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Palynotaxonomical study of honeybees (*Apis mellifera var. adansonii*) forage and/or preference plants in South-Western Nigeria

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Abstract

The disputed issues of higher plant taxonomy and phylogeny are greatly impacted by pollen morphology because pollen grains have clear distinctive characteristics that are typically labeled. Palynotaxonomical study of Honeybees preference plants in South-Western Nigeria were conducted between the months of May, 2019 and June 2021 using fresh polleniferous materials which were extracted through acetolysis methods. Results showed that ninety-two (92) plant species belonging to thirty-six (36) plant families of apicultural importance most visited by honeybees (*Apis mellifera var. adansonii*) were documented. At x100 magnification, thorough morphological studies were performed, and the results showed that pollen grains from plant species in the family Asteraceae were spinolous and spherical in shape; those from the Fabaceae sub-families Caesalpinoideae, Mimosoideae, and Papilionoideae, on the other hand, had a great deal of morphological diversity with variations in symmetry, position and distribution. Those of the families Malvaceae was echinate and Myrtaceae were colporate; syncolpate and prolate respectively. However, the variations above were generally reduced within species in the same genera. Tricolpate aperture type was observed in the genus *Euphorbia*; giving reason for their classification in the same genera. The genus *Combretum* was all heterocolpate, circular in shape and heteroporate. Sculpturing was psilate or scabrate and pollen shape class were sub-prolate, oblate-spheroidal or prolate spheroidal. Similar form and symmetry observed in all the species studied were reason for their classification into the same family. The study revealed that the flowering period for most of these honeybees' forage plants were between the months of October to March. Identification, propagation, cultivation, conservation, and sustainable exploitation of these honeybee (*Apis mellifera* var*. adansonii*) forage and preference plants would be beneficial in potentially increasing the efficiency of apiculture and commercial cultivation in South-Western Nigeria.

Keywords: Apiculture, Honeybees foraged plants, Pollen morphology, South-western Nigeria

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INTRODUCTION

Palynotaxonomy deals with the study of description of variation in organisms, the investigation of causes and consequences of this variation, and the manipulation of the data obtained to produce a system of classification. Taxonomy is defined as a science dealing with the study of nomenclature, description, classification, identification and relationships, with basic idea of determining the rank of the taxa. Several characteristic features of plants are used to determine the rank of the taxa, of which palynological evidence has proven useful at all taxonomic levels, particularly in verifying relationship in established taxonomic groups. On the basis of pollen characters, study of this nature is very useful in systematic considerations. Palynotaxonomy could provide a convenient method of identification and communication. A workable classification having the taxa arranged in hierarchy, detailed and diagnostic descriptions are essential for identification. It could also detect evolution at work: to reconstruct the evolutionary history of the plant kingdom, determining the sequence of the evolutionary change and character modification. For example, Chanda and Ghosh (1979) proposed a genealogical tree which reflects the evolutionary tendencies among the monocots and early dicots in terms of apertural evolution.

Chanda *et al*. (1988) studied the pollen morphology of the order Alismatales (including Butomaceae, Limnocharitaceae and Alismataceae). They reported that the pollen grains of monotypic Butomaceae are monosulcate and boat-shaped, those of Limnocharitaceae have 4 to 10 ill-defined, fimbriate globally distributed pores, and of Alismataceae are pantoporate and spheroidal, or rounded polyhedral. The bee is the most valuable insect on planet earth. This is not because of the value of its direct products as they represent only 0.5% of the total agricultural production, but because of the enormous benefits accruing from the cross pollination of plants. This cross pollination ensures the improved quality and quantity of produce, fruits and seeds, improved species of self-germinating plants and also maintain the eco-balance on earth (Sivaram, 1995).

The honey bees (*Apis mellifera var. adansonii*), the pollinators of plants the world over; play a crucial role for wild and cultivated plants, especially in the tropics where insect pollination is vital (Winfree, 2010; Ollerton *et al*., 2011). Some honey components, such as carbohydrates, water, traces of organic acids, enzymes, amino acids, and pigments, come from bees and plants, while others, such as pollen and wax, appear during honey maturation (Agwu and Okeke, 1997).

The *Apis mellifera var. adansonii* (African honey bee) is very defensive and unpredictable; darker and smaller; more energetic and aggressive; and also irritable during the hot hours and hates noise. It builds its nest in closed spaces but migrates (swarms) often and abandoned its nest (absconds) when disturbed. It produces more drones (male bees). It gathers food all the year round, produces large quantity of honey yields every year (Breadbear, 2009). Co-evolution and mutualism have been cited as examples of relationships between honeybees and flowering plants. Honeybees and flowering plants are mutually dependent; honeybees need flowering plants for food in the form of pollen and nectar, whereas plants need honeybees for pollination. Honey contains pollen grains which are collected by honeybees while foraging the flowers for nectar (Essien, 2020). Taxonomy, phylogeny, palaeobotany, aeropalynology, and pollen allergy study all rely heavily on pollen morphological characterization. Analysis of pollen (extant and extinct form or taxa) is the most important approach to reconstruction of past flora, vegetation and environment (Faegri and Iversen, 1989). Understanding pollen's functional characteristics, such as pollination biology and pollen-pistil interaction, depends on the knowledge of pollen morphology (Essien and Ige, 2019).

The microscopic analysis of pollen is a standard method and an effective tool to understanding the distribution and abundance of floral nectar sources in any given region (Agwu *et al*., 2013). Palynological analysis is used to determine the characteristics, types and quality of honey. Microscopical pollen assessment has been used to determine the geographical and floral origins of honeys (Maurizio, 1975; Agwu *et al*., 2015). The significance of a standardized procedure that minimizes characterization errors from the pollen analysis of honey obtained from various geographical locations was demonstrated by Low *et al*. (1989) and Lutier and Vaissière (1993).

Due to the fact that honeybees are known to travel more than 3 km in search of their preferred forage sources, studying the pollen content in honey significantly aids in understanding the geographical, ecological, and botanical origins of honey. Knowledge of botanical source of honey is a prerequisite for beekeepers to undertake migratory beekeeping for increasing honey production and pollination. When determining the honey's commercial quality, characterization is crucial because the season of flowering and nectar production for the same species can vary depending on location (Zamarlicki, 1984). Additionally, palynological investigations have been performed to determine single- and multiple-floral honeys (Seijo and Jato, 1998; Valencia-Barrera *et al*., 1994; 2000). Identification of honey sources in an ecological zone is important for commercial beekeeping with the goal of increasing honey production. Knowledge of honeybee plants and time of pollen and nectar flow greatly influence the brood rearing activity and the functioning of honeybee colonies and production of honey as well as other hive products (Sivaram, 1995; Ostrowsha, 1998).

Beekeeping is entirely depending on the types of flowering plants available in any given area. Understanding the relationship between honeybees and plants is important for researching honeybee food preferences and pollination needs. An essential prerequisite for developing apiary is pollen from various plants that could serve as potential sources of nectar and pollen for the honeybees (Kalpana and Ramanujam, 1997). Different plants have pollen with distinctive shapes, sizes, apertures, and ornamentations. Melissopalynology is the study of the pollen that bees intentionally and unintentionally gather and then incorporate into honey. A lot of research has been done using Melissopalynology to identify the floral, geographic, purity and origins of honeys (Waters, 1915; Nair, 1964; Agwu *et al*., 2013). It is also used to access correlations between *in-situ* climate parameters, such as temperature and rainfall, which are crucial in the context of outside factors affecting pollinators and pollination networks (Jato *et al*., 1994; Bilisik *et al*., 2008; Jens *et al*., 2008; Thomas *et al*., 2009). According to Bryant and Jones (2001), a variety of factors, including honeybees' capacity to filter out specific kinds and quantities of pollen from the nectar they gather before returning to the hive, affect the production of honey. They acknowledged that the complexity brought on by these various factors suggests a significant variation in the pollen content of honey produced in the same hives from year to year or season to season. Finding the source of honey in the area can be done using a well-established technique called microscopic analysis of pollen grains (Agwu *et al*., 2013; Essien *et al*., 2022). Around the world, numerous studies on pollen morphology have been conducted (Raj, 1969; Sowunmi, 1973; Tomb *et. al*., 1974; Nair and Kapoor, 1974; Gill and Chinnappa, 1982; Paul *et al*., 2014). On the basis of their pollen profiles, Kral (1992) conducted a palynological investigation of forest trees in relation to the history of the forest and the natural mixture of tree species. A palynological study of the cultivated plants in Rawalpindi, Pakistan, was conducted by Noor *et al*. (2004) while in Nigerian cultivated plants with 20 different pollen morphologies have been described by Adekanmbi and Ogundipe (2006). The Moringaceae and Berberidaceae families' pollen studies were carried out by Perveen and Qaiser (2009; 2010).

