

SOCIO-DEMOGRAPHICS AND HEALTH IMPLICATIONS OF AIRBORNE POLLEN AND SPORES IN IBADAN METROPOLIS, SOUTHWEST, NIGERIA

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ABSTRACT

Airborne pollen and spores of certain plants elicit allergic reactions in hypersensitive humans. These allergic reactions cause health and socioeconomic problems for nations. To evaluate the effects of these aeropalynomorphs, an aeropalynological study was conducted with a demographic survey in the metropolis of Ibadan, Southwest Nigeria, from November 2012 to February 2013, in three strategic locations. Demographic variables evaluated were the gender, allergic responses, location of respondents, season of occurrences of symptoms, sources and choices of relief from allergies. Collected aerosamples were palynologically treated using Erdtman (1969) acetolysis method. Pollen counts were integrated with weather parameters and clinical data. Pre-tested and validated questionnaires and oral interview approaches were adopted among inhabitants for the demographic survey. Clinical data were sourced from local hospitals and pharmacy outlets. The symptoms of allergies experienced by respondents included catarrh, runny nose, eye, and skin itching. Out of all the symptoms, catarrh was the most prevalent, followed by eye itching. The highest percentage of sufferers of recorded symptoms prefer local drug stores known as 'chemists' to prescriptions by medical doctors or pharmacists. The results also showed that symptoms are not gender-specific. High frequency and severity of cases occurred during the drier and harmattan periods, which coincided with the highest pollen counts. Notable allergenic pollen of interest include Poaceae (*Zea mays*), Asteraceae, Anacardiaceae, and Euphorbiaceae (*Alchornea cordifolia*), as well as Fungal spores. This work documents the first combined approach of demography, meteorological parameters, and aeropalynology in a palynological research study in Nigeria.

Keywords: Aeropalynology, allergy, health, demographics, meteorology, Ibadan.

Introduction

Airborne pollen and spores of certain plants elicit allergic reactions in hypersensitive humans. The symptom experienced as a result of allergic reaction to the inhalation of pollen is Pollinosis (D'Amato *et al.*, 2007; Rogers, 2008; May and Smith, 2008; Bartra *et al.*, 2009; Waqar *et al.*, 2010). The inflammation of the nasal airways, known as allergic rhinitis (Druce, 1998; Togias, 2000; Walls *et al.*, 2001; Haberal and Corey, 2003; Rogers, 2008; May and Smith, 2008), is characterized by symptoms such as sneezing, nasal congestion, nasal itching, and rhinorrhea (Druce, 1998). This leads to allergic reactions in certain susceptible individuals due to the allergenic protein constituents in pollen grains (Adeniyi *et al.*, 2017, 2018). These allergies cause significant health and socioeconomic problems of high magnitude to nations. As it is a fact that palynomorphs from several plant taxa have allergic effects on humans, it is of utmost necessity that their types and concentration be determined (Al-Qura'n, 2008).

In Nigeria, several studies have shown the effects of weather parameters such as rainfall, temperature, average humidity, and wind (Agwu *et al.*, 2004; Adekanmbi and Ogundipe, 2010; Adeonipekun and John 2011; Ajikah *et al.*, 2015; Adekanmbi *et al.*, 2017) on the types, quantity, duration, abundance, and distribution of airborne palynomorphs. However, these studies could not ascertain the health risk posed by these airborne palynomorphs except for the work of Adeonipekun and John (2011), which suggested the potential risk of the abundance of pollen of *Vitex cf. doniana* and *Isobertina doka*. The studies by Adeniyi *et al.*, (2017, 2018) identified and revealed allergenic effects of pollen from plants like *Alchornea cordifolia*, *Amaranthus hybridus*, *Casuarina equisetifolia*, and various grasses (Poaceae) on blood serum from humans, while pollen from *Leucania leucocephala* and *Terminalia catappa* (Alebiosu and Adekanmbi, 2022) showed allergenic potential on *Mus musculus* mice. The studies by Adeniyi *et al.*, (2017, 2018), Alebiosu and Adekanmbi (2022), and others in Nigeria did not investigate or reveal the potential effects of pollen grains and spores on the socio-demographic variations amongst the people in their studies. Though, the prevalence of asthma and allergic rhinitis as opined by Ozoh *et al.*, (2019) across five Nigerian cities, are widespread, with approximately 13 million cases reported across the regions.

Despite the published works on aeropalynology in Nigeria, none have been reported from the Ibadan metropolis, known to the authors. There is no known study that integrates the combined approach of socio-demography, meteorological parameters, and airborne palynomorphs amongst people in a given area in Ibadan or elsewhere across Nigeria. By integrating aeropalynological, clinical, and sociodemographic data, this research will move beyond identification of potential culprit allergens to directly inform public health awareness and pinpoint appropriate treatment sources for the Ibadan populace, providing a comprehensive solution to a recognized and costly health problem. This study aims to provide a holistic understanding of the allergy problem in Ibadan by linking the environmental cause, the medical effect, and the characteristics of the affected population. The results from this combined approach are expected to be useful for identifying the culprit allergens responsible for the allergic reactions in the Ibadan populace, improving public health awareness regarding allergies, and increasing the sensitivity of the populace on appropriate treatment sources.

Materials and Methods

i. The study sites:

Ibadan Metropolis

Ibadan, the capital of Oyo State, in southwest Nigeria, is historically reputed to be the largest indigenous city in West Africa, south of the Sahara. The area was established in 1829 as a

war camp for warriors because of its forest sites and hills (Fourchard, 2003). The forest sites and hills which vary in elevation from 160 to 275 metres above sea level according to Fourchard (2003), offered strategic defense opportunities for warriors during the time. The city is 78 miles inland from Lagos and serves as a prominent transit point between the coastal region and the area to the north. The total area of Ibadan is 3,080km² (Collins Map, 2012), on a Latitude of 7° 24' and 45''N and Longitude 3° 55' 45'' E with a population of 3,565,108. Ibadan has an equatorial climate consisting of a tropical dry and wet season. The average daily temperature is between 25 °C (77.0°F) and 35 °C (95.0°F), while the mean maximum and minimum temperatures are 26.46 °C and 21.42 respectively. The mean total rainfall is estimated to be 1420.06mm with a relative humidity of 74.58%. The city is influenced by the moist-laden, south-westerly monsoon and dry, north-east trade winds. The vegetation of Ibadan is dry, lowland rainforest in the southern part, which gradually changes northwards to derived and Guinea savanna.

Airborne pollen and spores were recovered from three strategic locations within Ibadan metropolis (Fig. 1). These locations were the Agbowo shopping complex (7° 26' 23.6'' N, 3° 54' 28'' E), Mapo hall (7° 22' 34'' N, 3° 53' 49'' E) and Oyo state library (Dugbe) (7° 23' 21'' N, 3° 52' 45'' E) at 274.9m, 261.6m and 210m above sea level respectively (Fig.3-5). The period for the monthly collections of airborne pollen and spores was from November 2012 to February 2013 spanning four months.

