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## Melıssopalynologıcal study of *Apıs Mellıfera* L. honey sourced from dıfferent localıtıes in the mıddle belt of Nıgerıa

**§[1]Ikegbunam Nchedochukwu Clara, [3]Walter John Okwong, [2]Osayi Emeka Emmanuel, [2]Njokuocha Reginald Chukwuemeka, [2]Ezeadim Meshach Ikechukwu, [2]Nweze Nkechinyere Onyekwere**

[1] Nnamdi Azikiwe University, Faculty of Biosciences, Department of Botany, Awka, Nigeria
[2] Department of Plant Science and Biotechnology, University of Nigeria Nsukka, 410001 Nsukka, Nigeria.
[3]University of Lagos, Faculty of Science, Department of Botany, Lagos, Nigeria

**§Corresponding author: Ikegbunam Nchedochukwu Clara. Email: nc.ikegbunam@unizik.edu.ng, Phone: +2347065224331**

### Abstract

Melissopalynological studies are useful to determine the floral contents and geographical origin of honey samples. The great diversity of plants allows bees to produce honey that is highly valuable to consumers. This study was carried out to determine pollen types in honey samples collected from the Middle Belt region to provide information on botanical origin of honey samples. Six honey samples were collected from Benue and Kogi States in North Central, Nigeria. According to their pollen spectra, they were multiflora honeys. The honey samples collected from Benue State had a total pollen count of 8, 932, thirty nine pollen types in twenty five (25) families of plants and samples from Kogi State recorded 3,859 pollens, 29 pollen types in nineteen (19) plant families. A total of thirteen pollen types were identified to generic level, fifteen to species and nine to family level in honey samples collected from Benue State whereas in Kogi State samples, eleven pollen types were identified to generic level, eight to species and nine to family level. The major pollen types in Benue honey samples were *Sarcocephalus latifolius* , *Phyllanthus* sp., *Lannea* sp., *Hymenocardia acida, Syzygium guineense*, *Solanum* sp., *Parkia biglobosa*, members of Anacardiaceae, Combretaceae/Melastomataceae, Euphorbiaceae and Sapindaceae whereas *Hymenocardia acida, Elaeis guineensis, Solanum* sp., *Cassia* sp., *Sarcocephalus latifolius,* members of Combretaeaeceae/Melastomataceae and Fabaceae were dominant in samples from Kogi State. The pollen analyses provided important information on the floral source preferences of bees and on honey contents, which can be used by traditional beekeepers and the public in general to promote the production and consumption of high-quality honey in the Middle Belt region of Nigeria.

**Keywords**: Honey, Pollen analysis, Kogi State, Benue State, Middle Belt

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## INTRODUCTİON

Public awareness regarding the pollination role of honeybees in agriculture has led to an increase in the number of small-scale bee keeping operations in Nigeria, particularly in the rural areas. Bees rely on the abundance and availability of plant species. The diversity of nectar-source plants determines the variety of honey kinds generated in a given area (Sibel and Mustafa, 2007). Also, the geography, climate, cultural practices and farming methods, plant species composition and flowering duration vary from place to place (Fichtl ahd Addi, 1994). An important technique for defining such beekeeping management operations as frequency of honey harvest and projecting the honey flow period of a region is measuring the availability of bee floral resources and constructing a floral calendar in different agro-ecological zones of Nigeria.

Nigeria is a major consumer of honey, although the country's total production falls short of self-sufficiency. Threats to honey bee health, identification of local nectar/pollen sources and their bloom periods, and how to increase adult foraging numbers are all concerns that every beekeeper faces. These challenges have resulted in an increase in the use of quantitative analyses to authenticate the geographical and botanical origins of honeys. Pollen analysis is used to validate the claimed geographical and botanical origin of honey (Adekanmbi *et al*., 2019). Adulterated products are sometimes passed off as genuine thereby posing a threat to the honey business. There are no requirements for assessing the quality of honey in the market because there is no special legislation. As a result, national legislation is required, and Nigeria's regulatory authorities must embrace pollen analysis as one of the food quality methods for honey samples in order to determine the geographical origin and botanical source. In addition, poor hive management and the harvesting of larvae and honey may result in contamination, impacting the fragrance and taste. There are certain rudimentary ways of determining authenticity, such as the flame and water test, which have shown to be unreliable. Pollen analysis is used to characterize honeys, which is important for both scientific and commercial purposes (Sik *et al*., 2017).

Some authors investigated the pollen content of honey produced in Nigeria and discovered disparities in pollen content (Njokuocha and Ekweozor 2007; Adekanmbi and Ogundipe, 2009, Adeonipekun, 2012; Aina *et al.,* 2015, Ikegbunam and Okwu, 2021; Ikegbunam *et al*., 2022). Similarly, physicochemical attributes and pollen profile of samples from different areas (Adekanmbi *et al.,* 2019; Ikegbunam and Walter, 2021), their botanical origin (Aina and Owonibi, 2011), antibacterial and antioxidant activity (Agbagwa and Frank Peterside, 2010; Adeonipekun *et al.,* 2016) and specific compounds such as sugars and phenolic or volatile compounds (Adetuyi *et al.,* 2009) have been investigated.

