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Pattern of Nectariferous Plant Diversity of African Honeybee (*Apis mellifera adansonii* L.) in Awka and Agulu Environs, Southeast Nigeria

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Abstract

This study was conducted between May 2014 and April 2015, to assess the pattern of nectariferous plant diversity of African honeybee (*Apis mellifera adansonii*) in different areas in Awka and Agulu environs, Southeast Nigeria. Transect sampling method was used to determine the abundance, distribution and diversity of these plants. Plant species were collected and identified. A total of 83 nectariferous plant species categorized into 31 families were identified to be attractive to honeybees in Awka and Agulu environs with Asteraceae (31%, 25%) being the highly visited, followed by Euphorbiaceae and Vebenaceae in all the study areas. High diversity and richness of plants in all the study areas are good indication that Awka and Agulu environs are potential sites for apiculture and beekeeping. This study recommended that these plants be conserved in these areas.

Key words: Diversity, Nectariferous plants, Awka and Agulu environs, *Apis mellifera adansonii*

INTRODUCTION

Honeybees of the genus *Apis* are the most studied because of their fascinating and complex lifestyle, communication systems (Nieh and Roubik, 1998; Nieh, 1998) and role as key pollinators of wild plants, agricultural crops, and the valuable hive products that they produce, such as honey (Suwannapong *et al*., 2011; Akunne, 2015). *Apis mellifera adansonii* is the most common bee that has been given due attention in Nigeria probably because of its beneficial attributes as a natural agent of pollination and as the most important of all insect pollinators (Mutsaers, 1991; Kumar *et al*., 1994). It is well adapted to the Nigeria ecological conditions (Abdullahi *et al*., 2011) and gathers its own food freely throughout the year (Adjare, 1990). Thus flowering plants have been great essential source of nutrition to the African honeybees' life. The production of honey depends on the abundance of nectariferous plants within easy flight range of the bee colony (Ayansola and Davies, 2012).

The abundance and distribution of nectar and pollen producing plant species vary from one place to another due to variation in certain factors which Rodinov and Shabanshov, 1986; Bista and Shivakoti, 2001 listed them to be topography, climate and farming practices. Westphal *et al*. (2006) revealed that the relationship between bees' activities and floral densities is evidence that bees have higher recruitment, reproduction and survival rates in areas with more flowers. As a general rule stated by Awmack and Leather (2002), the performance of plant herbivores is dependent on the quality and quantity of plant resources at their reach in a given season. According to Teklay (2011),

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bee flora species are more abundant and distributed in wet season than dry season.

In Nigeria, there is limited data on the number of plant species available for the honeybees in the rainy and dry seasons. However, the distribution and abundance of nectariferous plants in the Northern part of Nigeria has been reported by several workers namely: Abdullahi *et al*. (2011), Dukku (2013), Ebenezer and Olugbenga (2010) and Mbah and Amao (2009), which they reported that Fabaceae and Leguminosae are the most abundant families in the region. Ayansola and Davis (2012), Nnamani and Uguru (2012) in the south-western and south-south regions of Nigeria, respectively, reported that the honeybees forage on various varieties of nectariferous plant species. The objectives of this research are to identify the nectariferous plants resources attractive to African honeybees (*Apis mellifera adansonii*) and determine the abundance and distribution of the plants resources in Awka and Agulu environs, Southeast, Nigeria.

MATERIALS AND METHODS

Study area

The study was carried out in Awka (6°25′ N, 7°-8°E) and Agulu (6°23′ N, 6°-7°E) (Onyido *et al*., 2009) between May, 2014 and April, 2015. Awka and Agulu lie in the tropical rain forest zone of Nigeria and experience two distinct seasons - rainy and dry. Study areas which comprise eight locations; including Apiary section and Fish Hatchery centre of the Department of Zoology, Emelda Hostel, Unizik Primary School, Library and Faculty of Engineering areas, within the Nnamdi Azikiwe University permanent site Awka, and a parcel of land (farmland) in Enu-Ifite Awka, Amatutu and Agulu Lake environs with good vegetations and water sources (Mbah and Amao, 2009; Akunne, 2015) were marked for this study.

