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Bee Fauna in and Around Kakum National Park

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Abstract

Even though several ecological studies on various fauna studies have been carried out in the Kakum National Park, record on the bee fauna is lacking in spite of the fact that bees are one of the most economically important insects. Bees constitute 60%-70% of all insect pollinators. This research was set out to assess the bee fauna within three landscapes (primary forest, secondary forest and agricultural land- in and around the Kakum National Park of Ghana. Pan traps (blue, white and yellow) were designed to collect bees at the canopies of forest trees as well as lower vegetation levels for thirteen months. Over 57 bee species belonging to three families (Apidae, Halictidae and Megachilidae) were identified from a total of 1, 288 bee specimens collected from the three landscapes. These were categorized into 31 genera. Significant differences in total abundance were recorded among the stingless bee and other bee species within the landscapes. In terms of sociality, variations occurred in the different landscapes with bees exhibiting four levels of sociality (parasitic, eusocial, quasisocial and solitary). Both long and short tongued bees were present in all the three landscapes.

Keywords: Bees; Fauna; Ghana; Landscapes

Introduction

The Kakum National Park (KNP) in the Central Region of Ghana is a tropical rainforest constituting the southern part of the Kakum Conservation Area (KCA). The conservation area covers an area of 350 square kilometres. Scientific surveys dated back to 1992 estimate the floral and faunal diversity to be in several thousands of species. The main fauna of KCA include Pygmy elephants, forest buffalo, bongo antelopes, Mona and Diana monkeys and over 800 rare species of birds, butterflies, reptiles and amphibians [1]. Apart from butterflies, there is no record on other insect fauna especially bees which are known to be responsible for providing most of the pollination services within ecosystems [2]. Among the hymenopteran insects, bees play a unique role in the world of Arthropods in that they are entwined into most aspects of human culture and mythology, not to mention agriculture, economy and general ecology [3,4].

Today, bees are known by far to be major contributors to essential ecological services especially pollination. Globally, pollination and pollinator issues have occupied keystone position in the maintenance of biodiversity, in both natural and agricultural ecosystems. Pollination services provided by most bee pollinators appear to be different from other essential ecosystem services in that, it is biodiversity dependant; many plant species require specific pollinators and similarly many pollinator species require specific food plant [5-8]. Bees are almost widely used in pollination management for agriculture [9-11].

It is therefore important to investigate the bee fauna of this important national park that is responsible for the park's maintenance and survival through the provision of pollination services. Bees may also form part of the food chain/web for other animals such as arachnids, reptiles, birds and mammals [2,12,13]. The outcome of this research would provide useful information to researchers, students and stakeholders for effective management and conservation strategies of the Kakum National Park. This research is intended to survey, determine and compare the bee diversity in three landscapes (primary forest, secondary forest and agricultural land) in and around KNP using standardized methodology.

Materials and Methods

Study areas

The study was conducted within three different landscapes (primary forest, secondary forest and agriculture land) in and around the Kakum National Park (KNP) where the bee fauna were surveyed. The Kakum National Park is located 30 km north of Cape Coast and has been under protection for over 20 years. The primary forest is located within the national park and made up of tree canopies up to 50m high with sparse understory. The secondary forest with canopy up to 25m and dense understory occupy an area of 207 ha surrounding the Kakum National Park. It was completely cleared in 1994 was left to regenerate since then. The agricultural land which is 1-2km south of Kakum National Park was intensively cultivated with oil palm and banana with regular clearing of the ground vegetation forming matrix outside the secondary forest.

Sampling

The sampling protocol followed that described in Nuttman et al [14]. A monthly survey was conducted in three replicated sites within each landscape described above. Two sets of three pan traps (blue, yellow and white) were located in each of the three landscapes. Pans consisted of 15 cm diameter X 10 cm deep (500 ml) plastic soup bowls (Pro-Pac, Vechta, Germany) sprayed on both interior and exterior surfaces with UV bright paint (Sparvar Leuchtfarbe, Spray- Color GmbH, Merzenich, Germany). Previous studies indicate that insect taxa are differentially attracted to various colors and blue, white and yellow have been shown to be effective [15]. For each round of sampling the traps were set out on the morning of the first day and collected on the morning of the third day giving 48 h of exposure. Pans were half-filled with water and a few drops of a detergent added to reduce surface tension. The contents of the traps were sieved to separate the insects, which were stored in 70% alcohol for later identification. In order