Several taxonomists use phenotypic characteristics of plants to identify plant species. Therefore, pollen morphological studies can serve as a foundation for identification of plant species. The full applications of pollen morphology in systematics, palaeobotany, and allergy have increased due to interest in these fields, which are all widely acknowledged (Noor *et al*., 2004). Therefore, the identification of bee plants is a significant application of pollen research. Understanding the main nectar and pollen producing plants and their flowering periods are of great benefit to maximize the effectiveness of the bees according to Jato *et al*. (2002) and Balasurbramanyam (2011). South-Western Nigeria has a wide variety of flowering plants and a promising future for commercial beekeeping. The floras of some areas in South-Western Nigeria are under threat from increased, unchecked, and indiscriminate destruction as a result of cultural and agricultural practices. The knowledge of the significant forage plants for honeybees in this area may one day result in their legal protection and/or planned propagation for the construction of bee farms. The purpose of this study are to identify the types of plants that honeybees (*Apis mellifera* var. *adansonii*) most frequently visited while collecting nectar, the plant that the bees prefer, and whether the study area is a suitable location for beekeeping.

MATERIALS AND METHODS

Field Studies

A field survey was carried out at various study locations (Ekiti State: Ikere: 7^{0}49'91.23"N and 5^{0}23'19.61"E; Ado: 7^{0}61'24.74"N and 5^{0}23'71.22"E; Ondo State: Ikare: 7^{0}52'48.53"N and 5^{0}66' 9.55"E; Owo: 7^{0}19'89.13"N and

$5^0$59'32.65"E; and Osun State: Owena: $7^0$40'34.18"N and 5^0 00'39.35"E; Ilesha: $7^0$61'03.75"N and $4^0$70'96.72"E) throughout South-Western Nigeria (Table 1). After the plant had been visually identified as a bee forage plant, samples of fresh polleniferous materials were directly collected from the field from the anthers of mature flower buds. To preserve them for additional taxonomic study, 70 % ethanol was used.

Extraction of pollen grains

With the help of a piercing needle and a pair of forceps, anthers from both flower buds and fully opened flowers from the preserved materials were carefully removed and crushed in an ethanol solution. These were then decanted after being sieved and centrifuged for five minutes at 2000 rpm. Before acetolysis, glacial acetic acid was applied to the pollen sediments, and then they were centrifuged and decanted to remove any remaining water. Acetic anhydride and concentrated sulphuric acid were used to make an acetolysis mixture that was freshly prepared in a 9:1 ratio. Agwu and Akanbi (1985), Paul *et al*. (2014), and Essien and Ige (2019) adaptations of Erdtman's (1969) methods were used in boiling the sediments in a water bath at 100^0C for acetolysis. The mixture was stirred for 5 minutes in a water bath set at 100^0C, after which it was centrifuged for 5 minutes, with the supernatant being decanted. The precipitates were decanted after being centrifuged twice with distilled water and washed once with glacial acetic acid. The recovered precipitates were kept in plastic vials with 2:1 solutions of glycerin and ethanol.

Microscopic examination and pollen analysis

On a 25.4 mm x 76.2 mm (1"×3") slide 1 mm-1.2 mm thick, one drop of thoroughly shaken precipitates suspension was mounted and covered with 18mm x 18mm cover slip. To keep the precipitation from drying out, the mount was sealed off at the edges with colorless nail polish. For thorough morphological studies, the prepared slide was then scrutinized under a microscope at x400 and x1000 magnifications. In the Palynology and Environment Research Laboratory, Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria, pollen samples were examined and analyzed morphologically using reference descriptions, photomicrographs (Bonnefille and Riollet (1980), Agwu and Akanbi (1985), Punt *et al*. (2007), Essien and Ige (2019), and prepared slides. In documenting the dimensions and other parameters, averages of ten (10) pollen grains were used and this helped in easy description and convenient identification of the pollen studied. Photomicrographs were taken using a Fluorescent PEC Medical Microscope Model No.: OZJ088.

RESULTS AND DISCUSSION

Palynotaxonomical study of Honeybees preference plants in South-Western Nigeria were conducted between the months of May, 2019 and June 2021 using fresh polleniferous materials and results showed that ninety-two (92) plant species belonging to thirty-six (36) plant families of apicultural importance were most visited by honeybees during the course of pollen and nectar collection. The study revealed great similarities and diversity in aperture types, sculpturing pattern, size of the pollen grain, exine thickness, colpi length and width among other diagnostic features (Table 1). Photomicrographs of some selected pollen types examined in the study are presented in Plate 1. The flowering calendar for these honeybees' preference plants and their forage sources were also documented in the study and these is anticipated to provide baseline information to beekeepers in determining major season of honey production in the study area. These would also make it easier to identify the botanical and geographic origins of Nigerian honeys for use in the region's developing, commercially viable honey industry. Similar findings were reported by Nair (1970). It has been established from this study that, the species belonging to the plant families Asteraceae and Malvaceae were spinolous and porate. Notwithstanding, there were noticeable variations in the pollen types of the species belonging to the family Fabaceae sub-families Caesalpinoideae, Mimosoideae and Papilionoideae (grains polyad or monad, 3-colp orate, 3-6-porate or heteroporate; oblate to prolate; circular, circular-lobate, inter-semi-angular, semi-lobate or semi-angular, aperture common type or drop type, ora various, tectum

Table 1: Palynotaxonomical characters of some selected honeybees' preference plants in South-western Nigeria

S/N	SCIENTIFIC NAME	YORUBA NAME	PLANT FAMILY	ORIGIN	POLLEN MORPHOLOGICAL FEATURES	FLOWERING PERIOD	FORAGE SOURCE
1	*Adansonia digitata* L.	Osè, Oshè	Malvaceae	Native	Triporate, shape suboblate; size- P: 77.1 µm; E: 91.2 µm; exine 2.1 µm thick; tectum 0.4 µm; nexine 0.5 µm thick; exine-subtectate, minutely reticulate with supratectal verrucae, radially symmetrical.	September to November	Tree
2	*Ageratum conyzoides* L.	Apasá, Imí-Imí-ewúré, Akó-yunyun	Asteraceae	Native	Tricolporate pollen grains, prolate, spinolous, colpi 17-21×3µm ora transversely elliptic; 2 -2.6×3-5µm; size-P: 20.05 µm; E: 18.35 µm; exine 2 µm thick; spine 2×2 µm; radially symmetrical.	January to December	Herb
3	*Albizia zygia* (DC.) J.F. Macbr.	Ayùnrè, Ayìnré-weere,	Mimosoideae	Native	Pollen grains clustered in polyads with sixteen grains in each; individual grain inaperturate; polyad is rounded tetragonal in shape; sides convex to straight; size 85-110 µm wide; exine 2 µm thick; sexine granulate; tectum psilate.	February to May	Tree
4	*Alchornea cordifolia* (Schum. & Thonn.) Muell. Arg.	Ìpa, Ewé-ìpa, Ewé-ifá, Esin,	Euphorbiaceae	Native	Aperture- tricolporate, shape- prolate spheroidal, size-P: 19.2 µm; E: 21.3 µm; exine 1.9 µm; thick; exine-subtectate, punctate to verriculate, operculum present, bilaterally symmetrical.	October to November, and from June to August.	Shrub
5	*Allophylus africanus* P. Beauv.	Eyín-eye,	Sapindaceae	Native	Pollen grains triporate, pore is large and are often not well seen in E.V., shape oblate to suboblate; size- P: 17.0 µm; E: 25.7 µm; exine 2.0 µm thick; exine subtectate, finely striate to striato-reticulate.	December to March	Shrub
6	*Alstonia boonei* De Wild	Ahùn,	Apocynaceae	Native	Pollen grains isopolar, tricolporate, goniotreme, sides convex-suboblate size- P: 22.0 µm; E 27.0 µm; exine 1.4 µm thick; sexine pertectate, punctate, stratification indistinct, radially symmetrical.	November to January	Tree
7	*Anacardium occidentales* L.	Ekaju, Kaju, Katonoyo, Kasu	Anacardiaceae	Exotic	Monad; medium size; isopolar; tricolporate; striate-reticulate exine, subprolate; size- P: 35 *µm*; E: 29 *µm*; colpi: 29 *µm*; exine: 2 *µm* thick.	November to December	Tree
8	*Annona senegalensis* Pers	Àbo, Arere,	Annonaceae	Native	Individual pollen grains are heteropolar, bilateral, tetragonal tetrad and have one proximal leptoma. The shape of the individual grain is variable, but it often	April to June	Tree

