Floral preference of honeybees in Ijumu, Kogi State, Nigeria: a melissopalynological and biodiversity conservation perspective

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Abstract

With the aim of ascertaining the preferred 'polleniferous' species, pH, geographical and ecological origin, a melissopalynological study was conducted in Ijumu, a human impacted region of Kogi State, Nigeria. Pollen weight was also measured in an attempt to differentiate pure from adulterated honey currently marketed. Routine pollen analysis was conducted on four honey samples. Findings revealed that pollen weight was between 0.25 and 0.40gram indicating that the honey samples were naturally produced. An inordinate morphological diversity of pollen in size, shape, aperture and sculpturing pattern was observed. A total of 40,795 pollen grains (13,027, 11,254, 7346 and 9178 for Ayehgbede, Ayegunle, Iyamoye and Ogidi respectively) were counted from 129 pollen types belonging to 49 known and one indeterminate plant families. The pollen types were identified to family (2), generic (29) and species (92) level while five remained unidentified. The most abundant plant families were Fabaceae (19.79%), Sapotaceae (12.80%), Arecaceae (10.64%), Euphorbiaceae (10.63%), Myristicaceae (5.18%), Anacardiaceae (5.01%), Combretaceae (4.93%), Phyllantaceae and Rubiaceae (3.75% each). The predominant pollen types were *Alchornea cordifolia, Alchorrnea latifolia, Brachystegia eurycoma, Vitellaria paradoxa, Combretum sp., Elaeis guineensis, Irvingia gabonensis, Morelia senegalensis, Pentaclethra macrophylla, Solanum melongena* and *Vitex grandifolia* worthy of conservation. The pollen representation revealed that Ijumu is currently a derived savanna/lowland rainforest mosaic impacted by inhabitants.

Keywords: Melissopalynology, honey, pollen analysis, food quality, biodiversity conservation

Introduction

Honeybees are one of the world's most essential pollinators capable of sustaining biodiversity and food security. Plants foraged by bees must be conserved for continuity if honey production is to be sustained. Honey remains one of the most consumed foods with very high nutritional and medicinal value. It is made from plant nectar and pollen primarily (Shubharani *et al*., 2013) and the digestive enzymes of bees carefully compressed, mixed, dehydrated and allowed to mature. Its uses date far back to Biblical times. For quality assurance purposes, pollen diversity and abundance is a determinant of the colour, nutritional richness and originality of honey (Bogdanov & Martin, 2002).

These pollen grains also reflect the honeybee preferred plants for pollen and/or nectar, geographical and organoleptic properties. Melissopalynology is a branch of palynology concerned with the botanical, ecological or geographical origin of honey. This is achieved by subjection of the honey a routine pollen analysis. The genesis of pollen in honey studies in Nigeria can be traced to the work of Sowunmi (1976).

The microscopic investigation provides evidence of the plant types visited by honeybees for the production of honey (Louveaux *et al*., 1978). A combination of the wind and animal-pollinated taxa found in honey gives a unique understanding of the particular area where the bees produced the honey. Several melissopalynological works have been carried out in different parts of Nigeria in the past five decades in an attempt to find their botanical affinities.

Currently, there is an evident cultural, agricultural, unscientific and uncontrolled practice threatening the flora of several parts of Ijumu, Kogi State. This indiscriminate destruction may lead to the loss of important honey plants. Ijumu has lost about 855 ha of tree cover from 10.9 Mha and over 12% of natural forest. In 2021 alone 96.5 Kha was lost due to forest encroachment (Global Forest Watch, 2022). Information on pollen analysis in Ijumu localities is almost non-existent, limited or somewhat scarce. This expanding destruction of flora could lead to loss of biodiversity and important bee plants.

Honeybees (*Apis mellifera* var. *adansonii*) foraged on plants for nectar and pollen for the production of honey. Due to the loss of flora and the long duration of production, adulteration of honey has become rampant in Nigeria. Adulteration of honey simply means glucose, dextrose, molasses, corn syrup and invert sugar have been added into an original honey to probably increase quantity or add to the taste. The component (physical and chemical properties) confers the uniqueness of each honey and to be sure of its authenticity, it is vital to perform extensive honey compositional analysis like pollen analysis. Seeking to

reveal the relative weight of pollen could be used in differentiating pure from adulterated honey.

This study, therefore, intends to ascertain the originality of honey produced and sold in Ijumu, Kogi State as well as the important bee plants that need to be conserved. Knowing the bee plants could be used as the basis of legalized protection and propagation of bee plants and farms. Melissopalynological studies have been found useful in deciphering such plants. There is still a dearth of information on western Kogi honey pollen flora. Aina *et al*. (2014) concentrated on Kogi East while Agwu *et al*. (2013) only reported on Dekina LGA and Essien *et al*. (2022) on Yagba West, hence a study on Ijumu will be worthwhile. The objectives, therefore, are to physico-chemically quantify the honey samples, carry out qualitative and quantitative analysis of pollen grains to determine the botanical and geographical origin of the honey.