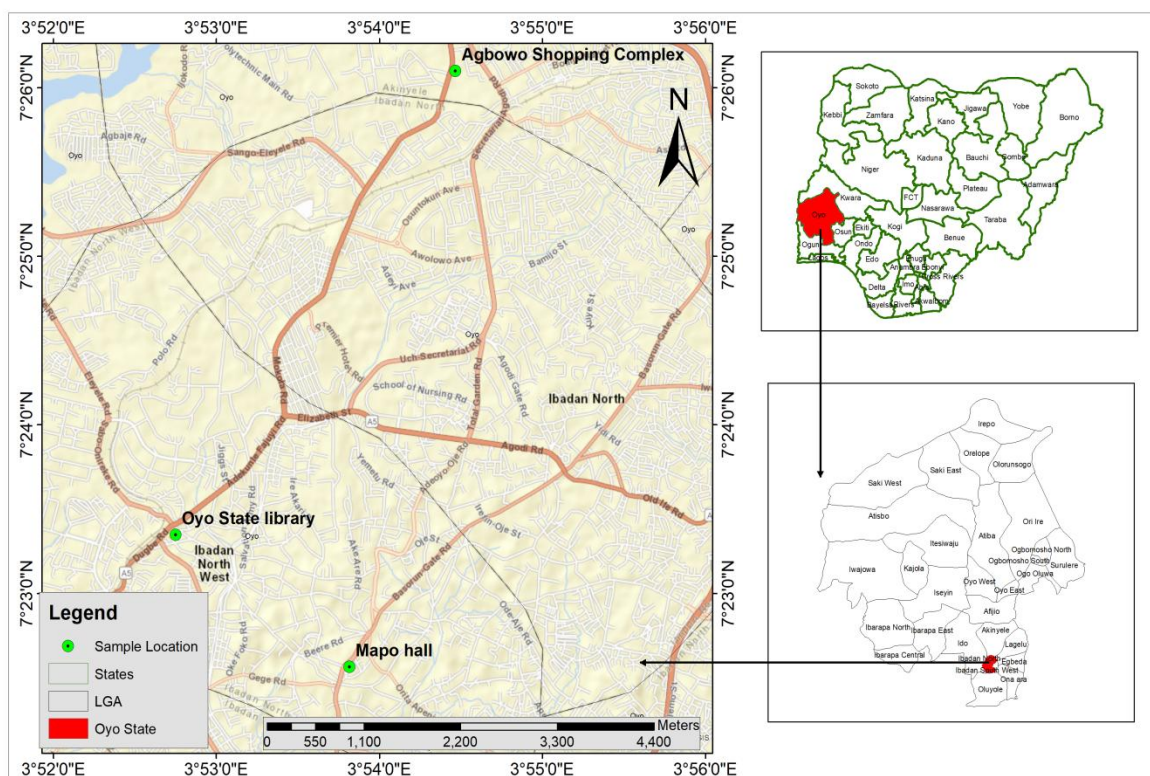


Fig.1 Map of Nigeria Showing Sampled Locations in Ibadan, Oyo State

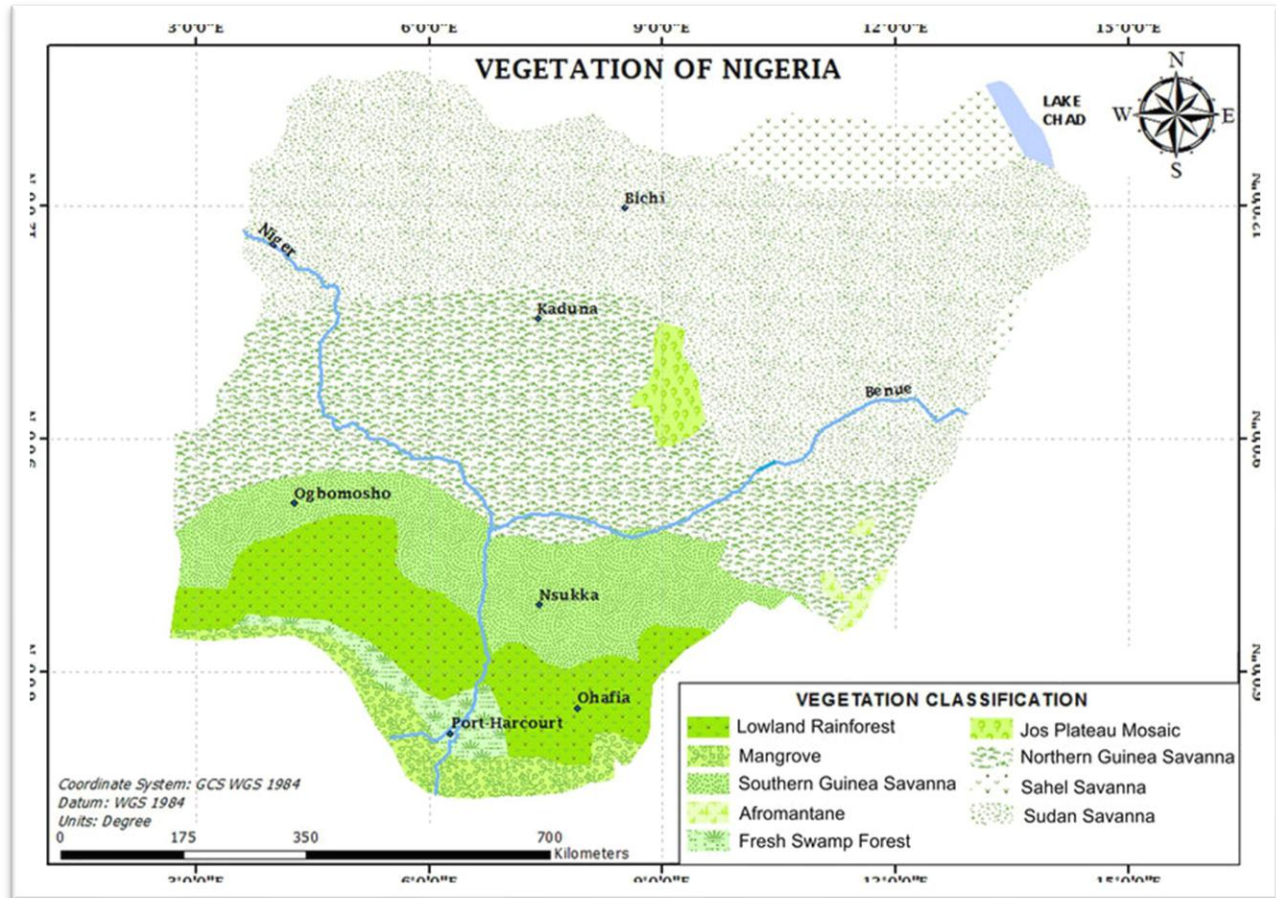


Fig. 2 Vegetation Map of Nigeria (Adapted from Adeonipekun et al. 2017)



FIG. 3: Agbowo Shopping Complex



Fig. 4: Mapo Hall



Fig. 5: Oyo State Library Building

ii. Pollen Samplers:

The pollen sampler used was the Gbenga-2 gravimetric sampler as used and described by Adeonipekun and Olowokudejo (2012).

iii. Sample treatment and analysis:

The pollen analysis was carried out in the Palynology Laboratory, Department of Archaeology and Anthropology, University of Ibadan, Ibadan. The collected aerosols in the

samplers were subjected to standard laboratory procedures using the Acetolysis method of Erdtman (1969) and Faegri and Iversen (1989), which consists of the mixture of nine parts of glacial acetic anhydride and one part of tetraoxosulphate (VI) acid. The identification of recovered palynomorphs was confirmed through the use of published works by Sowunmi (1973, 1995), albums of photomicrographs, Reference slides, and sets of collections in the Palynology Laboratory, Department of Archaeology and Anthropology, University of Ibadan.

iv. Weather data:

Meteorological data, which consists of atmospheric temperature, wind, rainfall, and relative humidity, were collected from the Nigerian Meteorological Agency (NiMet) in Oyo State. The data were used to evaluate the prevailing weather conditions of the studied areas.

Data collection on incidences of allergic reaction

Four strategic locations within the Ibadan metropolis, where aeropalynology was carried out were selected. These locations were Agbowo, Dugbe, Mapo, and the University of Ibadan. A pre-tested and validated questionnaire, expertly developed and confirmed by one of the authors, was used for the survey. These questionnaires were administered to 200 respondents, comprising students, academic and non-academic staff, traders, businessmen, and market women within these locations, using a convenience sampling method. The administration of the questionnaires was from November 2012 to April 2013. The sample size of 200 was chosen due to the constraints of the timeline, budget, and manpower for effective data collection and quality control in a multi-site urban setting. Ethical guidelines were followed, informed consent was sought from the respondents before administering the questionnaires, and the purpose of the study was explicitly explained. Meanwhile, additional interviews were conducted with medical personnel and pharmacists, who were visited at their respective hospitals, clinics, and pharmaceutical stores within the study areas. The socio-demographic parameters considered in the questionnaires included the age, gender, allergic status, symptoms of allergies, choice and source of relief, period of occurrence, and location of respondents.