Collection and identification of nectariferous plants in the study sites

The collection of the nectariferous plants at the study sites was done on each location twice a week between 8am-10am in the morning and 4~6pm in the evening, during the study periods. Before collection, plants with foraging honeybees were photographed with a digital camera of model Panasonic DMC-LZ 7. Only plants with honeybees found foraging on the flowers were collected and identified *in situ* using keys provided in Mann *et al*. (2013). Plants that could not be identified *in situ* were collected using a sharp kitchen knife; making sure that portion/twig of the plant with its botanical features like leaves and flowers were cut and placed in a wetted polythene bag, and immediately taken to the Department of Botany Herbarium, Nnamdi Azikiwe University, Awka for proper identification. The plants that could not be identified at Botany herbarium, Nnamdi Azikiwe University were placed horizontally in-between two newspaper sheets to absorb moisture and placed in a plant file bag and sent to Department of Botany herbarium, University of Uyo, Uyo, Akwa Ibom State within 24 hours with information on the name of collector, place of collection and date of collection for identification.

To ascertain the plants honeybees preferred more as nectar and pollen source, observations were done for a period of 10 minutes between 10.00 and 11.00am daily using Abdullahi *et al*. (2011) and Wayar *et al*. (2014) methods. Based on the frequency of visit, the plants were categorised thus: highly visited (if at least four honeybees visited the flowers in quick successions), moderately visited (if three honeybees visited the flowers) and Least visited (if at least two honeybees visited the plant species). Using Bista and Shivakoti (2001) and Waykar *et al*. (2014) methods the observation on nectar and pollen source was based on activities performed by the honeybees on different flowers. The plants in which honeybees were seen extending their proboscis into the flowers were considered as nectar producing plant species and the plants in which bees were seen carrying pollen on their hind legs were recorded as pollen producing plants. Plants in which honeybees were seen extending their proboscis into the flowers and also collecting pollen on their hind legs were considered as nectar and pollen yielding plants. The

findings on visitation frequency and foraging behaviour were recorded.

Determination of abundance of nectariferous plants in the study area

The quadrants and transect method as explained by (Teklay, 2011) was used to determined the abundance of the nectariferous plants in the surveyed areas. The quadrants were laid at random after the study site was stratified. The distance between transects was also taken. Then the remaining quadrants were laid at equal intervals along transects. The number of plant species within quadrant were taken and recorded.

Statistical analysis

Calculation of Relative frequency

The relative frequency of each of the identified nectariferous plant species foraged by the African honeybee during the study period across the locations was calculated as the percentage of the number of plots present over total number of plots:

Determination of Plant Species Diversity in the Study Areas

Shannon diversity (H^{I}) and Evenness (E^{I}) were calculated as a measure to incorporate species richness. In this study species richness (S) was computed as, the observed number of bee flora species for each study area during the study period (Teklay 2011). However, paleontological software (PAST Version II) was used to assess the plant diversity trends as the Shannon diversity index (H') and evenness index (E').

RESULT

A total of 83 species of nectariferous plant species, grouped into 31 families were identified to be visited and foraged by *Apis mellifera adansonii*, in the study locations in Awka and Agulu environs (Table 1). From the Table 1, the result shows that the family Asteraceae recorded more nectariferous plant species such as *Ageratum conyzoides* (Fig. 1), *Aspilia africana* (Fig. 2), *Chromolaena odorata* (Fig. 3) and *Pegolettia senegalensis* (Fig. 4). The family Asteraceae (31% and 25%) recorded the highest number of the nectariferous plant species identified in Awka and Agulu environs. The family Euphorbiaceae (9% and 14%) was the second family with high number of the nectariferous plant species such as *Croton hirtus* (Fig. 5), *Euphorbia heterophylla* (Fig. 6) and *Manihot esculenta* (Fig. 7). While the family Malvaceae (7%) being the third family with high nectariferous plants such as *Triumfetta rhomboidea* (Fig. 8), *Sida acuta* (Fig. 9) and *Triumfetta cordifolia* (Fig. 10) was recorded only in Awka. Other families were scantily present in the study areas.

The nectariferous plant species including herbs, shrubs and trees categorized based on presence of nectar, pollen and both nectar and pollen visited by honeybees are presented in Table 2. Eighteen (21.7%) of these plant species were observed to produce nectar only, Six (7.2%) pollen, fifty-eight (69.9%) produced nectar and pollen and one (1.2%) of the plant sources was not defined. 46 (55.4%) of the surveyed nectariferous plant species foraged by the honeybees in the study areas were herbs, 27 (32.5%) were shrubs and the remaining ten (12.1%) were trees. Table 2 also show the African honeybee visitation intensity to the plant species. 35 (42.17%) of the nectariferous plant species were highly visited, 33 (39.76%) were moderately visited and fifteen (18.07%) were least visited by the African honeybees.