Materials and Methods

Study Area: Ijumu Local Government Area of western Kogi State in the middle belt area of Nigeria lies between latitude $7^{0}51$ N and longitude $5^{0}58$ E. This region is characterized by the usual two seasons (rainy and dry) of April to September and November to March respectively with a peak around August and September. The harmattan season between December and January is basically influenced by the North-east Trade winds. It has mean annual temperature of between 25°C and 38°C. The vegetation remains a derived savanna with fire tolerant and sensitive tree plants, woody shrubs, herbs and grasses. Dominant tree plants include *Khaya senegalensis*, *Parkia biglobosa*, *Vitex grandifolia*, *Daniella oliveri*, and *Prosopis africana*. Forbs present include *Mirabilis jalapa*, *Crotalaria retusa*, *Senna obtusifolia*, *Indigofera hirsuta* as well as grasses like *Imperata cylindrica*, *Andropogon gayanus*, *Panicum maximum*, and *Pennisetum sp*. The four localities randomly selected were Ayehgbede, Ayegunle, Iyamoye, and Ogidi settlements known for honey production and sales.
Sample collection: Four honey samples were collected from vendors who sources from the wild at the study area. between the months of September to December, 2021. The honey were extracted by pressing and squeezing the combs, and filtered into a bottle through fine mesh-copper gauze to avoid the introduction of debris. Once collected the samples were labeled and transported to the Laboratory, Department of Plant Science and Biotechnology, Kogi State University, Anyigba for pollen analysis.
Determination of pH: Honey (10 g) was dissolved in 75 ml of distilled water in a beaker and vigorously mixed using a glass rod, pH electric meter was immersed in the honey and values were taken (AOAC, 1999).

Honey colour: the Munsell Soil Colour Chart was used. Pollen analysis: Three basic procedures were followed; honey quantification/dilution, pollen acetolysis and microscopy. All procedures followed the recommendation and techniques reported in Louveaux *et al*. (1978), Agwu *et al*. (2013) and Erdtman (1969). Microscopy was carried out using two drops of pollen suspension in microscope slide sealed off with 18 x 18 mm glass cover slip. Counting was done using Olympus microscope at x400 magnification while detailed pollen morphological studies to aid identification was done using Leica microscope at x 1000 magnification. Reference slides, pollen atlas and photomicrographs (Sowunmi, 1995; Agwu & Akanbi, 1985; Agwu *et al*., 2013; Shubharani *et al*., 2013) was used for identification.

Weight of pollen grains: Honey (50 ml) and beaker (71.65 g) was weighed using the weighing balance. The honey was diluted with 1000 ml of distilled water and the formula below was applied

Weight of pollen x factor of 20 = weight of beaker/litre of honey samples.

Data analysis: The data was subjected to descriptive statistics of frequency counts and percentages only. The classification for representation of pollen types followed was the one recommended by Louveaux *et al*. (1978) for expressing pollen grain frequencies: Very frequent (over 45%), frequent (16-45%), rare (3-15%) and sporadic (> 3%).

Results

The results are presented in Tables 1 - 4 and Figures 1 and 2.
Table 1: Physicochemical properties of the four honey samples

Localities	Colour	Honey Weight collected (g)	Weight of pollen (g)	pH Value	Weight of honey (gram/litre)
Ayehgbede	Yellowish-brown	10	0.32	3.52	1385
Ayegunle	Dark-brown	10	0.40	3.59	1392
Iyamoye	Brown	10	0.25	3.80	1284
Ogidi	Light-yellow	10	0.29	4.04	1286

Table 1 shows the physico-chemical characteristics of the four honey samples. The colour ranged from light yellow to dark brown. The pollen weight showed that the weight of pollen in Ajegunle honey sample was highest (0.40 g) while that of Iyamoye was lowest (0.25 g). The pH values showed that Ogidi honey had the highest pH value of 4.04 while Ayehgbede was lowest (3.52).