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to position the pan traps in the parts of the landscape where insect pollinators were active it was necessary to use different deployment methods for each habitat type. In the two forest landscapes pans were attached to ropes which ran over branches of high trees so that the pans could be hoisted to the level of the canopy: up to 15 m in the secondary forest and >30 m in the primary forest. A catapult or crossbow was first used to fire a fishing weight or blunt-ended arrow respectively, over a branch in the canopy of large trees. Attached to the projectile was strong (>5 kg breaking strain) fishing line, which was then used to pull thick string over the branch. Pan traps were arranged in a cradle, which was then attached to the string and raised carefully (to avoid spillage), into the canopy. The free end of the string was anchored at ground level to stabilise the pan traps. The position of the coloured pans was randomised between sites. Pans in the agricultural sites were hung on oil palms and shrubs at heights between 0.5m and 1.5 m in areas with flowers attractive to pollinators. Hence, the positioning of the traps at the three sites was at differing heights and allowed sampling where floral resources were most plentiful in each landscape. Bee samples were sorted into key taxa in the laboratory and bees identified to species wherever possible and to morphospecies otherwise. The taxa analysed were mainly bees [14,16,17].

Data analyses

Data from the entire sampling period were pulled together to produce one value per pan trap unit. The entire samples were sorted into species, genera and families as they occurred in each landscape and their abundance and diversity compared. Various graphical presentations and tables were used to illustrate the result of this investigation. Bee counts were $\log_{10}(n + 1)$ transformed and entered into a GLM with habitat as a fixed factor and replicate as a random factor nested within habitat (Minitab v14).

The floral phenologies of all plant species flowering at the time of insect collection were recorded and tabulated to assess possible forage providers for the various bee species.

Further, the percentage mass sucrose concentrations of the nectary of the flowers were measured using sucrose refractometer.

The terminology used in this study follows that of Michener [18,19]. Different morphological terms are explained in the text.

Results and Discussion

Bee fauna

Data generated from this research forms the baseline bee fauna in and around the Kakum National Park of Ghana. A total of 1288 bee samples were collected from the three landscapes studied. Bee specimens were initially categorised under stingless bees and other bees and later grouped based on family lines. Among the stingless bees and other bee species sampled, significant differences in total abundance were found between landscapes ($F2, 627=27.4$, $p<0.001$), ($F2, 627=53.4$, $p<0.001$) respectively (Figure 1). Variability in the presences of diverse floral resources with the different landscapes possibly account for the significant differences in total bee abundance as well as diversity.

Classification of bee species

Bees sampled in this present study were found within three bee families (Apidae, Halictidae and Megachilidae) of the seven known African families.

Family apidae: The Apidae are probably important visitors and pollinators of a range of forest plants as well as food crops. A number of nests of the stingless bees were encountered during the data collection. Members of this family were found to be the most dominant species in the entire sample.

(a) Stingless bees: Members of this group belong to the tribe Meliponini and are sometimes referred to as sweat bees. These bees are important visitors of a range of plant species and were observed visiting many forest trees in bloom. Stingless bees also were more commonly sampled in the agricultural landscape than either the forest landscape ($p=0.0267$), and the primary forest yielded significantly