					appears to be rounded-triangular, exine 2.5 µm thick; sexine subtectate and ornate (polyad – tetrad).		
9	*Anthonatha macrophylla* P. Beauv.	Àbàtà	Caesalpinoideae	Native	Pollen grains isopolar to sub-isopolar, tricolporate, peritreme-prolate, size- P:47.2 µm; E: 30.4 µm; exine 1.4 µm thick; colpi 40.5 µm long, 3.1 µm wide; sexine subtectate, striate, radially symmetrical.	April to July and October to December	Tree
10	*Antiaris toxicaria* Engl.	Òro, Akiro, Oriro, Òoro	Moraceae	Native	Pollen grains isopolar, triporate, pores with coarsely granulate membrane, gonio-treme (sides convex) to slightly peritreme–suboblate, size P: 14.5 µm; E: 16.6 µm; exine 1.5 µm thick; sexine pertectate, radially symmetrical.	November to February	Tree
11	*Antrocaryon micraster* L	Ifá òkété,	Anacardiaceae	Native	Tricolporate, shape ranges from prolate spheroidal to subprolate, mostly prolate spheroidal, size- P: 28.2 µm; E: 25.5 µm; exine 1.6 µm thick; exine sub-tectate, finely striate to striato-reticulate, bilaterally symmetrical.	March to April and from September to November	Tree
12	*Aspilia africana* (Pers.) C.D. Adams	Yunrinyun, Yonyon-agbute,	Asteraceae	Native	Tricolporate pollen grains, prolate, spinolous (spines sharp and elongated), exine 4 µm thick; spine 2 µm long; colpi 19.5 µm long, 2.0 µm wide; radially symmetrical.	January to December	Herb
13	*Aubrevillea kerstingii* (Harms.) Pelleg.	Not available	Mimosoideae	Native	Aperture tricolporate, pollen grains isopolar, goniotreme, sides convex-prolate, size- P: 39.5 µm; E: 24.5 µm; exine 1.3 µm thick; sexine sub-tectate, colpi united at the poles, ora clearly demarcated, appear to be elongated longitudinally with membranes distinct, radially symmetrical.	December to January	Tree
14	*Bauhinia monandra* Kurz	Abàfè	Caesalpinoideae	Exotic	Grain tricolporate; shape ranges from suboblate to prolate; size- P: 41.0 µm; E: 35.5 µm; amb circular-lobate or circular; exine 2.5 µm thick; tectum psilate or with scabrate processes; sexine granulate; ora-circular, bilaterally symmetrical.	February to April	Tree
15	*Berlinia grandiflora* (Vahl.) Hutch. & Dalziel	Àpadò,	Caesalpinoideae	Native	Grains isopolar, tricolpate to tricolporoidate, peritreme-prolate, size- P: 62.3 µm; E: 40.0 µm; colpi 52.4 µm long, 3.4 µm wide; exine 1.4 µm thick; sexine subtectate, striate, radially symmetrical.	January to July	Tree

16	*Blighia sapida* K.D. Koenig	Ìsín, Ùsín,	Sapindaceae	Native	Pollen grains isopolar, tricolporate, peritreme or goniotreme, sides straight or convex-prolate spheroidal, size- P: 21.0 µm; E: 18.2 µm; exine 1.3 µm thick; sexine subtectate, sexine striate to striato-reticulate, radially symmetrical.	March to June and from September to November	Tree
17	*Blighia unijugata* Baker	Ako-ìshín, Ìshín oko	Sapindaceae	Native	Pollen grains isopolar, tricolporate, peritreme or goniotreme, sides straight or convex-prolate spheroidal, size- P: 24.2 µm; E: 21.1 µm; exine 1.4 µm thick; sexine subtectate, sexine striate to striato-reticulate, radially symmetrical.	October to December	Tree
18	*Bombax buonopozense* P. Beauv	Ògbòlò, Èso, Póńpolá,	Malvaceae	Native	Tricolporate, isopolar, shape ranges from prolate to per-oblate, size- P: 41.5 µm, E: 44.6 µm; exine 3.0 µm thick; colpi length 12.5 µm long, and width 2.4 µm; sexine subtectate, reticulate, bilaterally symmetrical.	January to March	Tree
19	*Brachystegia eurycoma* Harms	Ekù,	Caesalpinoideae	Native	Pollen grains isopolar, tricolporate, peritreme-prolate spheroidal, size- P:54.1 µm; E: 45.5 µm; exine 4.5 µm thick; sexine subtectate, very coarsely reticulate, radially symmetrical.	April to May	Tree
20	*Caesalpinia pulcherima* (L.) Swartz.	Èko-omodé	Caesalpinoideae	Exotic	Grain tricolporate, sexine thicker than nexine, pollen wall thick, shape ranges from sub-oblate to prolate spheroidal, size- P: 45.6 µm; E: 40.55 µm; longest axis: 52.5 µm; sculpturing- coarsely reticulate, isopolar, bilaterally symmetrical.	March to June	Shrub
21	*Calliandra haematocephala* Hassk.	Not available	Mimosoideae	Exotic	Grain polyad (16 united grains); 165-177 µm wide; exine 3 µm thick; tectum psilate; sexine granulate; individual cell globose, shape prolate.	April to June	Shrub
22	*Callistemon viminalis* (Sol. ex Gaertn.) G. Don	Not available	Myrtaceae	Exotic	Grain syncolporate, or 4(-3)-colporate; shape ranges from oblate to suboblate; 15-22×20-30 µm; amb subangular; aperture common type; ora circular, bilaterally symmetrical.	February to May	Tree
23	*Canarium schweinfurthii* Engl.	Elémi, Àgbábúbú	Burseraceae	Native	Tricolporate, shape prolate, exine-tectate, faintly reticulate, size- P: 32.5 µm; E: 22.0 µm; exine 2.0 µm thick; colpi length 21.0 µm, width 0.5 µm; margo 0.2 µm thick, radially symmetrical.	September to October	Tree
24	*Canthium subcordatum* DC	Not available	Rubiaceae	Native	Isopolar, triporate, peritreme to goniotreme, sides convex or straight-oblate spheroidal, size- P: 35 µm; E: 36.3 µm; exine 2.8 µm thick; muri 0.6 µm wide;	September to January	Tree

