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Proximate, mineral and melissopalynological analyses of honeys produced by *Apis mellifera adansonii* maintained at the University of Lagos Apiary

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Abstract

This study focused on the management of established *Apis mellifera adansonii* colonies, and evaluation of the proximate, mineral, and pollen contents of honeys produced by these bees at the University of Lagos apiary. Two newly established bee colonies were managed using modern hive management techniques. Honeys produced by these colonies were subjected to further laboratory analyses. Proximate composition of honey samples was determined based on the official analysis methods from Association of Official Analytical Chemists (AOAC). Mineral composition was determined quantitatively using atomic absorption spectroscopy (AAS). Melissopalynological analysis was conducted to ascertain the amount, type and origin of pollen present in the samples. On the basis of the proximate composition, colony 1 honey had higher carbohydrate (81.29%), crude fibre (1.43%) and ash contents (0.70%) while colony 2 honey recorded higher protein (2.72%), crude fat (0.17%), moisture content (17.32%) and pH (4.6). Result of the mineral analysis showed that potassium was the most abundant element, while manganese was the least present trace element in both honeys. Investigated honey samples contained 8609 pollen and spore types belonging to 27 families and 29 species. Colony 1 honey had the highest pollen diversity, while colony 2 honey recorded the highest abundance. *Hippocratea* sp. was the predominant pollen type in colony 1 honey sample while *Phyllantus* sp. was the secondary dominant species in colony 2 honey. Celastraceae and Rubiaceae were the most dominant families recorded in the investigated honey samples. Investigated honey samples were multifloral, rich in minerals, and met the standard requirements of good honey as recommended by International Honey Commission. The study provided the basis for identification of major plants visited by *Apis mellifera* honeybees within the apiary. There is a need to conserve the existing flora within the study location, especially those found to be rewarding to *Apis mellifera adansonii*.

1. INTRODUCTION

Natural honey is a viscous sweetener prepared by honey bees from the nectar or secretion of flowering plants (Minhas and Dhaliwal, 2018). Its major constituents include 80% carbohydrates (35% glucose, 40% fructose, and 5% sucrose), small amount of water (20%), while its minor components include minerals, proteins, vitamins, organic acids, flavonoids, phenolic acids, enzymes and other phytochemicals (Afroz *et al.,* 2016; Abselami *et al.,* 2018). Proximate analysis involves investigation of the nutritional contents of food and derivatives (Chua and Adnan, 2014; Kambai *et al.,* 2015). Proximate composition of honey includes moisture content, ash content, crude protein, crude fat (or lipid), crude fibre, nitrogen-free extracts. The proximate composition of honey is vital in its quality assessment (Anikwe *et al.,* 2016). Honey contains mineral substances which are beneficial to human in small quantities (Vanhanen *et al.,* 2011). These include potassium, chlorine, sulphur, calcium, sodium, phosphorus, magnesium, silicon, iron, manganese.

In addition to its proximate and mineral compositions, honey contains pollen grains and other microscopic particles such as fungal spores (Kayode and Oyeyemi, 2014; Belay *et al.,* 2015). The study of the pollen and spores contained in honey in order to determine the floral sources is known as melissopalynology. Melissopalynology is of great importance for quality control of honey, as it helps in detecting honey adulteration (Anikwe *et al.,* 2016; Çelemli *et al.,* 2018). Melissopalynology also helps prospective beekeepers identify certain crops in an area that may benefit from bee-based pollination (Anikwe *et al.,* 2016). This is because the botanical and geographical origins of honey are indicated by the palynomorph contents (Njokuocha, 2019).

The African honeybee, *Apis mellifera adansonii* is most commonly reared honey bee and the major producer of honey in south-western Nigeria (Ayansola and

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Davies, 2012). Honey bees and their products are vulnerable to various diseases, parasites and pests (Tessega, 2009). These biotic stressors have been reported to be one of the major causes of colony losses in many African countries including Nigeria. A viable option to curtaining pests and diseases of honey bees is by practising modern hive management. Modern hive management (also known as integrated hive management) is an integrated approach which utilises different practices in a compatible manner in order to maximise hive production and maintain colony health. It encompasses proper apiary siting, hive placement and maintenance, regular hive inspection in order to check for pests and diseases as well as assess high performance.