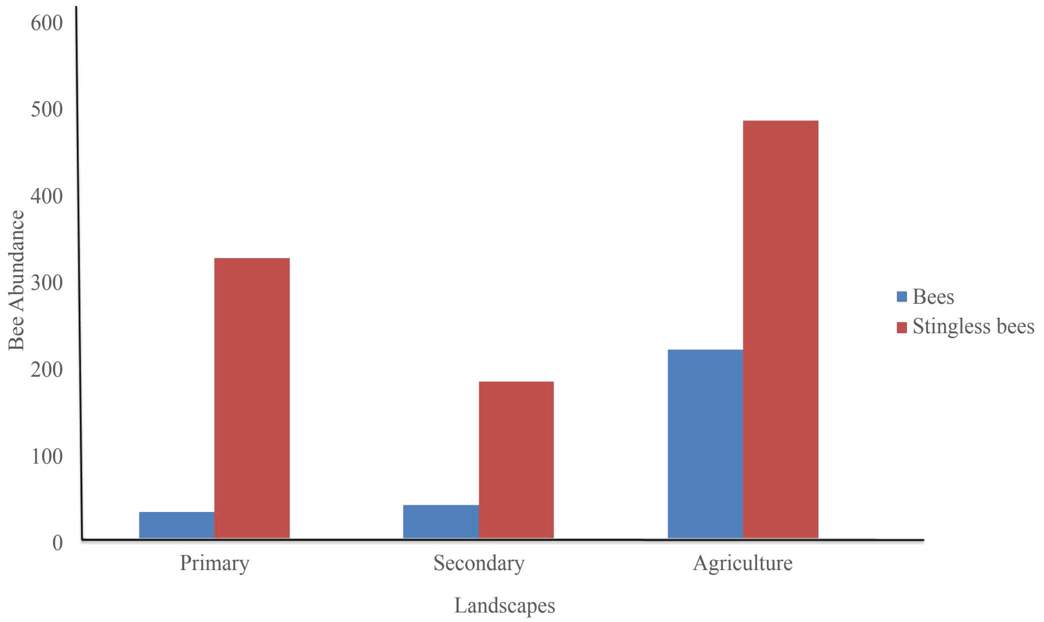

Figure 1: Bee abundance within the three landscapes (Primary forest, Secondary forest and Agriculture land).

more stingless bees than the secondary forest (p<0.0001) (Figure 1). Ten out of the 31 species listed in Eardley, 2004 and Eardley and Urban (2010) as African species were identified within the three landscapes. These included *Meliponula* (*Meliponula*) *bocandei* (*Spinola*, 1853), *Axestotrigona ferruginea* (Lepeletier, 1836), *Meliponula* (*Axestotrigona*) *cameroonensis* (Friese, 1900), *Meliponula (Meliplebeia) nebulata* (Smith, 1854), *Dactylurina staudingeri* (Gribodo, 1893), *Hypotrigona gribodoi* (Magretti, 1884), *Hypotrigona ruspolii* (Magretti, 1898), *Hypotrigona araujoi* (Michener, 1959), *Liotrigona parvula* Dachen (1971) and *Cleptotrigona cubiceps* (Friese, 1912).

(b) Genus *Xylocopa:* Six species of this genus were observed foraging and nesting in all three landscapes. These species are *Xylocopa olivacea* (Fabricius, 1778), *X. imitator* Smith (1854), *X. hottentotta* Smith (1854), *X. nigrita* (Fabricius, 1775), *X. torrida* (Westwood, 1838) and *X. varipes* Smith (1854). *Xylocopa olivacea* and *X. varipes*, occurred frequently in agricultural landscapes, whereas, *X. imitator, X. hottenttota*, *X. erythrina* Gribodo (1894), *X. nigrita* and *X. torrida* were common in forest and uncultivated ecosystems.

(c) Genus *Amegilla:* Within the genus *Amegilla*, five species were identified as *Amegilla calens* (Lepeletier, 1841), *Amegilla acraensis* (Fabricius, 1793), *Amegilla albocaudata* (Dours, 1869), *Amegilla atrocincta* (Lepeletier, 1841) and *Amegilla nila* Eardley (1994). Previously, the genus *Amegilla* and *Anthophora* were place under a separate family Anthophoridae. Members of this group of bees were predominantly sampled within the agricultural landscapes.

(d) Other bees in family apidae: In addition to these genera, other species were collected from the family that is *Ceratina moerenhouti* Vachal (1903), *Ceratina pennicillata* Friese (1905), *Allodape collaris* Vachal (1903), *Allodape derufata* Strand (1912), *Allodape interrupta* Vachal (1903), *Alldape bouyssoui* Vachal (1903), *Braunsapis facialis* (Gerstaecker, 1858), *Braunsapis leptozonia* (Vachal, 1909), *Compsomelissa nigrinervis* (Cameron, 1905), *Thyreus axillaris* (Vachal, 1903), *Thyreus bouyssoui* (Vachal, 1903), *Tetraloniella katangensis* (Cockerell, 1930). Only one species (*Apis melifera adansonii* Latreille, (1804)) of the genus *Apis* has been found to occur within the region. Apparently, *A. melifera* was found to frequently visit agricultural landscape, in most cases pollinating the host plants eventually. It was also found minimally in the primary forest.

