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Diversity and Abundance of Social Bees in Agro-Forest within the Guinea Savanna of Nigeria

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ABSTRACT

In a bid to determine diversity, abundance and water and resin collection behavior of social bees, survey and sampling of social bees were done at identified water and resin collection points with the aid of quadrat and the data collected were subjected to graphical analysis and analysis of variance using factorial design. Sampling of social bees in the morning, afternoon and evening at three water collection points at the University of Ilorin Agro-forest within the Guinea Savanna of Nigeria showed the presence of *Dactylurina staundingeri*, *Meliponula ferruginae*,*Hypotrigona spp.*and*Apis mellifera*. Observation at resin collection points showed that only *D. staundingeri* and *M. ferruginae* were frequent at the points. All the four bees were found in the afternoon and evening than in the morning. Highest number of the bees was recorded in the afternoon (34.29), followed by the evening (32.00) and the least in the morning (12.96). More of *A. mellifera*, *M. ferruginae* and *Hypotrigona spp.* were encountered in the evening than in afternoon while more of *D. staundingeri* was counted in the afternoon than in the evening. At the resin and all the water collection points, *D. staundingeri* was mostly in abundance, having a significant difference ($p < 0.05$) when compared to the numbers of other encountered bees. *A. mellifera* was abundant as *M. ferruginae* and *Hypotrigona spp.*in the study area.

Keywords: social bees, *Melliponula ferruginae, Dactylurina staudingeri, Hypotrigona spp.Apis mellifera,* abundance.

Introduction

Darwin as far back as 1859 was fascinated by bees and even recruited his children to trace their meandering paths through his garden (Freeman, 1968). Darwin's curiosity is part of a long history of interest in bee foraging biology. The popular notion that bees are key pollinators in diverse ecosystems calls for this good attention. In many tropical and subtropical areas of the world, a new scenario opens focusing on stingless bees use as crop pollinators (Cruz *et al.*, 2004; Malagodi-Braga and Kleinert, 2004; Aizen *et al.*, 2018) Bees (Apoidea) provide pollination of many wild and cultivated plant species (Delaplane and Mayer, 2000; Nicholls and Altieri, 2013) and important services to agriculture (Losey and Vaughan, 2006). Bees have special needs with regards to suitable nesting and floral sources but habitat loss has been a threat to their continued survival (Goulson *et al.*, 2008). However, their biodiversity in crop areas is threatened by increasing agricultural intensification, which includes the loss of natural and semi natural habitats and extensive monoculture plantings (Klein *et al.*, 2007; Kovács *et al.*, 2017). Despite the importance of wild bees in crop pollination, farmers still underestimate the importance of managing wild bee populations. Wild bees may be very successful in the pollination of crops, in particular some plants rarely exploited by honey bees or in areas affected by strong decline of honey bee populations (Greenleaf and Kremen, 2006). The quality of environment has an influence on stingless bee species composition in the community, as well as bees as pollinators influence the natural areas botanical composition through the ecosystem services provided by them. Bawa *et al*. (1985) reported that in wet lowland forest at La Selva, more than 50% of canopy species and 36% of sub canopy trees were pollinated by bees. A change in the pollinator's community will impact tree composition and the whole food chain.

Samejima *et al*. (2004) studied the effects of human disturbance (logging and shifting cultivation) on stingless bee community in a tropical rainforest, in Sarawak, Malaysia. In this area, stingless bees nests are in trees with >50 cm DBH (Diameter at Breast Height). They evaluated the richness of stingless bees in each sampled area, using baits, as well as a nest census and floral resources. They related nest density with density of large trees. The bait results indicated that some species were abundant in the primary forests, whereas other in disturbed forests. They focused on nest site availability as a limit for nest density. Eltz *et al*. (2002) evaluated the nest density of stingless bees in undisturbed and logged-over dipterocarp forests in Sabah, Borneo. They also focused on the population control mediated by nest predation; limitation of nest trees; and food limitation and they concluded that the abundance of stingless bees in forests in Sabah was chiefly dependent on the local availability of food resources.