Data analysis

For this study, simple descriptive and inferential statistics were employed. These involved the use of percentages, means, and frequency distribution to analyze the parameters in the questionnaires. Pearson Correlation Coefficients (r) at a 95% confidence interval and a Chi-square Test Analysis were employed to analyse the data using SPSS 17.0 version. The significance difference was tested at a 95% confidence interval.

Results

i. Aeropalynology

The palynomorphs recovered from the three strategic locations are remarkable in terms of variety and abundance (Table 1). From these recoveries, the identification of palynomorphs was confirmed to the species, genus, and family levels. The palynomorphs that could not be identified were grouped into pollen and spores indeterminate. A total of 30 and 13 palynomorphs were identified to species and genus levels, respectively. Palynomorphs, which are 19 were identified to the family level, included abundant fungal spores of *Alternaria* and *Cladosporium* species. The pollen and spores that are dominant are those from the families of Arecaceae, Anacardiaceae, Amaranthaceae, Euphorbiaceae, Moraceae, and Poaceae. Abundant fungal spores were also recovered.

Table1: Total recovered palynomorphs for the four months of study

No	PALYNOMORPHS	TOTAL	FAMILY
1	<i>Azadirachta indica</i>	10	Meliaceae
2	<i>Ageratum conyzoides</i>	8	Asteraceae
3	<i>Asteraceae</i>	22	Asteraceae
4	<i>Bosquiea angolense</i>	5	Moraceae
5	<i>Carica papaya</i>	1	Caricaceae
6	<i>Chromolaena odorata</i>	22	Asteraceae
7	<i>Epiphytic fern</i>	12	Epiphytes
8	<i>Mangifera indica</i>	1	Anacardiaceae
9	<i>Milicia excelsa</i>	39	Fabaceae
10	<i>Piptadeniastrum africanum</i>	8	Fabaceae
11	<i>Pterocarpus santalinoides</i>	2	Fabaceae
12	<i>Spondias mombin</i>	34	Anacardiaceae
13	<i>Tetrorchidium didemostemon</i>	1	Euphorbiaceae
14	<i>Tridax procumbense</i>	28	Asteraceae
15	<i>Vernonia</i> sp.	2	Asteraceae
16	<i>Alchornea cordifolia</i>	631	Euphorbiaceae
17	<i>Blighia sapida</i>	1	Sapindaceae
18	<i>Borreria</i> sp.	10	Rubiaceae
19	<i>Cocos nucifera</i>	4	Arecaceae
20	<i>Elaeis guineensis</i>	185	Arecaceae
21	<i>Mallotus</i> cf. <i>subulatus</i>	74	Euphorbiaceae
22	<i>Morinda lucida</i>	2	Rubiaceae
23	<i>Paulinia pinnata</i>	1	Sapindaceae
24	<i>Psidium guajava</i>	7	Myrtaceae
25	<i>Cyperus</i> sp.	6	Cyperaceae
26	? <i>Rhizophora</i> sp.	8	Rhizophoraceae
27	<i>Berlinia grandifolia</i>	4	Caesalpinaceae
28	<i>Delonix regia</i>	1	Caesalpinaceae
29	<i>Entadacabyssinica</i>	8	Fabaceae
30	<i>Phyllanthus discoides</i>	5	Euphorbiaceae
31	Poaceae	281	Poaceae
32	<i>Sida</i> cf. <i>acuta</i>	2	Malvaceae
33	<i>Zea mays</i>	123	Poaceae
34	Euphorbiaceae	22	Euphorbiaceae
35	Anacardiaceae	60	Anacardiaceae
36	Rubiaceae	1	Rubiaceae
37	Solanaceae	12	Solanaceae
38	Amaranthaceae	68	Amaranthaceae
39	Bignoniaceae	6	Bignoniaceae
40	Caesalpinaceae	1	Caesalpinaceae
41	<i>Cassia</i> sp.	17	Fabaceae
42	<i>Capsicum</i> sp.	20	Solanaceae
44	<i>Celtis</i> sp.	42	Cannabaceae

45	<i>Alternaria</i> sp.	354	Pleosporaceae
46	<i>Cladosporium</i> sp.	636	Devidlellaceae
47	<i>Chrysophyllum</i> sp.	2	Sapotaceae
48	<i>Cola</i> sp.	9	Malvaceae
49	Combret/Melastomaceae	39	Combretaceae/Melastomaceae
50	<i>Erythrina milbreadi</i>	1	Fabaceae
51	<i>Grewia</i> sp.	1	Tiliaceae
52	<i>Ixora</i> sp.	5	Rubiaceae
53	<i>Khaya</i> sp.	3	Meliaceae
54	<i>Lophira</i> sp.	9	Ochnaceae
55	Mimosaceae	15	Mimosaceae
56	<i>Mimusops warnecki</i>	1	Sapotaceae
57	Moraceae	49	Moraceae
58	Myrtaceae	2	Myrtaceae
59	Papilionaceae	3	Papilionaceae
60	Pollen indeterminate	10	-
61	<i>Ricinus communis</i>	1	Euphorbiaceae
62	Rosaceae	1	Rosaceae
63	<i>Hymenostegia afzelli</i>	1	Fabaceae
64	Rutaceae	1	Rutaceae
65	Sapindaceae	1	Sapindaceae
66	Sapotaceae	12	Sapotaceae
67	Spores indeterminate	475	-
68	Pteridophyte spores	43	-
69	TOTAL	3300	

Table 2. Total pollen grains recovered during the periods of study

	Nov	Dec.	Jan	Feb	Total
Agbowo	212	104	150	39	505
Library	253	97	318	17	685
Mapo	348	189	161	24	722
Total	813	390	629	80	1912

Table 3. Total Fungi recovered during the study

Location/Months	Cladosporium sp.	Alternaria sp.	Indeterminate fungal Spores	Total
Agbowo	138	54	82	274
Library	205	110	115	430
Mapo	293	190	167	650
Total	636	354	364	1354

Table 4. Meteorological data

MONTH	TEMPERATURE(°C) (Mean)	RAINFALL(mm)	WIND(km/hr)	RELATIVE HUMIDITY(%))
Nov.(2012)	28.0	54.9	91.0	82
Dec.(2012)	28.7	0.0	104.8	71
Jan.(2013)	28.9	3.3	120.9	61
Feb.(2013)	29.45	64.4	147.7	73
Mar.(2013)	28.9	139.0	158.3	80
Apr.(2013)	28.4	184.0	134.8	81

ii. Questionnaire and Interviews

The socio-demographic parameters used in the questionnaire and interviews are the following: gender, age, causes of allergies, symptoms of allergies, period(seasons) of occurrence of allergies, choice of relief from allergies, source of relief, and the behavioral changes of respondents when experiencing allergic reactions (Tables 5-11). However, age is not reported in this study due to the inconsistency in the age responses by the respondents. A total of 200 respondents were questioned and interviewed on their knowledge of allergies. The respondents consisted of 139 males and 87 females (Table 5). From these 200 respondents, 149 experienced allergic reactions at a given time, while the remaining 51 did not at all (Table 6). According to the symptoms of allergies respondents experienced, 114 (57%) out of 149 respondents experienced catarrh, 9 (4.5%) respondents experienced eye itching, and 8 (4.0%) respondents experienced skin itching. Six (6) respondents (3.0%) experienced a runny nose, while 12(6.0%) experienced all the symptoms above (Table 8). During the season that respondents experienced allergies, four groups were highlighted. Group A (rainy), B (dry), C (Harmattan), and D (both dry and rainy) periods.