Abundance and Distribution of the Identified Plant Species in the Study Areas

The abundance and distribution of the nectariferous plants recorded in Awka and Agulu environs during the survey are represented in Table 2. During the rainy (April and October) and dry (November and March) seasons, in Awka, the identified plant species are more abundant than that identified in the Agulu environs. For instance in Awka, during rainy and dry seasons, a total of 16383 and 9612 were recorded respectively, while in Agulu environs 758 and 258 were recorded for rainy and dry seasons respectively. However, 1589 and 1464 against *Aspilia*

Table 1. The Nectariferous plant species attractive to *Apis mellifera adansonii* in Awka and Agulu environs, southeast, Nigeria

Family	Common name	Scientific name	Plant sources		Plant type	Intensity
			Nectar	Pollen		
Asteraceae	Bristly starbur	*Acanthospermum hispidum*	N	-	H	+++
Asteraceae	Goat weed	*Ageratum conyzoides*	N	P	H	++++
Asteraceae	Haemorrhage weed	*Aspilia africana*	N	P	H	++++
Asteraceae	White flowered haemorrhage	*A. bussei*	N	P	H	+++
Asteraceae	Cobblers pegs	*Bidens pilosa*	N	P	H	+++
Asteraceae	Siam weed	*Chromolaena odorata*	N	P	H	++++
Asteraceae	Cosmos	*Cosmus sulphurens*	-	P	S	++++
Asteraceae	Yellow tassel flower	*Emilia coccinea*	N	P	H	+++
Asteraceae	Sunflower	*Helianthus annuus*	N	P	S	++++
Asteraceae	-	*Pegolettia senegalensis*	N	P	H	++++
Asteraceae	Coat buttons	*Tridax procumbens*	N	P	H	++++
Asteraceae	Iron weed	*Vernonia ambigua*	N	P	H	++++
Asteraceae	Bitter leaf	*V.amygdalina*	N	P	S	++++
Asteraceae	Little Iron weed	*V.cinerea*	N	-	H	+++
Acanthaceae	Chinese violet	*Asystasia gangetica*	N	P	H	+++
Amaranthaceae	Creeping cock's comb	*Pupalia lappacea*	N	P	H	+++
Amaranthaceae	Globe amaranth	*Gomphrena globosa*	N	P	H	+++
Amaranthaceae	Purple princess	*Cyathula prostrate*	N	-	H	+++
Anacardiaceae	Mango	*Mangifera indica*	N	P	T	++++
Annonaceae	African pepper	*Xylopia aethiopica*	N	P	T	++++
Arecaceae	African fan palm	*Borassus aetheopum*	N	-	T	++++
Caesalpiniaceae	Japanese tea	*Chamaecrista mimosoides*	N	P	S	+++
Caesalpiniaceae	Negro coffee	*Senna occidentalis*	N	P	S	+++
Caricaceae	Pawpaw	*Carica papaya*	N	P	T	++++
Clusiaceae	Harungana	*Harungana madagascariensis*	N	-	T	++++
Capparidaceae	Chicken weed	*Cleome viscosa*	N	P	H	++
Commelinaceae	Spreading day flower	*Commelina diffusa*	N	P	H	+++
Commelinaceae	Wandering jaw	*C. benghalensis*	N	-	H	+++
Cucurbitaceae	Melon	*Citrullus vulgaris*	N	P	H	+++
Cucurbitaceae	Water melon	*C. lanatus*	N	P	H	+++
Cucurbitaceae	Sponge plant	*Luffa cylindrica*	N	P	H	++++
Cucurbitaceae	Fluted pumpkin	*Cucurbita maxima*	N	P	H	++++
Combretaceae	Bush willows	*Combretum spp.*	N	P	S	++++
Combretaceae	Terminalia	*Terminalia glaucoscens*	N	P	S	++
Combretaceae	Terminalia	*T. muntari*	N	P	S	+++
Convolunlaceae	Malayalam	*Hewittia sublobata*	N	-	H	++
Euphorbiaceae	Croton	*Croton hirtus*	N	-	S	++
Euphorbiaceae	Chaya	*Cnidoscolus aconitifolus*	N	P	S	++
Euphorbiaceae	Japanese poinsettia	*Euphorbia heterophylia*	N	P	H	+++
Euphorbiaceae	Physic nut	*Jatropha gossypiifolia*	N	P	S	+++
Euphorbiaceae	Euphorbia	*Phyllanthus discoidens*	N	-	T	++
Euphorbiaceae	Cassava	*Manihot esculenta*	N	-	H	++++
Euphorbiaceae	Mallotus	*Mallotus subulatus*	N	P	S	+++
Euphorbiaceae	Castor oil	*Ricinus communis*	N	P	S	++++
Fabaceae	Giant sensitive plant	*Mimosa invisa*	N	P	S	+++
Fabaceae	White lead tree	*Leucaena leucocephala*	N	P	S	+++
Fabaceae	Schrankia	*Schrankia leptocarpa*	N	P	S	++++
Fabaceae	Ear leaf acacia	*Acacia auriculiformis*	N	P	T	++++
Lamiaceae	Pignut	*Hyptis suaveolens*	N	P	H	++
Lamiaceae	Dalziel	*Plastostoma africanum*	N	P	H	++++

