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Comparative study of aeropollen and pollinosis cases

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Abstract Research linking pollen grains in the air with allergy cases (pollinosis) is still incipient in Africa. To close this gap, aerosamplers were placed in Gbagada, Lagos State and harvested monthly from January 2013 to December 2014. Data obtained was correlated with allergy cases (wheezing cough, rhinitis, and allergic conjunctivitis) from Gbagada General Hospital Lagos. Dominant pollen grains recovered were those of *Alchornea cordifolia*, Amaranthaceae, *Casuarina equisetifolia*, Cyperaceae, and Poaceae. Pollinosis data revealed that wheezing cough had the highest records in 2013 (1153) and 2014 (1409) while individuals of the age group 15–49 years had the highest number of pollinosis cases for both years. Peak pollen season in 2013 was from October–December; similarly, October, November, and December recorded the highest incidence of wheezing cough (225), rhinitis (21), and allergic conjunctivitis (56) respectively. In 2014, peak pollen season was from October–March while October recorded the highest number of cases of allergic conjunctivitis and rhinitis (81 and 32 respectively) and wheezing cough cases were highest in November (299). Total pollen count had positive significant correlation ($p \leq 0.05$) with wheezing cough cases for both years. Individually, each dominant pollen had positive significant correlation ($p \leq 0.05$) with wheezing cough cases in 2013 while only Cyperaceae and Poaceae pollen had positive significant correlation ($p \leq 0.05$) with wheezing cough in 2014. Continuous collection of aeropollen and pollinosis data from more locations within Nigeria is recommended to provide an appropriate epidemiology of pollinosis cases in the country and ascertain possible responsible pollen grains.

Keywords Aeropollen · Correlation · Gbagada · Lagos · Nigeria · Pollinosis

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Introduction

It is often difficult to believe that the seasonal catarrh or wheezing cough or "apollo" (conjunctivitis) is just an abnormal condition of our immune system. When an adaptive immune response is mounted excessively or in an exaggerated form, the term "hypersensitivity" is applied (Roitt et al. 2001). Hypersensitivity can be divided into four categories viz., types I, II, III, and IV. Roitt et al. (2001) remarked that the term "allergy" is basically used to refer to a type I immediate hypersensitivity reaction. Allergenic conditions are characterized by intense sneezing (rhinitis), watery eyes, nasal obstruction, itchy eyes and nose, and very often coughing (Kay 2000). All the symptoms result from allergenic reaction on the upper respiratory tracts while on the lower respiratory tracts the result is asthma. Allergens are antigens that stimulate allergic reaction (Blumenthal and Rosenberg 1999). These allergens can be food, drugs, pets (cats), insects (dust mites, cockroaches), fungal spores and hyphae, pollen, and fern spores. Pollen has been defined as the fine granular or powdery substance, produced by and discharged from the anther of a flower, constituting the male gamete which fertilizes the ovules during pollination

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by Pat (2011). Pollen properties such as weight, wall pattern, and buoyancy have resulted in their deposition onto the mucosal surfaces of human, subsequently resulting in allergies/pollinosis (Pat 2011). Pollinosis encompasses nasal congestion, coughing, runny nose, sneezing, and breathing difficulties caused by seasonal allergies mainly to pollen. Common symptoms elicited in allergic patients are rhinitis, conjunctivitis, rhino-conjunctivitis, sinusitis, and asthma (Traidl-Hoffmann et al. 2003; Bartra et al. 2009). The consequences of pollinosis are significant morbidity, employment absenteeism, and loss of quality of life, and in some instances, fatal outcomes. Allergies also pose huge health costs in affected regions, affecting people of all ages, from the poorest to the richest (Potter et al. 2009). Aeropalynology is not new in Nigeria as several researchers, such as Agwu and Osibe (1992), Agwu et al. (2004), Njokuocha and Osayi (2005), Njokuocha (2006), Adeonipekun and John (2011), Adeonipekun (2012), Adeonipekun and Olowokudejo (2013), Adeniyi et al. (2014), Adeonipekun et al. (2016), Ezike et al. (2016), and Adeniyi et al. (2017), have published informative reports that have laid the needed solid foundation for further research. Among these works however, only Adeniyi et al. (2014) compared the aeropollen data obtained with pollinosis cases. Thus, research efforts on the relationship between aeropollen and pollinosis cases in Nigeria can be said to be incipient. This present work aims at comparing aeropollen counts with pollinosis cases over a 2-year period so as to further gain insight into and firmly establish the relationship between clinical data and aeropalynology in Gbagada, Lagos State, Nigeria.