In the Middle Belt, few melissopalynological studies have been recorded. Palynological investigation of honey samples from four localities in Yagba West Local Government of Kogi State was undertaken by Essien *et al*. (2022). The authors were able to identify pollen *of Elaeis guineensis, Pentaclethra macrophylla, Lannea acida, Alchornea cordifolia, senna occidentalis and Crossopteryx fabrifuga* as the most common plant species forage by bees in the area. Similar studies on honey from the Middle Belt have also been conducted by some authors (Ige and Modupe, 2010; Agwu *et al*., 2013; Aina, *et al*., 2015) in the past to identify the melliferous plant species in the area. This study therefore provides further insights regarding the foraging ecology and floral preferences of honey bees and identifies the “predominant,” “secondary,” and “important minor” plant taxonomic groups in the Middle Belt from which honey bees collect pollen grains for honey production .

## MATERİALS AND METHODS

### Honey Sample Collection

The honey samples used for the study were collected from the beekeepers in Omala, Bassa, Ofu, Kwande, Otukpo and Gwer-West in Kogi and Benue States respectively (Figure 1).

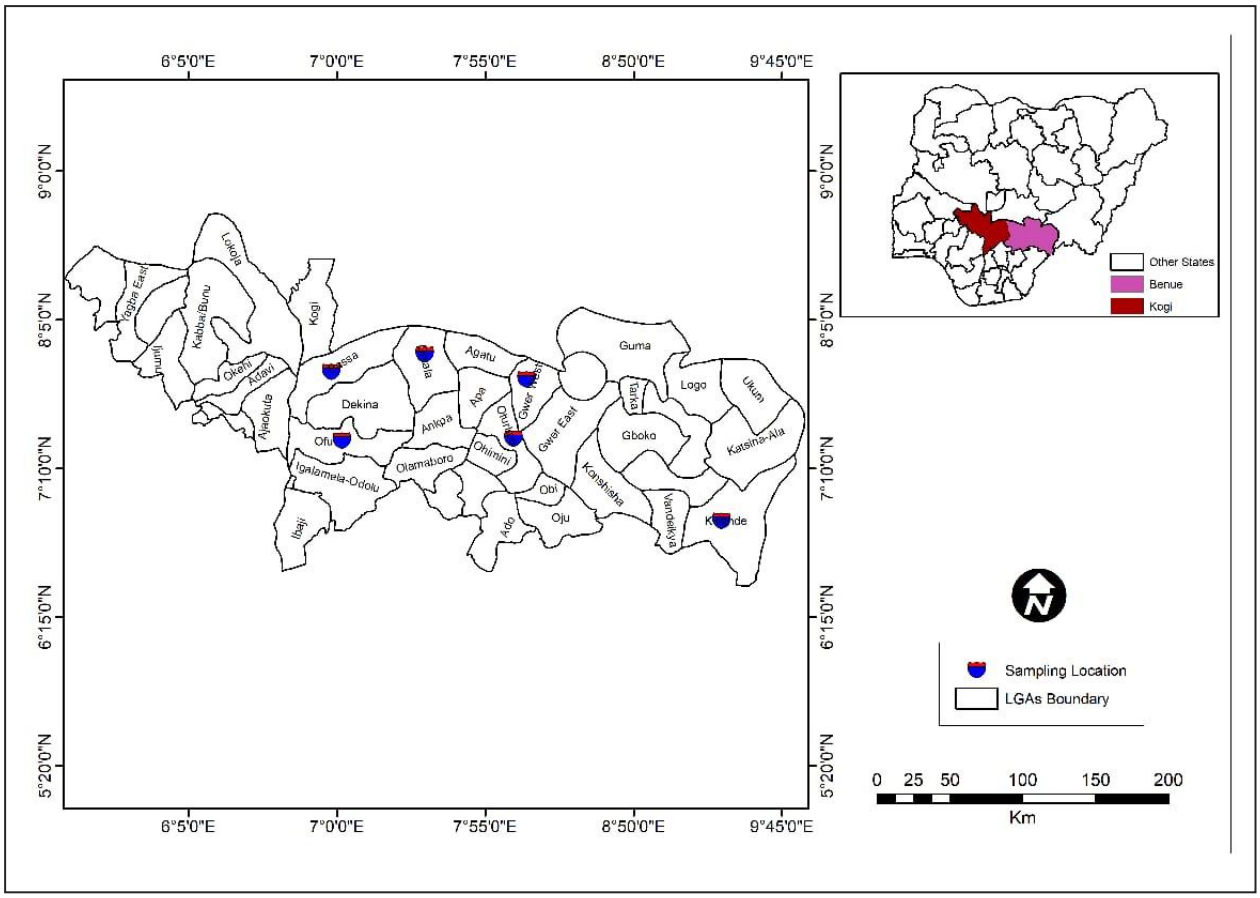

Figure 1: Showing the sites of the study location

**Pollen Analysis**

During the 2017–2018 year, samples were collected directly from beekeepers and stored in plastic containers with tight lids until analysis. Following sample homogenization, all measurements were made. To dissolve colloidal particles and sugars, honey samples were diluted with 35 ml of warm acidified water and centrifuged at 2500 rpm for 10 minutes. Before acetolysis, the supernatant was properly decanted and 10 ml of glacial acetic acid was used to remove the water. Faegri and Iversen (1975) technique was used to acetolyze honey samples. Polliniferous residue was mounted on glycerine jelly and examined under a compound microscope at a magnification of x400. At least 500 pollen grains were counted in each honey sample. For the pollen spectra of the samples, the relative frequency, represented as a percentage, of all identified pollen types was taken into account. The pollen grains were identified with the help of descriptions and photomicrographs in books and Journals ( Ybert, 1979; Gosling *et al.*, 2013). They were also compared with reference slide collections in the Palynology Laboratory, Department of Plant Science and Biotechnology, University of Nigeria, Nsukka. Photomicrographs of some important pollen were taken with a Motic camera 2.0. Pollen was classified depending on the percentage of each pollen type present: pollen grains were assigned to one of the following pollen frequency classes: Predominant (> 45% of the total pollen grains counted); Secondary (16% - 45%); Important Minor (3% - 15%) and Minor pollen types (<3%) (Jones and Bryant, 2004).

