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POTENTIALS OF PALYNOTAXA FOR APICULTURAL ENTREPRENEURSHIPS: IMPLICATION FOR CONSERVATION AND POLICY

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ABSTRACT

The contemporary global economic meltdown has devastating effect on the economy of most rural people in Africa in general and Nigeria in particular. The frantic search for alternative source of national revenue aside from oil and gas has become imperative for economic emancipation of Nigerians. Knowledge of plants foraged by bees for pollen and nectar becomes a panacea to this challenge. This study analysed the pollen spectrum of four honey samples collected from Southern Nigeria in order to determine the richness of the honey plants in the area, and to highlight the potential of these species in apicultural entrepreneurship in Nigeria for green growth economy, using Shannon-Wiener Diversity Index after a standard acetolysis method. A total number of 39 palynotaxa belonging to 21 plant families and distributed in 39 genera were identified. Fabaceae had the highest plant species (11 species), followed by Euphorbiaceae (5 species). The study revealed that *Elaeis guineensis* Jacq, *Anacardium occidentale* L. *Diospyros mespiliformis* Hochist e*x* ADC, *Alchornea cordifolia* (Muell)Arg, *Daniella oliveri* (Rolfe) Hutch & Dalz, *Irvingia wombolu* Okafor *ex* Baill, *Treculia africana* Decne, *Nauclea latifolia* Smith and *Crossopteryx febrifuga* Afzil *ex* Benth, were the dominant honey plants. The palynotaxa spectrum did not vary greatly in the four samples; however, Shannon diversity index was low to moderate (H= 2.7 -3.1). This baseline information has provided opportunity and amazing potentials for apicultural enterprise in these areas. However, most of these honey plants are rare, threatened and endangered. This calls for urgent conservation strategies by all players. Policy programmes could increase production and productivity of hive products through capacity- building for local populace.

Key words: Palynology; honey plants; enterprise; income generation; Nigeria
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INTRODUCTION

The world honey production shows that approximately 600,000 metric tons are produced yearly, and on the average, about 50 million hives (64%) coming especially from developing countries are owned by non-commercialised small- scale farmers in local communities. Of interest too is the fact that the total value of honey exported by these developing countries cannot compare with that from developed countries because of the methods of harvest and lack of commercialised practices. Beekeeping for honey production is a profitable agricultural venture in all parts of the world. it also served as an important source of foreign exchange. It is equally critical for the attainment of food security, as about 80% of all agricultural crops are pollinated by this insect (Ja'Afarfuro, 2007; Ayansola, 2012).

As a promising economic activity for the rural and semi-rural communities, where most households are living below standard, it directly and indirectly contributes to the income- generating options of these households and could rightly contribute to sustainable livelihood of the people through output-products such as honey, beeswax, queen and bee colonies, honey wine, pollen meals, royal jelly, bee venom and propolis used in cosmetics and medicine (Gazahegn, 2001). Indirectly, it is an eco-friendly practice that provides channels for plant pollination, natural resource conservation and employment opportunities. Apiculture in African countries and indeed Nigeria is still practised as a hobby or as an additional source of income for the rural and resource-poor farmers. These people do this by harvesting honey from tree hollows, earthen pots hung on trees, or from logs of woods. Regrettably, apiculture as a commercial endeavour is still largely under exploited in Nigeria and the country meets its domestic demand for honey mostly by importation.

However, Nigeria is known as a rich biodiversity hotspot zone in Africa, as a result of its position within the tropical rainforest vegetation belt. A cursory look at the diversity of useful plant genetic resources in some African countries shows an estimated diversity of 2,090; 4,614; 2,200; 1,000; 3,600; 974 and 774 valuable flora in Sierra-Leone, Nigeria, Liberia, Guinea-Bissau, Ghana, Gambia and Cape Verde, respectively (Adebooye and Opabode, 2004).

In this 21st century, skill acquisition, value-addition and development are critical enablers for sustainable development goals, youth empowerment and wealth creation. Ajao and Oladimeji (2013) stated that the current global economic meltdown has had its devastating turn on Nigeria as a nation, biting hard on organisations, businesses, families and homes. The frantic search for alternative sources of revenue aside from oil has become imperative for economic emancipation of the lots of Nigerians. Agriculture and biotechnology including beekeeping offer unexploited succour capable of salvaging the people from abject hunger and poverty.

Creating renewed awareness and practice of beekeeping in the rural settings could go a long way in mitigating some of the economic challenges in the country. Microscopic analysis of honey known as melissopalynology, allows the identification and characterisation of pollen and nectar sources foraged by bees over the seasons for the production of honey. It is useful in finding out whether there are significant differences in the pollen composition of honey samples, their seasons of production, quantity and quality of the honey samples. It also facilitates the establishment of flowering calendar of different species and could also help in diagnosing the presence of plants poisonous to bees. Costa *et al.* (2013) and Oliveira *et al.* (2010) in support of the above, noted that melissopalynology is extremely useful for hive management and it allows the identification of likely plant genetic resources foraged by bees for the production of honey which beekeepers do not have information and/or knowledge of.

Furthermore, palynological analysis of honey contributes to landscape management via habitat conservation and the mitigation of predicted climate variability and changes. Current vegetation patterns are the result of complex interactions over many years and pollen analysis could supply longer-term view of changes on their management.

The analysis of honey for the identification of vital honey flora could contribute to sustainable development of apicultural entrepreneurship and alleviate the livelihood options of the teeming youths in Nigeria. Consequently, data from this analysis could be a useful guide to beekeepers, conservationists and policy in Nigeria. The major aim of this study was to analyse the pollen spectrum of four honey samples collected from Southern Nigeria in order to determine the diversity and the richness of the honey plants in these areas and to highlight the potentials of these species in apicultural entrepreneurship in Nigeria for green growth economy. The main objectives of this study were to (i) access the pollen spectrum of four honey samples from Nigeria, (ii) determine the diversity and richness of the honey plants using Shannon-Winner Index and (iii) to highlight the potentials of these species in apicultural entrepreneurship in Nigeria for green growth economy and the need for conservation.