Materials and methods

Sampling site

Gbagada is located in Shomolu local government area (LGA) of Lagos State (Fig. 1). As in any urban area, the most significant aspects of the flora are the depletion of the natural vegetation, abundance of ornamental plants, and an increase of weeds. The flora is dominated by weeds—*Alchornea cordifolia* (christmas bush), *Gomphrena* spp. (globe amaranth), *Axonopus compressus* (carpet grass), *Cynodon dactylon* (Bermuda grass), *Peninsetum purpureum* (elephant grass), *Panicum maximum* (guinea grass), Cyperaceae (sedges), and *Amaranthus* spp. (amaranth); and ornamentals—*Elaeis guineensis* (oil palm), *Mangifera indica* (mango tree), *Casuarina equisetifolia* (whistling pine), and *Terminalia catappa* (almond tree) (Adeniyi et al. 2014). Many people from various parts of the state visit the city for medical purpose because Gbagada is home to the Gbagada General Hospital, a state-funded medical institution with high-tech facilities and professional personnel. The hospital is also an annex to the Lagos State University Teaching Hospital (LASUTH). Due to these properties, the hospital has a massive coverage in the state and country.

Pollen collection

One aerofloral sampler, Gbenga-2, (Adeonipekun 2012; Adeniyi et al. 2014; Adeniyi et al. 2017) was used. The sampler was placed on the roof of a shop of about 2-m above ground level (Adeniyi et al. 2014; Adeniyi et al. 2017). Samples were collected monthly from January 2013 to December 2014. The sampler uses the gravimetric principle of aerosampling. It was constructed using a 10-cm-diameter plastic cylinder with 15-cm height. Five micron sized mesh sieve was used in covering one of the ends of the plastic cylinder with the aid of a band-like clamp. This setup was put inside an open 12-cm-diameter and 10-cm-high food flask. The entire setup was placed in a wooden box to prevent being dislodged by wind (Fig. 2). Fifteen milliliters of formaldehyde was added to 20 ml glycerol and 10 ml of distilled water in the plastic cylinder of the sampler. The mixture in the cylinder was monitored every week to assess its volume. The major gap of this sampler is that data are collected monthly, whereas daily pollen counts will give a more accurate interpretation of the pollen season. This gap is mainly due to the type of sampler and the inability of the country to provide sufficient electricity or security for the Hirst/Buckard samplers (Adeniyi et al. 2017).

Aeropollen preparation and identification

Standard palynological preparation technique was adopted where the aeroparticles were acetolyzed with nine parts of acetic anhydride and one part of tetraoxosulphate VI acid mixture (Erdtman 1969). Two slides were prepared and studied from the sampler residue for each month. The whole-slide area covered was scanned through for analysis using Olympus 2.0 light microscope. Pollen grains were identified by comparing with slides from reference collections at the Palynology Laboratory, Department of Botany, University of Lagos, and University of Ibadan as well as use of published