Four seasons (rainy, dry, harmattan, and dry-rainy) were highlighted for the period when respondents experienced Pollinosis. The frequency of occurrence of symptoms of allergies by respondents according to period (seasons) was Rainy (7.5%), Dry (17.7%), Harmattan (20.5%), Dry & Rainy (9.0%), and 20.5% for all of the seasons (Table 9). Those respondents who usually sought relief from the symptoms were 86(43%), while 62(31%) of the respondents did not (Table 10). In their search for relief from these symptoms when they occurred, 71(35.5%) of respondents visited pharmacy stores for drugs, while 10(5%) of the respondents visited hospitals. Only 12(6%) of them visited the clinic when experiencing Pollinosis (Table 11). The data on the allergic respondents were subjected to Pearson Correlation Coefficients (r) at a 95% confidence interval (Tables 12-14) and a Chi-square Test Analysis (Tables 15- 17).

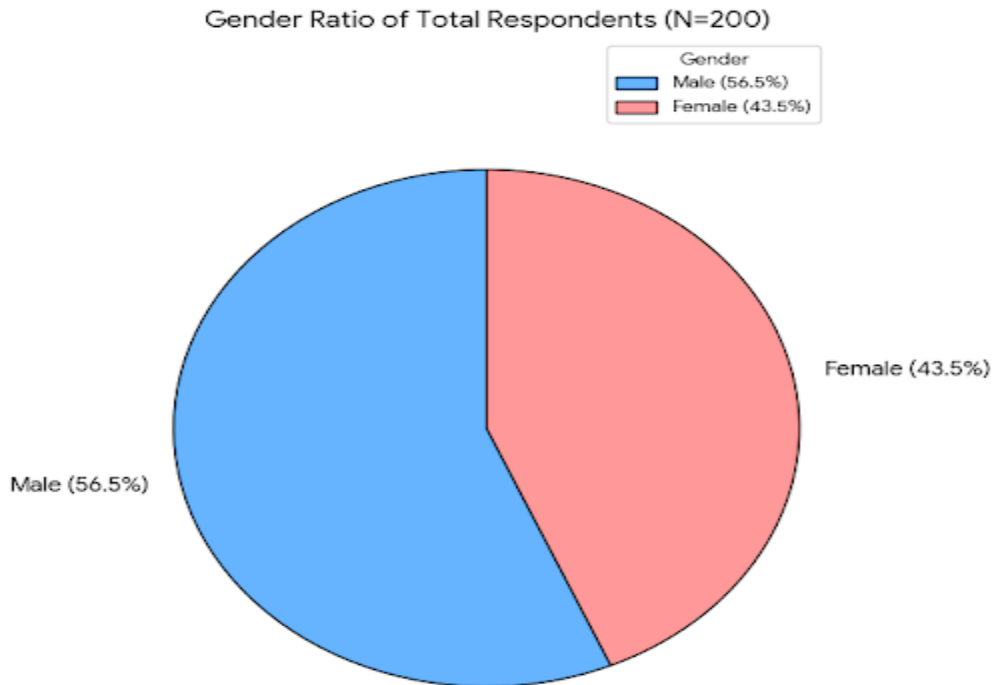


Fig. 6 Gender ratio of total respondents

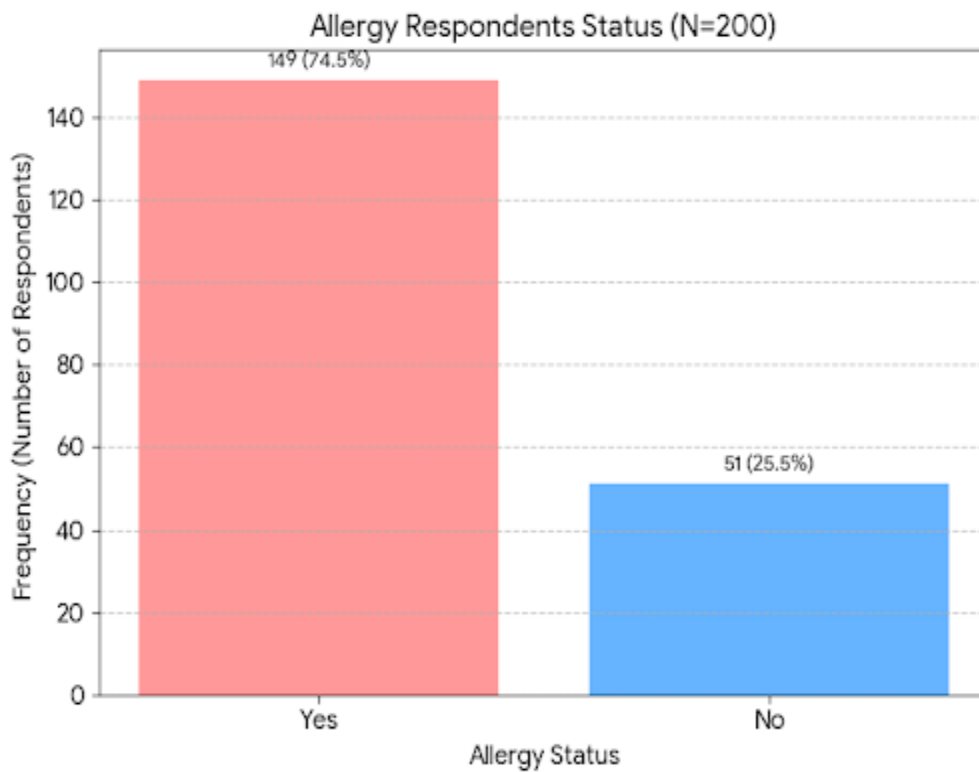


Fig. 7 Allergy respondents status

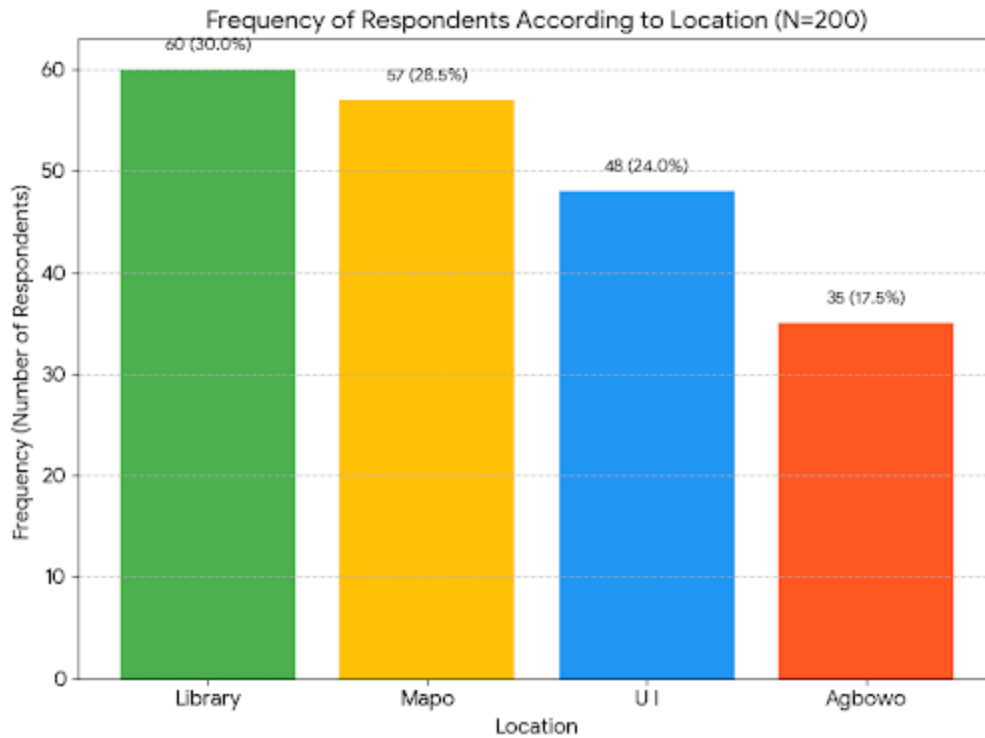


Fig. 8 Frequency of respondents according to location

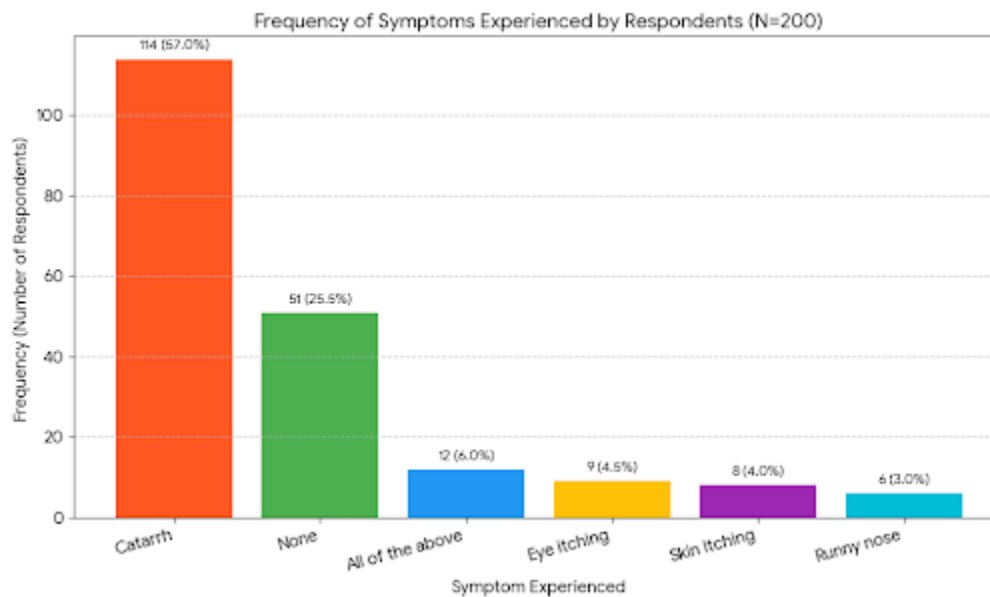


Fig. 9 Frequency of symptoms experienced by respondents

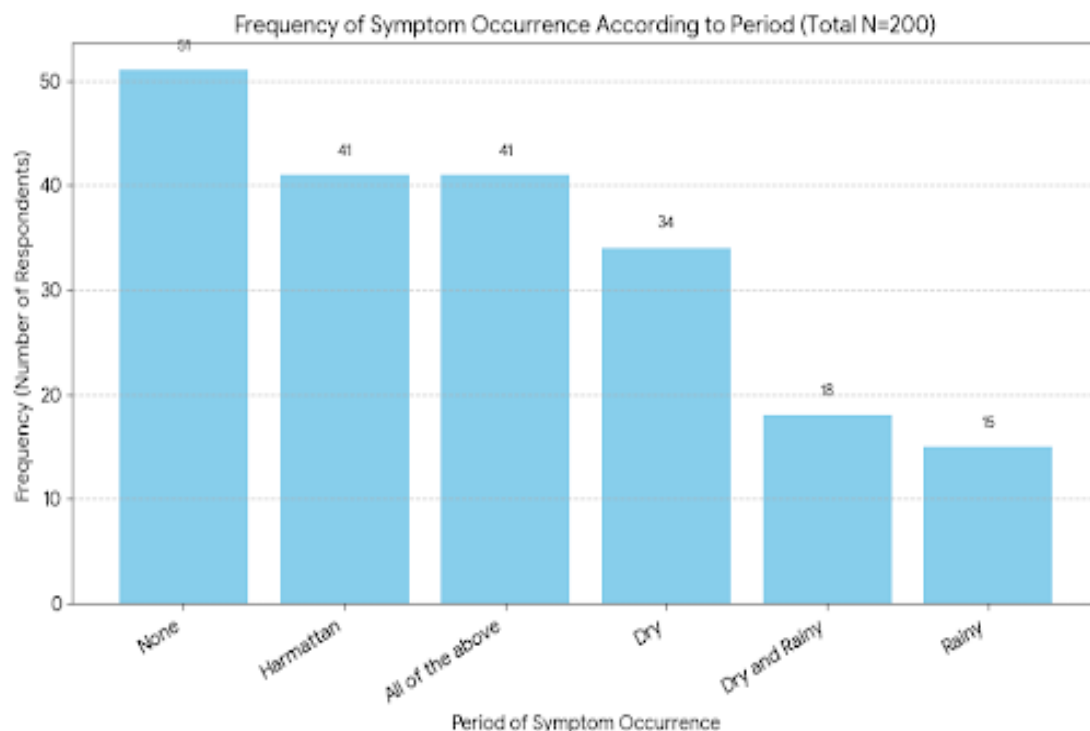


Fig. 10 Frequency of symptoms occurrence according to period

Discussion

Tropical rainforests are characterized by high plant species diversity. This is reflected in the amount of recovered palynomorphs in this study. The palynomorphs that were dominant belonged to Arecaceae, Asteraceae, Anacardiaceae, Amaranthaceae, Euphorbiaceae, Fabaceae, Moraceae, Poaceae and fungal spores. The recovered palynomorphs for these four months of study were characteristic of rainforest, freshwater, secondary/open forest, and savanna ecological zones (Table 1).

The presence of pollen grains of *Zea mays*, *Psidium guajava*, Amaranthaceae, Asteraceae, *Elaeis guineensis*, Asteraceae, *Cola* sp., *Azadirachta indica*, *Morinda lucida*, Poaceae, *Amaranthus* sp., *Solanum* sp., and fungal spores is an indicator of human impacts on the environment. This also indicates open vegetation resulting from bush clearance and farming purposes. This agrees with the views of Agwu and Osibe (1992), Agwu and Okeke (1997), Agwu (2001) and Agwu *et al.* (2004) that these species are either preserved for their economic values or are common weeds associated with farming activities.