MATERIALS AND METHODS

Study Area

Nigeria is located within longitudes $5^{o} 30^{1}$ and $9^{o} 30^{1}$ E and latitudes $4^{o} 30^{I}$ and $7^{o} 00^{1}$N, occupying a land area of about 75,488 km^2. According to Iloeje (1999) and Madu (2005), it is situated at the southern borders of the Gulf of Guinea coast on the Atlantic Ocean with precipitation that is received mainly during the Northern hemispheric summer, referred to as the wet season evolving from Moist South-westerly winds from the South Atlantic Ocean prevalent during summer while dry North-easterlies from the Sahara Desert is dominant in the winter (dry season). The confluence zone between both wind systems is the Inter-Tropical Discontinuity (ITD) that largely influences the rainfall (Nwaogu *et al.,* 2017).

Vegetation of the Study Area: In Nigeria there are two broad types of vegetation **-** forest and savanna. These vegetations, though zoned into belts corresponding to the rainfall zones, are still controlled by edaphic, climatic, anthropogenic and geomorphological factors (White, 1983). These vegetation types are characterised by tree species such as *Berlinia confusa, Coula edulis, Hannoa klaineana, Klainedoxa gabonensis, Isoberlinia doka, Brachystegia eurycoma, Uapaca togoensis, Monotes kerstingi, Khaya ivorensis, Harungana madagascariencis Brachystigia* and *Lophira alata (*Andem *et al.,* 2013). While the derived savanna zones are characterised by grasses and the presence of fire-tolerant and fire-sensitive trees such as *Elaeis guineensis, Lannea acida, Nauclea latifolia, Vitex doniana, Anthocliestra djonensis, Newbouldia leavis, Albizia* spp, *Alstonis boonei, Milicia excelsa, Parkia biglobosa, Ceiba pentandra, Antiaris africana, Syzygium guineense, Daniellia oliveri, Alchornea cordifolia, Berlinia grandifolia, Albizzia zygia, Irvingia spp, Hymenocardia acida, Anacardium occidentale, Mangifera indica and Dialium guineense* (Agwu *et al,*.2004). Nigeria is known as a rich biodiversity hotspot zone in Africa, as a result of its position within the tropical rainforest vegetation belt.

Ugep is a small town in Cross River State, southern Nigeria that lies between longitudes 08˚03'40"E and 08˚05'44"E, and latitudes 05˚47'30"N and 05˚48'33"N; occupying a total landmass of about 48 Km^2. It is located in one of the world’s richest biodiversity hotspots in the Lower Guinean Forest, separated from the rest of the Upper Guinean Forest by the Dahomey Gap (Poorter. 2004) having an average temperature of about 27˚C with a long wet season from April to July, interrupted by a short dry period in August and then another short wet season from September to October. Rainfall varies from 2500 mm to 3000 mm annually (Ofomata, 1975).

Sample Collection

Sampling was carried out at four different sites: Ugep in Cross River State, Izzi in Ebonyi State, Orba and Obupka both in Enugu State. All these are located in South- south and South-eastern States of Nigeria, respectively (Figure 1). In these states apiculture is still in its nascent stage; local farmers produce and harvest honey from tree hollows, earthen pots hung on trees, or from logs of woods.

These honey samples were sourced during the major honey-production periods of February to April in 2019 season. A total of four honey samples was sourced from local farmers’ apiaries produced in clay pots hanged on tree branches in the four states. Samples were collected directly from local beekeepers who harvested honey traditionally by squeezing them with their hands to press out the honey from their scattered small hives. These were stored in plastic bottles and transferred to Palynological Research Unit of the Department of Applied Biology, Ebonyi State University Abakaliki, Nigeria where they were kept in freezer until they were ready to be used for acetolysis and microscopy.