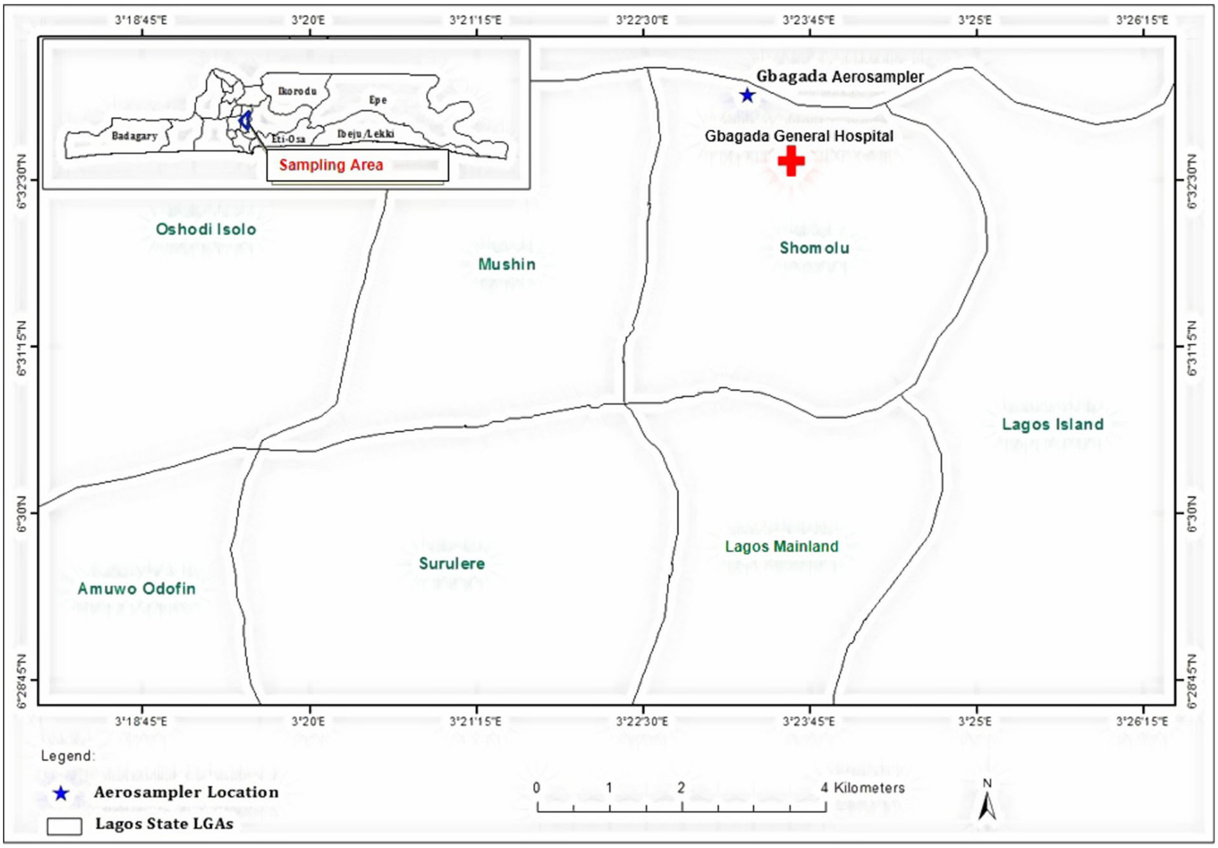

Fig. 1 Map showing aerosampler and Gbagada General Hospital locations

journals and albums—Erdtman (1952), Sowunmi (1973, 1995), and Gosling et al. (2013).

Pollinosis data collection

Medical data of patients with pollinosis cases of allergic rhinitis, wheezing cough, and allergic conjunctivitis were collected monthly from the Records Unit of Gbagada General Hospital, Lagos from January 2013 to December 2014. To ascertain that the pollinosis cases were caused by pollen grains, records of patients with seasonal pollinosis cases were obtained. However, this is not enough to justify that all data obtained were actually caused by pollen. Thus, this is a gap in data collection. The other parameters recorded include: the age group of patients and gender.

Comparative study

Pearson's correlation coefficient was used to analyze the relationship between total pollen counts and frequency of pollinosis cases. Correlation was also determined between dominant aeropollen counts and frequency of pollinosis cases.

Results

Aeropollen data

In 2013, the total pollen count was 1428. Highest pollen count was recorded in October and lowest count was recorded in July (Fig. 3). Dominant pollen grains were those of *A. cordifolia,* Amaranthaceae, *C. equisetifolia*, Cyperaceae, and Poaceae (Table 1). In 2014, the total pollen count was 938. Highest pollen count was recorded in March and lowest count was recorded in July (Fig. 3). Dominant pollen grains were those of *A. cordifolia,* Amaranthaceae, Cyperaceae, and Poaceae (Table 2).