The presence and recovery of pollen grains of *Alchornea cordifolia*, *Azadirachta indica* and *Morinda lucida* indicate that their source plants are of medicinal use to humans. Different parts of *A. indica* and *M. lucida*, like leaves and bark, are used for the treatment of illnesses such as malaria, haemorrhoids, and typhoid.

The abundance of fungal spores (cf. *Alternaria* sp. and *Cladosporium* sp.) recovered is worthy of attention because of their locations. These are densely populated and business areas. It likely shows the level of waste being generated in Ibadan due to human activities. This also shows that the waste being generated in these areas was not properly managed, while indicating the risk residents are exposed to from poor waste management. These fungal spores have been reported to be allergenic in previous studies (Raulf *et al.*, 2014; Levetin *et al.*, 2016; Businco *et al.*, 2018 and

Hong et al., 2023). Their allergenicity also supports the views of Adeonipekun and Olowokudejo (2012) in that they pose a great risk to the health of the people.

An analysis of the results showed that most of the palynomorphs recovered from this study have been reported previously in aeropalynological and allergological studies to be allergenic in Nigeria and elsewhere. Some of these species which have been identified to be allergenic are Arecaceae (*Cocos nucifera*, *Elaeis guineensis*), Apocynaceae (*Catharanthus roseus*), Casuarinaceae (*Casuarina equisetifolia*), Caricaceae (*Carica papaya*), Euphorbiaceae (*Alchornea cordifolia*, *Euphorbia heterophylla*, *Ricinus communis*), Asteraceae (*Tridax procumbense*), Combretaceae/Melastomaceae, Amaranthaceae, Meliaceae (*Azadirachta indica*, *Khaya* spp.), Mimosaceae (*Acacia* spp., *Calpocalyx cauliflorus*, *Entanda albissinica*), Poaceae (*Zea mays*), Sapotaceae (*Chrysophyllum* spp), Rutaceae (*Citrus* sp.), Cyperaceae, Caesalpinaceae (*Berlinia grandifolia*), Rubiaceae (*Borreria* spp.) and Anacardiaceae (Banik and Chanda, 1992; Jato et al., 1999; Al-Qura'n, 2008; Bartra et al., 2009; Adekanmbi and Ogundipe, 2010; Waqar et al., 2010, and Adeniyi et al., 2017, 2018).