The focus of this study is on management of newly established *Apis mellifera adansonii* honey bee colonies, and determination of the proximate, mineral and pollen contents of honeys produced by these bees at the University of Lagos apiary.

2. MATERIALS AND METHODS

2.1 Study area

The study was conducted at the University of Lagos apiary within latitude 6° 30' 59.99" N and longitude 3° 23' 5.99" E in Akoka, Yaba, Lagos State, Southwestern Nigeria. The environment is humid, and it is characterized by two rainy seasons, with the heavy rains occurring from April to July and the light rainy season from October to November while December to March is usually dry. A short dry season is experienced in August (Anikwe *et al.,* 2016). Mean annual rainfall varies between 1381.7 mm and 2733.4 mm with an average of 2500 mm while monthly rainfall ranges between 25 mm to over 400 mm. Maximum temperature ranges between 29 ºC and 34 ºC and minimum ranges between 24 ºC and 28 ºC. Relative humidity is high throughout the year, above 70 % throughout the year (Ogundele, 2012). University of Lagos is surrounded by swampy forest (consisting of the fresh water and mangrove swamps) and the Lagos lagoon (Anikwe *et al.,* 2016). Mangrove swamp forest with an array of flowering plants serve as nectar sources while the surrounding lagoon serves as source of water for foraging honey bees. The study location extends from the wetland beside Faculty of Science to Faculty of Engineering (Figure 1).

2.2 Hive management

Two hives with newly established honey bee colonies were selected within the apiary for the purpose of this study. The hive stands were greased regularly to prevent honey bee predators from gaining access into the hive. Phytosanitation was carried out at regular intervals to ensure the environment was favourable. Hive inspection was carried out fortnightly to evaluate the strength of the colonies and check out for parasites and predators as well as signs of diseases in honeybee colonies. Before every inspection, the entrance holes of the hives were lightly smoked and the lids gently removed. Hive interior, bars and combs were checked for signs of pest infestations and disease infection as described by Anikwe *et al.* (2016). Also, presence of all developmental stages of honeybee (eggs, larvae, and pupae) was examined for colony strength. Sealed capped cells were observed for honey. After every hive inspection, the cover lids were properly placed on top of the hives and the equipment used was thoroughly cleaned before being stored. Monitoring of the colonised hives was conducted from May 2018 to October 2018.

2.3 Collection of honey samples

Two (2) different honey samples were obtained from colonised hives. The cut comb method was used to harvest honeycombs from hives while honey extraction from harvested honeycomb was by the use of mechanical honey extractor. Extracted honey samples were stored in clean airtight bottles at an ambient temperature to avoid moisture absorption. The honey samples were later taken to laboratories for various analyses. Melissopalynological analysis of honey samples was conducted at the Palynological Laboratory of the Department of Botany, University of Lagos while the proximate and mineral composition analyses were conducted at the Biochemistry Research Laboratory, Lagos University Teaching Hospital (LUTH).

2.4 Proximate analysis

The proximate content, namely protein, crude fat, crude fibre, carbohydrate, moisture and ash were determined based on the official analysis methods from Association of Official Analytical Chemists (AOAC, 2003).

2.5 Mineral analysis

The honey samples were analysed for mineral contents including K, Na, Ca, Mg, Mn, Fe and Zn. Determination of K and Na present in the samples was carried out using flame photometer while Ca, Mg, Mn, Fe and Zn were determined quantitatively using an atomic absorption spectrophotometer (AAS), after digestion by the wet ashing method (Escuredo *et al.,* 2011).

