectively while diversity by plots using Shannon
121 Diversity Index (H) was 1.750688 and Shannon Equitability Index (EH) was 0.977078.

122 This information is shown on Table 1.

123

124 Table 2 represents the number of bee species according to their families. All the bees
125 sampled were members of three (3) families' namely; Andrenidae, Apidae and Megachilidae.
126 Apidae (443) took the lead, followed by Megachilidae (120) and the least was Andrenidae
127 (13).

128

129 The percentage composition of bees varied across the three (3) families and genera. Honey
130 Bee recorded the highest percentage composition of 42.53%, followed by Memic Bee
131 (15.45%), then Stingless Bee (12.15%) and the least was Leafcutter Bee (*Osmia sp*)
132 (0.35%) as shown below in Table 3.

133

134 **Table 1. Number of bees captured in six (6) plots during the survey**

S/N	Common Name	Scientific name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Total
1	Leaf cutter Bee	<i>Ammobatodes scriptus</i>	3	-	5	5	-	-	13
2	Mining Bee	<i>Andrena cineraria</i>	6	4	-	3	-	-	13
3	Honey Bee	<i>Apis mellifera</i>	40	70	65	15	15	40	245
4	Bumble Bee	<i>Bombus sp.</i>	7	-	13	9	-	3	32
5	Memec Bee	<i>Megachile sp.</i>	9	10	30	19	13	8	89
6	Stingless Bee	<i>Meliponulabeccarii</i>	16	-	4	-	45	5	70
7	Manson Bee	<i>Osmia caerulea</i>	-	-	12	4	-	-	16
8	Leafcutter Bee	<i>Osmia sp.</i>	2					0	2
9	Carpenter Bee	<i>Xylocopa augusti</i>	-	9	5	-	11	-	25
10	Carpenter Bee	<i>Xylocopa caffra</i>	7	-	10	-	-	10	27
11	Violet Bee	<i>Xylocopa violacea</i>	19	11	-	10	-	-	40
12	Squash Bee	<i>Penonapis sp.</i>	3	-	-	-	-	-	3
	Total		112	104	144	65	84	66	575

135 *Diversity by species*

136 *Shannon Diversity Index (H) = 1.694893*

137 *Shannon Equitability Index (EH) = 0.736083*

138

139 *Diversity by plots*

140 *Shannon Diversity Index (H) = 1.750688*

141 *Shannon Equitability Index (EH) = 0.977078*

142

143

144

Table 2. Number of bee species according to family

S/N	Family Name	Common Name	Scientific Name	Number
1	Andrenidae	Mining Bee	<i>Andrenidae cineraria</i>	13
2	Apidae	Bumble Bee	<i>Bombus sp.</i>	32
		Honey Bee	<i>Apis mellifera</i>	245
		Stingless Bee	<i>Meliponulabeccarii</i>	70
		Carpenter Bee	<i>Xylocopa augusti</i>	25
		Carpenter Bee	<i>Xylocopa caffra</i>	27
		Violet Bee	<i>Xylocopa violacea</i>	41
		Squash Bee	<i>Penonapiss.p</i>	3
		Total		443
		3	Megachilidae	Leafcutter Bee
Manson Bee	<i>Osmia caerulea</i>			16
Leafcutter Bee	<i>Ammobatodes scriptus</i>			13
Memic Bee	<i>Megachile sp.</i>			89
Total				120

145

146

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

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

149 **3.2 Discussion**

150 Bee diversity plays a crucial role in maintaining the health and resilience of ecosystems,
151 particularly in forests and grasslands. Bees, as key pollinators, facilitate the reproduction of
152 flowering plants, ensuring the production of seeds, fruits, and other plant resources.
153 Brosiet *al.* (2008) and McGavin (1997) reported that targeted sweep netting was the best
154 method of sampling bees. This assertion is in agreement with the present study which
155 recorded large populations of bees' species collected using the same method. In the current
156 study, only three (3) families of bees were found within the Reserve, this is in contrast to the
157 six (6) families previously reported by Michener (2000) and Masigà (2017) that out of the
158 eleven (11) bees' families, six (6) are found in Africa. The carpenter bees (*Xylocopa sp.*)
159 were more diversified. Bees rely on flowers for protein, oils and sugar throughout their life
160 cycle (Michener, 2000). All bees in the study area were captured on flowering plants. It was
161 also observed during the survey that as flowering plants increased so also the number of
162 bees increased, this agrees with the report by Kasina *et al.* (2007) who reported that bees
163 need plants for other uses such as getting nest materials, hiding, mating or just as resting
164 sites.

165
166 Out of the six (6) plots created within the Reserve, plot three (3) had most of the bees'
167 species as almost all the species were found in the plot, this was because all plants in the
168 plot were in bloom during the survey, while plot 4 had least species because the plot was on
169 high elevation; this agrees with the report by Lefebvre *et al.* (2018) who reported that
170 abundance and diversity of pollinators decrease with increasing elevation. The honey bees
171 (*Apis mellifera*) were found across all the six (6) plots making them more abundant than the
172 other species.

173
174 Percentage abundance composition also showed that honey bee (*Apis mellifera*) is the most
175 abundant species with about 245 (42.53%) individuals captured; this is because honey bees
176 are social insects and live in colony with each worker visiting flowers 8-10 times daily in
177 search of pollens (Abou-shaara, 2015) and the least was *Osmia sp.* with only 2(0.31%)
178 individuals captured during the survey, probably because it is uncommon and rare.

179
180 **4. CONCLUSION**

181
182 In conclusion, the present survey has shown that Ngel-Nyaki Forest Reserve is rich in bees'
183 diversity. The bee diversity found in Ngel-Nyaki Forest reserve is similar and consistent to
184 most primary forest. Although, the level of diversity may be related to the sampled forest
185 strata used in this study. In the same vein, since most bees can fly a considerable distance to
186 forage, there is a possibility of migration of various bee species into the forest especially due
187 to loss of habitat in the low lands. In this, study also we have documented probably for the
188 very first time, the bees' fauna in the Forest Reserve. At the end of the survey a total of 12
189 different bee species were caught belonging to three (3) bees' family. Result obtained
190 showed that honey bee (*Apis mellifera*) was the most abundant bee species found within the
191 Reserve while the least was the *Osmia sp.*

192
193 **COMPETING INTERESTS**

194
195 The authors declare no conflict of interest.

196
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