**RESULTS**

Palynological analysis of the samples showed high diversity in the plants represented in the pollen spectra. The honey samples collected from Benue State had a total pollen count of 8, 932 belonging to 25 families and 39 pollen types, while samples from Kogi State recorded 3,859 pollen count belonging to 19 families and 29 pollen types (Tables 1 and 2). A total pollen count of 6,438, 1,816, and 678 was recorded in Kwande, Gwer-West and Otukpo respectively in Benue State (Table 1). Kogi honey samples had pollen counts of 1,405, 1,374 and 1,080 for the honey collected from Omala, Bassa and Ofu

respectively (Table 2). The highest pollen count was recorded in honey sample collected from Omala Local Government Area. All the honey samples were multi floral honeys derived from various honey plants (Table 3, Plate 1, Fig. 2).

In Gwer-West, the pollen grains fell mostly under secondary (*Sarcocephalus latifolius* 22.5%, *Phyllanthus* sp. 15.7%, Euphorbiaceae 18.3%) and important minor (members of Poaceae 4.4%) frequency classes. Similarly, in Kwande the honey sample stood out with secondary pollen grains (Combretaceae/Melastomataceae (27.3%), Sapindaceae (21.7%), *Sarcocephalus latifolius* (18.2%) and important minor (*Lannea* sp 13.8%, and *Hymenocardia acida* 3.4%). Pollen grains of *Syzygium guineense* (15.6%), Anacardiaceae (11.6%), *Solanum* sp. (10.9%) and *Parkia biglobosa* (6.8%) were dominant in Otukpo sample and majority of the pollen grains were within the important minor class with the exception of Combretaceae/Melastomataceae (38.3%) which is secondary (Table 4). In Omala, pollen of Caesalpinoideae (44.1%), *Hymenocardia acida* (23.7%),*Elaeis guineensis* (18.0%), *Ziziphus* sp. (3.5%), *Syzygium guineense* (2.9%) were classified as secondary, important minor and minor respectively (Table 4). In Bassa, dominant pollen grains were classified as secondary (Caesalpinoideae 39.4%), and important minor (*Cassia* sp. 12.6%, *Sarcocephalus latifolius* 11.9%, Combretaeaeceae/Melastomataceae 7.1%, Faboideae 6.4%). Pollen grains of *Solanum* sp. (29.9%), Caesalpinioideae (19.4%), *Syzygium guineense* (7.4%), *Mussaenda* sp. (4.6%) *Lannea* sp. (4.6%) were recovered in Ofu and the pollen grains were classified as secondary and important minor (Table 5).

## DISCUSSION

The presence of a diversity of key pollen types in the samples proved that the honey samples were of botanical origin and provided a clear indication of their geographical origin (Ige and Modupe, 2010). The pollen composition of the honey samples revealed vital details about the flora of the location from where the samples were sourced. Pollen of various forms, sizes and morphological traits were found in the honey samples, indicating that they were all multifloral honeys made from a range of nectar sources. The honey samples sourced from Benue State demonstrated that honeybees foraged for both indigenous and exotic species from different floral sources in the honey production. The pollen spectrum of the samples revealed the plant species visited by the bees and reflected the derived savannah vegetation of North Central, Nigeria. According to Ige and Modupe (2010), typical honey plants of North Central Nigeria include *Parinari kerstingi, Lannea* sp., *Syzygium* sp., *Elaeis guineensis, Entada abysinica and Vitellaria paradoxa* pollen grains. Similarly, some of these plant species were identified in this investigation. Their dominance reflects the diversity of plant species available to honeybees for nectar, other sweet secretions, and pollen grains required for honey production. It also indicates the abundance and variety of melliferous plants that can be used in the establishment of a bee farm. The honey samples were all multifloral indicating that the bees had access to varieties of honey plants in their environment.

The pollen counts in Otukpa and Gwer-West honey samples were quite low when compared to other samples analyzed. This could be due to anthropogenic activity such as indiscriminate tree felling and over-exploitation of bio resources in these areas for various purposes. To avoid aggression, bees should live in a woodland environment with as little human contact as possible. Also according to Ekhuemelo *et al*. (2017), charcoal manufacturing is a common activity in many villages in Benue State and is one of the leading drivers of deforestation, which could explain the low pollen count in the Otukpa and Gwer-West honey samples. Pollen grains of *Prosopis africana* and *Parkia biglobosa* are two of the most important bee foraged plants in the area, according to Agbidye and Hyamber (2015), but from the reports of Ekhuemelo *et al*. (2017), these plant species (*Afzelia africana, Prosopis africana* and *Parkia biglobosa*) are the most preferred wood species for charcoal production in Benue State. As a result, all of these plant species were underrepresented in honey samples. In Kwande Local Government, pollen recovery from the honey samples was high due to the undisturbed plant diversity in this area. As well, honey bees in this area tend to concentrate their foraging efforts on a few species because the preferred sources are more numerous and supply specific nutrients that colonies need at a particular time.