Kwanpong *et al.* (2010) reported that stingless bees forage to collect resources needed for their daily survival and these include: Nectar for energy requirement**;** Pollen for protein and other nutritional needs; Water for cooling nests (hives) and for metabolic processes; Resins and other plant materials for nest building and Soil and sand particles for nest building. Water is essential for hydrating all the individual bees within a hive and cooling it throughout the year. Approximately 500 gallons of water required to hydrate and cool the colony each year (Hooper, 1976). Resins (propolis) is collected by bees for nest building, stingless bees used it in making pollen and honey pots (Cerumen) (Liadi *et al.*, 2013).

Bees are the predominant and most economically important group of pollinators in most geographical regions. Potential values of stingless bee pollination service even though stingless bees are common pollinators in many agricultural ecosystem, their contributions to human socio - economic, their abundance and behaviour are yet to be quantified or importance to agriculture even appreciated in Nigeria. There is need to identify the species of stingless bees available and determine their abundance and behaviour in Nigeria. This will pave way for further research works on their economic value in pollination, medicine, etc. This study exploits the diversity, abundance and behaviour of social bees (stingless bees and common honey bees) at their water collection and resin collection points at the University of Ilorin Agro-Forest mosaic within the Guinea savanna ecosystem.

Materials and Methods

Study Area : The study was carried out in the University of Ilorin Agro-Forest located in the Guinea Savanna region of Nigeria is predominantly rich in trees and shrubs with evergreen plants that produce pollen in the wet and dry seasons. It lies between 8° 29`10``N and 4° 40`38``E with the elevation of 408 m. The climate of Ilorin is characterized by wet and dry seasons, with annual rainfall of between 1088 and 1089 mm (Oriola and Olanrewaju, 2017). There was, generally, a wide range of variation in climatic elements in the study area; the wet season usually commences around March and ends in October while the dry season is normally from November till February (Liadi *et al.*, 2013). Mean monthly temperature varies from17°C to 41°C, and the relative humidity varies from 70% in the dry months to 80% in the wet months (Oriola and Olanrewaju, 2017). The University Agro-forest mosaic was partly clear felled and planted with Jatropha *(Jatropha curcas*, Citrus species, Teak (*Tectonagrandis*), Date palm (*Phoenix dactylifera*), Moringa (*Moringaoleifera)* and Cashew (*Anacardiumo ccidentale*) plantations and these plantations form the dominant vegetation type in the area (Liadi *et al.*, 2013).

Bees Sampling Methods: The sampling methods used in the field for the regular sampling of bees include the use of quadrat. Apart from these, other methods employed in the field include visual estimation of the bees. Sampling of bees was done in three places identified as points where bees were always found collecting water. Point A was about 5 km away from point B and point C was about 3 km away from point B. The number of species that visited the points was recorded three times a day for two consecutive days of every week in April and May, 2018. Visual counts of forager bees were made in 1 m × 1 m quadrat at each location. Counts of the bees were made in the morning (9:00 am), afternoon (1:00 pm) and evening (5:00 pm) for about 3 minutes. Using resin collection in determining the abundance, a deep cut was made on each of four big mango trees for the exuding of resin; the number and species of stingless bees collecting resin from the cut points were identified and recorded for five consecutive days.

Identification of stingless bees: Stingless bee species were collected using entomological net and stored in 70% ethanol for identification at the University of Ilorin Apiary Unit and further identification was done using Eardley descriptions and identification keys to African stingless bees (Eardley, 2004). Key to the genera of workers of social African bees, key to the species of Meliponula and diagnostic characters of the African species of Dactylurina were used. Data collected were subjected to analysis of variance (Factorial Design) using SPSS 16 full version package and significantly different means were separated using Duncan's Multiple Range Test at P = 0.05 level of probability while data collected at resin collection points were subjected to graphical analysis.

Results and Discussion

Three species of stingless bees belonging to the family apidae and tribe melponini were found in the study area namely: *Dactylurina staudingeri*, *Meliponula ,ferruginae* and *Hypotrigona spp*. *Apis mellifera*, common honey bee, belonging to the family apidae was also found at the water collection points. Water is one of the resources that honey bees forage for because it is used for metabolic activities, curing of honey and cooling hives. Number and frequency of honey bees at water collection points was used to determine their abundance in the study area. Based on the counts of different bee species made at water collection points in the morning, afternoon and evening, the analysis of variance (Factorial Design) showed that there was interaction (0.027) between the bee species and period and a significant difference ($p<0.05$) in the number of bees. There was also a significant difference ($p<0.05$) in the mean numbers of the species in the periods.