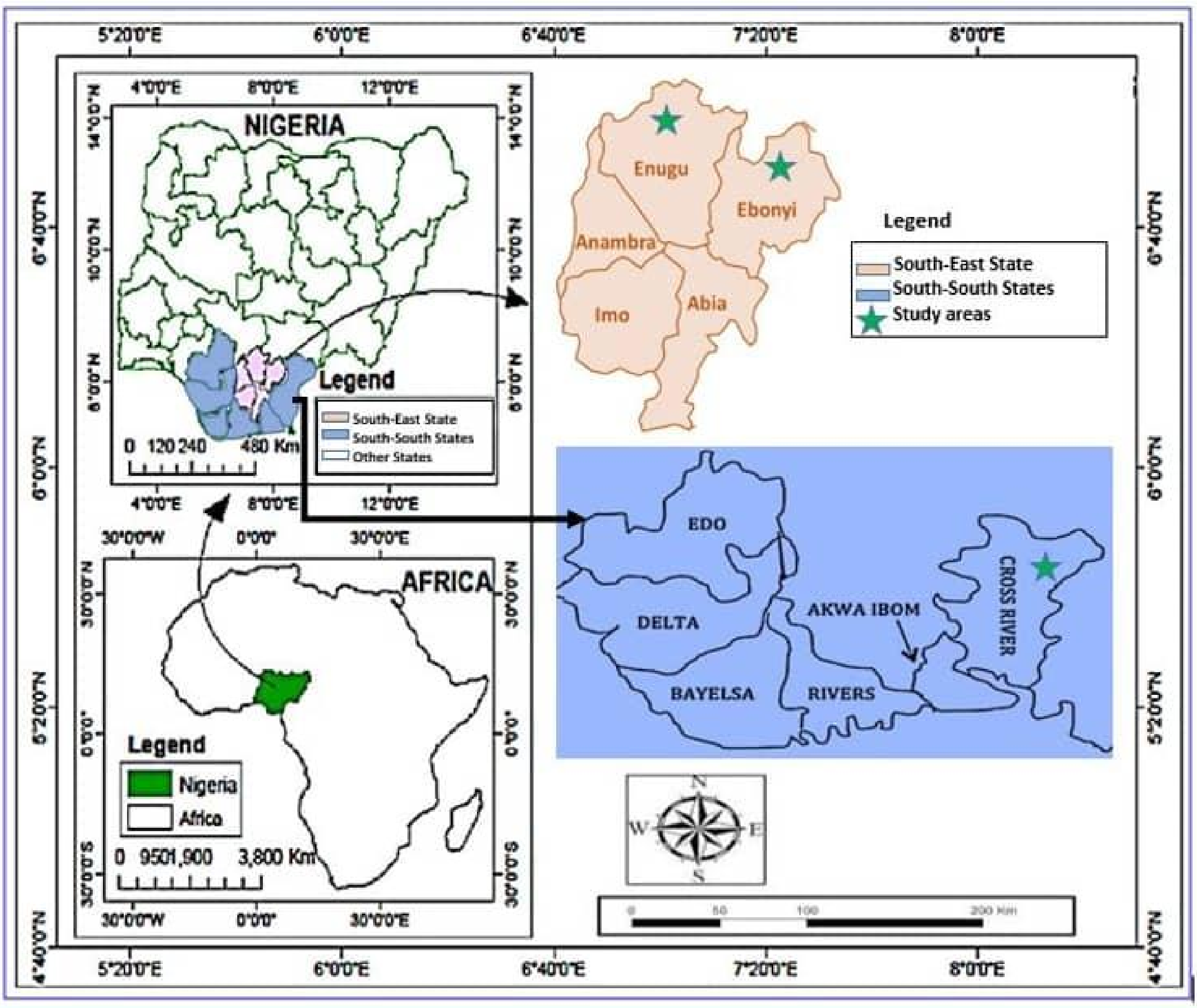

Figure 1: Sample collection sites in Nigeria.
Source: Modified from Nnamani *et al.* (2017)

Preparation of Honey for Pollen Analysis

The four honey samples were vigorously shaken to have a fair distribution of the biological components. Ten (10) grams of each of the samples was weighed out with the aid of Microwa, 7720 sensitive beam balance into well-labeled beakers and diluted with 35 ml of warm dilute sulphuric acid solution (Lieux, 1972). Samples were sieved with thin network of meshed wire gauze to remove unwanted plant tissues. The acidified honey samples were centrifuged for 5 minutes at 2000 revolutions per minute (RPM), decanted and later washed with 5 ml of distilled water. Thirty- five (35) ml of glacial acetic anhydride together with 1 ml of dilute sulphuric acid solution was added to the samples and later centrifuged at 2000 revolutions per minute for 15 minutes. The solutions were decanted to recover the precipitates.

Acetolysis

The recovered precipitates were finally acetolysed using Erdtman (1969) acetolysis method of 9: 1 (conc. sulphuric acid and acetic anhydride solution) with some minor modifications. The precipitates were then boiled in water

bath for 10 minutes at 100°C and centrifuged at 2000 revolutions per minute (RPM) for 5 minutes. They were decanted to recover the precipitates which were later stored in 10 drops of glycerin in plastic vials.

Microscopy

For microscopic study, four slides were prepared from each sample for microscopy. Temporary slides were prepared; pollen grains were mounted in glycerine jelly and examined using light Olympus CH Trinocular microscope (LM) fitted with 650 IS Cannon Digital Camera at x 400 and x 100 magnifications.

Qualitative Analysis

Qualitative pollen analysis referring to pollen spectrum and types were assessed in the four samples and determined based on identification of Ybert (1979) and Sowunmi (2001).

Quantitative Analysis

The quantitative analysis was performed by counting 300 pollen grains on one slide from the replicate samples. Percentages and classes of occurrence were determined according to Louveaux *et al.* (1978) where a percentage count > 45% of the total grains is referred to as the dominant pollen (Dp), accessory pollen (16 to 45%) (Ap), important isolated pollen (3 to 15%) (Iip), and occasional isolated pollen (< 3%) (Oip). The results presented here correspond to the average of four counts. The characteristics regarding the habit (tree, shrub, herbaceous and climber) of the plants related to each pollen type were recorded. The multipurpose uses and status of the predominant honey plants were assessed using Inyang, (2003) and Okafor (2013). Photomicrographs of some of the major honey plants were taken using light Olympus CH Trinocular microscope (LM) fitted with 650 IS Cannon Digital Camera at x400 magnification.

Data Analyses

A diversity index analysis which ensures a mathematical measure of species variety in a given community or sample, species richness standing as the number of species present in that community while the species abundance relates to the number of individuals per species. The more species you have, the more diverse the sample or community. Species diversity in each of the honey samples was calculated using PAST (Paleontological Statistics Software) Package for Education and Data Analysis (Hammer, *et al.,* 2001) in which the Shannon-Wiener Diversity Index (H') was chosen. This method was selected because it provides an account for both abundance and evenness and does not disproportionately favour some species over the others as it counts all species according to their frequencies.

Sample Calculations: The Shannon-Wiener Diversity Index, H, was calculated using the Equation: S H' = -∑ pi ln(pi)i=1, where: H' = Shannon-Wiener diversity index, S = Total number of species in the community, Pi = Proportion of S made up of the ith species, ln = Natural logarithm. If the Diversity index is <1.5, the diversity is low, if the diversity is 1.5 to 2.5 the diversity is medium and if it is >2.5, the diversity is high. Species richness (S) is defined by: = ∑nS, where, n is number of species in a community. Species evenness is often assessed by Shannon's equitability index (H'E) which is calculated by: max = /" HHEH, where, Hmax is defined as ln S. H'E values ranges from 0 to 1, in which 1 indicates complete evenness.

Ethical Statement

No specific permit was required for the described field study and collection of samples. The sampling sites are not protected in any way and the field studies did not involve endangered or protected species and human beings.

RESULTS

Diversity of Honey Taxa in the Four Honey Samples

Table 1 shows the different honey plants recorded in the four honey samples and their relative abundance. A total of 39 honey plants belonging to 20 families (comprising of 19 dicots and 1 monocots) and distributed in 38 genera

were identified excluding other 238 unidentified pollen grains. Of all the species recorded from all the four honey samples, 99% were identified to the species level with just 1% identified to genus level. Of the 20 families of honey plants recorded in this study, the Fabaceae had the highest number of genera (11) and species (11), followed by the Euphorbiaceae with 5 species and 5 genera (Table 1).