Family halictidae

Fourteen species of bees were sampled during the survey belonged to the Family Halictidae. Some of these species belonged to the subfamily Halictinae (long tongued halictid). Bee species within this category includes *Thrinchostoma torridum* (Smith, 1879), *Halictus sp*, *Lasioglossum duponti* (Vachal, 1903) and *Lasioglossum aburiense* (Cockerell, 1945). Four genera of short tongued halictid bees belonging to the subfamily Nomiinnae were observed foraging mostly in the agricultural area. These species are *Lipotriches natalensis* (Cockerell, 1916), *Lipotriches orientalis* (Friese, 1909), *Lipotriches cirrita* (Vachal, 1903), *Nomia bouyssoui* Vachal (1903), *Nomia candida* Smith (1875), *Nomia chandleri* (Ashmead, 1899), *Pseudapis squamata* (Morawitz, 1895), *Pseudapis interstitinervis* (Strand, 1912), *Pseudapis amoenula* (Gerstaecher, 1870) and *Steganomus junodi* Gribodo (1895).

Family megachilidae

Five genera representing three tribes *viz* Osmiini, Anthidinii and Megachilini were collected during this survey. Species encountered includes *Chalicodoma rufipes* (Fabricus, 1781), *Chalicodoma congruens* Friese (1903), *Chalicodoma cincta* (Fabricus, 1781), *Coelioxys torrida* Smith (1854), *Lithurgus pullatus* (Vachal, 1903), *Pseudoanthidium truncatum* (Smith, 1854), *Pachyanthidium bicolor* (Lepeletier, 1841) and *Megachile sp.* respectively. Among the three genera, *Megachile sp.* was found to be the most abundant taxon in all the landscapes.

Bee diversity appeared to have direct relations with the diversity of floral composition in a particular landscape. The agricultural matrix with very diverse floral composition had highly diverse bee genera and species (Tables 1 and 2). This asserts to the fact that bees are more likely to be found in locations that provided preferred forage resources [20-24]. Further, the species diversity within the three landscapes suggested that more bee species tend to visit landscape closer to their nests and which harboured high nutritional food resources (Figures 2 and 3). Most organisms have also been found to maximize energy gain activities during foraging and minimize energy loss activities [25-26].

Floral sucrose analyses for some of the plants surveyed in this work also indicated high sucrose content for most plants within the agriculture matrix (Tables 2 and 3). According to the economics of bee foraging, key factors that influence foraging behaviour includes

Bee Genera	Tongue Length	Sociality	Nest Preference	Type of Ecosystem		
	Long/ Short	Eusocial/ Quasisocial/ Solitary/ Parasitic	Expose/ Twig/ Varied/ Ground	Primary Forest	Secondary/ Regenerating Forest	Agriculture/ Farmland
Apis	Long	Eusocial	Varied	✓	✓	✓
Xylocopa	Long	Solitary	Twig	✓	✓	✓
Ceratina	Long	Solitary	Twig	✓	✓	
Braunsapis	Long	Solitary	Twig	✓		✓
Tetraloniella	Long	Solitary	Twig			✓
Allodape	Long	Solitary	Twig	✓	✓	✓
Compsomelissa	Long	Solitary	Twig		✓	✓
Coelioxys	Long	Parasitic	Variable& depends on host bees	✓	✓	
Steganomus	Short	Solitary,	Ground			✓
Thrinchostoma	Short	Solitary	Ground	✓		✓
Halictus	Short	Solitary	Ground		✓	
Lasiogiossum	Short	Solitary	Ground	✓	✓	✓
Pseudapis	Short	Quasisocial	Ground			✓
Lipotriches	Short	Quasisocial	Ground			✓
Amegilla	Long	Solitary	Ground	✓		✓
Anthophora	Long	Solitary	Ground			✓
Thyreus	Long	Parasitic	Variable & depends on host bees	✓		✓
Lithurgus	Long	Solitary	Twig	✓		✓
Chalicodoma	Long	Solitary	Exposed			✓
Megachile	Long	Solitary	Leaves	✓		✓
Pachyanthidium	Long	Solitary	Varied	✓		
Pseudoanthidiutn	Long	Solitary	Varied			✓
Nomia	Short	Solitary	Ground			✓
Liotrigona	Long	Eusocial	Varied	✓		✓
Cleptotrigona	Long	Parasitic	Variable & depends on host bees	✓		✓
Meliponula	Long	Eusocial	Twig/ Wood	✓		
Hypotrigona	Long	Eusocial	Varied	✓	✓	✓
Dactylurina	Long	Eusocial	Exposed	✓		✓