2.6 Melissopalynlogical analysis

Honey samples were acetolysed according to Erdtman (1960) method as described by Adeonipekun (2012). The tubes were immersed in boiling water bath for 3-5 min, centrifuged and the supernatant decanted. The residue was washed with water and decanted, about few drops of glycerine was added. A micropipette was used to transfer 0.1 ml of the residue onto glass slides and coverslipped with nail polish used as sealant. Each slide was observed using an Olympus 2.0 light microscope, and the recovered pollen was counted and recorded. The view count method was used in the palynological analysis of which 20 representative focal points were picked on each

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slide and studied. Identification was done using published floras and atlases provided by Sowunmi (1976a), Adeonipekun (1989, 2010, 2012), and Gosling *et al.* (2013) as well as the reference slide collection of the Laboratory of Palaeobotany/ Palynology, Department of Botany, University of Lagos, Akoka, Lagos. The percentage frequency of the pollen taxa in all the samples was calculated as described by Song *et al.* (2012). The types of pollen were allocated to one of four frequency classes: (i) predominant pollen types (>45% of the total pollen grains counted); (ii) secondary pollen types (16%–45%); (iii) important minor pollen types (3%–15%); and (iv) minor pollen types (<3%). The honey sample was characterised as unifloral if it contained a predominant pollen type. Otherwise, it was considered multifloral.

3.1 Hive management

The colonies of *Apis mellifera adansonii* were intact and appeared healthy, as all stages of the bees were observed. No signs of diseases were observed in honey bee broods and adults. Termites (*Macrotermes spp*), ant species small hive beetle (*Aethina tumida*), lesser wax moth (*Achroia grisella*), praying mantis (*Sphodromantis viridis*) and monitor lizards (*Varanus niloticus*) were common pests and predators observed in the located hives. These are common pests found everywhere beekeeping is practised as indicated in the studies conducted by several authors (Oyerinde and Ande, 2009; Tesfaye *et al.,* 2017; Haftu and Yoseph, 2018; Mekonnen *et al.,* 2018). Pests and predators were properly curtailed in order to prevent pests' escalation within the apiary.

