International Journal of Innovative Environmental Studies Research 12(2):78-89, April-June, 2024

© SEAHI PUBLICATIONS, 2024 www.seahipaj.org ISSN: 2354-2918

Diversity of honey producing plants of Ose Local Government Area of Ondo State, Nigeria: Basic Prerequisite for Conservation and Sustainability

[1]Adamu, Musa, [*1]Essien, Benjamin Christopher and [2] Adams, Olamilekan Samuel

[1]Department of Biology,
Faculty of Natural and Applied Sciences,
Nigerian Army University Biu, Borno State, Nigeria

[2]Department of Plant Science and Biotechnology,
Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria

***Email: benjaminessien8@gmail.com; benjamin.essien@naub.edu.ng**

ABSTRACT
The diversity and availability of indicator species which honey bees forage for pollen and nectar sources are threatened by the vicious impact of climate change, environmental degradation and over exploitation by man. Honey Samples from Ose Local Government Area, Ondo State, Nigeria was analyzed to determine the floral sources; botanical, geographical and ecological origin as well as the taxa most visited by bees. Results showed that out of twenty-two (22) pollen types belonging to eighteen (18) plants families encountered; two (2) was identified to family level, eighteen (18) to generic level, two (2) to species level, and none (0) was unidentified. The honey sample from Ifon recorded 20 pollen type (310 pollen counts), Ute 18 pollen type (251 pollen counts), Arimogija 17 pollen types (184 pollen counts) and Ikaro 15 pollen types (149 pollen counts). The predominant pollen types include those of *Elaeis guineensis*, Poaceae, *Hymenocardium acida*, *Irvingia gabonensis*, *Anacardium occidentale*, *Blighia sapida*, *Phyllanthus* spp., *Combretum* spp., *Talinum triangulare* and *Milicia excelsa* among others. Ifon, Ute, Arimojiga, and Ikaro each had pollen grain counts of 310, 251, 184 and 149 respectively. Study showed that the honey samples have complete information on the geographical and botanical origin and had also revealed the forage activities of the bees that produce them. Findings also revealed the indicator species that honey bees visit most for their pollen and nectar sources. Such plants could be properly conserved and their sustainable exploitation managed, to enhance economic production of honey from Ose Local Government Area of Ondo State and Nigeria in general. Poor pollen spectrum recorded in some samples could be a reflection of loss of bioresources attributed to high level of anthropogenic activities on the local vegetation. It is therefore, recommended that policy makers and indeed beekeepers in this study area as a matter of urgency should embark on extensive propagation, afforestation, and conservation of these predominant honey plants so as to improve food security, income generation and as carbon repossession in the ecosystem.
Keywords: *Apis mellifera*, Conservation, Honey plants, Multi-floral, Pollen analysis, Nigeria.

INTRODUCTION

Apis mellifera L. produce honey, a naturally occurring sweet viscid liquid, from blossom nectar and it has both medicinal and antibacterial properties (Essien *et al*., 2022a). Pollen, physical and chemical analyses are used to ascertain floral sources, the purity status, its botanical, ecological, and geographic origin, the

main honey-producing season, and the flora that honeybees most frequently visit while gathering pollen and nectar sources (Essien *et al*., 2022b).

Pollen is the dietary supplement that bees introduce into their hive to feed the colony in times of food scarcity. They contain all the nutrients required by the human body and are enormously rich in proteins, vitamins, minerals, beneficial fatty acids, carotenoids, and bioflavonoids which have anti-viral and antibacterial properties. It is also helpful in lowering cholesterol, stabilizing and strengthening blood capillaries (Krell, 1996).

Since ancient times, people have used honey, a complex liquid made by honeybees (*Apis mellifera*), as a source of energy, a natural sweetener, and a curative that inhibits the growth of disease-causing organisms (National Honey Board, 2002; Aina and Owonibi, 2011**;** Maddocks *et al*., 2012; Nwankwo *et al*., 2014; Ng and Lim, 2015; Adeonipekun *et al*., 2016; Ng *et al*., 2017).

In addition to other chemicals required for typical human growth and development, honey contains macro- and micronutrients such as water, carbohydrates, minerals, amino acids, organic acids, proteins, volatile substances, enzymes, and phenolic compounds. The nectar sources have a significant impact on the content of honey (Fernandez-Torres *et al*., 2005). High-quality honey has been proven to restore damaged intestinal mucosa and facilitates the emergence tissues (Kek *et al*., 2014; Nolan *et al*., 2019).

Nnamani and Uguru (2013) stressed that the production of honey is an eco-friendly activity that encourages good agricultural practices in maintaining the agricultural ecosystem balance, biodiversity conservation, promoting the sustainable use of natural resources, environmental quality and human health.