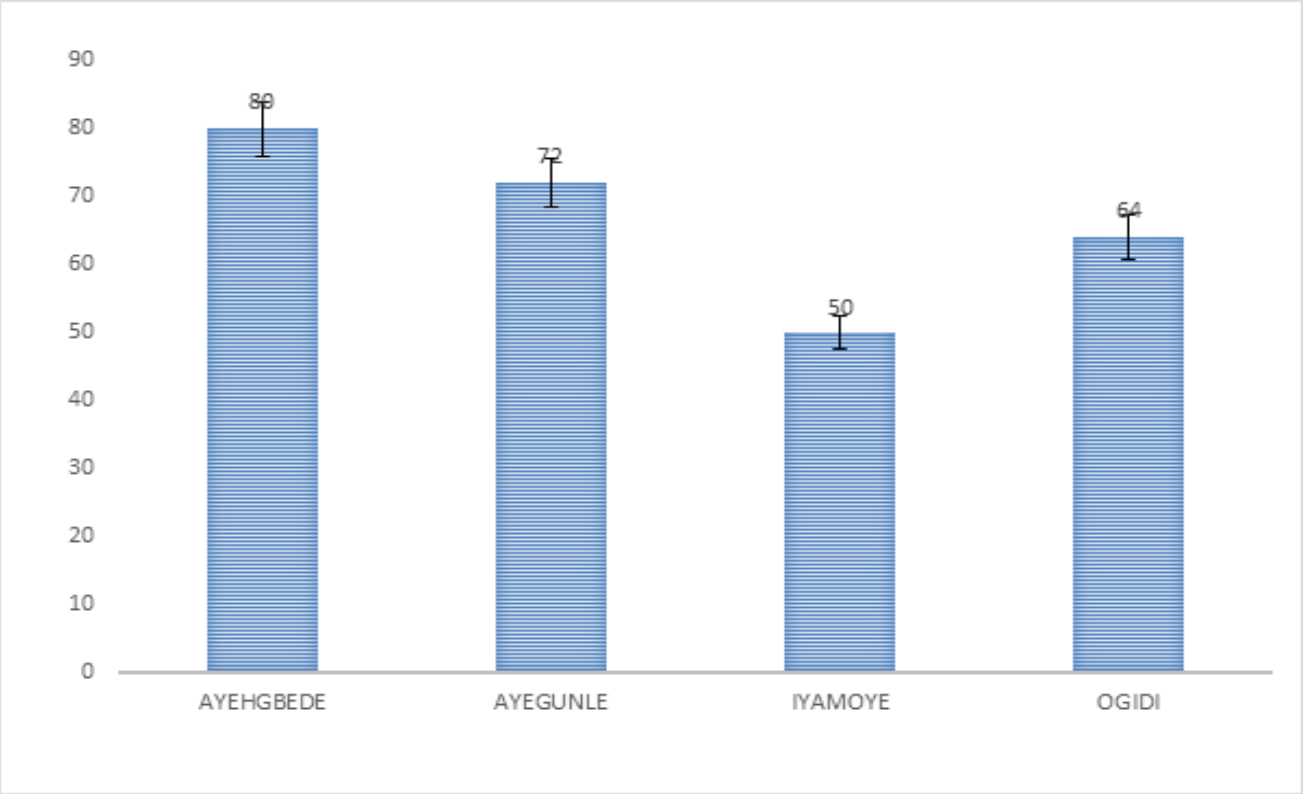

Figure 1: Number of identified pollen types in the four honey samples from the study area

Figure 1 showed the overall pollen types recovered from each of the honey samples. Ayehgbede honey samples had 80 pollen types which was highest while Iyamoye had the lowest (50) clearly an indication of the high diversity of pollen in Ijumu, Kogi State.

Figure 2 below showed that the most abundant plant families in order of reducing percentage were Fabaceae (19.79%), Sapotaceae (12.80%), Arecaceae (10.64%), Euphorbiaceae (10.63%), Myristicaceae (5.18%), Anacardiaceae (5.01%) Combretaceae (4.93%), Phyllantaceae (3.75%), Rubiaceae (3.75%) and Asteraceae (2.85%). While the least abundant were Oleaceae and Potamogetonaceae (0.001%), Umbrelliferaceae, Rosaceae, Caprifoliaceae and Casuarinaceae (0.01%), Apiaceae, Gentianaceae and Sapindaceae (0.02%).

Discussion

Honey originality: Deciphering the botanical or ecological origin and the authenticity of honey samples form Ijumu, Kogi State, Nigeria was the focus of this study. Complimentarily, understanding the best times for apiculture by understanding the flowering seasons of the plant was another objective. Having seen evident impact of humans in the study location, melissopalynological study will shed light on the important bee plants that may require preservation for continuous supply of quality honey in Kogi State. The study found that all honey samples were acidic in nature (Table 1) and pollen weight revealed that the honeys were not adulterated. Cases of honey adulteration have been reported in many cities in Nigeria before however, the ones from Kogi has been good e.g. Anidiobu (2016) from Kabba, this study confirms those from Ijumu that were randomly sampled are also of good quality. Honey quality can be measured by its pollen diversity and count (Oyeyemi, 2017). The high diversity of pollen types ranging from 50 to 80 (Figure 1) further supports the originality of the honey samples (Bogdanov & Martin, 2002).

Botanical Origin: This is based on the relative frequencies of the pollen types in the honey samples. The predominance of plant families like Fabaceae, Sapotaceae, Arecaceae, Euphorbiaceae, Anacardiaceae, Rubiaceae and Combretaceae (Figure 2) has been reported in many other reports (Dukku, 2013; Kayode & Oyeyemi, 2014. Adekanmbi & Ogundipe, 2019) which is clearly an indication of the relevance of these families in honey production. The least abundant families may not have been fully domesticated or their pollen does not make the top preferred by honeybees. The predominant pollen types (in Table 2) were also reported in Agwu et al. (2013) and Aina et al. (2014) whose works were done in Kogi State and in Adeonipekun et al. (2016) in Mambilla.