Table 1. Continued

Family	Common name	Scientific name	Plant sources		Plant type	Intensity
			Nectar	Pollen		
Longaniaceae	Worm bush	*Spigelia anthelmia*	N	P	H	+++
Melastomataceae	Osbeckia	*Osbeckia tubulosa*	N	P	H	++
Melastomataceae	Melastomastra	*Melastomastrum capitatum*	N	P	H	+++
Malvaceae	Triumfetta bur	*Triumfetta rhomboidea*	N	P	S	+++
Malvaceae	Sida	*Sida garckeana*	N	P	S	++++
Malvaceae	Broomweed	*S.acuta*	N	P	H	++++
Malvaceae	Hibiscus bur	*Urena lobata*	N	P	H	+++
Malvaceae	Bur weed	*Triumfetta cordifolia*	N	P	S	++++
Musaceae	Banana	*Musa sapientum*	N	-	H	++++
Myrtaceae	Guava	*Psidium guajava*	N	P	S	++++
Onagraceae	Water primrose	*Ludwigia decurrens*	N	-	H	+++
Onagraceae	Water primrose	*L. abyssinica*	N	-	H	+++
Papilionaceae	Hairy indigo	*Indigofera hirsuta*	N	P	S	+++
Papilionaceae	Rattlepod	*Crotalaria retusa*	-	-	S	++
Portulacaceae	Water leaf	*Talinum triangulare*	-	P	H	+++
Poaceae	Maize	*Zea mays*	-	P	H	++++
Poaceae	Guinea grass	*Panicum maximum*	-	P	H	++++
Rubiaceae	Guinea Peach	*Sarcocephalus latifolius*	N	P	S	++++
Rubiaceae	Brimstone tree	*Morinda lucida*	-	P	T	++
Rubiaceae	Small squareweed	*Mitracarpus villosus*	N	P	H	+++
Rubiaceae	Calycose millegrains	*Oldenlandia lancifolia*	N	P	H	++
Rutaceae	Orange	*Citrus sinensis*	N	-	T	++++
Solanaceae	Prickly solanum/ thorn apple	*Solanum torvum*	N	P	S	++
Solanaceae	Schwenkia	*Schwenkia americana*	N	P	H	++
Solanaceae	Wild cape	*Physalis angulata*	N	P	H	+++
Sterculiaceae	Sleepy morning	*Waltheria indica*	N	-	H	++
Tiliaceae	Bolo bolo	*Clappertonia ficifolia*	N r	P	S	++++
Urticaceae	Tropical wattle weed	*Laportea aestuans*	-	P	H	++
Verbenaceae	Teak	*Tectona grandis*	N	P	T	++++
Verbenaceae	False vervain	*Stachytarpheta cayennensis*	N	P	H	++++
Verbenaceae	Bastard vervain	*S.jamaicensis*	N	P	H	+++
Verbenaceae	Shrub verbena	*Lantana camara*	N	P	S	+++
Verbenaceae	Blue vervain	*Verbena hastate*	N	P	H	+++

Keys: -=Source not defined; ++++=Higher visitation; +++=Moderate visitation; ++=Least visitation

africana, 2878 and 1670 for *Tridax procumbens* and 4372 and 3164 for *Pegolettia senegalensis*, were recorded as compared to the abundance of the plant species recorded in the other study areas as shown in Table 2. In the study areas in Agulu environs, 131 and 91 recorded for *Helianthus annuus* and 39 and 32 for *Hyptis suaveolens* were the most recorded abundance plant species in the rainy and dry seasons respectively.