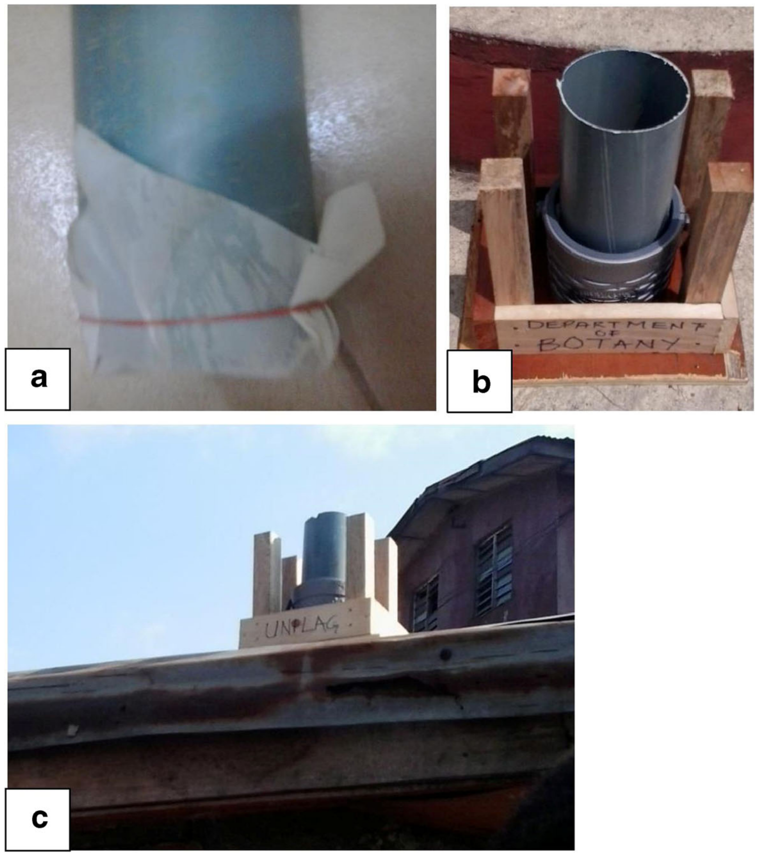

Fig. 2 Modified Gbenga-2 aerosampler. **a** Sampler cylinder with 5-µm sieve. **b** Complete sampler setup. **c** Mounted sampler

Pollinosis cases

In 2013, rhinitis and wheezing cough cases were reported throughout the year while there was no record of allergic conjunctivitis in August and September (Fig. 3). December recorded the highest incidence of allergic conjunctivitis (56); rhinitis (21) was highest in November, while wheezing cough (225) was highest in October. The most reported pollinosis case was wheezing cough (1153) while rhinitis was the least (111) (Table 3). For allergic conjunctivitis, individuals of the age group 15–49 years had the highest number of cases (125), children between ages 1 and 4 had the least (50). Also, female individuals (183) were more vulnerable than male (173). Similarly for rhinitis, individuals of the age group 15–49 years had the highest number of cases (51) while children between ages 1 and 4 had the least cases (8), female individuals (64) were also more vulnerable than male (47). Wheezing cough recorded the highest cases of individuals in the age group 15–49 years (493), children between ages 5 and 14 had the least cases (203). Also, female individuals (621) were more vulnerable than male (532) (Table 3).

In 2014, allergic conjunctivitis and wheezing cough cases were reported all through the year while there was no case of rhinitis in July and August (Fig. 3). October recorded the highest number of cases of allergic conjunctivitis and rhinitis (81 and 32 respectively) while wheezing cough cases were highest in November (299). The most reported pollinosis case was wheezing cough (1409) while rhinitis was the least (108) (Table 3). For allergic conjunctivitis, individuals of the age group 5–14 years had the highest number of cases (141); the elderly with ages greater than 50 years had the least cases (48). Also, male individuals (216) were more vulnerable than female (187). However for rhinitis, individuals of the age group 15–49 years had the highest number of cases (35) while children from age 1–4 had the least cases (16), male individuals (55) were more vulnerable than female (53). Wheezing cough recorded the highest cases of individuals of the age group 15–49 years (460), children in ages 1–4 had the least record of cases (268). Also, male individuals (761) were more vulnerable than female (648) (Tables 3, 4).