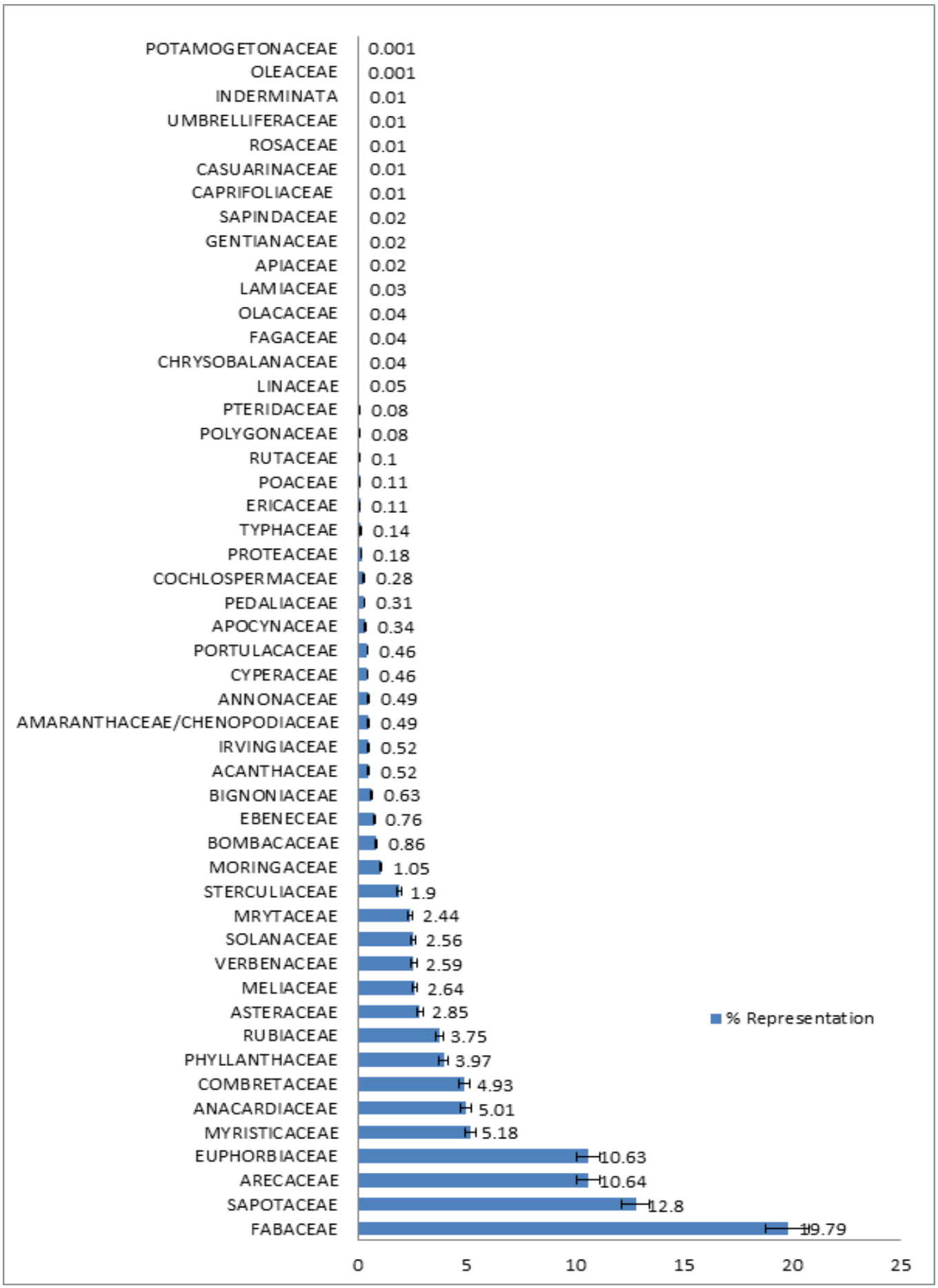

Figure 2: Percentage representation of plant families in the four pollen samples from Ijumu

Table 2 shows the pollen types recovered from the four honey samples. Pollen count of 13,027, 11,254, 7346 and 9178 were recorded for Ayehgbede, Ayegunle, Iyamoye and Ogidi honey samples respectively. The predomionant pollen types include Alchornea latifolia, Brachystegia eurycoma, Vitellaria paradoxa, Combretum sp., Elaeis guineensis, Irvingia gabonensis, Morelia senegalensis, Pentaclethra macrophylla, Solanum melongena and Vitex grandifolia.

Table 2: Pollen types recovered and counts from honey samples from Ijumu Kogi State

	Pollen types/families	Localities in Ijumu									
		Ayehgbede	%	Ayegunle	%	Iyamoye	%	Ogidi	%	Total	%
1	ACANTHACEAE										
	Blepharis sp.	102	0.78			10	0.14	100	1.09	212	0.52
2	ANACARDIACEAE										
	Anacardium occidentale			57	0.51	5	0.07			62	0.15
	Antrocaryon micraster					200	2.72	300	3.27	500	1.23
	Lannea acida	130	1.00	77	0.68	150	2.04	320	3.49	677	1.66
	Lannea sp.	50	0.38	100	0.89					150	0.37
	Mangifera indica	502	3.85			100	1.36	50	0.54	652	1.60
3	AMARANTHACEAE/ CHENOPODIACEAE										
	Amaranthus sp.					10	0.14	120	1.31	130	0.32
	Chenopodium sp.	5	0.04					66	0.72	71	0.17
4	ANNONACEAE										
	Annona senegalensis	153	1.17	25	0.22	20	0.27			198	0.49
5	APIACEAE										
	Scoriandrum sativum	8	0.06							8	0.02
6	APOCYNACEAE										0.00
	Periploca sp.	90	0.69	5	0.04	40	0.54	5	0.05	140	0.34
7	ARECACEAE										
	Elaeis guineensis	2168	16.64	550	4.89	1325	18.04	298	3.25	4341	10.64
8	ASTERACEAE										
	Aspilia africana	407	3.12	120	1.07	15	0.20	5	0.05	547	1.34
	Bidens pilosa	5	0.04							5	0.01
	Emilia sp.							20	0.22	20	0.05
	Eupatorium purpurum			10	0.09					10	0.02
	Guttenbergia sp.	10	0.08							10	0.02
	Tridax procumbens	410	3.15	100	0.89	55	0.75	10	0.11	575	1.41
	Vernonia sp.	2	0.02							2	0.00
9	BIGNONIACEAE										
	Kigelia africana							2	0.02	2	0.00
	Spathodea campanulata			100	0.89	79	1.08			179	0.44
	Stereospermum kuthianum			5	0.04					5	0.01
	Tecoma stans			25	0.22	50	0.68			75	0.18
10	BOMBACACEAE										
	Bombax buonopozense	150	1.15							150	0.37
	Ceiba pentandra	100	0.77	20	0.18	55	0.75			175	0.43
	Ceiba sp.			25	0.22					25	0.06
11	CAPRIFOLIACEAE										
	Knautia sp.	5	0.04							5	0.01
12	CASUARINACEAE										
	Casuarinas equisetifolia							3	0.03	3	0.01
13	CHRYSOBALANACEAE										
	Parinari sp.	15	0.12							15	0.04
14	COCHLOSPERMACEAE										
	Cochlospermum planchonii			115	1.02					115	0.28
15	COMBRETACEAE										
	Combretum glutinosum	420	3.22	345	3.07	298	4.06	50	0.54	1113	2.73
	Combretum sp.	450	3.45	340	3.02	90	1.23	18	0.20	898	2.20
16	CYPERACEAE	20	0.15	140	1.24	19	0.26	10	0.11	189	0.46
17	EBENECEAE										
	Diospyrus sp.	11	0.08	300	2.67					311	0.76
18	EUPHORBIACEAE										