However, the population of honeybee (*Apis mellifera* L.) has experienced serious decrease in Europe, North America and the world in general (Neumann and Carreck, 2010). These losses highlight the potential risks for our natural and agricultural biodiversity through lack of pollination, and the repercussions on food security and human nutrition (Ratnieks and Carreck, 2010). It has been recognized that a lack of food and particularly the dearth of pollen, within intensively farmed agricultural landscapes and degraded environment as a result of anthropogenic activities have actually contributed to the loss of plant species which honey bees forage for pollen. Other biotic factors such as availability of plant genetic resources and their ability of these plant species to blossom, compete for resources, fight against pathogens, parasites, predators, and abiotic factors such as climate and pollutants are all contributory factors to this decline (Gounari, 2006; Essien, 2020). Potts, *et al*., (2010) affirmed that nutritional stress due to habitat loss has played an important role in the collapsed of honeybee colonies. To date, the density and survival of these plant species are been threatened not just by the above factors but by the vicious impart of climate change and land degradation. Consequent to the global level of food security and its associated effects, there is a great deal of concerns on the declines of these two bioresources all over the world.

Meo and Khan (2004) stressed that, pollen analysis has been significantly utilized as a means of tracing the history of cultivated and uncultivated plants. Samuel and Luchsinger (1979) reported that, as a result of the stimulus in the discovery and the availability of Scanning Electron Microscope (SEM), taxonomists no longer overlook pollen as the basic source of data in identification and phylogeny. They further pointed out that, the availability of countless pollen samples from herbaria sheets and the relatively fast techniques for their preparation, allows palynological survey of many taxa in relatively short period of time.

Some of the taxonomic characters provided by pollen and spore include exine stratification, sculpturing pattern of the wall, polarity, symmetry, shape, apertural types, pollen sizes and pollen form index. Carlquist (2001) stated that exine details of pollen are such that they can be used in plant identification much in the same way as that of fingerprints used for the identification of criminals.

In Nigeria, the earliest references on pollen analysis as a tool in the identification of lora sources of honey were dated back to late seventies, when notable researchers like (Sowunmi, 1976; Agwu and Akanbi, 1985; Agwu *et al.*, 1989; Agwu and Abaeze, 1991; Sowunmi, 2001; Agwu and Njokuocha, 2004; Nnamani and Agwu 2007; Nnamani and Agwu, 2008; Ige and Modupe (2010), Agwu *et al*., (2013), Oyeyemi (2017); Essien *et al*. (2022) and Essien *et al*., 2023) have used pollen morphology in assessing the diversity of honey producing plants.

Their works have currently provided commendable quality data on the pollen spectrum of some honey samples in some states in Nigeria without much from the Southern Nigeria. This present study is anchored on the systematic identification of floral diversity foraged by *Apis mellifera* L. in Ose Local Government Area of Ondo State, Nigeria in order to bridge this gap. This will go a long way to enhance their sustainability and conservation, particularly in Nigeria. The aim of this study is to systematically identify the honey plants and the taxa which honey bees forage for their pollen and nectar sources; determine the predominant preference plants and to elucidate the conservation status of these honey plants.

MATERIALS AND METHODS

Study Area

The study area is located on the northern edge of the Yoruba Hills, between latitude 701146"N and longitude 503512"E. Two seasons: the dry season and the wet season - define the region's climatic conditions. The wet season begins in the month of March and lasts until the month of November. The dry season, which lasts throughout February; begins in December. In Ose, the month of August seems to have the lowest temperature of the year. Honey flows in these area between September and April. Despite a high level of anthropogenic activity, pollen assemblages provided evidence that the vegetation of the study region was of the tropical rainforest vegetation type (Essien and Ige, 2019).

Collection of honey samples

The four honey samples used for this study were obtained from Ifon, Ute, Arimogija and Ikaro localities in Ose Local Government Area of Ondo State, Nigeria. The honey samples were acquired and transported to the Department of Plant Science and Biotechnology Research Laboratory, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria; in sealed labeled plastic bottles.

Sample preparation, Mounting and Microscopic Examination

We carefully weighed 10 g of filtered honey from each sample using a weighing balance, and the colour was noted. Each sample of honey was vigorously shaken to fully mix and distribute the chemical and botanical components. The vigorously shaken sample was then diluted with 35 ml of warm (40–50^{o}C) dilute sulphuric acid solutions (3 ml in 100 ml of water) in accordance with the procedure of Agwu *et al*. (2013). The honey-acid solution was thoroughly shaken before being centrifuged for 5 minutes at a speed of 2000 rpm. The supernatant was then decanted. For each sample of honey, the density of the retrieved polleniferous granules was determined. The recovered particles were treated with ten milliliters of ethyl acetate to eliminate water prior to acetolysis. Fresh acetolysis mixture was made by mixing concentrated sulphuric acid and acetic anhydride in a 9:1 ratio. The strategies of Erdtman (1969) and Agwu *et al*. (2013) were used to do the acetolysis. In boiling water set at boiling point (100^{0}C), the solution was mixed with the sediment and suspended for five minutes before being removed to cool for ten to twelve minutes. After 5 minutes of centrifuging and stirring, the supernatant was collected. The recovered granules then were spun twice, washed two times using distilled water, and decanted. The recovered residues were kept in a glycerin and ethanol solution in storage plastic vials (2:1).