Table 1: Pollen spectrum of the honey samples collected from Benue State

| S/N | Pollen types | Gwer-West Pollen count (%) | Kwande Pollen count (%) | Otukpo Pollen count (%) |
|---|---|---|---|---|
| 1 | **Anacardiaceae** | 0 | 0 | 11.2 |
| | *Lannea* sp. | 2.0 | 13.8 | 0 |
| 2 | **Acanthaceae** | 0 | 0 | 0 |
| | *Justicia* sp. | 0 | 0.1 | 0 |
| 3 | **Asteraceae** | 2.2 | 0 | 2.4 |
| 4 | **Bombacaceae** | | | |
| | *Bombax buonopozense* P. Beauv. | 1.0 | 0.6 | 0 |
| 5 | **Boraginaceae** | | | |
| | *Trichodesma* sp. | 0 | 0.9 | 0 |
| 6 | **Capparidaceae** | | | |
| | *Crateva adansonii* Dc. | 4.1 | 0 | 0 |
| 7 | **Celastraceae** | | | |
| | *Hippocratea africana* (Wild.) Loes. | 0 | 0.2 | 0 |
| 8 | **Combretaceae/Melastomataceae** | 11.9 | 23.7 | 38.3 |
| | *Terminalia* sp. | 0 | 2.2 | 0 |
| 9 | **Cyperaceae** | 4.2 | 0 | 0 |
| 10 | **Euphorbiaceae** | 18.3 | 0 | 0 |
| | *Alchornea cordifolia* (Shum. & Thonn.) Mull. Arg. | 0 | 0.2 | 0 |
| | *Antidesma* sp. | 0 | 0.2 | 0 |
| 11 | **Fabaceae** | | | |
| | Faboideae | 0 | 0.4 | 0 |
| | *Pterocarpus* sp. | 4.3 | 0 | 0 |
| | Caesalpinoideae | | | |
| | *Afzelia africana* Sm. | 0 | 0.8 | 0 |
| | Mimosoideae | | | |
| | *Parkia biglobosa* (Jacq.) R.Br. ex G.Don | 0 | 0.9 | 6.8 |
| | *Prosopis africana* (Guill. & Perr.) Taub. | 0 | 0.1 | 0 |
| 12 | **Irvingiaceae** | | | |
| | *Irvingia* sp. | 4.2 | 0 | 0 |
| 13 | **Malvaceae** | 0 | 0.8 | 0 |
| 14 | **Meliaceae** | | | |
| | *Trichilia* sp. | 0 | 0.3 | 3.5 |
| 15 | **Myrtaceae** | | | |
| | *Syzygium guineense* Engl. | 0 | 2.3 | 15.6 |
| | *Psidium guajava* L. | 0 | 0.9 | 0 |
| 16 | **Moraceae** | 0 | 0.3 | 0 |
| | *Ficus* sp. | 0 | 0.1 | 0 |
| 17 | **Phyllanthaceae** | | | |
| | *Phyllanthus* sp. | 15.7 | 2.3 | 0 |
| | *Bridelia ferruginea* Benth. | 2.2 | 0.2 | 2.4 |
| | *Hymenocardia acida* Tul. | 0 | 3.4 | 0 |
| 18 | **Poaceae** | 4.4 | 0.5 | 0 |
| 19 | **Rhamnaceae** | | | |
| | *Ziziphus* sp. | 0 | 0.1 | 2.4 |
| 20 | **Rubiaceae** | | | |
| | *Sarcocephalus latifolius* (Sm.) Bruce | 22.5 | 18.2 | 0 |
| | *Morinda lucida* Benth. | 0 | 0.6 | 0 |
| 21 | **Sapindaceae** | 0 | 21.7 | 3.8 |
| 22 | **Sapotaceae** | | | |
| | *Mimusop* sp. | 0 | 0.2 | 0 |
| 23 | **Solanaceae** | | | |
| | *Solanum* sp. | 1.7 | 3.0 | 10.9 |
| 24 | **Ulmaceae** | | | |
| | *Celtis* sp. | 0 | 0.8 | 0 |
| 25 | **Urticaceae** | | | |
| | *Musanga* sp. | 1.3 | 0 | 0 |
| | Indeterminate | 0.3 | 0.1 | 1.2 |
| | Total (8932) | 1816 | 6438 | 678 |