	Alchornea cordifolia	602	4.62	1970	17.5	150	2.04	160	1.74	2882	7.06
	Bridelia ferruginea							15	0.16	15	0.04
	Croton sp.	11	0.08							11	0.03
	Euphorbia heterophylla			55	0.49					55	0.13
	Euphorbia hirta	15	0.12	150	1.33	50	0.68	117	1.27	332	0.81
	Jatropha sp.			400	3.55	100	1.36	120	1.31	620	1.52
	Hymenocardia acida	2	0.02							2	0.00
	Mallotus subulatus	9	0.07	45	0.40	20	0.27	13	0.14	87	0.21
	Manihot sp.			200	1.78					200	0.49
	Ricinus communis	72	0.55							72	0.18
	Sapium sp.	14	0.11	50	0.44					64	0.16
19	ERICACEAE										
	Empretum nigrum							44	0.48	44	0.11
20	FABACEAE: SUBFAMILY CAESALPINIOIDEAE										
	Afzillia africana			120	1.07			32	0.35	152	0.37
	Berlinia grandifolia	19	0.15	400	3.55			112	1.22	531	1.30
	Bauhinia purpurea							100	1.09	100	0.25
	Brachestygia eurycoma	2305	17.69	1755	16	10	0.14	57	0.62	4127	10.12
	Butea momosperms							10	0.11	10	0.02
	Daniella oliveri	55	0.42	340	3.02	55	0.75	324	3.53	774	1.90
	Delonix sp.			26	0.23					26	0.06
	Eligmocarpus cynometroides	1	0.01							1	0.00
	Erythrina mildbraedii	14	0.11			30	0.41		0.00	44	0.11
	Hylodendron gabunense	3	0.02							3	0.01
	Hymenostegia afzelii	1	0.01	74	0.66					75	0.18
	Gigasiphon humblotiana			20	0.18					20	0.05
	Senna occidentale					270	3.68	108	1.18	378	0.93
	MIMOSOIDEAE										
	Acacia senegal	24	0.18							24	0.06
	Acacia sieberiana	21	0.16	40	0.36					61	0.15
	Adenanthera pavonina	9	0.07							9	0.02
	Albizia adianthifolia			30	0.27					30	0.07
	Albizia zygia			50	0.44	278	3.78	105	1.14	433	1.06
	Aubrevillea kerstingii	3	0.02							3	0.01
	Parkia biglobosa			150	1.33	65	0.88	305	3.32	520	1.27
	Parkia clappertoniana	28	0.21					53	0.58	81	0.20
	Pentaclethra macrophylla	50	0.38	50	0.44	20	0.27	380	4.14	500	1.23
	Prosopis africana	50	0.38	20	0.18	15	0.20	58	0.63	143	0.35
	Tetrapleura tetreptera	19	0.15							19	0.05
	PAPILIONOIDEAE										0.00
	Dalbergia ecastaphyllum	7	0.05							7	0.02
21	FAGACEAE										
	Fagus sp.	15	0.12							15	0.04
22	GENTIANACEAE										
	Gentianella amarella	7	0.05							7	0.02
23	IRVINGIACEAE										
	Irvingia gaboneensis	17	0.13	50	0.44	79	1.08	67	0.73	213	0.52
24	LAMIACEAE										
	Hyptis suaveolens	8	0.06							8	0.02
	Ocimum sp.	5	0.04							5	0.01
25	LINACEAE										
	Linum catharticum	20	0.15							20	0.05
26	MELIACEAE										
	Entandrophragma angolense	8	0.06							8	0.02
	Entandrophragma utile			5	0.04					5	0.01
	Khaya ivorensis	30	0.23							30	0.07
	Khaya senegalensis	58	0.45	10	0.09		0.00	10	0.11	78	0.19
	Trichilia preuriana	510	3.91	100	0.89	305	4.15	45	0.49	960	2.35