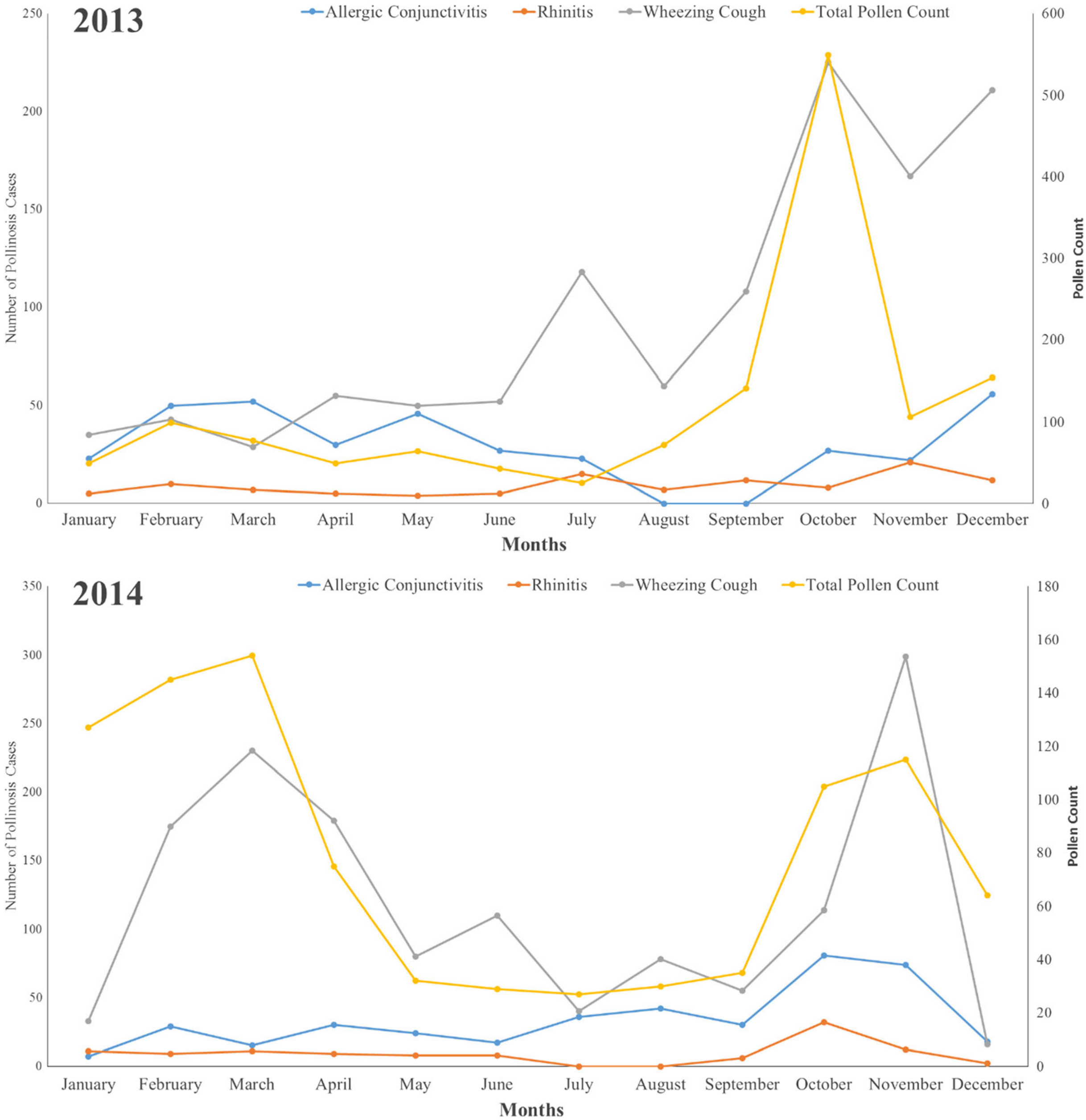

Fig. 3 Comparison of total pollen counts with pollinosis cases for 2013 and 2014

Correlations

Total pollen count had positive insignificant correlation ($p \leq 0.05$) with rhinitis cases for both years. Total pollen count had positive significant correlation ($p \leq 0.05$) with wheezing cough cases for both years. Individually, each dominant pollen had positive significant correlation ($p \leq 0.05$) with wheezing cough cases in 2013 while only Cyperaceae and Poaceae pollen had positive significant correlation ($p \leq 0.05$) with wheezing cough in 2014.

Discussion

The five dominant pollen types in both years (*Alchornea cordifolia,* Amaranthaceae, *Casuarina equisetifolia,* Cyperaceae, and Poaceae) had different