In terms of recovery of aeropalynomorphs, there was, no consistent pattern of increase or decrease in the recovered palynomorphs through the months of study. This irregular pattern of recoveries may be due to variations in the height of placement of the pollen sampler, topography, and differences in anthropogenic activities by inhabitants of the areas studied. This supports the view of Njokuocha (2006) in that the differences in the height of recovery of pollen and the geographical distribution of the vegetation source contribute to the abundance of palynomorphs in their recovery. From this study, the lowest recovery in the number of palynomorphs, which was recorded at the Agbowo shopping complex, was not expected from this location. It was expected that the highest number of recoveries would be recorded for this location since the University of Ibadan campus, which is known to be adorned with aesthetic tall trees of various species, is situated very close to Agbowo Shopping Complex, both are almost on the same longitude ($7^{\circ} 26' \text{N}$) and latitude ($3^{\circ} 54'$) in geographical position. The sampler was placed at a height of 274.9m above sea level, which was the highest of all the locations studied. The effect of local vegetation experienced around the University of Ibadan was expected to influence the amount of recovered palynomorphs in Agbowo Shopping Complex, but seemed to be minimised. This was probably because the height of placement of pollen samplers reduced the effect of local vegetation around this location. Since there was little or no influence on the number of recovered palynomorphs, it is likely that the higher the height of placement of the pollen sampler, the lower the influence of local vegetation on the number of palynomorphs recovered. The effect of local vegetation as observed separately and independently by Agwu et al. (2004), Njokuocha (2006), and Adekanmbi and Ogundipe (2010) in their studies was, however, minimised in this location. Also, this height showed that palynomorphs get that far into the atmosphere. For palynomorphs to be considered as being allergenic according to D'Amato (2007) and D'Amato et al. (2012), they must actually contain active ingredients (allergens), be produced in large quantities, and be buoyant enough to have a long-distance transport. Their production in large quantities and buoyancy for long-distance transport support their recoveries at such an elevated height. Among these recovered palynomorphs at such height were those of Anacardiaceae, *Delonix regia*, Poaceae, and Euphorbiaceae. The height of placement of the sampler supports the view of Wodehouse (1935), who recovered palynomorphs from a five-story high building in the city of Yonkers, New York, in 1932, and Njokuocha (2006) at two different heights (1.8m and 15m). Such elevations help to gain general average conditions by reducing the effects of local vegetation on the number of recovered palynomorphs (Wodehouse, 1935).

The Oyo State library had the lowest height of placement of the pollen sampler, as well as a substantial presence of a variety of species. Yet it did not record the highest number of recovered palynomorphs. Though it was observed that the majority of the plants were not flowering in November, while most of the recovered palynomorphs in this month must have enjoyed long-distance transport from nearby vegetation, and their deposition in this area must have been due to obstructions on their way, such as tall buildings around the location. Moreover, it was also observed that most of the buildings around the Oyo State library are high-storied, such as Cocoa House, and are used for offices and factories. This location is known for business of various sorts, while the popular Dugbe market is situated in this area. These high-storied buildings must have hampered the smooth transport of aeropalynomorphs, which were moving freely in the atmosphere.

The highest recovery was recorded for Mapo Hall despite low vegetation cover around this area. Mapo Hall is a three-storied building situated on hilly, rocky ground, which is 261.6m high above sea level. Standing on top of this building, where the sampler was placed, gives one the opportunity to see nearly the length and breadth of the Ibadan region. This is because Mapo Hall seemed to be the highest building in this area besides Bower's Tower, which is located a few distances away. Most of the species recovered from this location must have been influenced by the strength of the wind system prevailing at the time of the study.

The data survey on demography showed that allergic reactions were not sex-specific. This is because statistically, there was no significant difference in allergies between male and female respondents, and allergic reactions were induced regardless of the sex of individuals (Tables 12 and 15). The percentages of respondents who were allergic were more than those who were not, while the frequency, prevalence, and severity of these symptoms as experienced by respondents varied periodically across the locations. There was a highly statistically significant association between the allergic symptoms reported and the location of the respondent (Tab 16.) The likelihood of a person reporting a specific symptom (or no symptoms) is heavily dependent on whether they are from Agbowo, University of Ibadan, Mapo, or Library.

Respondents from Agbowo Shopping Complex, University of Ibadan, and Oyo State library locations were more susceptible to allergies than those in Mapo (Table 7). The prevalence of these symptoms in the three locations may be a result of the presence of species of tall trees, shrubs and herbs, many of which have been reported to be allergenic pollen producers. It was observed that most of these species were flowering during the period of collection. This period was characterized by intense heat and dryness with little or no rainfall. This corresponds to the dry and harmattan season from November through to February of the following year, when this study was carried out. This is in line with the views of Agwu and Okeke (1997) and Agwu *et al.* (2004) in that many plants of the tropics flower during the period of lesser rainfall when the sun shines more brightly and the atmospheric humidity is lower. Therefore, during this season, most people suffer more from various allergies, because most of the plants are at the peak of flowering. The most prevalent symptom in the Mapo area was catarrh. Respondents from this area complained less of a runny nose, eye, and skin itching. This might be due to the limited availability of plant species from around this area. Mapo Hall is situated at the center of Ibadan, surrounded by businesses where yams, flour, and foodstuffs are sold.

The frequencies of occurrence of symptoms according to period (Table 9) show that allergic reactions were mostly experienced during the dry and harmattan seasons. There was a highly statistically significant association between the allergic symptoms reported and the period of the year in which they occur (Tab 17). This confirms that allergic disease is a highly seasonal

problem in the study area. Catarrh, eye and skin itching were the symptoms mostly experienced during this season (Table 14). However, runny nose was noticed to be prevalent during the rainy season. Aeropalynomorphs circulating in the environment sometimes get deposited when it rains. This makes palynomorphs that might contact the eye or skin less available in the atmosphere for allergies. However, the prevalence of this symptom during the rainy season might be due to the release of cytoplasmic contents of these palynomorphs through osmotic shocks by thunderstorms during rainfall, as found by Roulston and Cane(2000), Dales *et al.* (2003) and D'Amato *et al.* (2007 and 2012).

Furthermore, the percentages of respondents who did not visit hospitals, clinics, or pharmacy stores were more compared to those who visited them for treatment (Table 11). However, those respondents who did visit pharmacy stores were more than those who sought relief from hospitals and clinics. The prescription of drugs for respondents who experienced allergies was prevalent from November through to March of the following year, which corresponds to the dry and harmattan seasons (Table 17). Medical personnel interviewed attributed the fact that pollen and dust are the major causative agents of the many cases of allergic reactions in susceptible individuals. The prescription of drugs during the dry and harmattan seasons supported the fact that pollen had been the major causative agent of these allergies. The types of drugs prescribed included antihistamines, *Chlorampheninamine*, *Loratadine*, *Loratadine*, *Piriton* etc. The mechanisms of reaction of these drugs inhibit the production of histamine. The histamine is usually activated when the body is exposed to foreign proteins, either on the skin or in the mast cells lining the nasal cavity. This supports the view of Rogers (2008) in that palynomorphs release certain proteinaceous materials (allergens) that induce the production of histamine from the immune system of the body when in contact with the nasal passages. Thus, the chief constituents of drug prescriptions by pharmacists and medical personnel involved anti-histamines and steroids. The weather data collected from the Nigerian Meteorological Agency, Abuja, through the Oyo state Agency showed that temperature increased throughout this period and caused a reduction in the moisture contents of the atmosphere, hence low relative humidity (Table 4). The increase in the intensity of heat and in the dryness of the atmosphere is favourable for the flowering of most species of plants during this period. The presence of little or no rainfall reduced the rate of deposition of airborne pollen and spores, making them abundant in the atmosphere. Hence, their effects were noticeable on the nasal passages when inhaled or in contact with the skin of susceptible individuals. This is further corroborated by the results of data extracted from questionnaires and interviews conducted with the pharmacists and medical personnel, claiming the fact that people are more susceptible to allergic reactions during dry and harmattan seasons. It is evident that pollinosis, as an allergic reaction to pollen, occurs mostly in the dry and harmattan season (November-February) in Nigeria. Harmattan is the highest respiratory risk period. The self-reported peak in Catarrh and other symptoms during the Harmattan and Dry seasons aligns directly with the highest measured airborne pollen and spores loads. The variations in palynomorph' type and abundance in this study were due to the geographical locations of selected sites, weather patterns, pollination mechanisms, local vegetation, the height at which pollen samplers were placed, and the intensity of human activities.