					lumina 2.2 µm wide; sexine subtectate, radially symmetrical.		
25	*Carica papaya* L.	Ibayin, Gbegbere, Ogolomasi	Caricaceae	Exotic	Grain tricolporate; prolate-spheroidal to spheroidal; 24-40 µm wide; amb circular; colpi crassimarginate, 22-23×7-8 µm; exine 1.5 µm thick; tectum with scabrate processes; aperture drop type; ora transversely parallel; sexine finely reticulate; nexine thinner than sexine.	Four months after planting.	Herb
26	*Cassia fistula* L.	Àbò-rere	Caesalpinoideae	Exotic	Polle grain tricolporate; shape oblate-spheroidal to subprolate; 24-38×28-36 µm; exine 1.5 µm thick; tectum psilate; bilaterally symmetrical.	March to August	Tree
27	*Ceiba pentandra* (L.) Gaertn.	Àràbà, Ogùngún,	Bombacaceae	Native	Pollen grains isopolar, tricolporate, pleurotreme to peritreme, sides convex to straight-suboblate, size- P: 50.2 µm; E: 62.0 µm; exine 2.5 µm thick; colpi 23.3 µm long, 3.4 µm wide; sexine subtectate, reticulate, radially symmetrical.	December to March	Tree
28	*Chrysanthellum indicum* DC	Abileré	Asteraceae	Exotic	Grain tricolporate; spheroidal to oblate spheroidal; 20-31×18-31 µm; amb circular; or inter-semi-lobate; colpi 15-19×2-3 µm; ora circular; 3 µm wide; exine 2 µm thick; spinolous; spine 2×1.5 µm, radially symmetrical.	January to December	Herb
29	*Citrus* spp.	Osan, Osan mimu, Oronmbo-nla, Orombo mimu	Rutaceae	Exotic	Pollen grains 3(-4)-colporate; tetracolporate; isopolar; goniotreme (4-sided, sides convex), to peritreme-oblate spheroidal; 26-30×20-27 µm; amb semi-angular; exine 1.5 µm thick; tectum with scabrate processes; sexine reticulate; ora elongated transversely with distinct margins; muri simpli-baculate, radially symmetrical.	August to September and December to March	Tree
30	*Cochlospermum planchonii* Hook.f.	Àwò òwú,	Bixaceae	Native	Pollen grains isopolar, tricolporate/ tricolporoidate, peritreme-subprolate, size- P: 13.5 µm; E: 10.2 µm; exine 0.5 µm thick; colpi length 11.5 µm, width 0.8 µm; sexine intectate, radially symmetrical.	March to September	Shrub
31	*Commiphora africana* (A.Rich.) Engl.	Not available	Burseraceae	Native	Pollen grains isopolar, tricolporate to tetracolporate, tricolporate grains peritreme-oblate spheroidal, tetracolporate grains tetragonal, sides convex-oblate spheroidal, sexine subtectate, size- P: 22.4µm; E: 23.7 µm; colpi length 13.0 µm, width 1.0 µm; sexine coarsely reticulate, radially symmetrical.	November to March	Shrub

32	*Coffea liberica* W. Bull ex Hiern	Kafi-igbo,	Rubiaceae	Native	Grain 3-4-colporate, spheroidal to oblate; 34-44×23-36 µm; amb semi-angular; colpi medium; exine 1.8 µm thick; tectum with scabrate processes; sexine faintly reticulate; 0.8-1 µm thick; exine forming a ring pattern, bilaterally symmetrical.	March to April	Shrub
33	*Combretum bracteatum* (Laws.) Engl. & Diels.	Ògàndùdù,	Combretaceae	Native	Grain heterocolpate; size- P: 37.5 µm; E: 29.4 µm; exine 4.2 µm thick; pore diameter 9.4 µm; shape sub-prolate; psilate.	April to October	Shrub
34	*Combretum calobotrys*	Not available	Combretaceae	Native	Grain heterocolpate; size- P: 32.2 µm; E: 30.5 µm; exine 4.4 µm thick; pore diameter 12.2 µm; shape oblate-spheroidal, psilate.	November to March	shrub
35	*Combretum dolichopetalum* Engl. & Diels.	Ògàn	Combretaceae	Native	Grain heterocolpate; size- P: 33.9 µm; E: 25.1 µm; exine 3.8 µm thick; pore diameter 9.3 µm; shape sub-prolate; scabrate.	October to February	Shrub
36	*Combretum platypterum* (Welw.) Hutch. & Dalziel	Ògàn ìbulè, Ògàn dùdù, Òkàn	Combretaceae	Native	Grain heterocolpate, size- P: 39.4 µm; E: 29.9 µm; exine 3.3 µm thick; pore diameter 12.2 µm; shape sub-prolate, scabrate.	October to March	Liana
37	*Combretum racemosum* P.Beauv.	Ògàn pupa, Ògàn-ìbulè, Òkàn, Ògàn	Combretaceae	Native	Grain heterocolpate; size- P: 30.1 µm; E: 20.5 µm; exine 3.9 µm thick; pore diameter 9.4 µm; shape sub-prolate, scabrate.	November to April	Liana
38	*Commelina diffusa* Burm.f.	Gòdògbò-odò, Itopére	Commelinaceae	Native	Grain 1-sulcate; shape sub-spheroidal; size- P: 25 µm; E: 48 µm; exine 1 µm thick; tectum psilate or with scabrate processes; nexine thinner than sexine; sexine granulate; bilaterally symmetrical.	July to October	Herb
39	*Croton scarciesii* Scott-Elliot	Not available	Euphorbiaceae	Native	Pollen grains inaperturate; shape prolate spheroidal; size- P: 43 µm; E: 53 µm; exine 3 µm thick; sexine with croton pattern; tectum with gemmate processes; nexine thinner than sexine, radially symmetrical.	January to December	Shrub
40	*Cyperus crassipes* Vahl.	Apari-ugun, Katapipi, Ukeregun	Cyperaceae	Native	Pollen grain 4-aperturate; obovidal (apple shaped) or rectangular in E.V. and subspheroidal or obovoidal in P.V.; size- P: 21 µm; E: 38 µm; tectum psilate; distal furrow 12 µm wide; lateral furrow 13×3 µm; exine 2 µm thick; sexine usually granulate with LO -pattern, endosexine infrategillar baculite.	March to June and June to September	Sedge
41	*Dalbergia ecastaphyllum* (Linn.) Taub.	Not available	Papilionoideae	Exotic	Tricolporate, pollen grains heteropolar; size- P: 28.6 µm; E: 22.5 µm; exine 2.5 µm thick; sexine subtectate and minutely reticulate, radially symmetrical.	March to May	Tree

42	*Daniella oliveri* (Rolfe) Hutch. & Dalziel	Òdòdó, Èkàn-iya	Caesalpinoideae	Native	Pollen grains isopolar, tricolporate, goniotreme, sides convex to straight-suboblates; size- P: 31.0 µm; E: 35.0 µm; exine 1.4 µm thick; exine subtectate, reticulate, radially symmetrical.	October to March	Tree
43	*Datura metel* L.	Òdòdó omodé, Apíkan	Solanaceae	Exotic	Grain tricolporate, shape ranges from subprolate to suboblate; 34-48 µm wide; or 34-48×36-48 µm; amb circular; colpi short; ora transversely parallel; exine 2 µm thick; tectum with scabrate processes; esxine striati-reticulate, with LO pattern; radially symmetrical.	January to December	Herb
44	*Delonix regia* (Bojer) Raf.	Sékésekè	Caesalpinoideae	Exotic	Grains tricolporate, isopolar, peritrem-prolate spheroidal, size- P: 53.5 µm; E: 52.6 µm; exine 5.2 µm thick; colpi 26.6 µm long, 4.4 µm wide; ora elongated transversely; sexine subtectate, finely reticulate, radially symmetrical.	April to August	Tree
45	*Elaeis guineensis* Jacq.	Òpe, Èkùró	Arecaceae	Native	Pollen grains heteropolar; trichotomocolpate or trichotomosulcate; kidney or elliptical-boat shaped in E.V.; tetrachotomocolpate grains is rounded-triangular sides convace-boat shaped in E.V.; size- P: 15.5 µm; E: 41.1 µm; exine 1.4 µm thick; sexine subtectate, radially symmetrical.	January to September	Tree
46	*Eucalyptus camaldulensis* Dehnh.	Not available	Myrtaceae	Exotic	Parasyncolporate, tricolporate, shape oblate; 15-18×22-28 µm; amb semi-lobate; ora circular, bilaterally symmetrical.	January to August	Tree
47	*Euphorbia heterophylla* L.	Egéle (Egúnjobí)	Euphorbiaceae	Exotic	Tricolpate, colpi clearly distinct, isopolar, exine pattern gemmate, sexine is thick, sculpturing- coarsely reticulate, shape prolate spheroidal, size- P: 44.0 µm; E: 37.8 µm; exine 1.8 µm thick; colpi length 38.6 µm, width 1.5 µm; radially symmetrical.	January to December	Herb
48	*Euphorbia hirta* L.	Èmí-ilè, Ègè-ilè, ìràwò-ilè,	Euphorbiaceae	Native	Tricolpate, colpi clearly distinct, isopolar, sexine finely reticulate, shape ranges from sub-prolate to prolate, sculpturing- fine reticulation, size- P: 18.5 µm; E: 13.7 µm; exine 1.5 µm thick; colpi length 15.3 µm, width 0.6 µm; nexine thinner than sexine, radially symmetrical.	January to December	Herb
49	*Euphorbia hyssopifolia* L.	Egéle (égúnjobí)	Euphorbiaceae	Exotic	Tricolpate, colpi clearly distinct, isopolar, fine reticulation, shape ranges from sub-prolate to prolate, size- P: 20.5 µm; E: 16.4 µm; exine 1.62 µm thick; colpi length 16.0 µm, width 0.92 µm; radially symmetrical.	February to August	Shrub