27	MORINGACEAE										
	Moringa oleifera	200	1.54	11	0.10	167	2.27	50	0.54	428	1.05
28	MYRISTICACEAE										
	Pycnanthus angolensis			1800	16		0.00	315	3.43	2115	5.18
29	MRYTACEAE										
	Combretodendron macrocarpun			2	0.02					2	0.00
	Eucalyptus globus	70	0.54					58	0.63	128	0.31
	Eugenia sp.	250	1.92	10	0.09	60	0.82			320	0.78
	Eugenia uniflora							25	0.27	25	0.06
	Psidium guajava	115	0.88	25	0.22	50	0.68			190	0.47
	Syzgium guineensis	180	1.38	25	0.22	20	0.27	110	1.20	335	0.82
30	OLACACEAE										
	Olax subcorpioidea	15	0.12							15	0.04
31	OLEACEAE										
	Ligustrum vulgare	2	0.02							2	0.00
32	PEDALIACEAE										
	Sesamum indicum	125	0.96							125	0.31
33	POACEAE	13	0.10	6	0.05	20	0.27	14	0.15	43	0.11
34	PHYLLANTHACEAE										
	Antidesma sp.			6	0.05					6	0.01
	Phyllanthus amarus			4	0.04					4	0.01
	Phyllanthus sp.			10	0.09			1600	17.43	1610	3.95
35	POLYGONACEAE										
	Polygonum sp.							30	0.33	30	0.07
	Fagopyrum esculentum			3	0.03					3	0.01
36	PORTULACACEAE										
	Talinum triangulare	45	0.35	20	0.18	100	1.36	22	0.24	187	0.46
37	POTAMOGETONACEAE										
	Potamogeton sp.			2	0.02					2	0.00
38	PROTEACEAE										0.00
	Protea elliotii	12	0.09	10	0.09	50	0.68			72	0.18
39	PTERIDACEAE										
	Pteris dentata							33	0.36	33	0.08
40	ROSACEAE										
	Rubus fruticocus							5	0.05	5	0.01
41	RUBIACEAE										
	Clausena sp.							58	0.63	58	0.14
	Crossopteryx febrifuga			50	0.44	271	3.69	330	3.60	651	1.60
	Morelia senegalensis			20	0.18	290	3.95	102	1.11	412	1.01
	Nauclea latifolia	12	0.09	30	0.27	252	3.43	112	1.22	406	1.00
42	RUTACEAE										
	Citrus sp.			15	0.13					15	0.04
	Zanthoxylum riedelianum			5	0.04	10	0.14	10	0.11	25	0.06
43	SAPOTACEAE										
	Butryospermum paradoxum	2200	16.89	100	0.89	1260	17.15	1650	17.98	5210	12.77
	Mimuscops warneckii							12	0.13	12	0.03
44	SAPINDACEAE										
	Allophylus africanus			5	0.04					5	0.01
	Paullinia pinnata	5	0.04							5	0.01
45	SOLANACEAE										
	Solanum melongena	423	3.25	120	1.07	300	4.08	200	2.18	1043	2.56
46	STERCULIACEAE										
	Nesogordonia papaverifera	12	0.09	20	0.18	270	3.68	41	0.45	343	0.84
	Sterculia oblonga	8	0.06	5	0.04					13	0.03
	Sterculia sp.	22	0.17	10	0.09			53	0.58	85	0.21
	Triplochiton scleroxylon			20	0.18			313	3.41	333	0.82
47	TYPHACEAE										
	Typha latifolia	44	0.34							44	0.11
	Typha sp.							14	0.15	14	0.03
48	UMBRELLIFERAE										
	Heracleum sphandylium	4	0.03							4	0.01
	Pastinaca sativa	2	0.02							2	0.00
49	VERBENACEAE										
	Vitex grandifolia	40	0.31	350	3.11	257	3.50	409	4.46	1056	2.59
50	INDERMINATA	3	0.02	1	0.01	1	0.01			5	0.01
	Total pollen count	**13027**	**100**	**11254**	**100**	**7346**	**100**	**9178**	**100**	**40795**	**100**

Photomicrographs of some selected pollen types documented in the study are presented in Plate

1.