Each vial's contents were vigorously shaken before two drops of each suspension were put on a microscope slide and covered with an 18x18 mm^2 cover slip. To keep the mount from drying out, it was sealed off with colourless nail polish. The 18 mm^2 surface was covered equally with the sample, and no samples leaked from the sides. The prepared slide was subsequently examined under an x40 Olympus microscope for counting and identification. Reference descriptions and photomicrographs from books and journals, including Sowunmi (1978; 1995), Agwu and Akanbi, (1985), Agwu *et al*. (2013), Shubharani *et al*. (2013), as well as Essien *et al*. (2023), were used for identification, counting, and categorization. Pollen grain frequencies are denoted by the Louveaux *et al*. (1978) classification of highly frequent (above 45 percent), frequent (16-45 percent), rare (3-15 percent), and sporadic (less than 3 percent).

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 formular below was applied:

Weight of pollen x factor of 20 = weight of beaker/liter 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 AND DISCUSSION

Pollen analysis

Results showed that out of twenty-two (22) pollen types belonging to eighteen (18) plants families encountered; two (2) was identified to family level, sixteen (16) to generic level, four (4) to species level, and none (0) unidentified. Ifon, Ute, Arimojiga, and Ikaro each had pollen grain counts of 310, 251, 184 and 149 respectively. The predominant pollen types include those of *Elaeis guineensis*, Poaceae, *Hymenocardia acida, Phyllanthus* spp., *Combretum* spp., *Talinum triangulare* and *Milicia excelsa* among others.

The identified species belong to varying genera of native herbs, shrubs, grass and trees. There were pollen of varying shapes, sizes and morphological features suggesting that the honey samples are multifloral. The highest number of pollen types, twenty (20) was recorded for Ifon, eighteen (18) for Ute, Arimogija seventeen (17) and Ikaro fifteen (15) which had the lowest pollen types. The predominant pollen types in the four honey samples were those of *Elaeis guineensis*, Poaceae, *Hymenocardia acida*, *Phyllanthus* spp., *Combretum* spp,, *Talinum triangulare*, *Solanum melongena*, *Combretum* spp., *Milicia excelsa* and *Phyllanthus* spp. among others. Some pollen types were frequent in almost all the sample and these include *Elaeis guineensis*, Poaceae, *Combretum* spp. and *Talinum triangulare*.

The recommended classification for expressing pollen grain frequencies by Louveaux *et al.* (1978) was adopted: Very frequent (over 45%), frequent (16-45%), rare (3-15%) and sporadic (Less than 3%).

Table 1: The occurrence/ abundance of honey plants in the honey samples from the study area

S/N	Plant Families/ Pollen types	LOCALITIES				
		IFON	UTE	ARIMOGIJA	IKARO	TOTAL
1	ANACARDIACEAE					
	Anacardium occidentale	12	4	0	6	22
2	ARECACEAE					
	Elaeis guineensis	35	52	15	12	114
3	ASTERACEAE					
	Chromolaena odorata	14	3	20	5	42
4	COMBRETACEAE					
	Combretum spp.	44	23	14	25	106
5	CYPERACEAE	4	3	6	17	30
6	EUPHORBIACEAE					
	Alchornea cordifolia	5	0	2	0	7
	Euphorbia hirta	0	0	0	4	4
7	CEASALPINIOIDEAE					
	Berlinia grandifolia	4	0	0	0	4
	Delonix regia	0	0	2	1	3
	Brachystergia eurycoma	0	6	7	3	16
8	MIMOSOIDEAE					
	Albizia zygia	0	8	0	0	8
9	IRVINGIACEAE					
	Irvingia gabonensis	14	13	6	5	38
10	MELIACEAE					
	Trichilia prieureana	10	7	0	0	17
11	MORACEAE					

	Milicia excelsa	14	10	15	22	61
12	MORINGACEAE					
	Moringa oleifera	6	3	0	1	10
13	PHYLLANTHACEAE					
	Hymenocardia acida	15	4	0	0	19
	Phyllanthus spp.	12	15	12	6	45
14	POACEAE	50	32	31	9	122
15	PORTULACACEAE					
	Talinum triangulare	14	16	20	12	62
16	SAPINDACEAE					
	Blighia sapida	0	14	6	7	27
17	SOLANACEAE					
	Solanum melongena	13	17	5	0	35
18	VERBENACEAE					
	Vitex grandifolia	11	21	8	0	40
	Total Pollen Counts	**310**	**251**	**184**	**149**	**894**