Table 1: Genera characteristic of Bee species collected within the three landscapes.

Ecosystem	GPS Location	Plants in flower
Primary forest	Elev. 200m	*Mellitia excelsa*
	N05°21.212'W001°22.967'	*Secamonie afzelii*
	(Canopy Walkway platform 3)	*Paulinia pinata*
		Dailive guineanse
		Aningere robusta
		Astonia boonei
		Baphia nitida
	Elev.l87m	*Myvanthus arboreies*
	N05°21.213'W001°23.048'	*Acredoearpus macrophylla*
	(Canopy Walkway platform5)	*Alchonia cordifolia*
		Psyanthus angulense
		Ficus vogelii
		Craterspernum caudatum
		Hilleria latifolia
		Polyaltia oliverii
		Thalia geniculata
		Funtumia elastica
	Elev.187m	*Mammea africana*
	N05°21.287'W001°22.864'	*Rauvolfia vomitoria*
	Elev. 166m	
	N05°21.168'W001°22.838'	*Rauvolfia vomitoria*
Secondary forest		*Palista hirsta*
		Hilleria latifolia
		Cleistopholis pateus
	Elev. I5lm	*Trichilia monadelpha*
	N05°21.017'W001°22.849'	
	Elev. 147m	*Thalia geniculata*
	N05°21.084'W001°22.836'	*Cissus ampoides*
		Mammea africana
Agriculture	Elev. 138m	
	N05°20.759'W001°22.974'	*Panicum maximum*
		Sida acuta
		Lantana camara
		Aspilia africana
		Justacia flava
		Elaeis guineensis
		Solanum torvum
		Puereria phaseoilodes
	Elev. 134m	*Chromolaena odorata*
	N05°21.069'W001°22.849'	*Tribulus sp*
		Asystasia gigantica
	Elev. I16m	
	N05°20.650 ;001°23.134'W	*Stachytarpheta indica*
		Momordica clicurcuthia
		Baphia nitida
		Synedrella nodiflora

Table 2: Plants in flower during time of survey.

good weather, shorter distances of food sources from nest, increased food quality and quantity [27], thus, it is possible for the agriculture landscape characterized by more diverse flower resources to harbour diverse bee species.

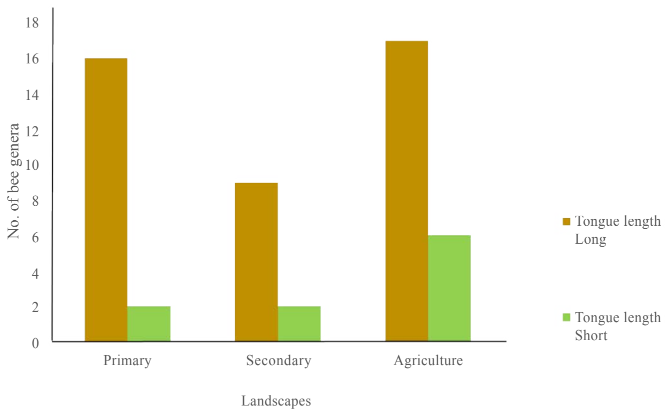

Figure 2: The distribution of long and short –tongue bee genera within the three landscape types.