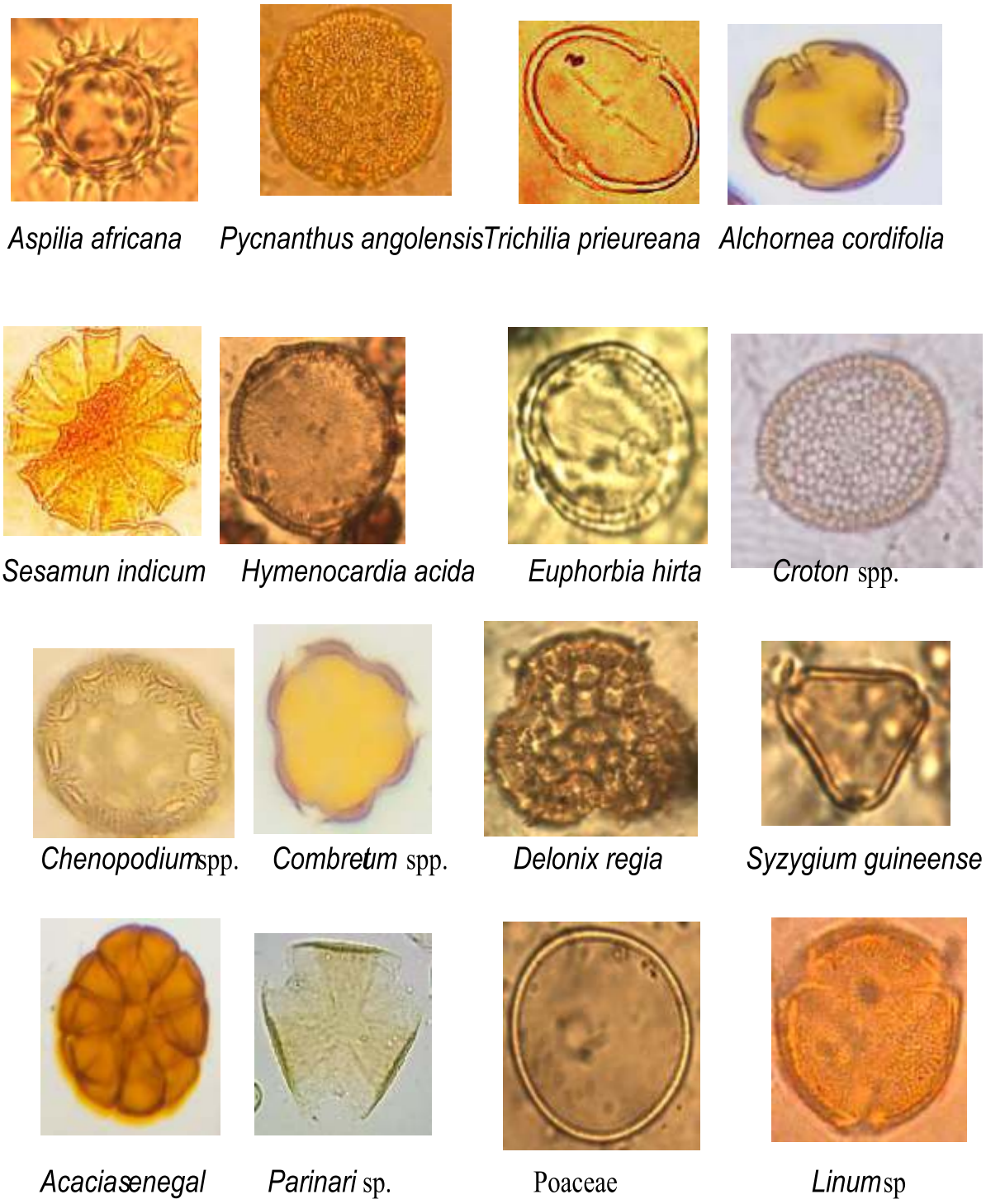

Plate 1: Photomicrographs of selected pollen types recovered from the honey samples

Table 3 shows the floral sources of the honey samples and it revealed that all honey were multifloral or polyfloral in nature and rightly belong to category I. There were no very frequent pollen types in any of the samples.
In Table 3, a detailed analysis of the floral origin, predominant pollen types in the honeys is presented, while in Table 4, a detailed analysis of the vegetation types inferred from the pollen types and count showed that Ijumu is a human impacted guinea savanna and low land rainforest mosaic.

Table 3: Floral sources of the honey samples from Ijumu Kogi State, Nigeria

Samples	Pollen type			Remark on floral origin	Pollen count/ Category
	Very Frequent (> 45%)	**Frequent (16 – 45%)**	**Rare (3 – 15.9%)**	**Sporadic (< 3%)**	
Ayehgbede	-	*Brachystegia eurycoma* (17.03), *Vitellaria paradoxa* (16.26), *Elaeis guineensis* (16.02), *Alchornea cordifolia* (4.44)	*Combretum glutinosum* (3.33), *Mangifera indica* (3.71), *Tridax procumbens* (3.77), *Vitex grandifolia* (3.02), *Solanum melongena* (3.03), *Trichilia preuriana* (3.11)	*Lannea* sp. (0.37), *Paullinia pinnata* (0.30), *Typha latifolia* (0.33), *Prosopis africana* (0.37), *Sesamum indicum* (0.92)	Multifloral	13,027/I
Ayegunle	-	*Alchornea cordifolia* (17.99), *Brachystegia eurycoma* (16.02), *Pycnanthus angolensis* (16.43)	*Afzelia africana* & *Berlinia grandifolia* (3.65), *Daniella oliveri* (3.10), *Elaeis guineensis* (5.02), *Hymenocardia acida* (3.65), *Vitellaria paradoxa* (3.20)	*Vitex grandifolia* (0.98), *Irvingia gabonensis* (0.54), *Pentaclethra macrophylla* (0.50), *Psidium guajava* (0.46), *Solanum melongena* (1.10).	Multifloral	11,254/I
Iyamoye	-	*Elaeis guineensis* (16.89) *Vitellaria paradoxa* (16.07), *Crossopteryx febrifuga* (3.46)	*Albizia zygia* (3.55), *Morelia senegalensis* (3.70), *Moringa oleifera* (3.44), *Phyllanthus* sp. (1.53), *Protea elliotii* (1.28), *Nauclea* sp. (0.64)	*Talinum triangulare* (1.28), *Tecoma* sp. (0.64), *Alchornea cordifolia* (1.91), *Anacardium occidentale* (2.55), *Amaranthus* sp. (0.26), *Annona senegalensis* (0.13), *Mangifera indica* (1.28)	Multifloral	7,346/I
Ogidi	-	*Vitellaria paradoxa* (16.87), *Phyllanthus* sp. (16.36)	*Diospyrus* sp. (3.27), *Daniella oliveri* (6.75), *Elaeis guineensis* (4.54), *Lannea acida* (3.49), *P. biglobosa* (3.11), *Pentaclethra macrophylla* (3.89), *Triplochiton scleroxylon* (3.20), *Anacardium occidentale* (3.07)	*Alchornea cordifolia* (1.64) *Causuarina equisetifolia* (0.58) *Chenopodium* sp. (0.67) Cyperaceae (0.75), *Emilia* sp. (0.44), *Kigelia africana* (0.13), *Mumusops warneckei* (0.23)	Multifloral	9,178/I

Floral origin selected based on most represented (very frequently and frequently) occurring plant species . Categories are in accordance with Parades and Bryant (2019)