50	*Funtumia elastica* (P. Preuss) Stapf	Ìré	Apocynaceae	Native	Pollen grains isopolar, triporate, goniotreme to peritreme, sides convex- suboblate, size- P: 32.6 µm; E: 41.2 µm; exine 1.1 µm thick; sexine subtectate, ornate, radially symmetrical.	All year round	Tree
51	*Gomphrena globosa* L.	Not available	Amaranthaceae	Exotic	Monad; apolar; grain pantoporate (12 pores), shape spheroidal, 28.5 µm wide; pores situated in luminoid depressions; pentagonal or hexagonal; 3.5 µm wide; exine 4 µm thick; tectum with scabrate processes; nexine thinner than sexine, radially symmetrical.	June to September	Herb
52	*Hibiscus rosa-sinensis* L.	Not available	Malvaceae	Exotic	Pollen grain isopolar; pantoporate; pores 32 in number; echinate; pantotreme-spheroidal; sexine intectate, exine 3.6 µm thick; spines 16.4 µm long; radially symmetrical.	January to December	Shrub
53	*Hymenocardia acida* Tul.	Òrùpa, Òròpa, Kelujeju	Phyllanthaceae	Native	Pollen grains isopolar, triporate, peritreme-oblate spheroidal, size- P: 22.2 µm; E: 24.0 µm; exine 1.3 µm thick; colpi 5.2 µm long, 2.2 µm wide; sexine subtectate with reticulate-like pattern, annulus distinct, radially symmetrical.	September to November	Tree
54	*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill	Òro, Òro-mopa, Àbíyé, Oyin, Ùro	Irvingiaceae	Native	Pollen grains isopolar, tricolporate, sexine sub-tectate and finely striato-reticulate, goniotreme with sides concave or straight-suboblate, size- P: 20.5 µm; E: 22.6 µm; exine 1.5 µm thick; colpi 14.5 µm long, 1.4 µm long; radially symmetrical.	March to June	Tree
55	*Ipomoea indica* Burm. (Merr.) (syn. *Ipomoea congesta* R. Br.)	Not available	Convolvulaceae	Pantropic	Pantoporate, pores 70-75 in number, spheroidal; 96-127 µm wide; exine 2.0 µm thick; tectum with echinate and bacculate processes; the echini 14 µm long; the bacula 5 µm long radially symmetrical.	January to December	Vine
56	*Ixora coccineaa* L.	Ìsáná omodé	Rubiaceae	Exotic	Grain tricolporate, shape prolate-spheroidal; size- P: 28.4 µm; E: 30.0 µm; colpi 1.5-3.5 µm wide; exine 2.0 µm thick; tectum with scabrate or verrucate processes; sexine 0.8-1 µm thick; radially symmetrical.	January to December	Shrub
57	*Jasminum multiflorum* (Burm.f.) Andrews	Not available	Oleaceae	Exotic	Grain tricolporate; shape ranges from sub- oblate to oblate, size- P: 43 µm; E:42 µm; furrows short, reticulate, radially symmetrical.	January to December	Shrub
58	*Jatropha curcus* L.	Làpálàpá	Euphorbiaceae	Exotic	Inaperturate, reticulate, exine pattern gemmate, shape sub-prolate, size- P: 60.2 µm; E: 62.3 µm; exine 3.5 µm thick; radially symmetrical.	January to December	Tree

59	*Jatropha gossypiifolia* L.	Ògégé, Bòtújè-pupa	Euphorbiaceae	Exotic	Inaperturate, coarsely reticulate, circular shaped and/or prolate spheroidal, isopolar, nexine thinner than sexine, grain tectate, size- P: 69.5 µm; E: 67.8 µm; exine 3.7 µm thick; radially symmetrical, stratification indistinct.	September to April	Shrub
60	*Khaya senegalensis* (Desr.) A. Juss.	Ògànwó, Ògònwó	Meliaceae	Native	Aperture- tetracolporate, size- P: 28.0 µm; E: 28.0 µm; exine 1.1 µm thick; shape ranges from oblate spheroidal to prolate spheroidal, exine- tectate.	February to April	Tree
61	*Kigelia africana* (Lam.) Benth.	Iyàn, Pándòrò	Bigniniaceae	Native	Tricolpate, subprolate, size- P: 57.2 µm; E: 48.1 µm; exine 2.5 µm thick; tectum 1.2 µm; exine pattern subtectate, coarsely reticulate, heterobrochate, radially symmetrical.	May to October	Tree
62	*Mallotus subulatus* Mull-Arg	Àpálúwore, Pepe, Ológbómodù	Euphorbiaceae	Native	Pollen grains isopolar, tricolporate, peritreme-oblate spheroidal, size- P: 20.2 µm; E: 20.6 µm; exine 1.5 µm thick; colpi 13.6 µm long, 2.3 µm wide; sexine pertectate, opercula granulate, ora faintly demarcated and circular, radially symmetrical.	March to April and June to November	Shrub
63	*Mangifera indica* L.	Móngòrò	Anacardiaceae	Exotic	Pollen grains tricolporate, goniotreme, pollen grain isopolar, shape prolate to prolate; 25-36×18-33µ; colpi crassimarginate, 29-34×2µ; exine 1-2µ thick; tectum with scabrate processes; sexine reticulate, radially symmetrical.	February to May	Tree
64	*Mimosa pudica* L.	Patanmó, Alùro	Mimosoideae	Exotic	Tetrad, tetragonal, psilate, size- P: 29 µm; E: 22 µm; radially symmetrical.	July to October	Herb
65	*Mimusops warneckei* Engl.	Not available	Sapotaceae	Exotic	Pollen grain tetracolporate (4-colporate), isopolar, goniotreme (tetragonal with sides straight or slightly convex-prolate spheroidal), size- P: 27.5 µm; E: 24.2 µm; exine 1.0 µm; thick; ora transversely elongated, apparently operculate, bordered by granulate annuli, radially symmetrical.	April to June	Tree
66	*Morelia senegalensis* A. Rich. ex DC.	Not available	Rubiaceae	Exotic	Pollen grain isopolar, radially symmetrical, triprorate; 3-(4)-por(or)ate, goniotreme, sides convex, or straight oblate, size- P: 19.2 µm; E: 22.4 µm; exine 1.3 µm thick; annulus and pollen tubes clearly distinct, sexine subtectate,	November to January, and March to April	Tree
67	*Morinda lucida* Benth	Oruwo, Owuru, Origho, Erewo	Rubiaceae	Native	Pollen grain tetracolporate (4-colporate), size- P: 40.5 µm; E: 45.2 µm; exine 3.0 µm thick; exine subtectate, coarsely reticulate, suboblate to oblate spheroidal in	February to May	Tree