3. RESULT AND DISCUSSION

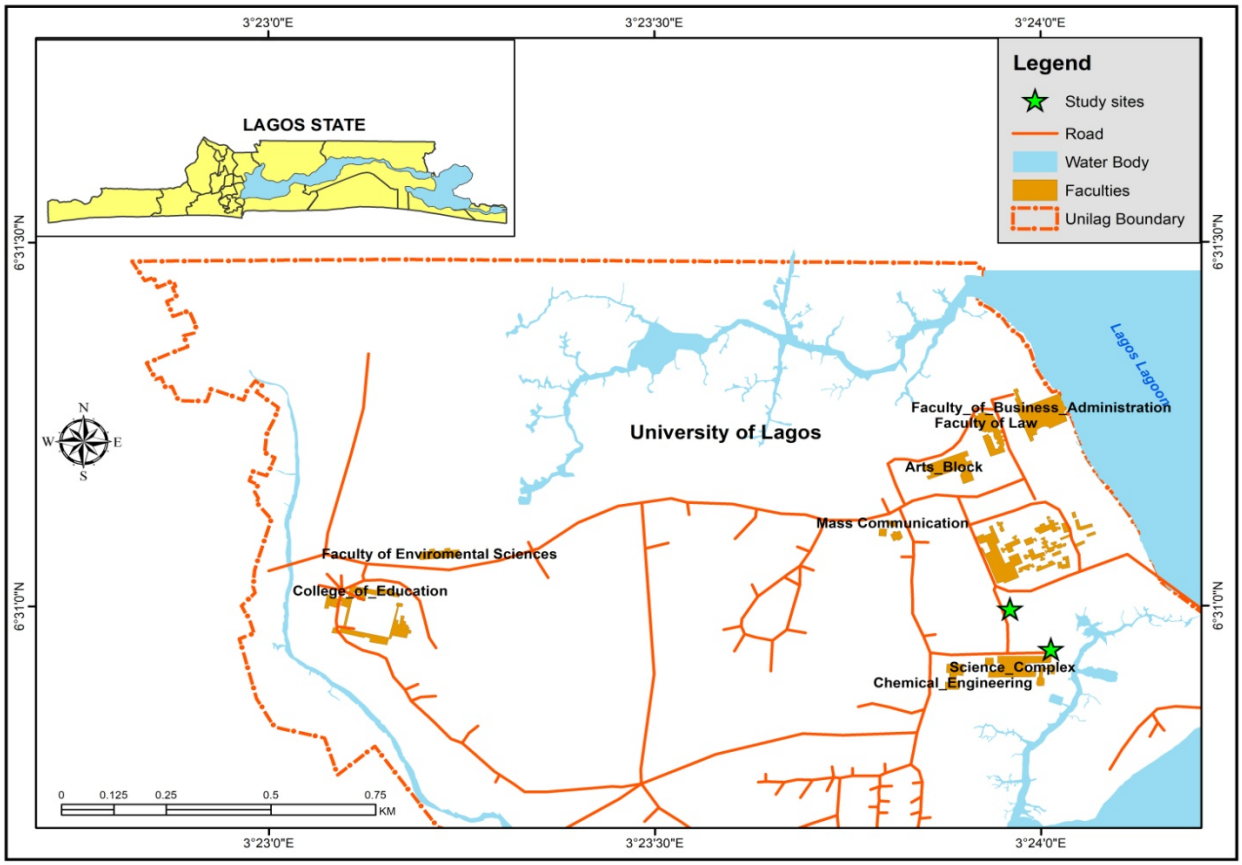

Figure 1: Geographical map of University of Lagos showing the study location

Ant nests around the apiary were removed while the hive stands were greased to prevent these species from gaining access to the hives. Small hive beetles found in the located hives were either mechanically removed by hand picking and crushed or cleared from combs by the use of hive brush. Combs infested by wax moths were cut off from top bars. There was no form of honey theft in the apiary as honey combs were intact in the hives. As at harvest time, the two colonies had 80% of heavy combs, filled with sealed and capped honey. Thus, honey samples were extracted from these hives for analysis, with the samples labelled colonies 1 and 2.

3.2 Proximate analysis

The result of proximate analysis of the honey samples is presented in Table 1. Colony 1 sample contained higher carbohydrate (81.29%), ash content (0.70%) and crude fibre (1.43%). Colony 2 honey had higher protein content (2.72%), moisture content (17.32%) and pH (4.6). The pH of the honey samples which was between 4.5-4.6 showed that they were acidic in nature. These pH values

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were within the acceptable range specified by Codex Alimentarius Commission (2001). According to Farooq Khan and Maqbool (2008), the pH of honey varied from pH 3 to pH 5. Honeys with pH above 5 are sometimes considered to be of low purity and low quality. The pH values of Algerian, Brazilian, Spanish and Turkish honeys have been found to vary between 3.49 to 4.53, 3.10 to 4.05, 3.63 to 5.01 and 3.67 to 4.57, respectively (Saxena *et al.,* 2010). The pH and the free acidity of honey influence its flavour, stability and storage conditions (Nombré *et al.,* 2010). Carbohydrate content (CHO) of the honey samples analysed was between 77.51 to 81.29%. These values were similar to those obtained by (Ndife *et al.,* 2014) who reported that the carbohydrate content of some Nigerian honeys were in the range of 79.94 to 82.71%. Carbohydrates are the main constituents of honey comprising about 95% of its dry weight (Bogdanov *et al.,* 2008). Fructose and glucose (hexoses), products of sucrose hydrolysis are the main sugars present in natural honey. The ratio of glucose to fructose present is useful in determining honey adulteration levels and their suitability for managing diseases such as diabetes (Buba *et al.,* 2013; Ndife *et al.,* 2014).