The diversity index trends for the nectariferous species sampled in Awka and Agulu Environs during the study period were recorded and are presented in Table 3. In Awka, the Apiary, Emelda Hostel, and Library areas recorded the highest diversity (Shannon's Wiener Index) of plant species and richness values of 2.25 (25), 2.21 (19) and 2.17 (14) respectively in the rainy season, while in the Agulu environs, Amatutu and Agulu lake areas recorded 2.36 (17) and 2.09 (12) for plant species diversity and richness values respectively. In the dry season, in Awka, Emelda hostel area recorded a relatively high diversity value of 1.98 and richness value of 12, whereas Ifite, Awka recorded a relatively low diversity value of 0.97 and richness value of 6.

Table 2. The Abundance and relative frequency of the plants species identified in quadrant in the studied areas in Awka and Agulu environs in the rainy and dry seasons

Plant Species	Awka						Agulu									
	AP	EH	FE	LIB	UP	IF	Seasons				Ama-tutu	Agulu-Lake	Seasons			
							Rainy		Dry				Rainy		Dry	
							ABD	RF(%)	ABD	RF(%)			ABD	RF(%)	ABD	RF(%)
Aspilia africana	+	+	+	+	+	_	1589	86	1464	86	+	_	31	50	18	50
Acanthospermum hispidum	_	_	_	_	_	_	_	_	_	_	+	_	2	50	_	_
Mallotus subulatus	_	_	_	_	_	_	_	_	_	_	+	+	3	100	3	100
Harungana madagascariensis	+	+	_	_	_	_	23	29	-	-_	_	_	_	_	_	_
Tridax procumbens	+	+	+	_	_	+	2878	57	1670	57	_	_	_	_	_	_
Citrullus vulgaris	_	_	_	_	_	_	_	_	_	_	+	_	10	50	_	_
Stachytarpheta cayennensis	+	+	_	_	+	_	320	57	-	-	_	_	_	_	_	_
Crotalaria retusa	_	_	_	_	_	_	_	_	_	_	+	_	8	50	_	_
Jatropha gossypiifolia	_	_	_	_	_	_	_	_	_	_	_	+	5	50	_	_
S. jamaicensis	+	_	_	_	_	_	91	29	-	-	_	_	_	_	_	_
Sida garckeana	+	_	_	_	+	_	348	29	158	29	+	_	69	50	_	_
S. acuta	+	_	_	_	+	_	162	29	-	-	_	_	_	_	_	_
Spigelia anthelmia	+	_	+	+	_	_	447	43	-	-	_	_	_	_	_	_
Emilia coccinea	+	+	_	+	_	_	139	43	107	43	_	_	_	_	_	_
Ageratum conyzoides	+	_	_	+	+	_	250	57	67	14	_	+	27	50	_	_
Hyptis suaveolens	_	_	_	_	_	_	_	_	_	_	_	+	39	50	32	50
Plastostoma africanum	+	_	+	_	_	_	286	26	112	14	_	_	_	_	_	_
Pegolettia senegalensis	+	+	+	+	+	+	4372	100	3164	100	_	+	46	50	21	50
Gomphrena globosa	+	_	+	_	_	_	141	43	-	-	_	_	_	_	_	_
Sarcocephalus latifolius	+	_	_	_	_	_	8	14	-	-	_	_	_	_	_	_
Vernonia cinerea	+	_	+	+	+	_	479	71	252	57	_	+	21	50	11	50
Helianthus annuus	_	_	_	_	_	_	_	_	_	_	_	+	9	50	_	_
V. ambigua	+	_	_	+	_	_	868	29	1257	29	_	_	_	_	_	_
V. amygdalina	_	_	_	_	_	_	_	_	_	_	+	_	_	_	33	50
Mitracarpus villosus	+	_	_	_	_	+	66	29	-	-	+	_	15	50	_	_
Melastomastrum capitatum	+	+	_	_	_	_	82	43	-	-	_	_	_	_	_	_
Zea mays	+	_	+	_	_	_	535	43	-	-	_	_	_	_	_	_
Senna occidentalis	+	_	_	_	_	_	2	14	-	-	+	_	4	50	3	50
Pupalia lappacea	_	_	_	_	_	_	_	_	_	_	_	+	9	50	_	_
Schwenkia americana	+	_	_	_	_	_	119	14	68	14	_	_	_	_	_	_
Verbena hastate	_	_	_	_	_	_	_	_	_	_	+	_	43	50	_	_
Triumfetta cordifolia	+	_	_	_	_	_	128	29	61	29	_	_	_	_	_	_
Urena lobata	+	_	_	_	_	_	123	29	74	29	_	_	_	_	_	_
Cyathula prostrate	+	_	_	_	_	_	106	14	-	-	_	_	_	_	_	_
Manihot esculenta	+	_	_	+	_	_	100	29	-	-	_	_	_	_	_	_
Musa sapientum	_	_	+	_	_	_	5	14	1	14	+	_	50	50	10	50
Talinum triangulare	_	+	_	_	_	_	165	14	25	14	_	_	_	_	_	_
Croton hirtus	_	+	_	+	_	_	240	29	-	-	_	_	_	_	_	_
Physalis angulata	_	+	+	_	_	_	11	29	-	-	+	_	15	50	_	_
Chamaecrista mimosoidea	_	+	+	_	_	_	153	43	-	-	+	_	5	50	_	_
Clappertonia ficifolia	_	+	_	_	_	_	156	14	27	14	_	_	_	_	_	_
Triumfetta rhomboidea	_	+	_	_	_	_	28	14	5	14	_	+	31	50	26	50
Euphorbia heterophylla	_	+	+	+	_	_	254	43	172	43	_	_	_	_	_	_
Schrankia leptocarpa	_	+	_	+	+	_	1080	43	456	43	+	_	36	50	_	_
Ludwigia decurrene	_	+	+	_	_	_	24	29	10	29	_	_	_	_	_	_
L. abyssinca	_	+	+	_	_	_	19	29	8	29	_	_	_	_	_	_

