Comparative Study of Dominant Aeropollen and Allergy-Related Cases in Akoko Environment, Ondo State, Nigeria

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Abstract—Analysis of the atmospheric pollen content of an area is important in providing standard baseline information on environmental change, vegetation type, species composition and their utilization for safety health and sustainable development. This study was carried out in forty randomly selected locations/ sites to examine comparatively, the temporal and spatial relationship between the dominant aeropollen and allergy-related cases in Akoko environment, Ondo State, Nigeria between October, 2016 to September, 2017. The aeropollen were collected with Modified Tauber Sampler using simple random sampling technique and analyzed palynologically. Results showed that a total of 28,205 aeropollen grains belonging to 18 dominant aeropollen types were encountered. The dominant aeropollen include *Azadirachta indica*, *Carica papaya*, *Casuarina equisetifolia*, *Ceiba pentandra*, *Cocos nucifera*, *Delonix regia*, and those of the families Asteraceae, Cyperaceae and Poaceae. Aeropollen grains were most abundant between September and January. Rainfall and relative humidity had more negative effect on aeropollen concentration. Furthermore, the occurrence of these dominant aeropollen indicates the availability of allergenic taxa in the atmosphere. A total of 3,826 patients were diagnosed of allergy-related cases with the highest values of 924 and 875 recorded in October and July respectively when aeropollen were most abundant in the studied environment. Adequate environmental monitoring through pollen rain analysis and avoidance of exposure to allergens during their season of prevalence are recommended for safety health and environmental sustainability. Extraction, isolation and quantification of allergenic proteins in the dominant aeropollen grains will provide baseline data for immunological research in the studied area.

Index Terms—Aeropollen, Allergy-Related Cases, Akoko Environment, Dominant.

I. INTRODUCTION

The atmosphere is laden with many kinds of suspended particles of organic and inorganic origin having great diversity in size, shape, and density and from diverse source (Essien and Agwu, 2013). Diagenesis and fragmentation give rise to microscopic inorganic particles which are wafted into the atmosphere by wind. Airborne particles are a major cause of respiratory ailments of humans, causing allergies and pathologic infections of the respiratory tract (Essien and Aina, 2014). The study of airborne pollen is very useful for proper diagnosis and treatment of allergy.

Aerobiological data are widely used by members of the

medical community to describe and predict atmospheric pollen and spore concentrations in an effort to help those sensitive to aeroallergens (Singh and Rawat, 2000). Data collected from pollen allergy studies are often used predictively; warning being given that the air will be strongly pollen-contaminated in the immediate future. As pollen is just one type of contaminant of air pollution. However, they can also be used for other predictions (Levetin *et al.*, 2000).

The term allergy was introduced in 1906 by C. von Pirquet. He described allergy as a changed responsiveness in individuals, who had previously been exposed to the antigen/allergen. From the clinical point of view, this term is use most frequently to describe different hypersensitivity reactions which are mediated through the immunological mechanisms like atopic disease, anaphylactic shock, Arthurs' reaction, etc.

A normal adult inhales about 14-15 cubic meters of air per day, which contains a good number of bioparticles including pollen grains. From medical, especially clinical point of view, it is important to know the details about the occurrence of the pollen load in the atmosphere. The correlation between the onset of different airborne pollen seasons and the occurrence of a patient's symptoms is now well known. Pollen grains causing allergy are quite variable in different ecozones and also in a particular place from season to season, year to year depending on changes in the ecological and climatic conditions. This makes it very important to identify pollinosis causing species from a given area so as to prepare extracts for them for diagnosis and immunotherapy (Adeniyi *et al.*, 2018a). That is why an aerobiological study is needed to develop/ make a pollen calendar of a particular area. In environmental pollution, much consideration is also given to smokes, dust, radionuclides, pesticides and the microbial forms viruses, bacteria, fungal spores, spores of ferns and mosses, pollen grains, etc. such bioparticles attack the mucous membrane causing respiratory allergic disorder symptomized in intense sneezing, watery eyes, nasal obstruction, itchy eyes and nose and frequent coughing which may take place minutes after exposure to the offending allergens (Bhattacharya *et al.*, 2011).

Allergic diseases are important to many people, about 10-15 percent of the world population having mild or severe allergy. The most common source of allergy are pollen grains, mold spores, mites, animal dander, house dust, some drugs and many food stuff, especially milk, nuts, egg and fish. Pollen grains are one the main causative agents for various allergic diseases like hay fever, rhinitis, asthma,

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dermatitis, among others (Shivanna, 2005).

Pollen grains induce allergic responses in susceptible individuals. Allergic pollen grains belong to three broad categories: grasses, weeds and trees. Allergy to pollen grains is called hay fever or pollinosis (Burge and Rogers, 2008). Generally, pollen that cause allergies are those of anemophilous plants (pollen that is dispersed by air currents). Such plants produced large quantities of light weight pollen because wind dispersal is random and the likelihood of one pollen grain landing on another flower is small) which can be carried for great distances and are easily inhaled, bringing it into contact with the sensitive nasal passages (Singh and Rawat, 2000). A characteristic feature of pollen allergy is its seasonal occurrence associated with the prevalence of pollen of that particular species in the atmosphere (Burge and Rogers, 2008; Essien and Aina, 2014).