The analysed honey samples from both colonies had protein content ranging from 1.71 to 2.72 % (Table 1). There is no fixed limit for permissible level of protein in honey, however, low levels of protein have been recorded by some authors (Buba *et al.,* 2013). The moisture content of the honey samples analysed were 14.75 and 17.32% (i.e 14.75g/100g and 17.53g/100g). These values were below 20% (i.e. <20g/100g) stipulated by the Codex Alimentarius Commission and European Union Commission as international standard for honey moisture. The moisture content of the samples falls within the range reported for some Nigerian commercial honeys (Omafuvbe and Akanbi, 2009; Adenekan *et al.,* 2012). Hygroscopic nature, maturity level of honey, hive type, storage and the climatic conditions during the harvesting period are some of the factors affecting moisture content of honey (Ambaye and Mekonen, 2016; Tesfaye *et al.,* 2016). Moisture content of honey determines its quality, viscosity, crystallization, fermentation and shelf life (Azeredo *et al.,* 2003; Bogdanov, 2009; Nombre *et al.,* 2010). Honey high in moisture is prone to granulation and could be adulterated (Nyau *et al.,* 2013; Anikwe *et al.,* 2016). Ash contents of the samples were 0.10% and 0.70% (Table 1). The difference in the ash content obtained could be attributed to the botanical origin, geographical location or level of maturity of the honey as reported by Saxena *et al.* (2010) and Adenekan *et al.* (2012). Honey sample from colony 2 had ash content (0.70%) higher than the recommended value of 0.60% by International Honey Commission and Codex alimentarius (2001) for nectar honey. This result is in agreement with the findings of Kambai *et al.* (2014), who reported high ash contents of 1.67, 0.70 and 0.71 % in analysed honey samples from Jos metropolis, Nigeria. Ash content is an indicator of the constituents of honey sample after incineration as well as its botanical origin (Marchini *et al.,* 2007; Mairaj *et al.,* 2008; Vanhanen *et al.,* 2011; Ambaye and Mekonen, 2016). The crude fat of the honey samples investigated fall within the range 0.13- 0.17%. The low fat content obtained in this study were in agreement with that reported by other authors (Azeredo *et al.*, 2003; Alvarez-Suarez *et al.*, 2010; Buba *et al.,* 2013; Ndife *et al.,* 2014; Anikwe *et al.,* 2016). High fat content makes foods susceptible to rancidity and subsequent spoilage during storage (Durrani *et al.*, 2011; Anikwe *et al.,* 2016). Therefore, natural honey for human consumption should be low in fat.

3.3 Mineral composition

Analysis of mineral composition of the honey samples revealed that mineral elements such as Na, K, Mg, Ca, Fe, Zn and Mn mostly found in honeys were all present. K, Na and Ca were abundant in samples from both beehives. Potassium with values ranging from 72.91 mg/100g to 82.40 mg/100mg (Table 2) was the most dominant element in honey samples from both colonies. This result is similar to that obtained by Kek *et al.* (2017), who reported that potassium, sodium and calcium where the three most abundant mineral elements in Malaysian honeys. It is also in agreement with that reported by Farooq Khan and Maqbool (2008), Vanhanen *et al.* (2011), Adenekan *et al.* (2012) and Ndife *et al.* (2014) on the dominance of potassium in honeys of Pakistan, New Zealand and Nigerian origins. Kambai *et al.* (2014) also reported high calcium content in honey samples from Nigeria. Potassium helps in lowering blood pressure in hypertensive individuals while calcium aids strong bones and effective muscle functioning (Bangash *et al.,* 2011; Arunachalam and Parimelazhagan, 2014; Kambai *et al.,* 2014). Manganese with values 0.23mg/100g and 0.09mg/100g was the least trace element present (Table 2). Manganese (Mn) is a constituent of some enzymes and an activator of other enzymes (Bangash *et al.,* 2011).