Pollen analysis of honey samples from the study localities indicates the presence of pollen grains of different plant families and different pollen types, probably a reflection of high species diversity characteristic of mosaic of lowland rainforest and secondary grassland. The honey samples from the source localities were fairly rich in pollen types**.** Certain species were common to some while others were found in all the samples studied despite the distinct source localities and the associated localized ecological characteristics. These include *Elaeis guineensis, Solanum melongena*, *Phyllanthus* spp., *Vitex grandifolia* and those of the plant families Poaceae and Cyperaceae, among others. Similar findings have been reported by Anklam (2010) that the composition and nutritional quality of honey depends on the environmental conditions, plant source and bee species.

Predominant Honey Plants

In relation to individual plant taxa most frequently visited by honey bees in this study localities, the results showed the predominant honey plants in all the four samples analyzed (Table 2). These predominant honey plants (*Elaeis guineensis Alchornea cordifolia Anacardium occidentale, Trichilia prieureana* and *Chromolaena odorata* among others are wild plants which are exposed to various levels of environmental hazards) are vestige of the Tropical Rainforest vegetation belt, characteristic plant species of mosaic of the lowland forest and secondary vegetation, found in Southern Nigeria. This was in line with the reports of Agwu and Abaeze (1991), Nnamani and Agwu, (2008), which in their various studies identified these species as good floral sources for pollen and nectars. *Elaeis guineensis* is not an entomophilous plant; it still stands out as a good nectariferous source of pollen for honey bees. This has actually confirmed the statement of Essien and Ige (2020) who opined that these species have a good aroma that attracts bees to the plant. This work confirmed the rich species diversity of the forest- savanna eco-vegetation zone of Southern Nigeria (Ofomata, 1975). Similarly, Agwu and Abaeze (1991) and Nnamani and Agwu (2008) in their studies in South-eastern Nigeria identified the abundance of these species and used them to determine the geographical and botanical origins of those honey plants found in their honey samples. *Alchornea cordifolia* and *Trichilia prieureana* pollen were equally encountered in these honey samples from Southern Nigeria. As these plants are good nectariferous taxa, they play important roles in apiculture and should be protected and conserved for sustainable exploitation and development in Nigeria.

Table 2: Percentage Frequency of Predominant plants

Study localities	Class of honey	Pollen types	Percentage composition	Frequency class
Ifon	Multi-floral	Poaceae	16.13	Frequent
		Combretum spp.	14.19	Rare
		Elaeis guinensis	11.29	Rare
		Euphorbia hirta	7.74	Rare
		Hymenocardia acida	4.84	Rare
		Talinum triangulare	4.52	Rare
		Chromolaena odorata	4.52	Rare
		Milicia excelsa	4.52	Rare
		Irvingia gabonensis	4.52	Rare
		Solanum molongena	4.19	Rare
		Anacardium occidentale	3.87	Rare
		Phyllanthus spp.	3.87	Rare
		Moringa oleifera	1.94	Sporadic
		Alchornea cordifolia	1.64	Sporadic
		Berlinia grandifolia	1.29	Sporadic
Ute	Multi-floral	*Elaeis guineensis*	20.72	Frequent
		Poaceae	12.75	Rare
		Combretum spp.	9.16	Rare
		Vitex grandifolia	8.37	Rare
		Solanum molongena	6.77	Rare
		Talinum triangulare	6.38	Rare
		Phyllanthus spp.	5.98	Rare
		Blighia sapida	5.58	Rare
		Irvingia gaonensis	5.18	Rare
		Milicia excelsa	3.98	Rare
		Anacardium occidentale	1.60	Sporadic
		Chromolaena odorata	1.20	Sporadic
Arimogija	Multi-floral	Poaceae	16.85	Frequent
		Talinum triangulare	10.87	Rare
		Chromolaena odorata	10.87	Rare
		Milicia excelsa	8.15	Rare
		Elaeis guineensis	8.15	Rare
		Combretum spp.	7.61	Rare
		Euphorbia hirta	7.07	Rare
		Phyllanthus spp.	6.52	Rare
		Blighia sapida	3.26	Rare
		Brachystergia eurycoma	3.80	Rare
Ikaro	Multi-floral	*Combretum* spp.	17.01	Frequent
		Milicia excelsa	15.00	Rare
		Cyperaceae	11.56	Rare
		Euphorbia hirta	10.88	Rare
		Talinum triangulare	8.16	Rare
		Phyllanthus spp.	4.08	Rare
		Brachystergia eurycoma	2.04	Sporadic
		Delonix regia	0.68	Sporadic