					shape, tetragonal, sides convex, pleurotreme, colpus with rounded ends, coarsely and densely granular membrane distinct.		
68	*Moringa oleifera* Lam.	Ewe ile, Idagba manoye, Ewe-igbale	Moringaceae	Exotic	Pollen grain 3-colporate; shape prolate spheroidal to spheroidal; 27-34×5 µm; ora circular or longitudinally elliptic; 4-8×4-5 µm; exine 1.5 µm thick; tectum psilate; and sexine granulate with obscure pattern.	April to May, and September to October	Tree
69	*Newbouldia laevis* Seem. Ex. Bureau	Akòko,	Bignoniaceae	Native	Pollen grains isopolar, tricolpate, peritreme-subprolate, size- P: 52.3 µm, E: 41.5 µm; exine 2.1 µm thick; colpi colpi 45.0 µm long, 6.6 µm wide; muri 0.6 µm wide; lumina 1.8 µm wide; sexine subtectate and reticulate, radially symmetrical.	July to September	Tree
70	*Nicotiana tabacum* L.	Ewe-taba, Kataba, Aasa.	Solanaceae	Exotic	Grain tricolporate; shape subprolate to prolate-spheroidal; 30-33×26-30 µm; amb circular; aperture common type; ora transversely parallel or circular; exine 1 µm thick; tectum psilate; sexine reticulate.	July to September	Herb
71	*Parinari curatellifolia* Planch ex Benth	Abó ìdòfún, Ìdòfún, Olóbútù	Chrysobalanaceae	Native	Tricolporate, shape oblate, size- P: 28.2 µm; E: 41.5 µm; exine 4.2 µm thick; exine- subtectate, finely reticulate to striato-reticulate, radially symmetrical.	January to April, and December	Tree
72	*Parkia biglobosa* (Jacq.) R.Br.ex Don	Ìgbá, Irúgbá, Abàtà, Irúgbá oso, Ùgbá kaba	Mimosoideae	Native	Pollen grains clustered in polyads with 18 to 20 grains in each, arranged irregularly and asymmetrical, the polyad is oval or rounded in shape, aperture indiscernible (inaperturate).	December to April	Tree
73	*Paullinia pinnata* L.	Obì-omodé, Kakansela, Ogbe-okuje, Obì-aiyé	Sapindaceae	Native	Pollen grains isopolar to sub-isopolar, triporate, annulus distinct, sexine subtectate, goniotreme with sides concave to straight-oblate, size- P: 27.0 µm; E: 47.1 µm; exine 1.3 µm; radially symmetrical.	December to January	Vine
74	*Pentaclethra macrophylla* Benth.	Àpàrá, Apàhá, Àpàpá,	Mimosoideae	Native	Pollen grains isopolar, triporate/triporoidate, (tricolporate) goniotreme, sides convex-oblate, size- P: 35.7 µm; E: 48.4 µm; exine 1.3 µm thick; sexine subtectate and minutely reticulate, radially symmetrical.	January to May, and July to December	Tree
75	*Piliostigma thonningii* (Schumach.) Milne-Redh.	Abefé, Abafé	Caesalpinoideae	Exotic	Pollen grains isopolar, triporate, peritreme- oblate spheroidal, size- P: 32.2 µm; E: 33.2 µm; exine 1.5 µm thick; tectum 0.4 µm thick; sexine pertectate, radially symmetrical.	December to February	Tree

76	*Pycnanthus angolensis* (Wellw.) Warb.	Aríwo, Akómu, Akùjadi	Myristicaceae	Native	Pollen grains heteropolar, monocolpate/ monosulcate, kidney shaped or elliptical-boat shaped at E.V., size- P: 14.2 µm; E: 20.0 µm; exine 1.5 µm thick; bilaterally symmetrical.	October to November	Tree
77	*Rauvolfia vomitoria* Afzel.	Asoféyeje	Apocynaceae	Native	Pollen grains isopolar, tricolpate, syncolpate, goniotreme, sides convex to straight-suboblate, size- P: 52.0 µm; E: 60.2 µm, exine 1.4 µm thick; sexine subtectate, reticulate, radially symmetrical.	February to June	Shrub
78	*Ricinus communis* L.	Èso lárà	Euphorbiaceae	Native	Tricolporate, isopolar, zonocolporate, colpi clearly distinct, scabrate, shape ranges from prolate spheroidal to sub-prolate, size- P: 27.3 µm; E: 24.0 µm; exine 0.97 µm thick; colpi length 22.6 µm, width 0.81 µm; radially symmetrical.	January to December	Shrub
79	*Senna alata* L.	Asunrun oyinbo	Caesalpinoideae	Exotic	Aperture tricolporate with nexine thinner, exine pattern granulate, sculpturing- coarsely scabrate, isopolar, shape sub-prolate, size- P: 32.25 µm; E: 30.55 µm; radially symmetrical.	October to December	Perennial shrubs to small trees
80	*Sesamum indicum* L.	Not available	Pedaliaceae	Native	Pollen grain anamotrme; size- P: 60 µm; E: 60 µm; shape sub-oblate; bilaterally symmetrical.	May to September	Herb
81	*Solanum lycopersicum* L. (Syn. Lycopersicon esculentum Mill.)	Tomato	Solanaceae	Native	Grain tricolporate; shape subprolate to oblate-spheroidal; 20-25×21-27 µm; amb circular or semi-angular; aperture drop type; exine 1 µm thick; tectum psilate; ora transversely elliptic; sexine granulate.	A month after planting.	Herb
82	*Spathodea campanulata* P. Beauv.	Ímí Èwu,	Bignoniaceae	Native	Pollen grains isopolar, tricolpate to tricolporate, peritreme-subprolate, size- P: 47.7 µm; E: 36.1 µm; exine 2.2 µm thick; colpi 38.6 µm long, 3.7 µm wide; sexine subtectate and reticulate, radially symmetrical.	March to June	Tree
83	*Syzygium guineense* (Willd.) DC.	Adère, Igi-aró, Orí-irà,	Myrtaceae	Native	Pollen grains isopolar, syncolpate, polymorphic apertures, goniotreme, sides straight or convex-oblate, size- P: 9.2 µm; E: 14.6 µm; colpi distinct and are united at the poles, sexine pattern and stratification not clearly distinct, radially symmetrical.	January to May, and November to December	Tree
84	*Talinum triangulare* (Jacq.) Willd.	Gbure, Gure.	Portulacaceae	Exotic	Grain pantocolpate (pericolpate); 31-45 µm wide; exine 2.5 µm thick; tectum psilate; sexine granulate; nexine thinner than sexine.	October to January	Herb

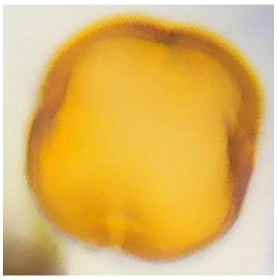
85	*Tetrapleura tetraptera* (Schumach.) Taub	Aídan, Arídan, Ayídan, Aídon	Mimosoideae	Native	Pollen grains clustered in polyads with 16 to 24 grains arranged irregularly and asymmetrically, each grain triporate, the polyad oval and/or circular in shape, grain isopolar to subisopolar and variable in shape, exine 1.5 µm thick; sexine –pertectate with aperture consisting of distinct circular pores.	September to December	Tree
86	*Tithonia diversifolia* (Helmsl.) A. Gray	Sepeleba	Asteraceae	Exotic	Aperture tricolporate, sculpturing- spinate with longer and sharper spines, exine pattern- echinate, isopolar, shape is prolate spheroidal, size- P: 40.95 µm; E: 37.35 µm; radially symmetrical.	All year round	From Herb, shrub and small tree
87	*Treculia africana* Decne.	Afòn, Ifòn	Moraceae	Native	Grains isopolar, triporate, pore circular, goniotreme or peritreme-suboblate, size- P: 12.1 µm; E: 13.5 µm; exine 0.5 µm thick; sexine pertectate, radially symmetrical.	October to February	Tree
88	*Tridax procumbens* L.	Sabaruma	Asteraceae	Exotic	Aperture tricolporate with pores densely situated, exine pattern spinate, isopolar, shape- prolate spheroidal, size- P: 38.2 µm; E: 35.7 µm; exine 2.4 µm thick; spine 2 µm long; colpi 13.5 µm long, 2.0 µm wide; radially symmetrical.	June to September	Perennial herb
89	*Trichilia prieureana* A, Juss.	Urera	Meliaceae	Exotic	Tetracolporate, goniotreme (4-sided), grain isopolar, shape prolate-spheroidal, size-P: 26.2 µm; E: 22.4 µm; colpi 15.5 µm long, 0.6 µm wide; sexine pattern indistinct and subtectate, radially symmetrical.	January to March	Medium sized tree
90	*Triplochiton scleroxylon* K. Schum.	Arere, Òbésè	Malvaceae	Native	Pollen grains isopolar, triporate, peritreme-oblate, size- P: 20.5 µm; E: 28.7 µm; exine 1.3 µm thick; sexine pertectate, radially symmetrical.	November to March	Tree
91	*Vitellaria paradoxa* C.F. Gaertn.	Akú malapa, Èmì, Èmì-emì, Èmí-gidi	Sapotaceae	Native	Tetracolporate, pollen grains isopolar peritreme-subprolate, size- P: 35.1µm; E: 28.5 µm; exine 1.4 µm thick; colpi 28.0 µm long, width 1.1 µm; sexine subtectate, radially symmetrical.	November to January	Tree
92	*Zea mays* L.	Agbado	Poaceae	Exotic	Grain monoporate, pore annulate, spheroidal, the annulus elevated, tectum psilate, exine 1.5 µm thick; pores 4.5 µm wide; annulus 11 µm thick; nexine thinner than sexine, sexine granulate, with LO - pattern.	92 to 196 days after planting	Grass