3.4 Melissopalynological analysis

In total, 8609 pollen types belonging to 27 families and 29 species were counted. Twenty- nine pollen were identified to specie level while nine were identified to family level (Table 3). The identified species belong to varying genera of native herbs, shrubs, grass and trees. The varying shapes, sizes and morphological features of the pollen types indicate that the honey samples are multifloral. Diversity value of colony 1 honey sample was higher than that of colony 2 despite the fact that they were within the same geographical location (Table 3). This could mean that colony 1 honey bees foraged more on varieties of plants than their colony 2 counterparts. It could also the attributed to the age of the colony as stated by Adeonipekun (2012) who reported age of the colony as an

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important factor in determining their foraging activity. In a palynological study of an apiary in Ibadan southwest Nigeria, he observed that an old and defensive colony of bees recorded higher abundance of pollen grains, while a young and gentle colony recorded lesser pollen grains but with higher species diversity. Colony 2 honey, however, recorded the highest pollen abundance (6524), while the colony 1 honey has the least (2085).

Hippocratea sp. was the predominant pollen type in colony 1 honey, while *Phyllantus* sp. was the dominant (secondary) pollen type in colony 2 honey. The dominance of *Hippocratea* sp. and *Phyllantus* sp. pollen types in the honey samples could be attributed to the quantity of pollen the source plants produced at the time of bee visits. According to Adekanmbi and Ogundipe (2009), the amount of pollen of a particular plant species present in the honey depends on the quantity produced at the time the bees visit and the number of those visits. Hippocratea is a genus of shrubs with the best-known species *Hippocratea*

Table 1: Proximate composition of honey samples.

	CHO %	Protein %	Crude Fat %	Moisture %	Ash %	Crude Fibre %	pH
Colony 1	81.29	1.71	0.13	14.75	0.70	1.43	4.50
Colony 2	77.51	2.72	0.17	17.32	0.10	1.30	4.60

Table 2: Mineral composition of honey samples (in mg/100g).

	Na	K	Mg	Ca	Fe	Zn	Mn
Colony 1 (mg/100g)	17.92	72.91	7.94	10.73	0.73	0.90	0.23
Colony 2 (mg/100g)	10.20	82.40	5.40	9.24	0.34	0.82	0.09

Table 3: Palynomorphs recovered from honey samples.

Palynomorphs	Family	Colony 1	Colony 2	Percentage Abundance (%)	
				Colony 1	Colony 2
Acacia sp.	Fabaceae	10	-	0.48	-
Acridocarpus macrocalyx	Mapighiaceae	2	-	0.10	-
Adenia nicobarica	Passifloraceae	12	1	0.58	0.02
Alchornea cordifolia	Euphorbiaceae	7	-	0.34	-
Anthocleista floribunda	Euphorbiaceae	5	-	0.24	-
Anthocleista grandifolia	Gentianaceae	-	1	-	0.02
Arecaceae	Arecaceae	40	15	1.91	0.23
Asteraceae	Asteraceae	-	2	-	0.03
Avicennia nitida	Avicenniceae	1	-	0.05	-
Broken pollen		20	23	0.96	0.35
Calpocalyx brevibracteatus	Fabaceae	2	1	0.10	0.02
Casearia guineensis	Salicaceae	15	135	0.72	2.07
Casuarina equisetifolia	Casuarinaceae	10	-	0.50	-
Celtis mibdraedii	Cannabaceae	18	-	0.86	-
Centroplacus glaucinus	Centroplacaceae	-	310	-	4.75
Cissus petiolata	Vitaceae	-	2	-	0.03
Combretum sp.	Combrentaceae	30	23	1.43	0.35
Cyperaceae	Cyperaceae	2	8	0.10	0.12
Elaeis guineensis	Arecaceae	80	409	3.84	6.27
Eugenia michoacanensis	Myrtaceae	5	-	0.24	-
Euphorbiaceae	Euphorbiaceae	40	135	1.91	2.07
Fungal hyphae		9	13	0.43	0.20
Funtumia elastic	Apocynaceae	1	-	0.05	-
Hippocratea sp.	Celastraceae	1165	-	55.88	-
Ipomoeae sp.	Convolvulaceae	-	2	-	0.03
Justicia flava	Acanthaceae	2	6	0.10	0.09
Marantaceae type	Marantaceae	100	-	4.80	-
Mimosa sp.	Fabaceae	-	115	-	1.76
Mitragyna inermis	Rubiaceae	-	720	-	11.04
Monolete spore		15	5	0.72	0.08
Myriaceae	Myriaceae	160	225	7.67	3.45
Nephrolepis biserrata	Polypodiaceae	1	135	0.05	2.07
Nephrolepis undulate	Polypodiaceae	3	-	0.14	-
Nymphaea lotus	Nymphaeceae	2	9	0.10	0.14
Phyllantus sp.	Euphorbiaceae	-	1615	-	24.75
Plant cuticle		-	11	-	0.17
Poaceae	Poaceae	15	45	0.72	0.69
Psychotria sp.	Rubiaceae	-	7	-	0.11
Pteridophyte spore		45	110	2.16	1.69
Rhizophoraceae type	Rhizophoraceae	140	-	6.71	-
Rubiaceae	Rubiaceae	-	2350	-	36.02
Syzygium guineense	Myrtaceae	86	-	4.12	-
Thecacoris gymnogyne	Euphorbiaceae	-	1	-	0.02
Trilete spore		15	-	0.72	-
Unidentified pollen		17	25	0.82	0.38
TOTAL ABUNDANCE		**2085**	**6524**		
SPECIES DIVERSITY		**20**	**17**		