Table 2: Pollen spectrum of the honey samples collected from Kogi State

| S/N | Pollen types | Omala Pollen count (%) | Bassa pollen count (%) | Ofu pollen count (%) |
|---|---|---|---|---|
| 1 | **Anacardiaceae** | 0.4 | 1.8 | 0 |
| | *Lannea* sp. | 0.6 | 0 | 4.6 |
| | *Mangifera indica* Linn. | 0 | 0.3 | 0 |
| 2 | **Ampelidaceae** | | | |
| | *Cissus refesceus* Guill. & Perr. | 0 | 0.2 | 0 |
| 3 | **Arecaceae** | 0 | 0 | 0 |
| | *Elaeis guineensis* Jacq. | 18.0 | 0.6 | 23.2 |
| 4 | **Apocynaceae** | | | |
| 5 | **Combretaeaeceae/Melastomataceae** | 0 | 7.1 | 1.9 |
| 6 | **Cyperaceae** | 0 | 0.2 | 0 |
| 7 | **Euphorbiaceae** | | | |
| | *Alchornea cordifolia* (Schum. & Thonn.) | 2.3 | 12.5 | 0.9 |
| 8 | **Fabaceae** | | | |
| | Caesalpinoideae | 44.1 | 39.4 | 19.4 |
| | *Cassia* sp. | 0 | 12.6 | 0 |
| | Faboideae | 0.7 | 6.4 | 0 |
| | Mimosoideae | 0 | 0.2 | 0 |
| | *Albizia* sp. | 0.6 | 0 | 0 |
| 9 | **Flacourtiaceae** | | | |
| | *Scottelia chevalieri* Chipp. | 0 | 0 | 0.5 |
| 10 | **Moraceae** | 0 | 2.1 | 0.5 |
| 11 | **Myrtaceae** | | | |
| | *Syzygium guineense* Engl. | 2.9 | 0.3 | 7.4 |
| 12 | **Olacaceae** | | | |
| | *Olax* sp. | 0 | 0.2 | 0 |
| 13 | **Phyllanthaceae** | | 0.2 | |
| | *Bridelia ferruginea* Benth. | 2.1 | 0 | 3.7 |
| | *Hymenocardia acida* Tul. | 23.7 | 0 | 0 |
| 14 | **Poaceae** | 0 | 1.2 | 1.9 |
| 15 | **Rhamnaceae** | | | |
| | *Ziziphus* sp. | 3.5 | 0 | 0.9 |
| 16 | **Rubiaceae** | | | |
| | *Sarcocephalus latifolius* (Sm.) Bruce. | 0 | 11.9 | 0 |
| | *Mussaenda* sp. | 0 | 0.3 | 5.5 |
| | *Morinda umbellate* L. | 0 | 0.2 | 0 |
| 17 | **Sapindaceae** | 0.4 | 0.7 | 3.7 |
| 18 | **Solanaceae** | | | |
| | *Solanum* sp. | 0.8 | 0.7 | 29.9 |
| 19 | **Ulmaceae** | | | |
| | *Celtis* sp. | 0 | 0.7 | 0 |
| | Indeterminate | 0.2 | 0.3 | 0.1 |
| | Total(3,859) | 1405 | 1374 | 1080 |

Table 3: Predominant pollen types, percentage occurrences and classification of the honey samples

| Location | Class of Honey | Pollen types | Percentage occurrences (%) |
|---|---|---|---|
| Gwer-West | Multi floral | *Sarcocephalus latifolius* (Sm.) Bruce. | 22.5 |
| | | *Phyllanthus* sp. | 15.7 |
| | | Euphorbiaceae | 18.3 |
| | | Combretaceae/Melastomataceae | 11.9 |
| | | Poaceae | 4.4 |
| Kwande | Multi floral | Combretaceae/Melastomataceae | 27.3 |
| | | Sapindaceae | 21.7 |
| | | *Sarcocephalus latifolius* (Sm.) Bruce | 18.2 |
| | | *Lannea* sp. | 13.8 |
| | | *Hymenocardia acida*Tul. | 3.4 |
| Otukpo | Multi floral | Combretaceae/Melastomataceae | 38.3 |
| | | *Syzygium guineense* Engl. | 15.6 |
| | | Anacardiaceae | 11.2 |
| | | *Solanum* sp. | 10.9 |
| | | *Parkia biglobosa* (Jacq.) R.Br. ex G.Don | 6.8 |
| Omala | Multi floral | Caesalpinoideae | 44.1 |
| | | *Hymenocardia acida* Tul. | 23.7 |
| | | *Elaeis guineensis* Jacq. | 18.0 |
| | | *Ziziphus* sp. | 3.5 |
| | | *Syzygium guineense* Engl. | 2.9 |
| Bassa | Multi floral | Caesalpinoideae | 39.4 |
| | | *Cassia* sp. | 12.6 |
| | | *Sarcocephalus latifolius* (Sm.) Bruce. | 11.9 |
| | | Combretaeaeceae/Melastomataceae | 7.1 |
| | | Faboideae | 6.4 |
| Ofu | Multi floral | *Solanum* sp. | 29.9 |
| | | Caesalpinioideae | 19.4 |
| | | *Syzygium guineense* Engl. | 7.4 |
| | | *Mussaenda* sp. | 5.5 |
| | | *Lannea* sp. | 4.6 |