Ageratum conyzoides

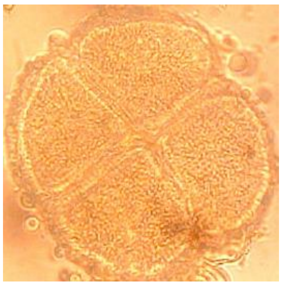
Senna alata

Albizia zygia

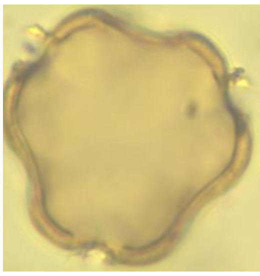
Cyperus crassipes



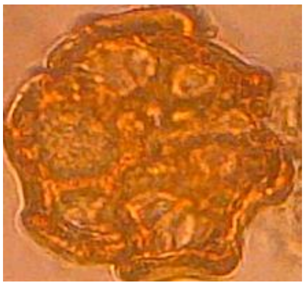
Morinda lucida



Annona senegalensis

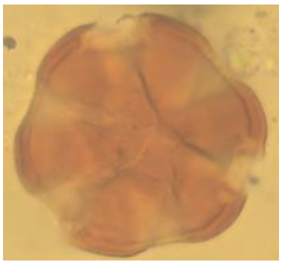


Combretum calobotrys



Brachystegia eurycoma

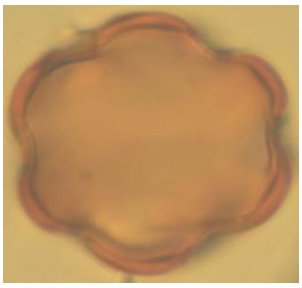
Ceiba pentandra



Combretum bracteatum

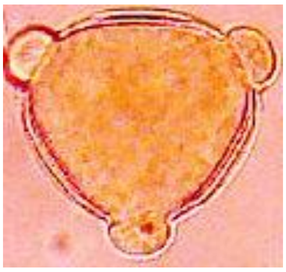
Aubrevillea kerstingii

Daniella oliveri



Combretum dolichopetalum

Elaeis guineensis



Morelia senegalensis

Plate 1: Photomicrographs (x 100) of some selected pollen types studied

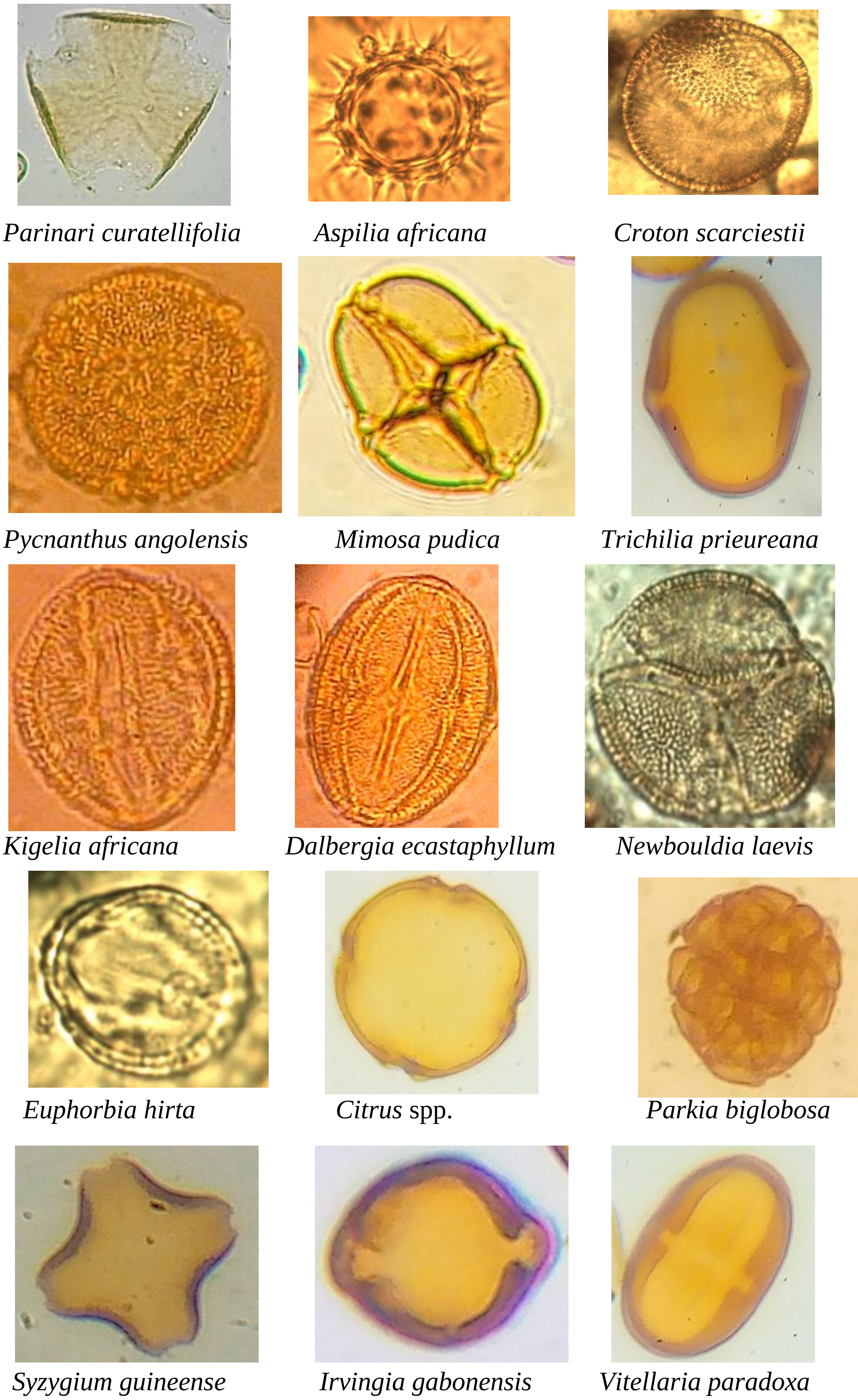


Plate 1: Photomicrographs (x 100) of some selected pollen types studied cont'd.