Table 4: Vegetation inference from pollen types recovered from honeys from Ijumu, Kogi State

		Vegetation type represented from absolute pollen count				
		Lowland rainforest	**Open forest**	**Savannah**	**Human impacted**	**Suggestive Inference on Ecological Origin of Honey**
Selected pollen types		*Brachystegia eurycoma Vitellaria paradoxa, Pentaclethra macrophylla*	*Alchornea cordifolia Elaeis guineensis, Albizia zygia*	*Daniella oliveri Phyllanthus* sp., *Parkia biglobosa,* Poaceae	*Solanum melongena, Jatropha* sp., *Manihot* sp., *Mangifera indica*,	
Total pollen count		**10,610**	**10,536**	**13,278**	**6,371**	
Localities	Ayehgbede (%)	40.65	30.60	17.52	26.20	-Guinea Savanna/lowland rainforest
	Ayegunle (%)	24.95	41.48	19.17	27.56	-Human impacted open forest
	Iyamoye (%)	14.17	16.40	18.09	21.70	-Open residential area
	Ogidi (%)	20.23	11.52	45.25	24.54	-Human impacted Guinean savanna
Total pollen indicator of the vegetation (%) of Ijumu		**26.00**	**25.83**	**32.55**	**15.62**	**Ijumu in Kogi is largely Guinea Savanna-Lowland Rainforest mosaic slighted impacted by human occupation**

_Total pollen count = 40,795

On floral sources, the study revealed that all honey samples were multifloral (Table 3) inferring that honeybees (Apis mellifera var. adansonii) foraged several preferred pollen and nectar to produce the honey. It could be said that most Nigerian honeys are relatively multifloral (Agwu et al. 2013; Kayode & Oyeyemi, 2014; Adeonipekun et al., 2016; Adekanmbi & Ogundipe, 2019; Essien et al., 2022) belonging to category I description by Parades and Bryant (2019).

Geographical Origin: Pollen analysis of these honey samples revealed that there are more of derived and guinea savanna taxa followed by those of the lowland rainforest taxa and open forest taxa. The pollen analysis

shows a fairly similar floral composition for the entire honey sample studied which is in line with the work of Sowunmi (1976) in Southeastern Nigeria and the high floral diversity of the forested-savanna ecozone by Agwu and Akanbi (1985) and Agwu and Abaeze (1991). The percentage of human impact indicator species could be attributed to anthropogenic activities in this region such as deforestation, urbanization, and agricultural activities in line with Nnamani and Agwu (2007) reports.

There are indications that the region of Ijumu is largely guinea savanna and lowland rainforest mosaic which is been impacted by humans (Table 4) although, with little variation with respect to the different localities. The vegetation type seem to be same as that of Kogi East, Dekina and Yagba West (Aina et al., 2014; Agwu et al., 2013; Essien et al., 2022). This further validates the fact that Kogi State is likely a mosaic of lowland rainforest/Guinea savanna. It is reported that most Nigerian honey comes from the savanna regions or mosaic of lowland rainforest and secondary grassland (Sowunmi, 1976). To decipher the geographical origin of honey, the entire spectrum being consistent within the flora of that particular region is considered (Louveaux et al., 1978). The dominance of Anacardium occidentale Nauclea latifolia, and Elaeis guineensis, indicates farming activity and the vegetation is very likely a lowland rainforest and derived/guinea savanna. The occurrence of the pollen of the above listed plants in the pollen spectrum of the studied samples confirms their geographical origin reflecting mainly derived/guinea savanna. Findings agree favourably with the report of Agwu and Akanbi (1985) and Agwu and Okeke (1997).

Season of Honey Production: Flowering is typically during the dry seasons for most plants which enable honeys to forage. This study looked at the different pollen types and their various flowering seasons for efficient production of honey in the study area. In accordance with the studies by Dalziel (1937) and Keay (1959), the flowering period are; Anacardium occidentale (November-January; May), Hymenocardia acida (January-March), Annona senegalensis (April), Bridelia ferruginea (August-October; March-April), Daniella oliveri (November-January; March-April), Elaeis guineensis (October-April), Khaya senegalensis (April-July). Sowunmi (1976) and Agwu & Akanbi, (1985) reported the flowering period of Phyllanthus sp. (January-October), Parkia biglobosa (December-March), Prosopis africana (December-January). These flowering seasons can be used by beekeepers to maximize the production of honey.

Conclusion and Recommendations

Pollen analysis is still an indispensable method for the authentication of honey based on its floral and geographical origin. It can to some extent reflect the floristic characteristics of the area the honey was collected from. This study has revealed some important indicator species of vegetation types in Ijumu as well as honey bees (Apis mellifera var. adansonii) preferred pollen and nectar sources. These plants included Alchornea latifolia, Brachystegia eurycoma, Vitellaria paradoxa, Combretum sp., Elaeis guineensis, Irvingia gabonensis, Morelia senegalensis, Pentaclethra macrophylla, Solanum melongena and Vitex grandifolia and others from 49 identified plant families and one group of indeterminate grains. The grains were also identified into two families, 29 genera and 98 species. Such plants should be properly conserved and their sustainable exploitation managed in the apiculture to enhance large scale production of honey in Ijumu Local Government Area of Kogi State, Nigeria. The study further revealed that the region which is a mosaic of lowland rainforest and derived savanna is currently being impacted by human activities of subsistence. The study also recommends the production of large photographic atlas of different pollen types for further plant ecological studies.

Declaration of Interest: The authors declare that there is no conflict of interest

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