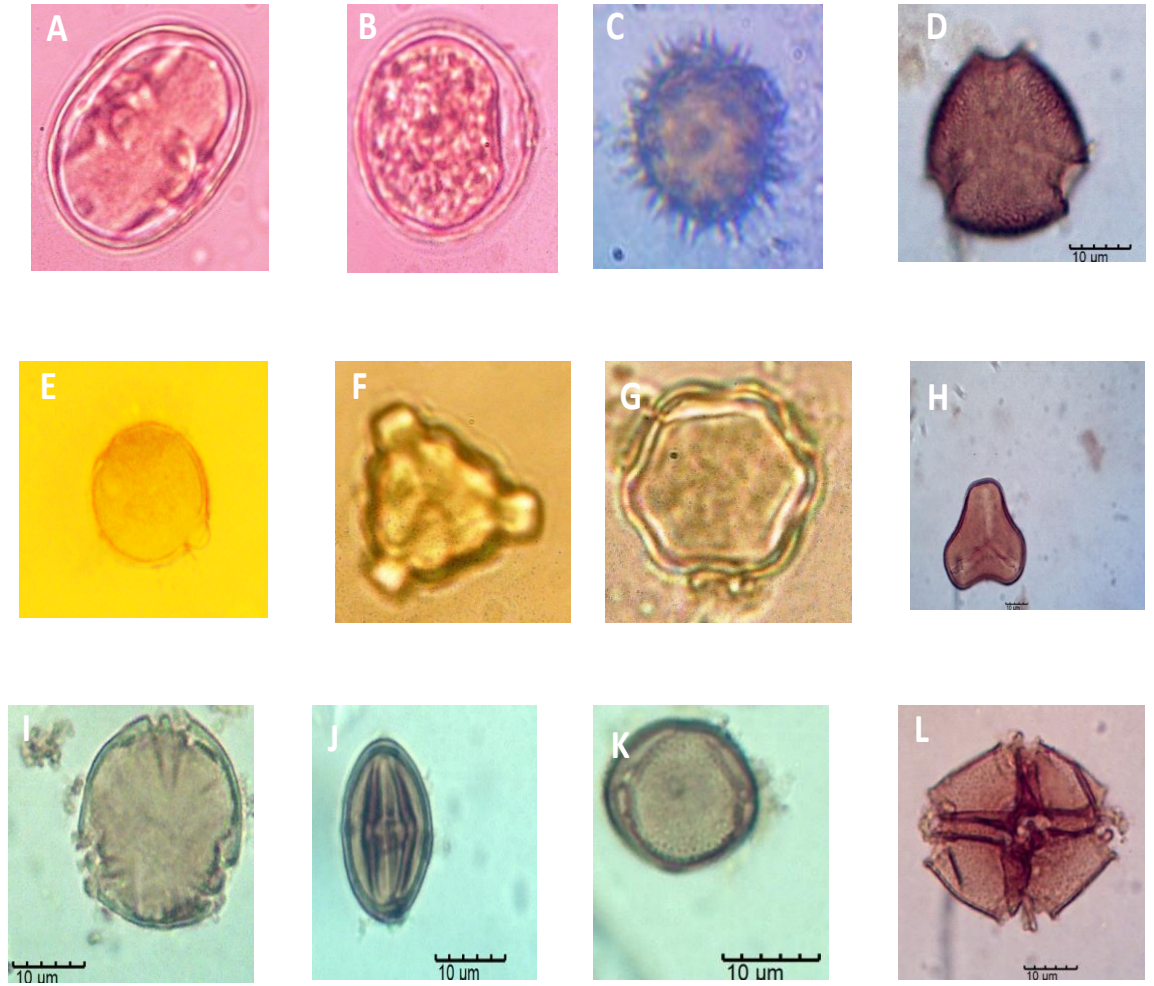


**Plate 1**: Photographs of some recorded pollen grains (A) Sapotaceae (b) Poaceae (c) *Aspilia africana* (d) Sapindaceae (E) *Solanum* sp. (F,G) *Terminalia catappa* (H) *Elaeis guineensis* (I) *Alchornea cordifolia* (J) *Antidesma* sp. (K) *Sarcocephalus latifolius* (L) unidentified pollen