Table 1: Species composition of the four honey samples, family, taxa, authority and habit

	Family	Pollen taxa	Authority	Habit
1	Arecaceae	*Elaeis guineensis*	Jacq.	Tree
2	Anacardiaceae	*Spondias mombin*	Linn.	Tree
		Anacardium occidentale	Linn.	Tree
3	Asteraceae	*Ageratum conyzoides*	Linn.	Herb
4	Malvaceae	*Bombax buonopozense*	P. Beauv.	Tree
5	Caricaceae	*Carica papaya* L	Linn.	Tree
6	Combretaceae	*Terminalia glaucescens*	Planch.	Tree
7		*Luffa cylindrica*	M. J. Roem	Climber
8	Chrysobalanaceae	*Parinari curatellifolia*	Planch. ex Benth.	shrub
9	Ebenaceae	*Diospyros mespiliformis*	Hochist	Tree
10	Euphorbiaceae	*Securinega virosa*	(Roxb ex Willie) Baill.	Shrub
		Manihot esculenta	Crantz	Shrub
		Phyllanthus muellerianus	(O. Ktz) Exell.	Shrub
		Alchornea cordifolia	Muell, Arg.	Tree
		Hymenocardia acida	Tul	Shrub
11	Fabaceae	*Isoberlina doka*	Craib & Stapf	Tree
		Albizia zygia	(DC.) Macbr	Tree
		Brachystegia eurycoma	Harms	Tree
		Senna occidentalis	(L.) Link	Shrub
		Dialium guineense	Willd.	Tree
		Daniellia oliveri	(Rolfe) Hutch.	Tree
		Crotalaria retusa	Linn.	Herb
		Senna hirsuta	LINN.	Shrub
		Parkia biglobosa	(Jacq) R. ex Don	Tree
		Erythrina senegalensis	D. C.	Tree
		Tephrosia bracteolata	Guill. &Perr.	Tree
12	Irvingiaceae	*Irvingia wombolu*	Okafor *ex* Baill.	Tree
13	Loganiaceae	*Anthocleista vogelii.*	A. Chev.	Tree
14	Meliaceae	*Azadirachta indica*	Juss.	Tree
		Trichilia spp	-	Tree
15	Moraceae	*Milicia excels*	(Welw) C.C	Tree
		Treculia africana	Decne.	Tree
16	Olacaceae	*Olax subscorpioidea* Oliv.	Oliv	Shrub
17	Proteaceae	*Protea madiensis* Oliv.	Oliv.	Herb
18	Rubiaceae	*Nauclea latifolia*	Smith.	Tree
		Crossopteryx febrifuga	Afzil Benth.	Tree
19	Rutaceae	*Zanthoxylum zanthoxyloides*	Lam	Tree
20	Sapindaceae	*Paullinia pinnata*	Linn.	Climber
21	Verbenaceae	*Vitex doniana*	Sweet.	Tree

Table 2 shows the different honey plants and their relative abundance. The species with the highest number of individuals was *C. febrifuga* (179) with a relative abundance of 15.89 %, followed by *N. latifolia* (131 individuals) and relative abundance of 15.33 %. These two species are from the same family of Rubiaceae

Off the 21 families of honey plants recorded in these four honey samples, only three families, namely Fabaceae, Meliaceae and Sapindaceae were not common with Fabaceae having two species, *Isoberlinia doka* and *D. guineensis; A. indica and Pualinia pinata* belong to the families Meliaceae and Sapindaceae, respectively (Table 2). In the honey sample from Ugep, 38 species were recorded from 21 families and 21 genera. The most abundant species were *E. guineensis* (14.1%) and *I. wombolu* (12.6%) with most other families having only one species representative (Table 2).

In Izzi honey sample, 38 species were recorded from 21 families and 21 genera. The most abundant species were *C. febrifuga* (20.4%) and *N. latifolia* (14.5%) both in the family Rubiaceae while *I. wombolu* had 14.3% abundance recorded from the family Irvingaceae. Other families had only one species representative in this sample (Table 2). Honey sample from Orba had 37 species from 20 families coming from 20 genera. The most abundant species were from *N. latifolia* (18.7 %), followed by *C. febrifuga* (14. 4%) in the family Rubiaceae. The honey sample from Obupka recorded the highest number of 39 species distributed in 21 families and 39 genera with *C. febrifuga* (20.2%) as the most abundant followed by *A. occidentale* (9.8 %). Table 2 shows that *N. latifolia* (15.33%) *and C. febrifuga* (15. 89 %) were the most abundant across the four samples in all the study locations followed by *I. wombolu* (10.6%) in the family Irvingaceae.

Table 2: Species diversity and relative abundance of four honey samples

	Family	Pollen taxa	Ugep	Izzi	Orba	Obupka	R. Abundance
1	Arecaceae	*Elaeis guineensis*	14.1	4.6	8.7	4.3	9.10
2	Anacardiaceae	*Spondias mombin*	0.3	1.3	1.4	1.1	0.93
		Anacardium occidentale	3.7	0.6	5.5	9.8	4.30
3	Asteraceae	*Ageratum conyzoides*	0.9	2.9	2.9	1.1	1.90
4	Malvaceae	*Bombax buonopozenese*	0.9	1.2	0.5	1.6	0.97
5	Caricaceae	*Carica papaya*	0.9	1.4	0.6	3.1	1.22
6	Combretaceae	*Terminalia glaucescens*	0.9	0.7	0.7	1.1	0.83
7		*Luffa cylindrica*	0.7	0.5	0.1	0.7	0.49
8	Chrysobalanaceae	*Parinari curatellifolia*	0.3	0.2	0.5	0.5	0.37
9	Ebenaceae	*Diospyros mespiliformis*	3.0	5.0	4.9	7.3	4.58
10	Euphorbiaceae	*Securinega virosa*	1.0	0.5	0.5	0.8	0.72
		Manihot esculenta	0.2	0.1	1.0	0.1	0.38
		Phyllanthus muellerianus	0.1	0.6	1.8	1.9	0.87
		Alchornea cordifolia	7.0	3.8	5.9	4.8	5.65
		Hymenocardia acida	0.5	0.3	0.2	0.2	0.34
11	Fabaceae	*Isoberlinia doka*	0.1	0.5	0.0	0.2	0.20
		Albizia zygia	0.6	0.3	0.1	0.1	0.33
		Brachystegia eurycoma	0.7	0.7	0.1	0.3	0.48
		Senna occidentalis	0.3	0.4	1.1	1.5	0.73
		Dialium guineense	0.7	0.4	0.0	0.5	0.32
		Daniellia oliveri	7.2	6.5	6.1	5.1	6.47
		Crotalaria retusa	0.2	0.1	0.3	2.4	0.52
		S. hirsute	0.1	0.2	0.9	0.2	0.33