Table 1 Pollen abundance in Gbagada for the year 2013

Pollen	Family	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Acalypha sp.	Euphorbiaceae	0	0	0	0	0	0	0	0	1	3	4	2	10
Albizia sp.	Mimosaceae	0	0	3	0	0	0	0	0	0	2	1	1	7
Alchornea cordifolia	Euphorbiaceae	6	21	8	4	2	3	1	0	5	87	6	16	159
Amaranthaceae	Amaranthaceae	16	32	21	16	3	13	7	12	13	73	18	38	262
Asystasia gangetica	Acanthaceae	0	0	0	0	0	0	0	0	0	0	0	3	3
Borreria sp.	Rubiaceae	0	0	0	0	0	0	0	0	0	0	1	0	1
Canthium sp.	Rubiaceae	0	0	0	0	0	0	0	4	2	11	2	0	19
Cassia sp.	Caesalpinaceae	0	0	0	0	0	0	0	0	0	0	2	0	2
Casuarina equisetifolia	Casuarinaceae	4	4	5	0	0	1	0	0	20	39	4	3	80
Chromolaena odorata	Asteraceae	0	1	0	0	0	0	0	0	0	0	0	0	1
Citrus sp.	Rutaceae	0	0	0	0	0	0	0	0	0	0	1	1	2
Cyperaceae	Cyperaceae	2	1	6	6	20	15	8	15	13	26	19	15	146
Elaeis guineensis	Arecaceae	2	3	1	2	3	0	0	3	1	12	2	1	30
Euphorbia sp.	Euphorbiaceae	0	0	0	0	0	0	0	0	0	0	0	1	1
Malvaceae	Malvaceae	0	0	0	0	0	0	0	0	2	1	1	1	5
Mangifera indica	Anacardiaceae	0	0	0	0	0	0	0	0	7	2	1	0	10
Musa sp.	Musaceae	1	0	0	0	0	0	0	0	0	0	0	0	1
Nymphaea sp.	Nymphaeceae	0	0	0	0	0	0	0	2	0	6	0	0	8
Pandanus candelabrum	Pandanaceae	0	0	0	0	0	0	0	2	1	12	3	1	19
Paullinia pinnata	Sapindaceae	0	0	0	0	1	0	0	0	0	0	0	0	1
Poaceae	Poaceae	15	30	25	19	28	8	8	28	69	246	26	62	564
Polygonum plebeium	Polygonaceae	0	0	1	0	3	1	0	0	0	0	0	0	5
Raphia hookeri	Arecaceae	1	1	2	0	0	1	0	2	1	15	5	1	29
Solanaceae	Solanaceae	1	3	3	0	0	0	0	0	0	0	9	3	19
Syzygium guineense	Myrtaceae	0	0	0	0	0	0	0	0	0	10	0	0	10
Terminalia catappa	Combretaceae	0	1	1	2	4	1	0	2	4	2	0	4	21
Tridax procumbens	Asteraceae	1	2	1	0	0	0	1	2	2	2	1	1	13
Total		49	99	77	49	64	43	25	72	141	549	106	154	1428

peaks. *A. cordifolia* pollen grains peaked in October and February. Njokuocha (2006) recorded *A. cordifolia* peak month in Nsukka in November 1993; Adeonipekun et al. (2016) recorded *A. cordifolia* peak in Ayetoro in March 2011, while Ezike et al. (2016) recorded *A. cordifolia* peak in Abuja in November 2011. There are variations in the peak month of *A. cordifolia* pollen in different regions and different years in Nigeria which can be due to the weather and surrounding vegetation peculiarities. However, the general trend observed is that *A. cordifolia* pollen peaks during the dry months of October to November and February to March. Amaranthaceae pollen grains peaked in October and January. Njokuocha (2006) also recorded its peak month in Nsukka in January 1994; Adeonipekun et al. (2016) recorded Amaranthaceae peak in Ayetoro in March 2011, while Ezike et al. (2016) recorded Amaranthaceae peak in Abuja in August 2011. There are also variations in the peak months of Amaranthaceae pollen in different regions and different years in Nigeria which were most likely due to the weather and surrounding vegetation in each area. However, the general trend observed is that Amaranthaceae pollen peaked during the dry months of October, January, March, and even the short dry season of August in Nigeria. This can also be attributed to different flowering periods of the different species of Amaranthaceae within the local region which cannot be differentiated by their pollen. This phenomenon was suggested by Adeniyi et al.