Predominant Flora

Fifteen (15) predominant species occur in Ifon including Poaceae which are most visited by bees for their pollen. Twelve (12) predominant species occur in Ute including *Elaeis guineensis* which are most visited by bees for their pollen and nectar sources. Ten (10) predominant species occur in Arimogija including Poaceae which are most visited by bees for their pollen and nectar sources whereas; eight (8) predominant taxa were reported in Ikaro including *Combretum* spp. which are most visited by bees for their pollen and nectar sources. Results showed that though the pollen of these plant species in the honeys was large, predominance of some few species was high. The reason might be that the bees preferred the nectar of particular plants than others or were more specific for forage preference. The proportion of essential pollen types ranged from "frequent to sporadic", bees prefer the very frequent plant. These species are relics of rain forest taxa characteristics of derive savanna vegetation.

This study has shown the indicator species that honey bees visit most for their pollen and nectar sources. Such plants could be properly conserved and their sustainable exploitation managed, to enhance large scale and economic production of honey from Ose Local Government Area, Ondo State and Nigeria in general. The four honey samples used in this study were all multifloral and were characterized by many pollen types indicating the presence of pollen diversity in the study area.

Phyto-ecological Indicator species

The pollen types recorded in this study were subsumed into four major phytoecological groups (Table 3). These are the Lowland rainforest taxa; Open-forest taxa; Savanna taxa and Human impact taxa. The floristic composition of Open-forest taxa in the vegetation of the study area is represented by *Milicia excelsa, Irvingia gabonensis*, *Brachystegia eurycoma*, *Combretum* spp., *Alchonea cordifolia*, *Elaeis guineensis,* and *Albizia zygia* among others. Savanna taxa are represented by those of Poaceae, *Hymenocardia acida, Trichilia prieureana, Phyllanthus* spp., and Cyperaceae among others; Lowland rainforest taxa are represented by *Talinum triangulare, Diospyrus* spp,, *Chromolaena odorata,* and *Berlinia grandifolia* whereas the Human impact taxa reflect evidence of agriculture and anthropogenic activities. They include *Euphorbia hirta, Delonix regia, Moringa oleifera, Anacardium occidentale*, and *Solanum melongena* among others.

This study showed that Open-forest taxa were the highest pollen contributors followed by those of the Savanna taxa (with 33.18% and 29.15%) respectively, as compared to the indicators of Human impact and Lowland rainforest taxa (with 13.79% and 18.61%) respectively. The low percentage of Lowland rainforest taxa and Human impact taxa can be attributed to the high level of anthropogenic activities in this region such as felling of trees for urbanization, construction and agricultural activities. This finding is in line with the report of Nnamani and Agwu (2007) who reported the low percentage of these indicators' species in their samples.

Table 3: Absolute pollen counts for the Phyto-ecological indicator species from the Study Area

S/N	PLANTS	IFON	UTE	ARIMOGIJA	IKARO	TOTAL
	Lowland rainforest taxa					
	Berlina grandifolia	4	0	0	0	4
	Chromolaena odorata	14	3	20	5	42
	Irvingia gabonensis	14	13	6	5	38
	Talinum triangulare	14	16	20	12	62
	Brachystergia eurycoma	4	6	7	3	20
	Sub-total	50	38	53	25	166
	% Composition					18.60%
	Open forest taxa					
	Albizia zygia	0	8	0	0	8
	Alchornea cordifolia	5	0	2	0	7
	Combretum spp.	44	23	14	25	106
	Milicia excelsa	14	10	15	22	61
	Elaeis guinensis	35	52	15	12	114
	Sub-total	98	93	46	59	296
	% Composition					33.18%
	Savanna taxa					
	Blighia sapida	0	14	6	7	27
	Cyperaceae	4	3	6	17	30
	Hymenocardia acida	15	4	0	0	19
	Phyllanthus sp.	12	15	12	6	45
	Poaceae	50	32	31	9	122
	Trichilia prieureana	10	7	0	0	17
	Sub-total	91	75	55	39	260
	% Composition					29.15%
	Human impact taxa					
	Delonix regia	0	0	2	1	3
	Euphorbia hirta	24	0	13	16	53
	Anacardium occidentale	12	4	0	6	22
	Moringa oleifera	6	3	0	1	10
	Solanum melongena	13	17	5	0	35
	Sub-total	55	24	20	24	123
	% Composition					13.79%
	Grand total	310	251	184	147	892

The pollen types recorded in this study were grouped into different Phyto-ecological groups thus: Lowland rainforest taxa, Open Forest taxa, Savanna taxa and Human impact taxa (Table 3). A total of 894 pollen counts were documented. Indicators of Lowland rainforest taxa contributed 167 (18.72%), Open Forest taxa 296 (33.18%), Savanna taxa 260 (29.15%) and Human impact taxa 123 (13.79%). Plant with predominant pollen types based on the Phyto-ecological indicator taxa were appropriately documented (Table 4).