		Parkia biglobosa	0.1	1.2	0.5	0.7	0.55
		Erythrina senegalensis	1.1	1.5	1.2	1.0	1.19
		Tephrosia bracteolate	1.0	2.0	1.0	1.8	1.33
12	Irvingiaceae	*Irvingia wombolu*	12.6	14.3	8.7	2.2	10.56
13	Loganiaceae	*Anthocleista vogelii*	0.2	0.1	0.3	0.7	0.24
14	Meliaceae	*Azadirachta indica*	0.0	0.1	0.3	0.5	0.19
		Trichilia spp	1.5	1.5	1.8	0.8	1.49
15	Moraceae	*Milicia excels*	0.4	0.5	1.0	0.8	0.49
		Treculia africana	4.1	7.3	3.7	4.0	4.74
16	Olacaceae	*Olax subscorpioidea*	0.3	0.2	0.3	1.9	0.48
17	Proteaceae	*Protea madiensis*.	0.7	1.5	0.5	1.1	.88
18	Rubiaceae	*Nauclea latifolia*	16.1	14.5	18.7	8.6	15.33
		Crossopteryx febrifuga	12.4	20.4	14.4	20.2	15.89
19	Rutaceae	*Zanthoxylum zanthoxyloides*	0.3	0.6	0.4	1.7	0.62
20	Sapindaceae	*Paullinia pinnata*	0.4	0.0	0.3	0.7	0.32
21	Verbenaceae	*Vitex doniana*	1.5	0.6	0.9	3.2	1.38
	Unidentified		3.4	0.6	1.7	1.6	2.07
	Total						100

Diversity, richness and evenness of the four honey samples

The Shannon-Weiner Diversity Index (H^1) of evenness and the species richness (d) of the different study sites are shown in Table 3. The honey samples were low to moderate. In terms of evenness, the honey sample from Obupka was most evenly distributed with species evenness value of 0.51 with the least of 0.3 coming from Ugep (Table 3).

Table 3: Diversity, evenness and equitability index of honey plants in the four Honey Samples (10g)

	Ugep	Izzi	Orba	Obupka
Taxa_S	38	38	37	39
Individuals	3398	2212	2380	1321
Shannon_H	2.7	2.7	2.8	3.1
Evenness_e^H/S	0.3	0.40	0.44	0.51
Equitability_J	0.7	0.74	0.77	0.81

Dominant Honey Families and Honey Plants

Data accruing from the analysis revealed some predominant families of these plant genetic resources which are the most frequently foraged by honey bees. These families include Anacardiaceae, Combretaceae, Euphorbiaceae, Fabaceae, Meliaceae, Moraceae and Rubiaceae (Fig. 2). Results showed that some species were the most frequently visited by honey bees. Those plants were *E. guineensis, A. occidentale, D. mespiliformis, A. cordifolia, D. oliveri, I. wombolu, T. africana, N. latifolia* and *C. febrifuga* with *N. latifolia and C. febrifuga* having the highest number of honey pollen % of 20 and 20.73 %, respectively (Fig.2; Plate 1).