Table 2. Continued

Plant Species	Awka						Agulu									
	AP	EH	FE	LIB	UP	IF	Seasons				Ama-tutu	Agulu-Lake	Seasons			
							Rainy		Dry				Rainy		Dry	
							ABD	RF(%)	ABD	RF(%)			ABD	RF(%)	ABD	RF(%)
Aspilia bussei	_	+	+	_	_	_	62	29	-	-	_	_	_	_	_	_
Waltheria indica	_	+	_	_	_	_	10	14	-	-	_	_	_	_	_	_
Chromolaena odorata	+	+	+	_	_	_	_	_	409	57	_	_	_	_	_	_
Commelina diffusa	_	_	_	_	+	+	80	29	_	_	_	_	_	_	_	_
C. benghalensis	_	_	_	_	_	+	41	14	_	_	_	_	_	_	_	_
Panicum maximum	_	_	_	_	+	_	5	14	_	_	_	_	_	_	_	_
Xylopia aethiopia	_	_	_	+	_	_	62	29	14	14	_	_	_	_	_	_
Ricinus communis	_	_	_	+	_	_	4	14	2	29	_	_	_	_	_	_
Bidens pilosa	_	_	_	+	_	_	49	14	-	-	_	_	_	_	_	_
Asystasia gangetica	_	_	_	_	_	_	104	14	-	-	_	_	_	_	_	_
Solanum torvum	_	_	+	_	_	_	13	29	9	29	_	_	_	_	_	_
Psidium guajava	_	_	+	_	_	+	7	29	5	29	_	_	_	_	_	_
Cleome viscose	_	_	_	_	_	+	20	14	-	-	_	_	_	_	_	_
Combretum sp	_	_	_	_	_	+	27	14	_	_	_	_	_	_	_	_
Citrus sinensis	_	_	_	_	_	+	3	14	3	14	_	_	_	_	_	_
Lantana camara	_	_	_	_	_	+	36	14	8	14	+	+	92	100	10	50
Laportea aestuans	_	_	_	_	_	+	25	14	_	_	_	_	_	_	_	_
Morinda lucida	_	_	_	_	_	+	1	14	_	_	_	_	_	_	_	_
Luffa cylindrical	_	_	_	_	_	+	21	14	_	_	_	_	_	_	_	_
Mallotus subulatus	_	_	_	_	_	+	3	14	2	14	_	_	_	_	_	_
Cucurbita maxima	_	_	_	_	_	+	11	14	-	-	+	_	56	50	_	_
Phyllanthus discoidens	_	_	_	_	_	+	2	14	2	14	_	+	10	50	_	_
Total							16383		9612				758		258	