Table 2 Pollen abundance in Gbagada for the year 2014

Pollen	Family	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Albizia sp.	Mimosaceae	0	0	0	0	0	0	0	0	0	1	0	1	2
Alchornea cordifolia	Euphorbiaceae	16	40	10	10	1	1	2	0	1	7	8	6	102
Amaranthaceae	Amaranthaceae	38	26	6	11	2	6	6	2	3	13	13	8	134
Asystasia gangetica	Acanthaceae	3	2	1	0	0	0	0	0	0	0	0	2	8
Canthium sp.	Rubiaceae	0	0	2	0	0	0	0	0	0	0	0	0	2
Cassia sp.	Caesalpinaceae	0	0	3	0	0	0	0	0	0	0	0	0	3
Casuarina equisetifolia	Casuarinaceae	3	1	4	0	0	0	0	0	6	19	23	5	61
Citrus sp.	Rutaceae	0	0	1	0	0	0	0	0	0	0	0	0	1
Cyperaceae	Cyperaceae	16	19	29	19	10	9	9	10	8	16	19	12	176
Dalbergia sp.	Papilionaceae	0	0	1	0	0	0	0	0	0	0	0	0	1
Elaeis guineensis	Arecaceae	1	0	1	1	1	0	0	2	1	2	2	1	12
Euphorbia sp.	Euphorbiaceae	0	0	0	0	0	0	0	1	0	0	0	0	1
Malvaceae	Malvaceae	1	0	0	0	0	0	0	0	1	1	1	0	4
Nymphaea sp.	Nymphaeceae	0	1	5	0	0	0	0	0	0	0	1	0	7
Pandanus candelabrum	Pandanaceae	0	0	0	0	0	0	0	0	0	0	1	0	1
Poaceae	Poaceae	42	50	86	32	15	12	10	12	13	39	40	26	377
Polygonum plebeium	Polygonaceae	0	0	0	0	1	0	0	0	0	0	0	0	1
Raphia hookeri	Arecaceae	1	0	0	0	0	0	0	0	0	2	1	0	4
Syzygium guineense	Myrtaceae	0	0	0	0	0	0	0	0	0	1	1	0	2
Terminalia catappa	Combretaceae	2	6	3	2	2	1	0	2	2	2	3	2	27
Tridax procumbens	Asteraceae	4	0	2	0	0	0	0	1	0	2	2	1	12
Total		127	145	154	75	32	29	27	30	35	105	115	64	938

(2017) for Poaceae pollen grains. *C. equisetifolia* pollen grains peaked in October 2013 and November in 2014. Njokuocha (2006) recorded *C. equisetifolia* peak month in Nsukka in September 1993, while Adeonipekun et al. (2016) and Ezike et al. (2016) recorded no dominance of *C. equisetifolia* pollen. There are variations in the peak month of *C. equisetifolia* pollen in different regions and different years in Nigeria which were due to the weather (Morton 1980) and surrounding vegetation. However, the general trend observed is that *C. equisetifolia* pollen peaked during the months of September to November. Cyperaceae pollen grains peaked in October and March. Njokuocha (2006) recorded Cyperaceae peak month in Nsukka in May 1993; Adeonipekun et al. (2016) recorded Cyperaceae peak in Ayetoro in February 2011, while Ezike et al. (2016) recorded Cyperaceae peak in Abuja in November 2011. There are variations in the peak months of Cyperaceae pollen in different regions and different years in Nigeria which were most likely due to the weather and surrounding vegetation. However, the general trend observed is that Cyperaceae pollen peaks during the months of October to November, February to March, and May. This can also be attributed to different flowering periods of species of Cyperaceae within the local region which cannot be differentiated by their pollen. This phenomenon was suggested by Adeniyi et al. (2017) for Poaceae pollen grains. Poaceae pollen grains peaked in months of October and March. Njokuocha (2006) recorded Poaceae peak month in Nsukka in November 1993; Adeonipekun et al. (2016) recorded Poaceae peak in Ayetoro in March 2011, while Ezike et al. (2016) recorded Poaceae peak in Abuja in October 2011. There are variations in the peak month of Poaceae pollen in different regions and different years in Nigeria which can be due to the weather and surrounding vegetation as reported by Adeniyi et al. (2017). However, the general trend observed is that Poaceae pollen peaks during the months of October to November, and March in Nigeria. From the different peak seasons of the same pollen across Nigeria as discussed above, the importance of studying