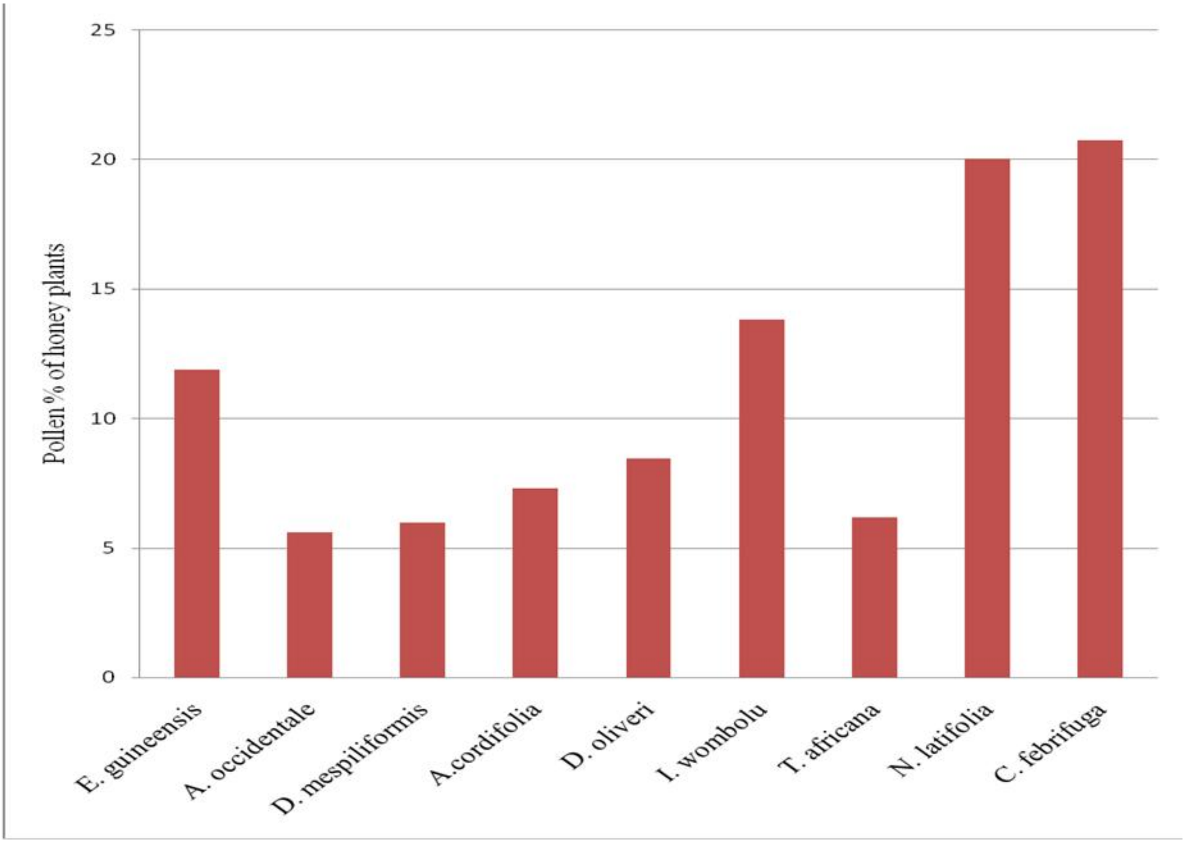

Figure 2: Dominant honey plants in the four honey samples

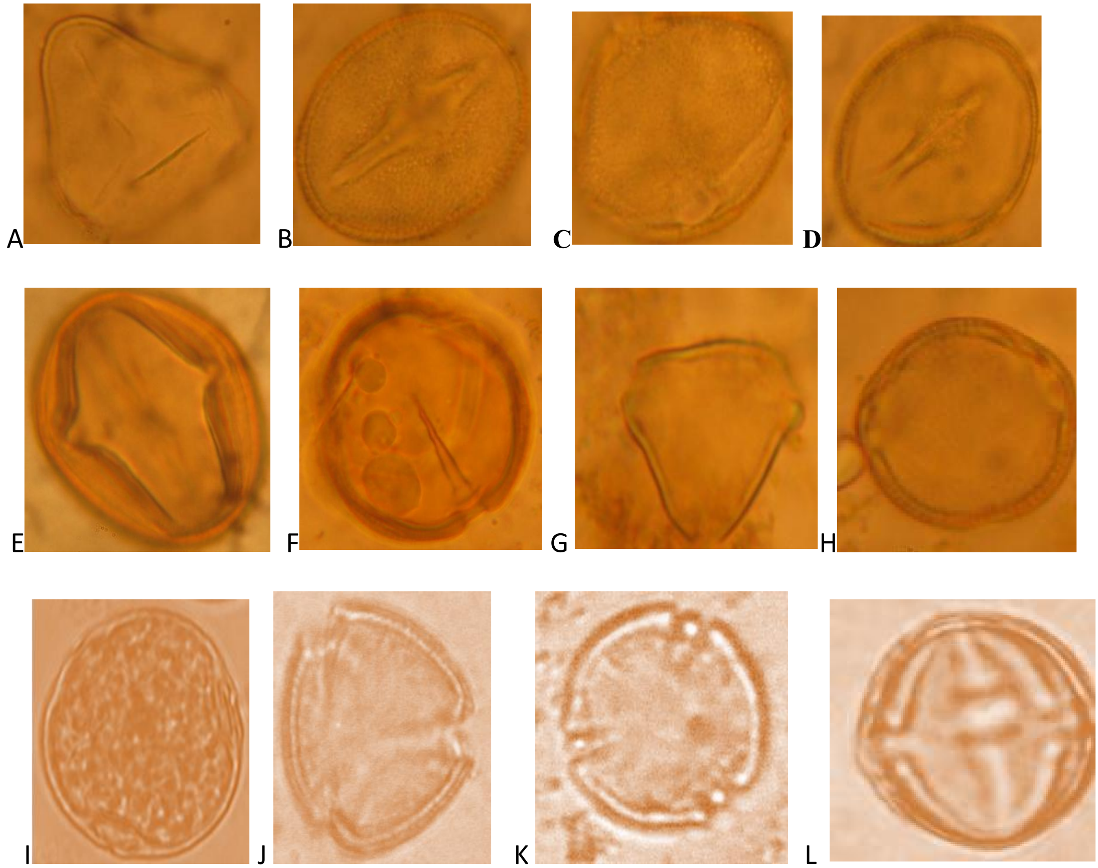

Plate 1: **A= Poaceae** - *Elaeis guineensis* Jacq. **B -D**: **Anacardeceae** - *Anacardium occidentale* L. **E-F: Fabaceae** - *Daniella oliveri* (Rolfe) Hutch & Dalz. **G-H**: **Irvingiaceae** - *Irvingia wombolu* Okafor *ex* Baill. I-J: **Euphorbiaceae** - *Alchornea cordifolia* Muell, Arg. **K: Moraceae** - *Nauclea latifolia* Smith. and **L:** *Crossopteryx febrifuga* Afzil ex Benth. Mag. x40u

Multipurpose Uses of the Dominant Honey Plants in the Four Honey Samples

Results showed other uses, sources and conservation status of these dominant honey plants from Southern Nigeria. They are mostly found in the wild and are prone to environmental threat which could lead to genetic erosion (Table.3).

Table 3: Multicultural uses and status of predominant honey plants in the four honey samples

Pollen Taxa	%	Food	Medicin	Other uses	Sources	Stat
Elaeis guineensis	11.88	+	+	+	C	T
Anacardium occidentale	5.61	+	+	+	C/W	NT
Diospyros mespiliformis	5.97	_	+	+	W	T
Alchornea cordifolia	7.3	_	+	_	W	NT
Daniellia oliveri	8.45	_	+	_	W	NT
Irvingia wombolu	13.79	+	+	+	C/W	NT
Treculia africana	6.19	+	+	+	C/W	T
Nauclea latifolia	20.00	_	+	_	W	NT
Crossopteryx febrifuga	20.73	_	+	_	W	NT

Legend: C= cultivated, W= wild, T=threatened, NT= not threatened, += positive, - = negative

DISCUSSION

This is the first case study of melissopalynological evaluation of honey samples as a prerequisite for apicultural entrepreneurship in Southern Nigeria using four honey samples from Izzi, Ugep, Orba and Obupka as a representation. Findings from this work point to the potentials of apicultural enterprises in these regions. Qualitative palynological analyses in the present study demonstrated rich plant genetic resources, very rich in honey plants with potentials of apicultural enterprise.

A total number of 39 honey plants belonging to 21 families and distributed in 39 genera were identified. This collaborated other studies in various ecological zones of Nigeria where such diversity of honey taxa has been reported in the country. Abdullahi *et al.* (2011) identified 103 species from the Sudan Savanna zone of the Country. Ayansola (2012) reported 49 species from the Tropical Rain Forest and Derived Savanna zones of southwestern Nigeria while Nnamani and Uguru (2013) reported 56 species from Southeastern Nigeria and Adeonipekun (2012) reported 36 species from Lagos samples in Southwest Nigeria. Although these numbers were far above what were recorded from this study, they actually indicate the richness of flora of the study zone. It was interesting to note that this number of palynotaxa was very low when compared to the 82 honey plants belonging to 44 families recovered from 51 honey samples collected from Coastal Districts of Eastern India (Upadhyay and Bera, 2012).