Keys: AP=Apiary station of Zoology Department; EH=Emelda Hostel area; UP=Unizik Primary School area; LIB=Library area; FE=Faculty of Engineering area; IF=?Ifite, Awka; ABD=Abundance; RF=Relative frequency; _ =Not present; + = present

DISCUSSION

A total of 83 nectariferous plant species grouped into 31 families were identified in this study in the Southeast, Nigeria. 35 nectariferous plant species such as *Acacia auriculaeformis*, *Aspilia africana, Ageratum conyzoides, Mangifera indica, Tectona grandis, Tridax procumbens, Vernonia amygdalina, Zea mays, Carica papaya, Manihot esculenta, Luffa cylindrical, Musa sapientum, Sida acuta, Urena lobata, Citrus sinensis, Chromolaena odorata, Talinum triangulare, Cucurbita maxima, Chamaecristis mimosoides, Cleome viscose, Crotalaria retusa, Jathropa gossypiifolia, Physalis angulata, Psidium guajava, Ricinus communis, Sarcocephallus latifolius, Solanum torvum, Parkia biglobosa, Triumfetta cordifolia, Cosmus sulphurens, Ludwigia decurrens, Borassus aetheopum, Senna occidentalis, Watheria indica and Combretum* sp, were also reported in the Sudan Savannah, guinea savannah and tropical rainforest of southwest and South-south of the vegetative zones of Nigeria (Omoloye and Akinsola, 2006; Mbah and Amao, 2009; Ebenezer and Olugbenga, 2010; Abdullahi *et al*., 2011; Abel and Banjo, 2012; Nnamani and Uguru, 2012; Dukku 2013). Other nectariferous plant species such as *Harungana madagascariensis, Plastostoma africanum, Pegoletia senegalensis, Spigelia anthelmia, Panicum maximum, Vernonia ambigua, Commelina diffusa, C. benhalensis, Xylopia aethiopia* and *Stachytarpheta jamaicensis* are being reported for the first time as the major plants visited by the African honeybees in Nigeria. The availability of

Table 3. Diversity index of the plant species in the study areas during the rainy and dry seasons

	Awka					Agulu		
Nectariferous plant species diversity index	AP	EH	FE	LIB	UP	IF	AM	AL
Rainy Season								
Number of taxa (S)	25	19	17	14	10	16	17	12
Number of individual (N)	6943	1730	2239	1334	1621	691	342	416
Shannon Wiener Index (H^l)	2.25	2.21	1.75	2.17	1.86	1.86	2.36	2.09
Evenness (E)	0.70	0.75	0.62	0.82	0.81	0.67	0.83	0.84
Dominance (D)	0.16	0.15	0.26	0.15	0.21	0.27	0.11	0.16
Dry Season								
Number of taxa (S)	11	12	11	7	5	6	6	8
Number of individual (N)	4773	655	1604	453	665	262	105	225
Shannon wiener Index (H^l)	1.62	1.98	1.47	1.60	1.40	0.97	0.81	1.72
Evenness (E)	0.67	0.79	0.61	0.82	0.86	0.54	0.45	0.83
Dominance (D)	0.22	0.18	0.30	0.23	0.30	0.47	0.26	0.23

Keys: AP=Apiary station of Zoology Department; EH=Emelda Hostel area; UP=Unizik Primary School area; LIB=Library area; FE=Faculty of Engineering area; IF=Ifite, Awka

Fig. 1. *Ageratum conyzoides* (Asteraceae).

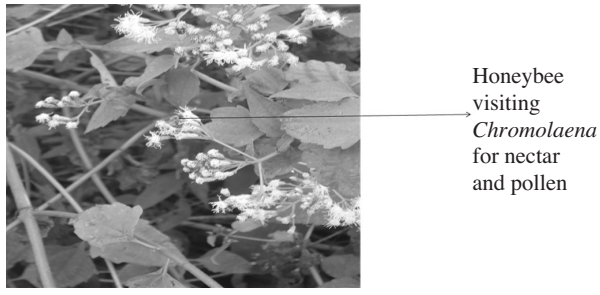

Fig. 2. *Chromolaena odorata* (Asteraceae).

Fig. 3. *Pegolettia senegalensis* (Asteraceae).