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volubilis (medicine vine) having medicinal value. Phyllanthus is a genus of small annual plants widely distributed throughout the tropical and subtropical regions of world. It is a very large genus containing approximately 550-750 species with a long history of use in traditional medicine. Few authors have reported the presence of *Hippocratea* sp. and *Phyllantus* sp. in Nigerian honeys (Aina *et al.,* 2015; Adeonipekun , 2016; Orijemie, 2017; Njokuocha, 2019) but none have indicated their dominance.

Important minor pollen types in the honey samples include *Centroplacus glaucinus*, *Elaeis guineensis, Mitragyna inermis,* and *Syzygium guineense*. Important minor pollen types in the honey samples include *Centroplacus glaucinus*, *Elaeis guineensis, Mitragyna inermis,* and *Syzygium guineense. Elaeis guineensis* and *Syzygium guineense* are commonly encountered in honeys from Southern Nigeria (Nnamani and Uguru, 2013; Fasasi and Alluh, 2019). *Elaeis guineensis* pollen appeared as important minor pollen type in investigated honey samples despite being reported as dominant type in honey honeys of Nigerian origin by several authors (Adekanmbi and Ogundipe, 2009; Ebenezer and Olugbenga, 2010; Nnamani and Uguru, 2013; Adeonipekun , 2016; Njokuocha, 2019). Fasasi and Alluh (2019) described *Elaeis guineensis* as a cosmopolitan plant in Nigeria. *Elaeis guineensis* is not a source of flower nectar, and it is only visited by bees for pollen (Njokuocha, 2019). This could be the reason why it was less visited by *Apis mellifera adansonii* within the study area. Honey bees frequently visit plants with good nectar or floral attractiveness (Ebenezer and Olugbenga, 2010). Also, honey bees adapt to rewarding forage resources within a vegetation zone where hives are located (Larinde *et al.,* 2014). *Elaeis guineensis* pollen dominated honeys have been reported to have unpleasant smell and taste (Ibrahim *et al.,* 2012). Thus, its presence in moderate level is good for the quality of honey. Minor pollen types in honeys from both colonies include Acacia sp., *Adenia nicobarica, Alchornea cordifolia , Anthocleista floribunda, Anthocleista grandifolia, Avicennia nitida, Calpocalyx brevibracteatus, Casearia guineensis, Casuarina equisetifolia, Celtis mibdraedii, Acridocarpus macrocalyx, Thecacoris gymnogyne, Cissus petiolata, Combretum* sp., *Eugenia michoacanensis, Ipomoeae* sp., *Justicia flava, Mimosa* sp., *Nephrolepis biserrata*, *Nephrolepis undulate*, and *Nymphae lotus*. Although recorded as minor pollen types in this study, *Alchornea cordifolia, Combretum* sp., and *Nymphae lotus* have been reported to be dominant in honeys from Southwest Nigeria by several authors (Nnamani and Uguru, 2013; Kayode and Oyeyemi, 2014; Adeonipekun *et al.,* 2016; Anikwe *et al.,* 2016). In addition, fungal, bryophyte and pteridophyte spores, as well as palynodebris possibly from sources such as honey comb debris and particles were also recovered.