Conclusion

It can be strongly suggested that allergic reactions constitute a significant public health issue in the Ibadan metropolis. This study clearly confirms a linkage between the presence of airborne palynomorphs, symptoms with the period of occurrence of allergic reactions to environmental triggers among people in Ibadan metropolis. The Chi-Square test confirmed a

highly significant association between symptoms experienced and periods of occurrence of allergic reactions in the study areas. This is in conformity with the aeropalynological study showing increased pollen and spore release during the dry and early transition months in Ibadan. Mapo stands out as reporting a significantly higher rate of no symptoms, while University of Ibadan, and the Library appear to be the hotspots for both the major symptom (Catarrh) and multiple minor/chronic symptoms. There was no significant association between gender and symptoms of allergies. Catarrh is the most commonly reported symptoms which occurs predominantly during the dry/Harmattan season, a period reported with high abundant airborne pollen and spores. It is also pertinent to note that most people did not visit hospitals and clinics for treatment, but they consulted pharmacists for their source of relief. People should dispose of their waste properly and regularly in order to reduce the amount of fungi that would be spread into the atmosphere from decaying waste materials.

The government should step up measures to minimize, if not eradicate, indiscriminate dumping of refuse in the drainage system. This contributes to the number of fungi that are exposed to the atmosphere and was noticed around the Oyo state library location and the Mapo area, which are surrounded by markets. Medications should be taken by susceptible individuals, especially during a period known for an abundance of allergic reactions.

Limitation and Future Research

This study is limited in that it reported four months of research, mostly during the dry and harmattan season. Further research should be extended to other seasons and the remaining months of the year to get a fuller picture of the occurrence of allergic reactions in the Ibadan metropolis. Future research must prioritize a robust multi-stage probability sampling technique to ensure generalizability. Furthermore, future studies should include a direct measurement of pollen and fungal spore counts across the Mapo, University of Ibadan, and Library areas to definitively correlate aeroallergen levels with the reported symptom frequencies.

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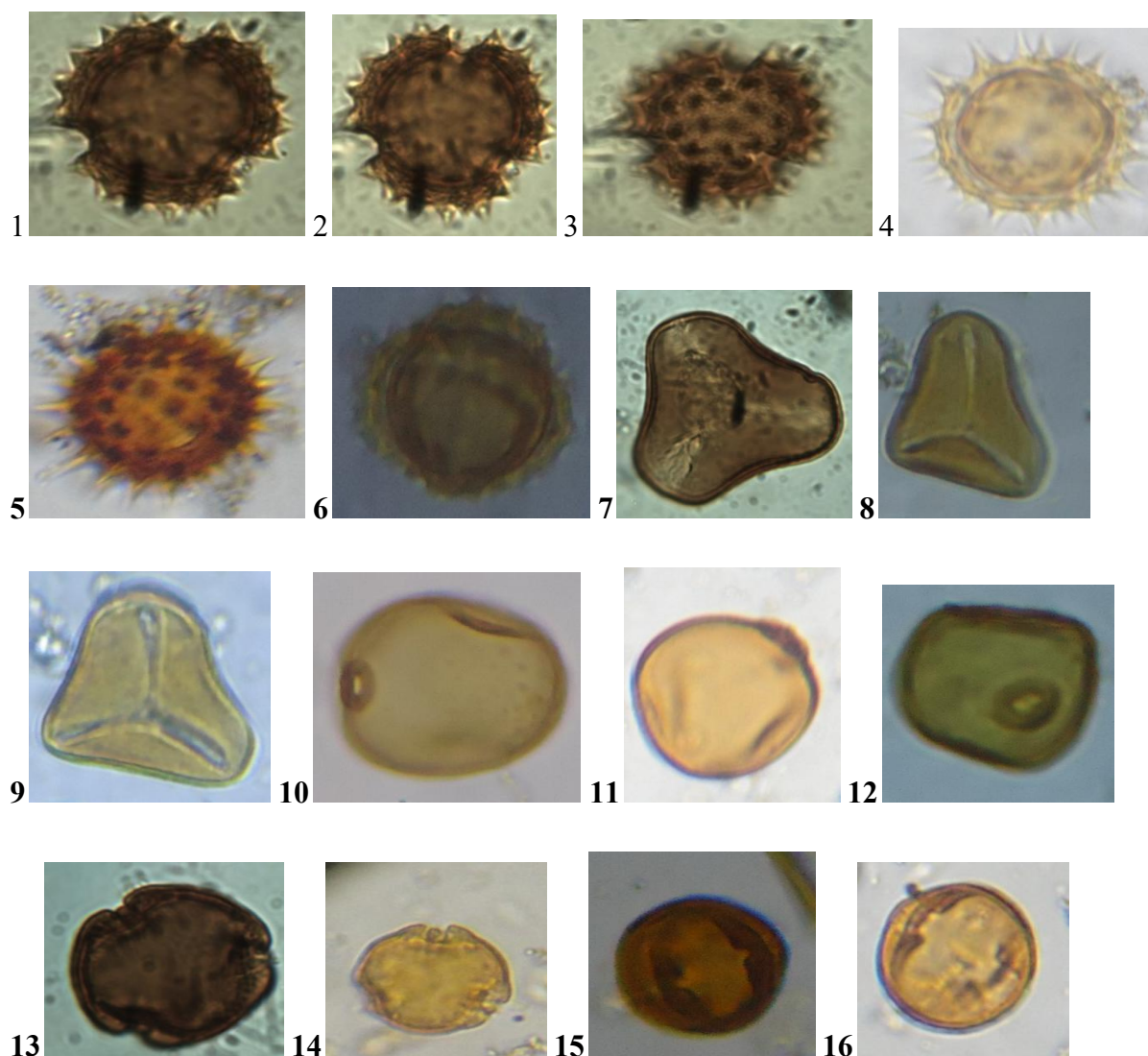
Conflict of Interest

No conflict of interest was declared by the authors in this research work.