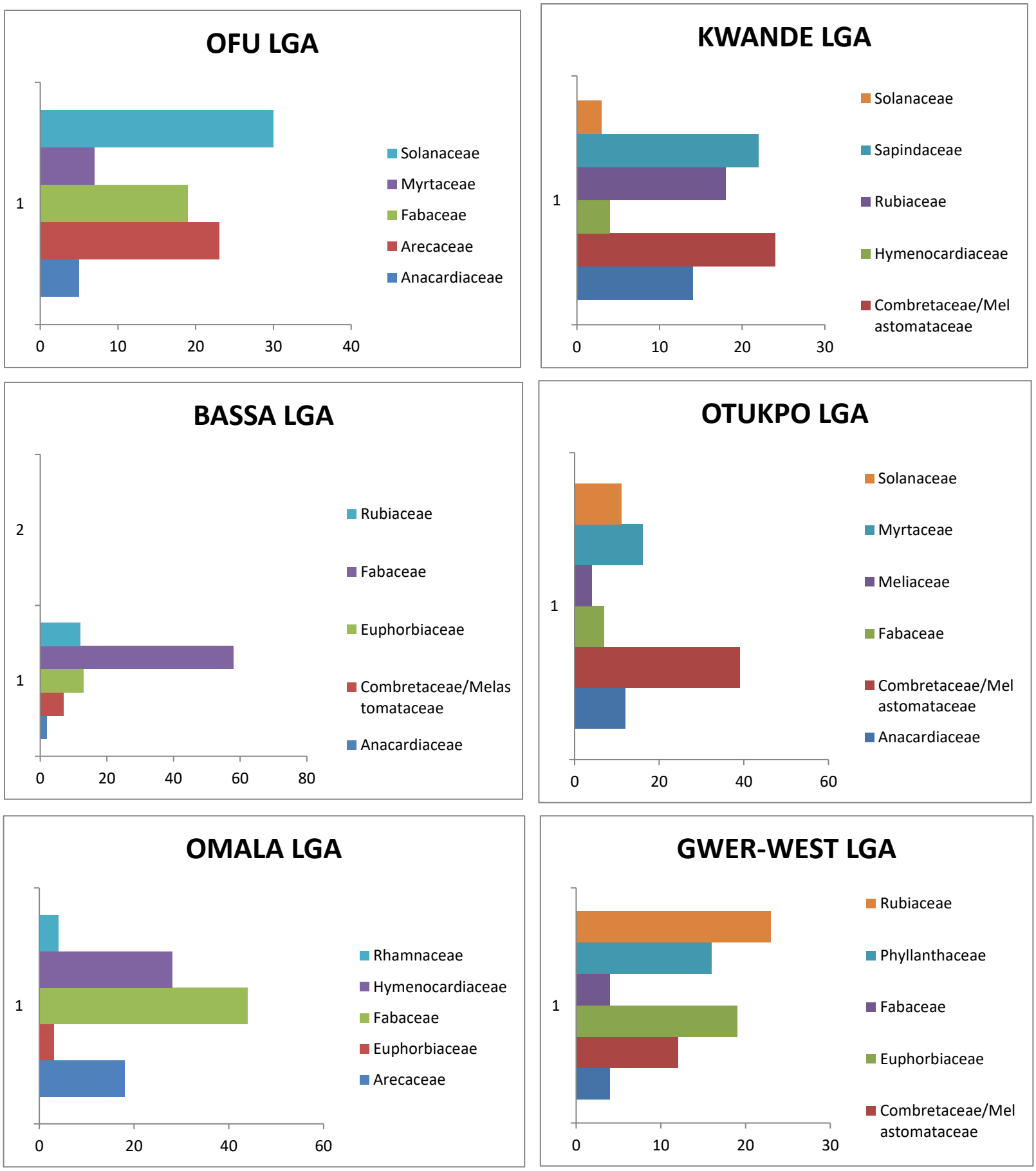


Figure 2: Bar charts of the main families of plants in the multifloral honeys

Table 4: Frequency class of pollen types in honey samples collected from Benue State

| S/N | Pollen types | Gwer- West | Kwande | Otukpo |
|---|---|---|---|---|
| **1** | **Anacardiaceae** | - | - | Important minor |
| | *Lannea* sp. | Minor | Important minor | - |
| **2** | **Acanthaceae** | | | |
| | *Justicia* sp. | - | Minor | - |
| **3** | **Asteraceae** | Minor | - | Minor |
| **4** | **Bombacaceae** | | | |
| | *Bombax buonopozense* P. Beauv. | Minor | Minor | - |
| **5** | **Boraginaceae** | | | |
| | *Trichodesma* sp. | - | Minor | - |
| **6** | **Capparidaceae** | | | |
| | *Crateva adansonii* Dc. | Important minor | - | - |
| **7** | **Celastraceae** | | | |
| | *Hippocratea africana* (Wild.) Loes. | - | Minor | - |
| **8** | **Combretaceae/Melastomataceae** | Important minor | Secodary | Secondary |
| | *Terminalia* sp. | | Minor | - |
| **9** | **Cyperaceae** | Important minor | - | - |
| **10** | **Euphorbiaceae** | Secondary | - | - |
| | *Alchornea cordifolia* (Shum. & Thonn.) Mull. Arg. | - | Minor | - |
| | *Antidesma* sp. | - | Minor | - |
| **11** | **Fabaceae** | - | | - |
| | **Faboideae** | - | Minor | - |
| | *Pterocarpus* sp. | Important minor | - | - |
| | **Caesalpinoideae** | | | |
| | *Afzelia africana* Sm. | - | Minor | - |
| | **Mimosoideae** | | | |
| | *Parkia biglobosa* (Jacq.) R.Br. ex G.Don | - | Minor | Important minor |
| | *Prosopis africana* (Guill. & Perr.) Taub. | - | Minor | - |
| **12** | **Irvingiaceae** | | | |
| | *Irvingia* sp. | Important minor | - | - |
| **13** | **Malvaceae** | - | Minor | - |
| **14** | **Meliaceae** | | | |
| | *Trichilia* sp. | - | Minor | Important minor |
| **15** | **Myrtaceae** | | | |
| | *Syzygium guineense* Engl. | - | Minor | Secondary |
| | *Psidium guajava* L. | - | Minor | - |
| **16** | **Moraceae** | - | Minor | - |
| | *Ficus* sp. | - | Minor | - |
| **17** | **Phyllanthaceae** | | | |
| | *Phyllanthus* sp. | Important minor | Minor | - |
| | *Hymenocardia acida* Tul. | - | Important Minor | - |
| | *Bridelia ferruginea* Benth. | Minor | Minor | Minor |
| **18** | **Poaceae** | Important minor | Minor | - |
| **19** | **Rhamnaceae** | | | |
| | *Ziziphus* sp. | - | Minor | Minor |
| **20** | **Rubiaceae** | | | |
| | *Sarcocephalus latifolius* (Sm.) Bruce | Secondary | Secondary | - |
| | *Morinda lucida* Benth. | - | Minor | - |
| **21** | **Sapindaceae** | - | Secondary | Important minor |
| **22** | **Sapotaceae** | | | |
| | *Mimusop* sp. | - | Minor | - |
| **23** | **Solanaceae** | | | |
| | *Solanum* sp. | Minor | Important minor | Important minor |
| **24** | **Ulmaceae** | | | |
| | *Celtis* sp. | - | Minor | - |
| **25** | **Urticaceae** | | | |
| | *Musanga* sp. | Minor | - | - |