Many of the plants whose pollens were recorded in the investigated honey samples have a history of use in traditional medicine in Nigeria. A*lchornea cordifolia* is used in traditional medicine for the treatment of fever and diabetes (Nnamani and Uguru, 2013). *Ipomoeae* sp. is used in the treatment of convulsion (Bassey and Effiong, 2011). *Phyllanthus* sp. has been reported to be effective in the treatment of gallstones and kidney stones and is also known to have anti-carcinogenic properties (Lee *et al.,* 2011; Narendra *et al.,* 2012). *Syzygium guineense* is used as a remedy for dysentery, while a decoction of the bark is used as an anti-diarrhoeic (Amusan *et al.,* 2002; Oladosu *et al.,* 2017).

Celastraceae (55.88%) and Rubiaceae (47.17%) were the most well represented families in terms of pollen abundance (Table 4). While few authors have reported the dominance of pollen types belonging to the family Rubiaceae (Oyeyemi and Kayode, 2013; Njokuocha, 2019), no known author has reported the dominance of those belonging to the family Celastraceae in honeys of Nigerian origin. Presence of pollen types belonging to families such as Avicenniceae and Rhizophoraceae is an indication that the honey samples were produced from a mangrove vegetation area.

Table 4: Families and their relative abundance.

Family	Colony 1 Abundance (%)	Colony 2 Abundance (%)
Rubiaceae	-	47.17
Euphorbiaceae	2.49	26.84
Combrentaceae	1.43	0.35
Arecaceae	3.84	6.5
Myriaceae	7.67	3.45
Poaceae	0.72	0.69
Cyperaceae	0.1	0.12
Convolvulaceae	-	0.03
Asteraceae	-	0.03
Rhizophoraceae	6.71	-
Marantaceae	4.8	-
Fabaceae	0.58	1.78
Gentianaceae	-	0.02
Vitaceae	-	0.03
Centroplacaceae	-	4.75
Salicaceae	0.72	2.07
Acanthaceae	0.1	0.09
Mapighiaceae	0.1	-
Celastraceae	55.88	-
Myrtaceae	7.67	-
Cannabaceae	0.86	-
Passifloraceae	0.58	0.02
Apocynaceae	0.05	-
Casuarinaceae	0.5	-
Avicenniceae	0.05	-
Polypodiaceae	0.19	2.07
Nymphaeceae	0.1	0.14

4. CONCLUSION

Proper hive management practised in this study meant the established bee colonies remained in healthy state. Although pests and predators of honey bees were encountered during the course of this study, they appeared to be of no threat to *Apis mellifera adansonii* as they were

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adequately curtailed. Investigated honey samples were multifloral, rich in minerals, and met the standard requirements of good honey as recommended by International Honey Commission. The multifloral nature of these honeys implies that they were in their natural state, and not adulterated. Melissopalynological analysis provided the basis for identification of major plants visited by honeybees within the apiary. There is a need to conserve the existing flora within the study location, especially those found to be rewarding to *Apis mellifera adansonii*. Also, bee researchers and beekeepers around this region are encouraged to cultivate more of the plants whose pollens were indicated in this study as predominant, secondary dominant and important minor pollen types. This will not only boost hive performance and survival of these bees, but it will also improve honey bee colony establishment in this region.

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