Table 4: Plants with predominant pollen types based on Phyto-ecological indicator taxa

Phyto-ecological groups	Plants	Family	Pollen count	%
Lowland rainforest taxa	*Chromolaena odorata*	Asteraceae	42	25.15
	Brachystergia eurycoma	Fabaceae	20	12.00
	Talinum triangulare	Portulacaceae	62	37.13
Open-forest taxa	*Albizia zygia*	Mimosoidaee	8	2.70
	Elaeis guineensis	Arecaceae	114	38.52
	Milicia excelsa	Moraceae	61	20.61
Savanna taxa	*Phyllanthus* spp.	Phyllanthaceae	45	17.31
	Poaceae	Poaceae	122	46.92
	Trichillia preuriana	Meliaceae	17	6.54
Human impact taxa	*Euphorbia hirta*	Euphorbiaceae	53	43.10
	Moringa oleifera	Moringaceae	10	8.13
	Solanum molongena	Solanaceae	35	28.46

Honey Type

The result of these study showed that more than fifty honey plants species were identified from the four samples, giving these samples a multifloral honey types. However, bees forage different plants; thus, honey is always a mixture of several floral sources. This is in conformity with the report by Ameenah (2011), who stated that traditional medicine often aims to restore balance by using chemically complex plants, or by mixing together several different plants in order to maximize a synergistic effect or to improve the likelihood of an interaction with a relevant molecular target. Similarly, differences in their composition also mean differences in the organoleptic and nutritional properties of these honeys. The above is a reflection of the report by ASICUMPON, (2005), who reiterated that most members of some families of angiosperms such as Anacardiaceae, Fabaceae and Euphorbiaceae have been implicated to elaborate high potency of

bioactive compounds. Species such as *Anacardium occidentale*, *Phyllanthus* spp., *Euphorbia hirta*, *Alchornea cordifolia* and *Hymenocardia acida* are used topically used in ethno-medicine for the treatment of fever, diabetics and other types of illness. This study has shown their dominating influence as important and prevalent honey plants in this study area.

Status of these genetic plant resources

Apart from *Anacardium occidentalis* and *Elaeis guineensis* which are cultivated, other honey plants may be in a vulnerable state as most taxa are found in the wild species. Considering the level of climate variability and change on biodiversity globally and in the tropics particularly, coupled with environmental degradation, they could be threatened. Therefore, the policy makers should take charge for urgent policy intervention on sustainable conservation. Low pollen spectrum recorded in some samples could be a reflection of loss of bioresources attributed to impact of climate change and high level of anthropogenic activities in these localities. This is in line with the report by Potts *et al.* (2010) who suggested that nutritional stress due to habitat loss has played an important role in honeybee colony collapse, and thereby stressed the usefulness of protecting and enhancing the availability of floral resources by using rules and policies for efficient environmental management and conservation.

CONCLUSION

The diversity of predominant honey producing plants such as *Anacardium occidentale*, *Chromolaena odorata*, *Brachystegia eurycoma*, *Alchornea cordifolia*, *Trichilia prieureana* and *Elaeis guineensis* identified from this study has actually highlighted the rich diversity of honey producing species of Ose Local Government Area of Ondo State, Southern Nigeria and their conservation status. These species make a significant contribution to the livelihood of the poor rural farmers who depend on honey extraction for their main source of income.

Apis mellifera (honeybees) enhance agricultural productivity and help maintain biodiversity by providing valuable pollination services. Therefore, effective policy programmes should be placed for the propagation and protection of those predominant taxa to prevent loss of biodiversity in future. Moreover, the contribution of honey in mitigating malnutrition and hidden hunger cannot be over emphasized while carbon sequestration effects of plant genetic resources globally have attracted so many discuss.

It is therefore; recommended that, policy makers should conduct programmes for their sustainable management, protection and indeed to beekeepers in these localities, to embark on extensive propagation, afforestation, and conservation of these predominant honey plants. This will go a long way to enhance food security, reduction in hidden hunger/malnutrition and at the same time serve as a tool for carbon sequestration within this study area. The cost of inaction far outweighs the financial implications of ensuring a safe and healthy environment for the present and future generations.

Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

REFERENCES

Adeonipekun, P.A., Adeniyi, T.A. and Eden, D. (2016). Antimicrobial and Melissopalynology, Proximate and Elemental Analysis of Honey from Three Different Ecozones in Nigeria. *Noctulae Scientia Biologicae*, 8(3): 326 - 333.