This study indicates that apiculture is an enterprise that could be established with less difficulty as some of the major honey taxa are quite available and accessible in these zones. It will go a long way in ameliorating the migration of youths to the cities in search of white-collar jobs and thereby improve the socio-economic status of the local inhabitants of such regions. This is in line with the report of Upadhyay *et al.* (2014), who noted that initiating apicultural enterprises in regions with high diversity of honey plants such as Coastal Districts of Eastern India could improve the socio-economic status of the local inhabitants. Ayansola (2012) suggested that beekeeping should be encouraged among the people because it could reduce poverty and improve the living standard of the rural farmers. Rodolfo *et al.* (2020) noted that the identification of plants visited by bees is of fundamental

importance for beekeepers because it indicates the food sources used for collecting nectar and pollen, aiding the maximisation of the use of trophic resources, contributing to the implementation and maintenance of local bee pastures for natural vegetation conservation.

Species diversity and richness are said to be rich if it has a Shannon Diversity value ≥3.5. In this study, Shannon-Weiner diversity index values were below 3.5, indicating that all the honey samples were relatively poor in diversity. The honey from Obupka was the most diverse and also the most relatively distributed in evenness than the other honey samples, followed by that from Orba. The most relative abundant species were *Nauclea latifolia, Crossopteryx febrifuga and Anacardium occidentale.* This could be due to the fact that these species have multipurpose values in nature within these communities and as such were relatively undisturbed through anthropogenic factors such as agriculture and cut-down for energy. Two out of the three species belong to the Rubiaceae. This is in conformity with the report by Barbhuiya *et al.* (2014) that Rubiaceae is commonly found distributed across the whole world except Antarctica and that the family has been reported to exhibit high species diversity and richness proliferation from low to mid-altitude in humid forests (Davis *et al.,* 2009). Secondly, these plants, for example *Nauclea latifolia, and Crossopteryx febrifuga, flower profusely.*

The re-occurrence of some floral families during the analysis at the percentage count > 45% of the total pollen grain was of great interest to the establishment of apicultural entrepreneurship in this country (Louveaux *et al.,* 1978). Most of these honey plants are of continental importance since they are distributed throughout the study zones. These families include Anacardiaceae, Combretaceae, Euphorbiaceae, Fabaceae, Meliaceae, Moraceae and Rubiaceae, contributing the highest taxa and honey pollen (Fig.2). This is in conformity with the report by Adeonipekun (2012), who reported the presence of Fabaceae and Meliaceae from some honey samples collected from Southwestern Nigeria. Nnamani and Uguru (2013) reported the dominant presence of Anacardiaceae, Euphorbiaceae, Fabaceae, Moraceae and Rubiaceae in the honey samples collected from Southeast Nigeria.

Knowledge about these identified dominant honey families could help apiculturists set up their hives where these families are more dominant. Dearth of information on the availability of these peculiar honey plant families could hamper apicultural productivity coupled with its attendant fruitless efforts and resource wastage. Ajao and Oladimeji (2013) reported that in tropical Africa, local beekeepers exploit scattered plant genetic resources by moving from one area to another in search of location for their hives, resulting in situations where some hives remain empty for most part of the year especially under adverse weather conditions.

E. guineensis, A. occidentale, D. mespiliformis, A. cordifolia, D. oliveri, I. wombolu, T. africana, N. latifolia and *C. febrifuga were the dominant* honey plants frequently visited by honey bees for their pollen and nectar (Fig. 2; Plate 1). These plants flower profusely during their flowering periods and have a very strong aroma when in flower. This is in agreement with the findings of Mba and Amao (2009) who identified most of these honey plants as natural sources of food for African honey bee, *Apis mellifera adansonii,* in Zaria, Northern Nigeria.

Ja'Afar-furo *et al.* (2006) noted that in a comparative analysis of beekeeping and crop production in Adamawa State in Nigeria, farm budgeting analysis and descriptive statistics revealed that beekeeping was a far more profitable and cost-effective form of farming among the respondents with the knowledge of where to establish their hive. According to Kent and Coker (1992), species community is said to be rich if it has a Shannon Diversity value of ≥3.5. The result of the Shannon- Weiner diversity index, recorded in this study indicated that the four honey samples were low to moderately diverse. The low to moderately diverse species diversity observed in these samples could be due to the high level of anthropogenic activities in these regions. However, Obukpa honey sample collected near the fringes of Benue forest with the relics of the derived lowland forest and savannah vegetation contributed 76.14% of the individual plants while the equitability values of these four honey samples ranged between 0.74 and 0.82, indicating that they were equitably distributed in abundance. This is in line with the report of Gentry (1988) who noted that high species richness was a symbol of species richness of tropical forests.

The range of plant habits observed from these honey plants varied with sxty-six (66 per cent) of the honey plants recovered tree as against other forms while the least of 8 % were herbs and climbers (Fig. 2). This is in agreement with the findings of Aina *et al.* (2015) who reported the presence of *P. biglobosa, B. buonopozense, N. latifolia, Euginea* sp., *S. guineensis* and *Lannea* sp as the dominant honey plants from their samples and suggested that these were all trees typically of Mosaic and Guinea savannah.

Since the identified plants have uses other than for bee forage, apiculture could be of benefit in other ecosystem services and land-use activities involving these plants. These include agriculture, food and nutritional security. Pollination helps to increase fruit and seed production within their vicinity. Among these dominant taxa *E. guineensis, A. occidentale, I. wombolu and T. africana* are utilised as food by the local communities. This is in line with the report by Jones and Bryant (2004) who noted that pollination improves the yield of most crop species and contributes to about one-third of global crop production, although this phenomenon is underestimated by international policies and research.