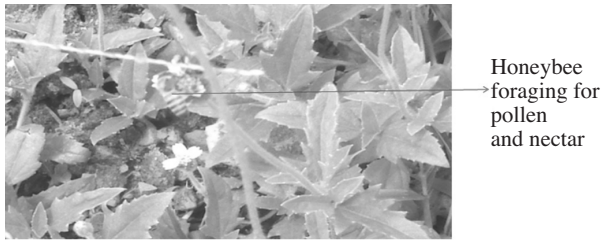

Fig. 4. The African honeybee foraging on *Tridax procumbens* (Family: Asteraceae).

these nectariferous plant species in the study areas as an important biological resources in beekeeping practices as they produce nectar and pollen, the food source of honeybees is in agreement with the aforementioned authors as well as Sanford (2003), Grozeva and Budakov (2010), who reported that nectariferous plants provide food, for honeybees in the form of nectar and pollen. No wonder, Akunne (2011) reported of having bumper yield of honey from Apiary of the Department of Zoology, Nnamdi Azikiwe University, Awka due to the presence of these nectariferous plants in the site. The high result obtained on the number of the plant species that produced nectar alone and both nectar and pollen is an indication that honeybees's colony performance and productivity in the Southeastern zone of Nigeria will be sustained.

Fig. 5. *Vernonia amygdalina* (Asteraceae).

Fig. 7. *Combretum* sp (Combretaceae).

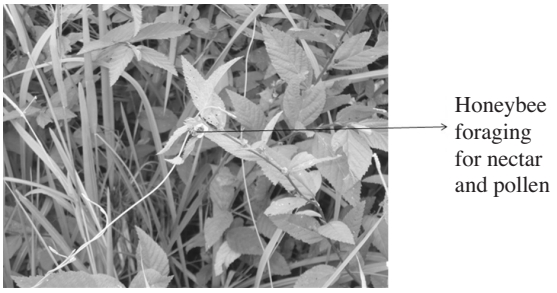

Fig. 9. *Sida acuta* (Malvaceae).

Fig. 11. *Zea mays* (Poaceae).

Fig. 6. African honeybee (*Apis mellifera adansonii*) foraging on *Harungana madagascariensis* (Clusiaceae).

Fig. 8. *Platostoma africanum* (Lamiaceae).

Fig. 10. *Musa sapientum* (Musaceae).

Generally, the honeybees's visitation and exploitation of the plant species varied from one plant species to another as shown in the result, thus making some of the plant species to be identified as highly visited, some moderately visited and least visited. For instance plant species such as *Ageratum conyzoides, Aspilia africana, Chromolaena odorata, Pegolettia senegalensis, Tridax procumbens, Vernonia ambigua, V. amygdalina, Harungana madagascariensis, Combretum* sp and *Manihot esculenta* are highly visited and exploited by the African honeybees in the study areas, *Cleome viscose*, *Terminalia glaucoscens* and *Hewittia sublobata*, are moderately visited by the African honeybees.

The family Asteraceae has the highest number of species across the study areas in Awka and Agulu environs in South-east of Nigeria, it is in contrast to the findings of Mbah and Amao (2009) in Northwest, Nnamdi and Uguru (2011) in South-south and Dukku (2013) in Northeast of Nigeria, who reported that Leguminosae, Euphorbiaceae and Fabaceae were the most predominant respectively.

The abundance and distribution of the nectariferous plant

species was higher in the rainy season than the dry season. In Awka environs, during the rainy and dry seasons, more of the plant species were recorded than Agulu environs, yet among the study sites in Awka, the Apiary section recorded more of the nectariferous plant species richness than other areas. This may explain why the section is chosen for apicultural practices, which according to Akunne (2015) stated that apiaries should be located in areas with abundant pollen and nectar producing plants. Rodinov and Shabanshor (1986) noted that slight variations in nectar resources across areas are common, and this may not pose a serious challenge to profitable apiculture.

The result also showed that during the dry season Agulu Lake Site in Agulu environ had more plant species diversity and richness than Amatutu area. This also supports Akunne (2015) who reported that the availability of water is prerequisites for setting apiary. However, the high diversity and distribution of foraging sources as recorded in Awka and Agulu environs, in this study provide the necessary good environment for the beekeeping since pollen and nectar are in abundance.

Having these vegetative qualities, Awka and Agulu environs, show good indication for beekeeping as a cottage industry for honey production and farmers will enjoying bumper crop harvest due to adequate pollination. It is pertinent to recommend that many of the nectariferous plant species that abound in these areas be conserved for foraging resources of the African honeybees through extensive cultivation and propagation. The areas in which this research was carried out, for instance Apiary section and Agulu Lake areas should be demarcated and safeguarded as 'bee sanctuaries for African Honeybees'.

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