Table 5: Frequency class of pollen types in honey samples collected from Kogi State

| S/N | Pollen types | Omala | Bassa | Ofu |
|---|---|---|---|---|
| **1** | **Anacardiaceae** | Minor | Minor | |
| | *Lannea* sp. | Minor | - | Important minor |
| | *Mangifera indica* Linn. | - | Minor | - |
| **2** | **Ampelidaceae** | | | |
| | *Cissus refesceus* Guill. & Perr. | - | Minor | - |
| **3** | **Arecaceae** | | | |
| | *Elaeis guineensis* Jacq. | Secondary | Minor | Secondary |
| **4** | **Apocynaceae** | | | |
| **5** | **Combretaeaeceae/Melastomataceae** | - | Important minor | Minor |
| **6** | **Cyperaceae** | - | Minor | - |
| **7** | **Euphorbiaceae** | Minor | Important minor | Minor |
| | *Alchornea cordifolia* (Schum. & Thonn.) Mull.Arg. | | | |
| **8** | **Fabaceae** | | | |
| | **Caesalpinoideae** | Secondary | Secondary | Secondary |
| | *Cassia* sp. | - | Important minor | - |
| | **Faboideae** | Minor | Important minor | - |
| | **Mimosoideae** | - | Minor | - |
| | *Albizia* sp. | Minor | - | - |
| **9** | **Flacourtiaceae** | | | |
| | *Scottelia chevalieri* Chipp. | - | - | Minor |
| **10** | **Moraceae** | | Minor | Minor |
| **11** | **Myrtaceae** | | | |
| | *Syzygium guineense* Engl. | Minor | Minor | Important minor |
| **12** | **Olacaceae** | | | |
| | *Olax* sp. | - | Minor | - |
| **13** | **Phyllanthaceae** | | Minor | |
| | *Bridelia ferruginea* Benth. | Minor | - | Important minor |
| | *Hymenocardia acida* Tul. | - | secondary | - |
| **14** | **Poaceae** | - | Minor | Minor |
| **15** | **Rhamnaceae** | | | |
| | *Ziziphus* sp. | Important minor | - | Minor |
| **16** | **Rubiaceae** | | | |
| | *Sarcocephalus latifolius* (Sm.) Bruce. | - | Important minor | - |
| | *Mussaenda* sp. | - | Minor | Important minor |
| | *Morinda umbellate* L. | - | Minor | - |
| **17** | **Sapindaceae** | Minor | Minor | Important minor |
| **18** | **Solanaceae** | | | |
| | *Solanum* sp. | Minor | Minor | Secondary |
| **19** | **Ulmaceae** | | | |
| | *Celtis* sp. | - | Minor | - |

Pollen count was low in honey samples from Kogi State. This may have resulted from processing and packaging. Similarly, in a study of honey samples taken from several locations in Kogi State. Aina (2016) found similar results, which it attributed to anthropogenic activities and packaging procedures such as sieving. However, artificial feeding of honey bees with sucrose syrup may reduce the amount of pollen grains in the honey since the bees may no longer need to collect nectar and pollen from plant blooms to make honey. Pollen of *Hymenocardia acida, Elaeis guineensis, Solanum* sp., *Cassia* sp., *Sarcocephalus latifolius* , and members of the Combretaeceae/Melastomataceae and Fabaceae families dominated the samples. This matches the findings of Agwu *et al.* (2013), who discovered identical pollen types in honey samples collected from four locations in Dekina Local Government Area, Kogi State. Pollen grains of *Alchornea cordifolia, Syzygium guineense, Ziziphus* sp., and Phyllanthaceae, Poaceae, and Sapindaceae families were also found in the samples. Honey bees, according to Salonen *et al*. (2009), are picky about which plants they use for nectar and pollen during foraging activities. Although, weather circumstances, flowering season, and changes in plant phonological behavior may all influence foraging. Furthermore, pollen foragers do not visit the same plants that nectar foragers from the same colony do, resulting in variations in the sorts of plants that a colony forages based on its nectar and pollen requirements (Sajwani *et al.,* 2014).

The presence of these pollen types in the samples validated their geographic origin and reflected the North Central's guinea savannah vegetation. Representative species of the lowland rainforest and derived savannah vegetation, according to White (1983), include *Anacardium occidentale*, *Lannea acida*, *Hymenocardia acida*, *Elaeis guineensis*, *Parkia biglobosa*. The honey samples were botanically evaluated on the basis of their percentage pollen frequency, revealing that they were made up of numerous plant species, classifying them as multifloral honeys. According to the EU standard (EU Council, 2002), multifloral honeys are those in which no single pollen type accounts for more than 45 percent of the total pollen collected and identified throughout the examination. The pollen grains in the honey samples were classified as secondary, significant minor, and minor, respectively, because they were all multifloral. The identification of plants used by honeybees is of great importance since the combination of wind and insect pollinated taxa found in a honey sample will often produce a pollen spectrum that is unique for the specific geographical region where it was produced (Ige and Obasanmi, 2014).

## CONCLUSİON

The pollen profile shows that the honeys were formed from multiple taxa and therefore multifloral. This shows that the vegetation of the source locations have abundant milleferous plants and therefore capable of supporting the large scale honey production in Benue and Kogi State. As well, the identified pollen types reflected the guinea savannah vegetation of the North central.

### Conflict of İnterest

The authors declear that they have no conflict of interest.

### Author contribution

INC and WJO conceptualized the research idea and provided the theoretical framework, carried out data collection, sample analysis and wrote the original draft of the manuscript. OEE and EMI validated, reviewed and edited the research work and made technical inputs. NRC and NNO designed the study and supervised the research work. All authors read and approved the final manuscript.

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