Other plants among the 39 palynotaxa recorded in this study such as *Elaeis guineensis, D. mespiliformis,* and *Crossopteryx febrifuga* are used as timber, shelter belts and windbreaks. Some of these honey plants such as *A. occidentale, D. mespiliformis, D. guineense* and *Spondias mumbin* are traditionally secured by farmers while clearing their lands for agricultural activities for their fruit-yielding potentials. Some of these dominant honey plants are used as topical remedy. *Elaeis guineensis, A. occidentale, D. mespiliformis, A. cordifolia, I. wombolu, T. africana, N. latifolia* and *Crossopteryx febrifuga* are used in ethnomedicine by the local communities within this region. This is in agreement with Muanza *et al.* (2008) who reported that the crude methanol extracts from *A. cordifolia* and *T. africana* were bactericidal and fungicidal. Nnamani and Uguru (2013) noted that amongst the many health benefits of honey are its potentials of having antioxidant, antifungal, anticancer and bacteriostatic properties. They concluded that its free fat and low cholesterol values are the basic reasons why many people prefer it to the other sweeteners and this is probably why honey is highly medicinal and mostly effective for the treatment of many diseases by traditional healers. A notable species with multiple uses like *D. mespiliformis* is utilised as both herbal medicine and in the production of condiments for seasoning soup called Maggi cube, Dawa dawa and their allies.

Regarding the availability and status of these honey plants in this region, about 66% of them are sourced from the wild while a few of them are domesticated. However, *A. occidentale, D. mespiliformis, A. cordifolia, T. africana, N. latifolia* and *Crossopteryx* species were discovered to be vulnerable to bush burning, environmental degradation and other anthropogenic activities. They are prone to be threatened in the near future as a result of constant anthropogenic activities, climate variability and change if they are not conserved. It becomes imperative for their identification for sustainable conservation plans. This is in agreement with the report by FAO (2017), who stressed that food security is supported by pollinators, contributing to an estimated sum of US $ 220 billion each year. This represents 9.5 percent of the world's agricultural food production.

The abundance of *E. guineensis* as well as *Alchornea cordifolia* identified in these honey samples is of great interest. These species are typically anemophilous, usually small and inconspicuous, and do not possess scent or produce nectar; however, they were recovered in large numbers in the entire honey samples. This sugests that bees could visit non- entomophilous taxa for their pollen sources. This is in line with T e r r a b *et al.* (2001), who recorded pollen grain of Poaceae, *Quercus, Plantago* and *Fragaria* among the most commonly found non-nectariferous taxa in honeys of Morocco. Allen (1928) reported that pollen or nectar could come from sources other than the nectarifillous plants, which he noted could be due to accidental contamination of nectar or purposeful foraging of pollen from these plants, or pollen adhering to the body of bees which accidentally fall into hives, thereby contaminating the nectar and/or airborne pollen easily contaminate hives during honey extraction process.

Yao *et al.* (2006) reported that honeybees gather pollen grain from anemophilous plants to supplement their protein sources for survival and reproduction. These bees frequently collect a wide variety of such pollen.

Ernest (2009) noted that the presence of the non-nectariferous pollen in honey might be associated with contamination of nectar with pollen within a flower, secondary contamination of honey in combs or the blowing of these non-nectariferous pollen into a hive.

There was evenness in distribution and abundance of *E. guineensis* in all the samples by the 868.4 honey pollen contributed by this species. The dominant pollen of *Elaeis guineensis* generally recorded in all the honey

samples from there zones is an indication that the pollen and nectar from the plant species are very important bee foods. Ige and Modupe (2010) reported that the dominance of this species was widely dispersed, hence their abundance in honey samples, making it to serve as a robust bee forage plant.

With the wealth of knowledge on potentials of honey plants, those interested in beekeeping can now enjoy the fascinating and motivating activities in apiculture. It is eco-friendly and a diversified option of entrepreneurship with great potentials for income-generation through green job creation. Data accruing from this work showed the unexploited values that bee farmers in the study areas could key into. It is an environmentally sound, geographically suitable and economically feasible income-generating sector for poverty alleviation and food security (Taylor, 2014). This enterprise should be reported by various tiers of policy to create a competitive business both nationally and internationally. This is in line with Upadhyay *et al.,* (2014), who noted that honeybees are effective pollinators in agricultural and natural ecosystems improvement, resulting in enhanced crop productivity and overall socio-economic status of the local communities.

Most of the other bee products such as bee wax could generate good income for the local communities. Hilmi *et al.* (2011) reported that in most countries of the world bees and their products have a wide market demand and consumer preference and provide sustainable livelihoods to many small-scale farmers and other rural and semi -rural populace. Beekeeping can encourage self-reliance so as to reduce the hardship of unemployment and associated social vices. Policy makers can onow initiate apicultural enterprises in these areas to improve the socio-economic status of the local communities in the regions. Ajao and Oladimeji (2013) noted that the ecosystem approach developed by the Convention on Biological Diversity is a strategy for the integrated management of land, water and living resources which promotes conservation and sustainable use in an equitable way. They suggested that management and policy measures need to focus on species not just on human dominated landscapes because these will help people to strengthen their livelihoods while sustaining the habitat and biodiversity.

Understanding the economics of climate change on major staple crops could engender policy makers to building capacities of local farmers by initiating programmes aimed at sharing this knowledge, particularly with and among youths. Such approaches could proffer solutions to improved green economy and ensure green job resilience. Local farmers/communities could be trained on the availability and accessibility of honey plants by bees and their possible conservation programme. Ayansola (2012) noted that apiculture remains one of the most productive resources that has not been adequately tapped into in most African countries due to lack of knowledge of its potentials. Equipment and credit facilities should be provided for the unemployed youth to be engaged in bee-farming in various vegetation zones. Policy- makers should ensure the protection/conservation of bee plants by legislating against their indiscriminate exploitation.

CONCLUSION

This study highlighted how the characterisation of honey through melissopalynological analysis could be a useful tool to enhance beekeeping knowledge, activities and productivity. It has also highlighted apiculture as tool for the conservation of floral diversity. The study identified several frequently foraged plant families in the various localities, which beekeepers could exploit for a profitable enterprise. The knowledge of these major honey plants is necessary for gainful and cost -effective apicultural enterprise. Many species of these plants have been listed as very important for bee honey and for other multipurpose activities. More than 39 genera contributed to the bee pastures, seven of which were more frequently visited than the others. These families include Anacardiaceae, Combretaceae, Euphorbiaceae, Fabaceae, Meliaceae, Moraceae and Rubiaceae. Their prevalence in the entire honey samples positions them as good candidates for apicultural entrepreneurship in these regions.

Policy-makers could key into the accruing data and engage some of the unemployed youth in the business of apiculture, thereby creating green growth as a profitable enterprise. Apiculture also appears to be economically much more viable than previously recognised and needs better support through adequate agricultural management and policy.

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