Authors Contribution

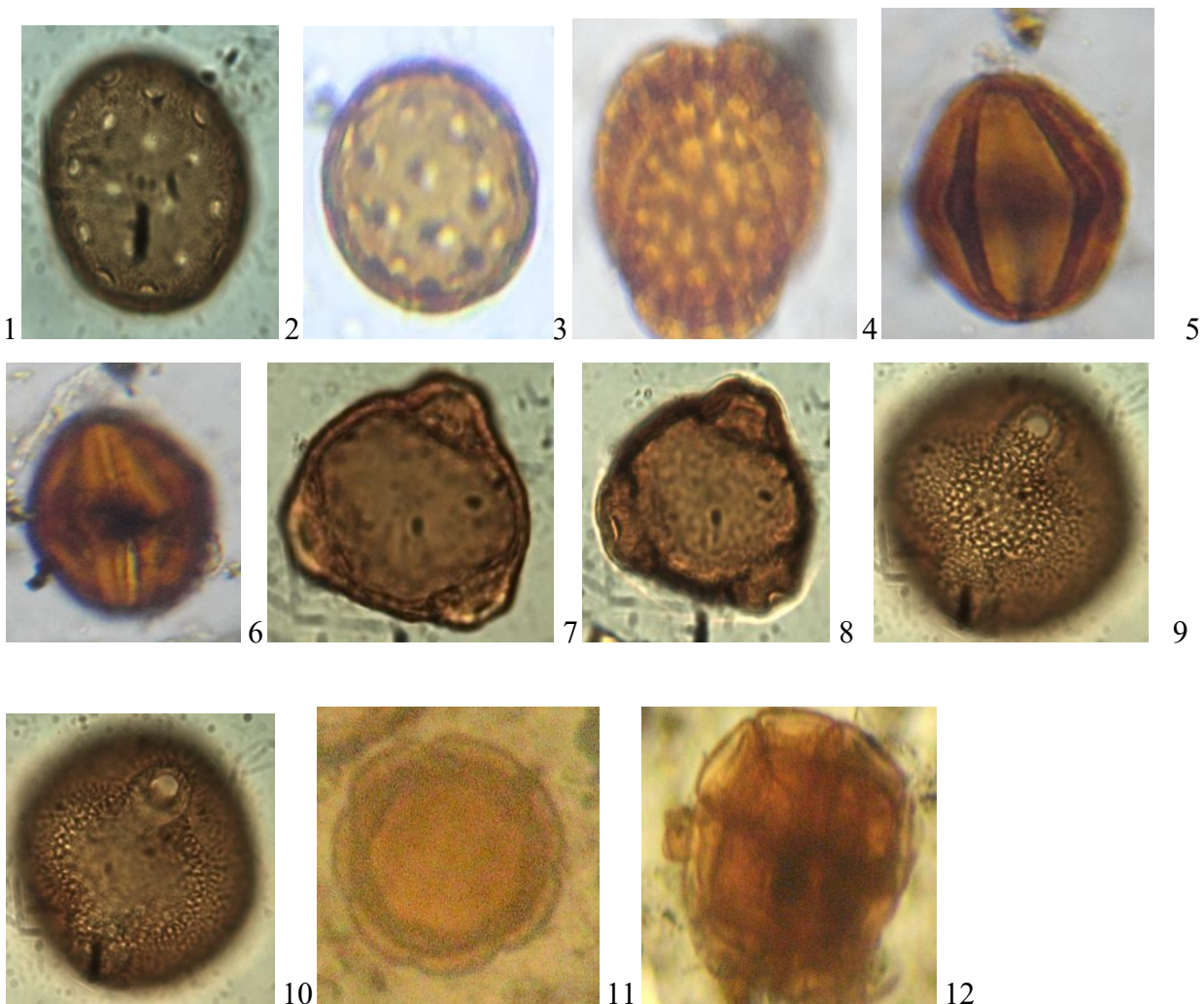
M. O AKASORO carried out the field and laboratory works(50%). M. A Sowunmi (30%) supervised and edited the manuscript. P A Adeonipekun reviewed and improved the final manuscript(20%).

APPENDIX I



Legend A. 1 – 3 : *Ageratum conyzoides* 4-5: Asteraceae, 6. *Chromolaena odorata*

7-9: *Elaeis guineensis* 10-12: *Zea mays*, 13-16: *Alchornea cordifolia* (Magnification: X400)



Legend B. 1-2: Amaranthaceae, 3. *Delonix regia* 4-5: Tricolpate grains 6-7: *Casuarina equisetifolia* 8-9: *Morinda lucida*. 10. *Borreria* sp. 11. *Albizia lebbeck* (Magnification: X400)

APPENDIXES II

Table 12. Correlation between symptoms experienced by respondents and gender of respondents

Symptoms experienced by respondents * Gender ratio Crosstabulation						
			Gender ratio		Total	
			Male	Female		
Symptoms experienced by Respondents	None	Count	20	31	51	
		% within Symptoms experienced by respondents	39.2%	60.8%	100.0%	
	Catarrh	Count	74	40	114	
		% within Symptoms experienced by respondents	64.9%	35.1%	100.0%	
	Eye itching	Count	5	4	9	
		% within Symptoms experienced by respondents	55.6%	44.4%	100.0%	
	Skin Itching	Count	4	4	8	
		% within Symptoms experienced by respondents	50.0%	50.0%	100.0%	
	Runny nose	Count	4	2	6	
		% within Symptoms experienced by respondents	66.7%	33.3%	100.0%	
	All of the above	Count	6	6	12	
		% within Symptoms experienced by respondents	50.0%	50.0%	100.0%	
	Total	Count	113	87	200	
		% within Symptoms experienced by respondents	56.5%	43.5%	100.0%	

Table 13. Correlation between symptoms experienced by respondents and sampled locations

Symptoms experienced by respondents * Location of Respondents Crosstabulation							
			Location of Respondents				Total
			Agbowo	U I	Mapo	Library	
Symptoms Experienced by respondents	None	Count	1	6	39	5	51
			2.0%	11.8%	76.5%	9.8%	100.0%
	Catarrh	Count	23	35	16	40	114
			20.2%	30.7%	14.0%	35.1%	100.0%
	Eye itching	Count	4	1	0	4	9
			44.4%	11.1%	.0%	44.4%	100.0%
	Skin Itching	Count	4	1	0	3	8
			50.0%	12.5%	.0%	37.5%	100.0%
	Runny nose	Count	2	1	0	3	6
			33.3%	16.7%	.0%	50.0%	100.0%
All of the above	Count	1	4	2	5	12	
		8.3%	33.3%	16.7%	41.7%	100.0%	
Total		Count	35	48	57	60	200
			17.5%	24.0%	28.5%	30.0%	100.0%

Table 14 Correlation between symptoms experienced by respondents and periods of occurrence
Symptoms experienced by respondents * Periods of occurrence of symptoms Crosstabulation

			Periods of occurrence of symptoms						Total
			None	Rainy	Dry	Harmat tan	Dry and Rainy	all of the abov e	
Symptoms experienced by respondents	None	Count	51	0	0	0	0	0	51
			100.0%	.0%	.0%	.0%	.0%	.0%	100.0%
	Catarrh	Count	0	11	26	37	14	26	114
			.0%	9.6%	22.8%	32.5%	12.3%	22.8 %	100.0%
	Eye itching	Count	0	0	2	0	1	6	9
			.0%	.0%	22.2%	.0%	11.1%	66.7 %	100.0%
	Skin Itching	Count	0	2	3	1	1	1	8
			.0%	25.0%	37.5%	12.5%	12.5%	12.5 %	100.0%
	Runnin g nose	Count	0	2	1	1	1	1	6
			.0%	33.3%	16.7%	16.7%	16.7%	16.7 %	100.0%
	All of the above	Count	0	0	2	2	1	7	12
			.0%	.0%	16.7%	16.7%	8.3%	58.3 %	100.0%
Total	Count	51	15	34	41	18	41	200	
		25.5%	7.5%	17.0%	20.5%	9.0%	20.5 %	100.0%	

Table 15. Chi-square test of correlation between symptoms and the gender of respondents

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.081 ^a	5	.073
Likelihood Ratio	10.089	5	.073
Linear-by-Linear Association	.502	1	.478
N of Valid Cases	200		
a. 5 cells (41.7%) have expected count less than 5. The minimum expected count is 2.61.			

Table 16. Chi square test of Correlation between symptoms and locations of respondents

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	91.181 ^a	15	.000
Likelihood Ratio	91.207	15	.000
Linear-by-Linear Association	.401	1	.527
N of Valid Cases	200		
a. 16 cells (66.7%) have expected count less than 5. The minimum expected count is 1.05.			

Table 17. Chi square test of Correlation between symptoms and period of occurrence

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.327E2 ^a	25	.000
Likelihood Ratio	252.250	25	.000
Linear-by-Linear Association	45.963	1	.000
N of Valid Cases	200		