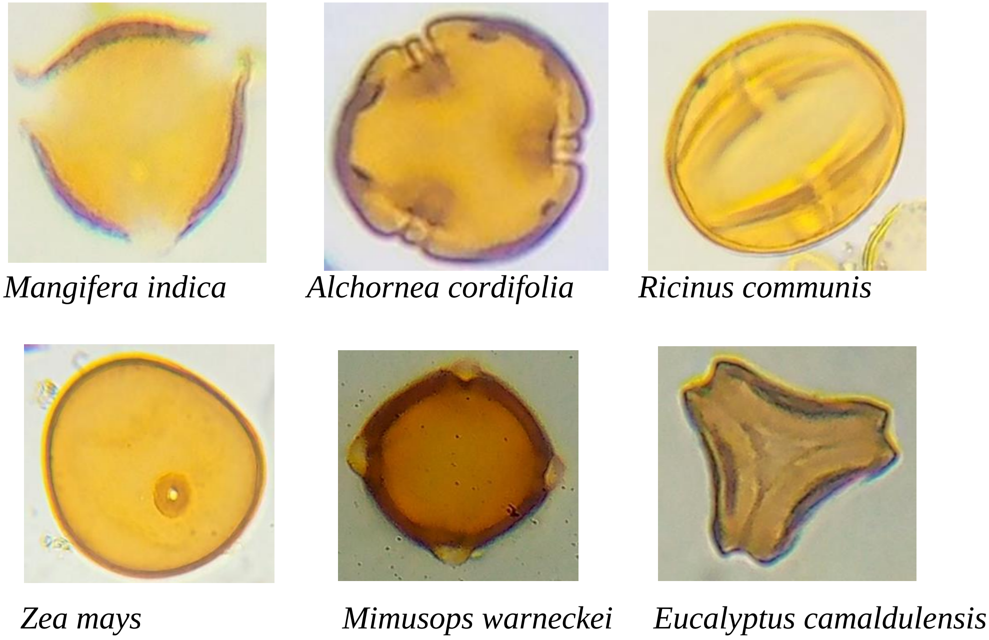


Plate 1: Photomicrographs (x 100) of some selected pollen types studied cont'd.

psilate, with scabrate, verrucate or gemmate processes; nexine thinner than sexine). As such, it is therefore necessary to examine large numbers of pollen types from each family so as to obtain an elaborate, comprehensive, detailed and complete information on different species and genera within that family.

Among the Monocotyledoneae for example **Glumiflorae**: Poaceae, the grains are monoporate (ulcerate), spheroidal, pore with annulus, exine psilate to scabrate. Cyperaceae grains are inaperturate with 1-3aperturoid areas, subspheroidal to pear-shaped, exine with fine supratectal processes. **Principes**: Arecaceae pollen grains are monosulcate or trichotomosulcate, oblate to peroblate, exine verrucate to reticulate. Within the Dicotyledoneae for example **Centrospermae**: Portulacaceae pollen grains are polycolpate, spheroidal, colpi arranged in the form of pentagon, exine reticulate with spinules. **Ranales:** Annonaceae grains are tetragonal tetrad and oblate. In **Geraniales**: Rutaceae grains are 3-4-colporate, exine puntitegillates, whereas in **Sapindales**: Annacardiaceae grains are 3-colporate or 3-colporoidate and exinereticulate to striato-reticulate. **Tubiflorae**: Convolvulaceae grains are pantoporate or 3-colpate, pantocolpate, spheroidal, exines spinulate with variable spines; and Solanaceae grains are 3-colporate, shape variable, exine psilate, reticulate to striato-reticulate. Bignoniaceae grains are 3-colpate, 3-colporoidate, 3-colporate, polyzonocolpate or 5- parasyncolpate, shape and exine variable. **Ebenales**: Sapotaceae have 4-5 colporate, oblate spheroidal pollen grains, exine puntitegillate. In **Rubiales**: Rubiaceae pollen is 3-colporate, polyzonocolpate or 3-porate, shape and exinevariable. In Mimosoideae, the grains are monad, tetrad, polyads or Ppollinia, monad grains tricolporate, and exine psilate. In Caesalpinoideae, the grains are tricolporate with variable shape, size and exine ornamentations. In Fabaceae, 3-colpate, 3-colporate or 3 to pantoporate with varaiable size, shape and exine ornamentations. Similar findings were reported by Chanda and Ghosh (1979) and Frietas *et al*. (2020). Species in the family Myrtaceae, the pollen grains are 3-parasyncolporate, peroblate; exine psilat whereas those of the family Euphorbiaceae are inaperturate (for example, *Croton scarciesii*, *Jatropha curcus* and *Jatropha gossypiifolia*); tricolpate and reticulate (for example, *Euphorbia hirta*, *Euphorbia heterophylla* and *Euphorbia hyssopifolia*), and tricolporate (for example, *Mallotus subulatus* and *Ricinus communis*). Noticeable variations were also observed in the pollen morphology of plant species within the family Rubiaceae. Findings corroborated favourably with the reports of Shubharani *et al*. (2013). The identification, propagation, cultivation, conservation and sustainable exploitation of these honeybee (*Apis mellifera* var. *adansonii*) forage and preference plants could be useful in providing the bee forage which in turn will improves the efficiency of apiculture and commercial honey production in South-Western Nigeria. Findings is in line with the report of Bhattacharya *et al*. (2011).

This study is anticipated to be useful to beekeepers in South-Western Nigeria to formulate these seasonal bee management strategies and schedule especially for migration of bee colonies to different floral sources. The pollen morphology of the taxa examined could also provide useful information about their respective families. Study is also anticipated to aid in ascertaining the ecological, geographical as well as the botanical origin of honey (Agwu and Akanbi, 1985; Ige and Apo, 2007; Essien *et al*., 2022).

This study also showed that most of these honeybees' forage plants taxa flowers during the period of reduced rainfall (dry season). That is, the months of November to March when the sun shines more brightly and the atmospheric humidity is lower. The finding is in line with the report of Jato *et al*. (2002) who opined that these climatic conditions are most suitable for the flight of insects (for example honeybees) and positive pollination ecology. The information obtained during this phenology study has a great significance because it did not only provide knowledge about the plants flowering calendar but also gives insight into how environmental variables, such as selective pressure on flowering, can affect a species' behavior, demonstrating how food is produced year-round in the study area. Findings conformed favourably with the report of Essien (2020).

CONCLUSION

The pollen taxa described in this work reveal a wide spectrum of plant communities common in the Southwestern Nigeria. In the present study, palynotaxonomy of some selected monocots and dicots foraged by honey bees in Southwestern Nigeria are presented. Modern bee keeping is the art of handling bees and maximizing their benefits such as harvesting of honey, pollen, wax, royal jelly, propolis, bee-venom and other bee products. Plants flowering and honeybees have been used as illustrative examples of co-evolution and mutualism. The findings of this study indicated that majority of these foraged plants flower primarily between the months of October and March.

This study revealed that pollen grains of plant species belonging to the family Asteraceae were spinolous and spherical in shape; those of the Fabaceae sub-families Caesalpinoideae, Mimosoideae and Papilionoideae had great morphological diversity with variations in symmetry, position and distribution of apertures, exine structure and sculpture of the pollen wall. The pollen grains of plants belonging to the family Malvaceae were echinate (spinolous) and those of the family Myrtaceae were syncolpate and prolate. However, the variations above were generally reduced within species in the same genera. Tricolpate aperture type was observed in *Euphorbia heterophylla* L, *Euphorbia hirta* L and *Euphorbia hyssopiifolia* L; a possible reason why they are classified in the same genera. Pollen grains of the genus *Combretum* were all heterocolpate, circular in shape and heteroporate. Sculpturing was psilate or scabrate and pollen shape class were sub-prolate, oblate-spheroidal or prolate spheroidal. Similar form and symmetry observed in all the species studied were reason for their classification into the same family.The morphological characteristics of pollen grains are manifested in the outermost pollen wall (exine). The stratification of exine along with number, position and character of apertures are useful in classifying pollen grains. Hence the orientation of polarity is an important criterion in the identification and description of pollen grains. On the basis of apertural characters along with shape, size and surface ornamentations of the exine, a comparative study of pollen grains is very useful in systematic consideration.

Palynologically, plant families can be segregated into two groups: Stenopalynous, where the taxa of the family display more or less the same type of pollen grains, for example, Poaceae, etc. and Eurypalynous, where the taxa are characterized by an obvious difference in pollen types, for example, Rubiaceae, Solanaceae, Convolvulaceae and Fabaceae, among others. The knowledge of pollen morphology has been to substantiate many taxonomic revisions sometimes even up to the formation of new taxa. Segregation of Bombacaceae from Malvaceae is an example of the contribution of pollen morphological study to taxonomy.

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Conflict of interest

Authors have no conflict of interest to declare.

Author contributions:

EBC was involved in: field studies, extraction of pollen grains, microscopic examination and pollen analysis, photomicrography, and drafting of the manuscript. IOE was involved in the providing logistics during field studies, interpretation of research findings and critical review of draft manuscript. IYO was involved in carrying out plagiarism check on the draft manuscript. FSO was involved in field studies, extraction of pollen grains, microscopic examination, and interpretation of scientific names into indigenous Yoruba dialect.

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