The results showed that the mean number of A. *mellifera* (5.17) recorded in the morning was significantly different compared to afternoon (16.71) and evening (20.00). However, highest number of *A.mellifera* was recorded in the evening (Table 1).The mean number of *D. staudingeri* recorded in the morning (41.83) was significantly different ($p<0.05$) compared to afternoon (105.67) and evening (91.67). However, highest mean number of *D.staudingeri*(105.67) was recorded in the afternoon.

Meliponula ferruginae and *Hypotrigona spp.*follow the same trend with *A. mellifera.* The mean numbers of *M.ferruginae (*3.67*)* and *Hypotrigona spp.*(1.17) recorded in the morning were significantly different compared to afternoon (10.50), (4.83) and evening (11.00), (5.33) respectively. However, highest mean numbers of *M. ferruginae* (11.00) and *Hypotrigona spp.* (5.33) were recorded in the evening.

Highest number of bees collecting water was recorded in the afternoon (34.29) followed by the evening (32.00) and the least in the morning (12.96). Though as shown in Table 1 there is no significant difference in the abundance of stingless bees in the afternoon and evening, the mean population in the afternoon is larger than in the evening while that of *Apismellifera* is more in the evening (20.00) than in the afternoon (16.17).

D. staudingeri (79.72) was most in abundance in all the water collection points followed by *A. mellifera* (13.78), *M.*

ferruginae (8.39) and *Hypotrigona spp.* (3.78).

There was a significant difference ($p<0.05$) in the mean number of species of *D. staudingeri* compared to other species.

At 5% level of significance there was no significant difference comparing *Hypotrigona spp.* *Meliponula ferruginae* and *Apis mellifera* indicating that *M. ferruginae* and *Hypotrigona spp.* were abundant as *Apis mellifera* which is a common bee known in the study area. Though the mean number of *Apismellifera*was more than *Hypotrigona spp.* and *M. ferruginae* and *M. ferruginae* more than *Hypotrigona spp.*

Table 1**.** Mean Numbers of Bee Species encountered in the Morning, Afternoon and Evening during the Study.

Bee species	Morning	Afternoon	Evening	SEM
A. Mellifera	5.17^{b}	16.17^{a}	20.00^{a}	±2.20
D. staudingri	41.83^{b}	105.67^{a}	91.67^{a}	±11.70
M. ferrugine	3.67^{b}	10.50^{a}	11.00^{a}	±1.81
Hypotrigona spp	1.17^{b}	4.83^{a}	5.33^{a}	±1.48
Total mean	12.96^{b}	34.29^{a}	32.00^{a}	±6.51

Means in the same row having the same letter are not significantly different at p = 0.05 level of probability using Duncan's multiple range test.

Two species were found collecting resins at cut points on Mango trees namely *D. staudingeri* and *M. ferruginae*. Fig. 1 showed that both *D. staudingeri* and *M .ferruginae* were frequent at collecting resins and *M. ferruginae*was not abundant as *D. staudingeri*at the resin collection points. More numbers of *D.staudingeri* (30.20) were found at resin collectionpoints *than M. ferruginae* (14.00). More bees were found in the first two days when the resins were still fresh.

The significant difference with large mean obtained when *D. staudingeri* was compared to other species indicated that *D. staudingeri* was more abundant in the study area. The abundance of *D. staudingeri* at the water collection points might be because they are not cavity nesters but having aerial nest (Kwapong *et al*., 2010; Liadi *et al*., 2013) will make them need more water.

Little difference between the means of afternoon and evening shows that many bees that went out to forage were still foraging before the sun set. Abundance of honey bees in the afternoon and evening might be because of the rise in the temperature due to the rising of the sun and this was in agreement with the findings of Matthew *et al.*, (2017) who reported that Increasing temperatures enhance flight activity while decreasing temperatures have the inverse effect and also Kovac, and Stabentheiner (2011) who showed that temperature appears to be an important factor affecting the foraging activity of honey bees. The rise in temperature will also make the bees to collect more water because they need water in cooling their nests (Kwanponget *al*., 2010). Though there is no significant difference in the abundance of stingless bees in the afternoon and evening, the mean population in the afternoon was larger than in the evening while that of *Apis mellifera* was more in the evening than in the afternoon. This could be due to their colour and body size. The same was reported by Pereboom & Biesmeijer 2003, Willmer and Stone, (1997) and Bishop and Armbruster, (1999) who reported that the activity patterns of bees during the day also depend on the bees' coloration and body size. Corbet *et al*., 1993 also reported that small, light-coloured Trigona bees in Costa Rica foraged on the flowers of *Justicia aurea* in full sunlight, while large, dark-coloured bees foraged in the morning and evening to avoid overheating.