Agwu, C.O.C., Essien, B.C. and Badmus, S.A. (2013). Melissopalynological study of honey samples from four localities in Dekina Local Government Area of Kogi State, Nigeria. *J. Biol. Chem. Res*., 30(2): 921 - 928.

Agwu, C. O. C. and Njokuocha, R. C. (2004). Pollen analysis of honey and the biological effects of honey as a rooting medium. *Nigerian Journal of Botany*, *17*: 74-82.

Agwu, C.O.C. and Abaeze, C.C. (1991). The palynological study of honey from Anambra, Enugu and Kogi States of Nigeria. *J. Agric. Sci. Technol*., 1(2**)***:* 126 - 131.

Agwu, C.O.C., Obueke, A.J. and Iwu, M.M. (1989). Pollen analytical and thin layer chromatographic examination of Nsukka (Nigeria) honey. *Pollen et Spores*, 31(1-2): 29 - 43.

Agwu, C.O.C. and Akanbi, T.O. (1985). Palynological study of honey from four vegetation zones of Nigeria. *Pollen et Spores*, 27(3-4): 335 - 348.

ASICUMPON, (2005). *Check List of Medicinal Plants of Nigeria and their Uses*. Nigeria: Trinity Biz Publishers. 135.

Aina, D.O. and Owonibi, K. (2011**)**. Beekeeping prospects: Palynology and the environment. *Adv. Appl. Sci. Res*., 2 (4): 79 - 85.

Anklam, E (2010). A review of the analytical methods to determine the geographical and botanical origin of honey. *J. Food Eng*., 96(3): 469 - 479.

Carlquist, S. (2001). Wood and Stem Anatomy of Rhabdodendraceae is Consistent with Placement in Caryophyllales Sensu Lato. *Journal of International Association of Wood Anatomists,* 22: 171–181.

Erdtman, G. (1969). *Handbook of Palynology, Morphology-Taxonomy-Ecology: An Introduction to Study Pollen Grains and Spores*. Scandinavian University Books, Munksgaard. Pp. 486.

Essien, B.C**.**, Ige, O.E., Ibrahim, Y.O. and Fatoyinbo, S.O. (2023). Palynotaxonomical study of Honeybees (*Apis mellifera var. adansonii*) forage and/or preference plants in South-

Western Nigeria. *Journal of Biological Research and Biotechnology (Bio-Research),* 21(2): 1973–1994.

Essien, B.C., Atukpa, M.E., Anwana, E.D., Oni, A.S. and Fatoyinbo, S.O. (2022a). A Palynological Study of Honey Samples from four Localities in Yagba West Local Government Area of Kogi State, Nigeria. *Int. J. Innovative Biosci. Res*., 10(3): 1 - 14.

Essien, B.C**.**, Obigba, S.O. and Falaye, I.S. (2022b). Floral preference of honeybees (*Apis Mellifera* var. *adansonii*) in Ijumu, Kogi State, Nigeria: a melissopalynological and biodiversity conservation perspective. NABDA *Journal of Biotechnology Research*, 1(1): 126-136.

Essien, B.C. (2020). The study of floral activities and flowering calendar of some selected plant taxa in Akoko environment, Ondo State, Nigeria. GSC Advance Res. Reviews. 4(1): 59 - 68.

Essien, B.C. and Ige, O.E. (2020). Recent pollen analysis in Akoko environment as indicators of the vegetation of Ondo State, Nigeria. *GSC Biol. Pharm. Sci.*, 12(1): 116 - 137.

Essien, B.C. and Ige, O.E. (2019). Diversity, morphology and comparative study of season of airborne pollen grains abundance in four Local Government Areas in Akoko division, Ondo State, Nigeria. *South Asian Res. J. Biol. Appl. Biosci.*, 1(1): 9 - 19.

Ferna´ndez-Torres, R., Pe´rez-Bernal, J.L., Bello-Lo´pez, M.A., Callejon-Mochon, M., Jim´enez S´anchez, J.C. and Guira´um-P´erez, A. (2005). Mineral content and botanical origin of Spanish honeys. *Talanta*, 65: 686 - 691.

Gounari, S. (2006). Studies on the phenology of *Marchalina hellenica* (gen) Hemiptera: *Coccoidea margarodidae*) in relations to honey dew flow. *Journal of Agricultural Research*, 45(1): 8-12.

Ige, O.E. and Modupe, T.O. (2010). Pollen characterization of honey samples from North Central Nigeria. *J. Biol. Sci*., 10 (1): 42 - 47.

Kek, S.P., China, N.L., Yusofa, Y.A., Tan, S.W. and Chua, L.S. (2014). Total Phenolic Contents and Color Intensity of Malaysian Honeys from the *Apis* spp. and *Trigona* spp. Bees. *Agriculture and Agricultural Science Procedia*, 2: 150 - 155.