Table 3 Summary of pollinosis cases for 2013 and 2014

Variables	2013			2014		
	AC	Rh	WC	AC	Rh	WC
Months						
January	23	5	35	7	11	33
February	50	10	43	29	9	175
March	52	7	29	15	11	230
April	30	5	55	30	9	179
May	46	4	50	24	8	80
June	27	5	52	17	8	110
July	23	15	118	36	0	40
August	0	7	60	42	0	78
September	0	12	108	30	6	55
October	27	8	225	81	32	114
November	22	21	167	74	12	299
December	56	12	211	18	2	16
Total	356	111	1153	403	108	1409
Age group						
1–4 years	50	8	233	95	16	268
5–14 years	82	17	203	141	28	298
15–49 years	125	51	493	119	35	460
≥ 50 years	99	35	224	48	29	383
Gender						
Male	173	47	532	216	55	761
Female	183	64	621	187	53	648

AC allergic conjunctivitis; *Rh* rhinitis; *WC* wheezing cough

Table 4 Correlation coefficients between pollen counts and pollinosis data from Gbagada

Pollen	Pollinosis cases		
	Allergic conjunctivitis	Rhinitis	Wheezing cough
2013			
Total pollen count	− 0.012	0.041	0.696*
A. cordifolia	0.118	− 0.032	0.605*
Amaranthaceae	0.237	0.042	0.656*
C. equisetifolia	− 0.205	0.050	0.570*
Cyperaceae	− 0.175	0.152	0.647*
Poaceae	− 0.048	− 0.005	0.678*
2014			
Total pollen count	0.071	0.489	0.573*
A. cordifolia	− 0.106	0.169	0.308
Amaranthaceae	− 0.135	0.284	0.029
Cyperaceae	0.034	0.380	0.728*
Poaceae	− 0.047	0.405	0.602*

*Correlation is significant at the 0.05 level (two-tailed)

the aeropollen of local area instead of regional sampling is evident. Gbagada General Hospital recorded more cases of pollinosis in 2014 than in 2013; this could possibly be caused by weather conditions, aeropollen dominance, or a growing awareness of allergy in Nigeria. Generally, individuals of the age group 15–49 years had the highest number of cases which could be due to the fact that they were more conscious of their health and could visit the hospital more frequently to report cases. Also, this age group is the work force of the economy with more outdoor movement and greater exposure to allergens. Children cases are least reported because of the neglect of most parents who seem to generalize ailments in children to fever or malaria which according to Pawankar et al. (2008) are more severe and fatal among children in Nigeria. Exposure of children to allergens is also limited except during school hours and when playing. Sanchez Mesa et al. (2005) observed similar results from their survey of two cities in Spain; children cases were least reported while adults between ages 21 and 30 had the highest number of cases. They suggested that another reason could be the population of the cities which had more adults than children. This may be related to Nigeria as well which currently has a youth population (ages 13–35) of more than 80 million, which is about 52% of the population (Nigerian Population Commission 2016). Also, females and males pollinosis records showed similar vulnerability; this could null the general hypothesis that females are more conscious of their health than males. During the peak pollen season of October–March, allergic conjunctivitis cases had highest records in December and October; rhinitis cases had the highest records in November and October, while wheezing cough had the highest records in October and November. This could explain why total pollen count had positive correlations with all three cases in 2014. Further investigations of the dominant pollen during these months showed that Poaceae dominated in October, November, and December for both years. However, *A. cordifolia,* Amaranthaceae, and Cyperaceae were the dominant pollen with positive correlations with all three cases in 2014. This suggests that though Poaceae is dominant, less people are allergic to the pollen grains compared to the other plant species, recommending further research on allergenicity studies of the pollen grains. Simultaneously, the low pollen season of June–July had low records of wheezing cough and allergic conjunctivitis, though rhinitis recorded a minute rise in July of 2013. This might be due to increase in chest bacterial infections during cold rainy season which sometimes produce similar symptoms to allergies especially in asthmatic patients (Dykewicz and Fineman 1998).

Conclusion

Dominant pollen grains in the air of Gbagada are those of *Alchornea cordifolia,* Amaranthaceae, *Casuarina equisetifolia,* Cyperaceae, and Poaceae. These pollen grains statistically have an impact on the health of hypersensitive individuals in the area, especially those with wheezing cough symptoms. Also, the age group of reported pollinosis cases has shown that more awareness is required to sensitize the elderly and parents about allergy. Furthermore, the importance of keeping accurate pollinosis records in Nigerian hospitals is revealed. Nonetheless, continuous aeropalynology and pollinosis data collections from more locations within Nigeria are recommended to provide an appropriate epidemiology of pollinosis cases in the country and ascertain possible responsible pollen grains.

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