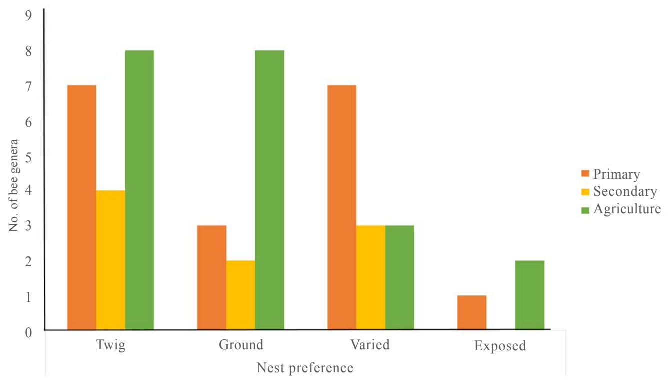

Figure 3: Variability in nest preference of bee genera encountered in the three landscapes.

Host plant	Mean values of selected host plant indicating nectar quality	
	Volume/ mm	% Mass sucrose concentration
Tribulus sp	18.0	18.0
Stachytarpheta indica	9.0	29.0
Thalia geniculata	16.0	19.0
Hilleria latifolia	9.8	19.7
Cleistopholis pateus	9.6	15.0
Baphia nitida	8.2	10.4
Asystasia gigantica	3.2	10.2
Aspilia africana	4.3	11.3
Lantana camara	30.0	29.4
Puereria phaseoloides	9.0	32.8
Chromolaena odorata	20.0	25.0
Citrulus sp	15.0	17.3
Sida acuta	17.7	11.7
Cissus ampoides	25.0	19.3
Rauvolfia vamitoria	8.0	11.6
Mammea africana	11.5	15.2
Funtumia elastica	7.5	12.2
Clerodendron thirnsonii	30.6	33.8

Table 3: Floral Sucrose Content.

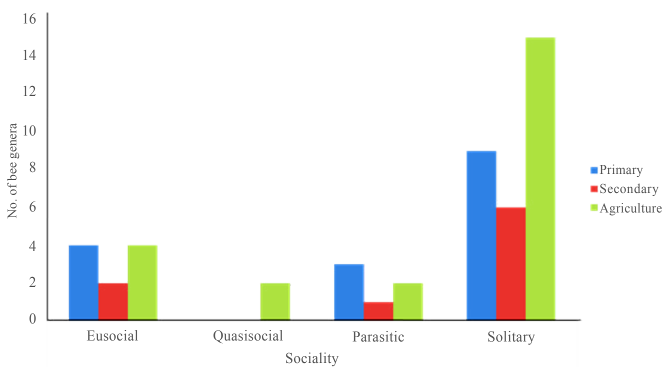

Figure 4: Sociality of bee genera that occurred in the landscapes.

Sociality and Nesting Behaviour

This present studies reveal bee sociality to be more varied in the agricultural matrix than the other studied landscapes (Figure 3). For instance two quasisocal genera (*Lipotriches* and *Pseudapis*) were recorded only within the agriculture landscape (Table 1 and Figure 4). Ground nesting bees were also abundant in this landscape than any other landscape studied. Further, more solitary bees and twig nesting bees were found in the agricultural landscape than the secondary and the primary forest landscapes. Vegetation cover of the agriculture landscape comprises of soft woody tree crops as well as thickets of weeds with soft pith that could easily be excavated by many species of bees that are solitary twig nesters and do not require large cavities to nest. In the same landscape, soil texture and close proximity of potential forage resources offered by agriculture landscape possibly encourage soil dwelling solitary group to nest. Eusocial bees generally require large nesting material to house the large colony capacity associated with social bees, hence their low presence in the agriculture that does not provide conducive nesting habitat for these bees.

Conclusion

The Kakum National Park habours diverse species of bees that are possibly growing the forest through the essential ecosystem services of pollination. Significant differences were however observed in bee total abundance among the three landscapes. Three bee families were recorded in KNP and these include: Apidae, Halictidae and Megachilidae. Of these, members of the family Apidae recorded the highest total abundance and diversity. Agriculture landscapes support highly diverse bee communities than forested areas. Thus, when an agricultural landscape that is often characterized by disturbance of natural vegetation is augmented with plants of high forage value, such landscapes can sustain high diversity of bee communities.

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