Krell, R. (1996). Value-added Products from Beekeeping. *Food and Agricultural Organization of the United Nations, Faculty of Agricultural service Bulletin*, 92: 5-6.

Louveaux, J. A., Maurizzio, A. & Vorwohl, G. (1978). Melissopalynology. *Bee World*, 51 (3): 125-138.

Maddocks, S.E., Lopez, M.S., Rowlands, R.S. and Cooper, R. A. (2012). Manuka honey inhibits the development of *Streptococcus pyogenes* biofilms and causes reduced expression of two fibronectin binding proteins. *Microbiology*, 158: 781–790.

Meo, A.A. and Khan, M.A. (2004). Diversity of ollen morphology in the family Compositae (Asteraceae) from Northern areas of Pakistan. International Symposium in Biodiversity in Northern areas of Pakistan. September 8-10, 2003.

National Honey Board (2002). Honey, Health and Therapeutic qualities.

Neumann, P. and Carreck, N. L (2010). Honey bee colony losses. *Journal of Apicultural Research*, 49: 1-6.

Ng, W. J. and Lim, M. S. (2015). "Anti-staphylococcal activity of Melaleuca honey*", Southeast Asian Journal of Tropical Medicine and Public Health*, 46(3): 472-479.

Ng, W.E. Chan, Y.J. Lau, Z.K. Lye, P.Y. and Ee, K.Y. (2017). Antioxidant Properties and Inhibitory Effects of Trigona Honey against Staphylococcus aureus Planktonic and Biofilm Cultures. *International Journal of Geomate*, 12: 37-28-33.

Nolan, V.C., Harrison, J. and Cox J.A.G. (2019). Review and dissecting the antimicrobial composition of Honey. A*ntibiotics*, 8 (351): 1- 16.

Nnamani, C.V. and Uguru, A.N. (2013). Diversity of pollen producing plants of southern Nigeria: basic prerequisite for conservation and sustainability. *Journal of Sustainability Science and Management*, 8(1): 103-112.

Nnanami, C. V., and Agwu, C. O. C. (2007). Pollen Analysis of Honey Samples from Ebonyi State of Nigeria. *Bio-Research*, 5(1): 184-188.

Nnamani, C. V. and Agwu, C.O.C. (2008). Index of Phytoecological Indicator Species in five Honey Samples from Ebonyi State Nigeria. *Nigerian Journal of Botany*, 21(1): 129-135.

Nwankwo, C. M. Ezekoye, C. C. Igbokwe, S. O. (2014). Phytochemical screening and antimicrobial activity of apiary honey produced by honey bee (*Apis mellifera*) on clinical strains of *Staphyloccus aure*us, *Escherichia coli* and *Candida albicans*. *African Journal of Biotechnology*, 13(23): 2367-2372.

Ofomata, G. E. K. (1975). *Nigeria in Maps*. Benin City, Nigeria: Eastern States, Ethiope Publishing House. 186.

Oyeyemi, S. D. (2017). Quality Assessment of honey sourced from natural and artificial apiaries in Ekiti State, Nigeria. *Turkish Journal of Agriculture, Food Science and Technology*, 5(10): 1125-1129.

Potts, S.G, Roberts, S.P.M., Dean, R., Marris, G., Brown, M.A., Jones, R, Neumann. P. and Settele . J. (2010). Declines of Managed Honey Bees and Beekeepers in Europe. *Journal of Apicultural Research*, 49: 15-22.

Ratnieks, F.L.W.and. Carreck, N. L. (2010). Clarity on Honey Bee Collapse. *Science*, 327: 151-152.

Samuel, J. J. and Luchsinger, A. L. (1979). *Plant Systematics*. McGraw-Hill Book Company, 388.

Shubharani, R. Roopa, P. and Sivaram, V. (2013). Pollen Morphology of Selected Bee Forage Plants. *Global journal of Bio-Science and Biotechnology*, 2(1): 82-90.

Sowunmi, M.A. (1976). The potential value of honey in palaeoecology and Archaeology. *Rev. Palynol. Palaeobot.*, 21:171-185.

Sowunmi, M. A. (1976). The Potential values of Honey in Palynology and Archaeology. Review of *Palaeobotany and Palynology*, 21: 171-185.

Sowunmi, M.A. (1978). Pollen Grains of Nigerian Plants. *Grana*, 13:145-186.

Sowunmi, M.A. (1995). Pollen grains of Nigeria plants II: Woody species. *Grana, 34*, 120-141.

Sowunmi, M.A. (2001). Microscopic analysis of honey. *The Nigerian Field*. 66:125- 133.