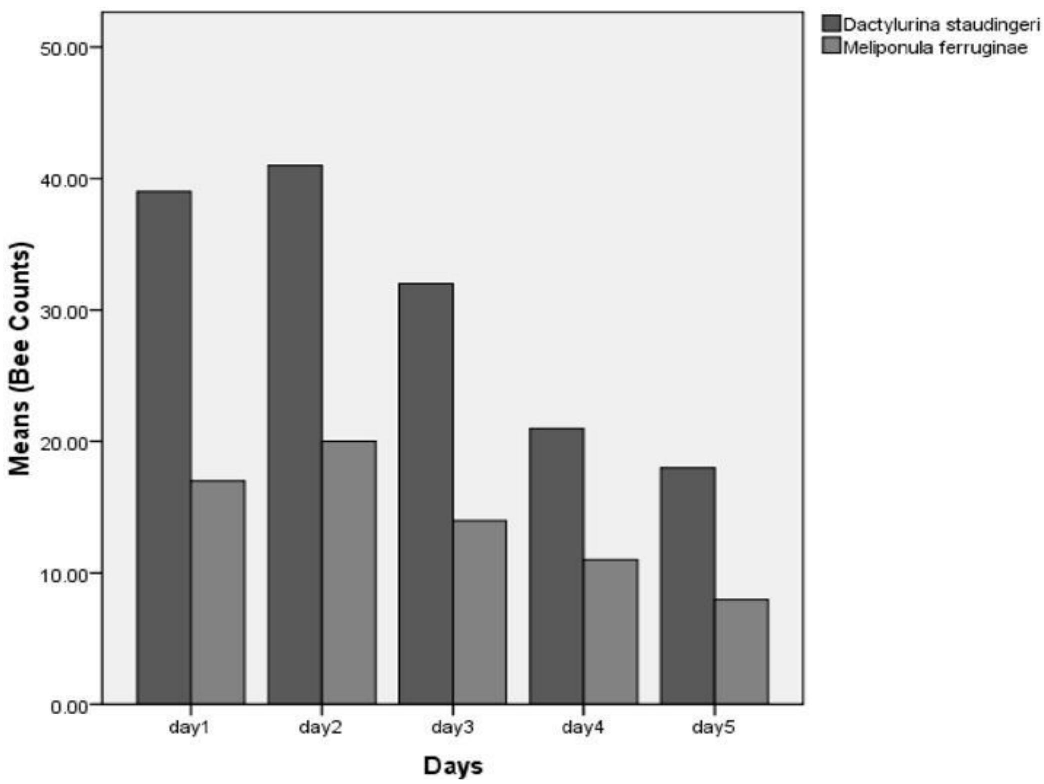

Fig. 1. Collections of resins by *Dactylurina staudingerin* and *Meliponula ferruginae*.

The results at resin collection points demonstrate graphically that *D. staudingeri* was more abundant at resin collection points than *M. ferruginae*. Finding both species collecting resin might be due to the fact that both species use resins in building their nests (Kwapong *et al*., 2010; (Liadi *et al*., 2013). They use resin in making cerumen and batumen. The graphical observation (Fig. 1) showed that *D. staudingeri* visited the resin collection points more than *M. ferruginae* which might also be because *D.staudingeri* construct their nest themselves building external nest unlike *M. ferruginae* that is a cavity nester (Abramson *et al.*, 2007; Liadi *et al.*, 2013). It was also observed that both bees were frequent at collecting fresh resins as large numbers of the bees were encountered in the first two days.

Dactylurina staudingeri, *Meliponula ,ferruginae*, *Hypotrigona spp*. and *Apis mellifera* were found in abundance at University of Ilorin agro- forest but *Dactylurina staudingeri* was most abundant. All these social bees are good pollinators that require further research works to enable their use in commercial pollination of crops. This research work showed that *Dactylurina staudingeri* and *Meliponula ,ferruginae* are good resin collectors, developing a technology in the keeping of these species can produce a good yield of cerumen, batumen and stingless bee honey in the study area.

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