Availability of authentic pollen samples and dependable pollen calendars would greatly facilitate diagnosis and treatment of allergy. Avoidance of allergenic pollen is the best way to prevent allergy. Treatment with allergenic drugs is the predominant management method. Authentic pollen supply is also required for biochemical characterization of allergens and for understanding their structure (Adeniyi *et al.*, 2018a).

Developing pollen calendar of an area is essential to test the relevant antigens on the patients and to correlate the seasonal occurrence of the pollen types to the patients' allergic symptoms. Pollen calendars are very useful for effective diagnosis and treatment of pollen allergy. Pollen calendar gives information on diurnal, seasonal and annual variations in the pollen types and their concentration in the air. A continual check on pollen counts in the air of the studied environment is necessary in order to forecast pollen incidence. Such studies are useful in finding areas and periods that are comparatively safe for allergic patients (Giesecke *et al.*, 2010).

Pollen grains contain proteins that can be allergenic in nature. A particular pollen grain may contain several types of proteins, all or some of which may be allergenic. Pollen grains causing allergy are quite variable in different ecozones, which makes it very important to identify allergy-causing species from every region and to prepare extracts from them for diagnosis and immunotherapy, which in turn are of immense importance for allergic individuals (Thomas and Leuschner, 2006; Essien and Aina, 2014).

The main aim of this study was to identify; study and compare the different aeropollen counts with allergy-related cases over a period of 12 calendar months and to also establish the relationship between clinical data and aeropalynology in Akoko environment, Ondo State, Nigeria.

II. MATERIALS AND METHODS

Fourty locations were randomly selected within the four Local Government Areas of Akoko division, Ondo State, Nigeria as sampling sites. The sampling sites for the study was purposely (Patton, 1990) selected to reflect as far as possible the Local Government Areas of the study. In choosing the sites, consideration was also given to urbanization, accessibility, and safety of the sampling

(experimental materials) instruments among others. At each site, a pollen trap (Modified Tauber Sampler) was mounted according to the methods of Tauber (1974; 1977; Pardoe *et al.*, 2010, and Giesecke *et al.*, 2010).

The solutions in the trap prevented the aeropollen from drying up, kill insects and also prevented the decay of dead organisms. The trap was left to stand throughout the duration of the study period. Fortnightly of each month, solution collection was done. The traps were washed with water to remove any contaminants and were then recharged with the above mentioned chemical solution. This procedure was repeated bi-monthly from March- December (dry season and rainy seasons' samples) for twelve calendar months. The aeropollen were recovered through centrifugation at 2000 r.p.m (revolution per minute) for 5 minutes and supernatant decanted each time. The precipitates were washed twice with distilled water and recovered through centrifugation. The sediments were treated with glacial acetic acid to remove water before acetolysis (Erdtman, 1969; Agwu and Akanbi, 1985). The recovered precipitates were washed with glacial acetic acid, and finally washed twice with distilled water, centrifuged each time and decanted. The recovered palynomorphs were stored in a plastic vials in glycerin and ethanol solution (2:1).

The palynomorphs were analysed palynologically and microscopically with Olympus microscope at x400 magnification for counting and Leica microscope at x1000 magnification for detailed morphological studies. Palynomorphs identification, counting and classification was done with the help of reference descriptions and photomicrographs from Agwu and Akanbi (1985); Bonnefille and Riollot (1980); Moore and Webb (1978); Sowunmi (1995); Shubharani *et al.*, 2013 and prepared slides of pollen samples in the Palynological Research Unit; Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba-Akoko, Nigeria.

III. RESULTS AND DISCUSSIONS

Results of this study showed that a total of 28,205 aeropollen grains belonging to 18 dominant aeropollen types were encountered. Although this study does not involves allergenic protein characterization, aerobiological studies have revealed some dominant aeropollen in the atmosphere which could be allergenic due to their relative abundance and the plant families they belong to. Examples of these dominant aeropollen types documented in this study are presented in Table 1. This dominance is due to the cosmopolitan nature of this group of plants in our environment. Photomicrograph of some selected aeropollen grains are presented in Plate 1.

Many airborne pollen grains are potent biopollutant responsible for human respiratory and skin itching allergies. They cause or exacerbate a number of allergic manifestations such as bronchial asthma, naso-bronchial allergy, bronchitis, conjunctivitis, dermatitis, pollinosis or hay fever, rhinitis, and upper respiratory tract infection among others. The occurrence of pollen from *Acacia* sp., *Azadirachta indica*, *Bombax buonopozense*, *Carica papaya*, *Casuarina equisetifolia*, *Ceiba pentandra*, *Cocos nucifera*,

Delonix regia, *Ipomoea* sp., *Justicia* sp., *Prosopis africana*, *Ricinus communis* and those of the families *Amaranthaceae*/ *Chenopodiaceae*, *Asteraceae*, *Cyperaceae* and *Poaceae* during the months of June to July and September to January indicates the availability of allergenic taxa in the atmosphere. For instance, *Poaceae* (grass) pollen grains have been reported by Subiza *et al.* (1992) to be one of the most important factors for rhinitis and/or asthma in Spain, as well as in the other Western European countries. In Catalonia (NE Spain) *Poaceae* pollen showed symptoms in 35% of patients and are thus the highest ranking taxa with allergenic significance (Belmonte *et al.*, 2000).

Comparison between the pollen counts and allergy-related cases documented in this study was made and the results revealed that pollen counts has 43.08% influence on allergy, 21.84% influence on upper respiratory tract infection, 19.51% influence on hay fever and 18.11% influence on bronchitis among others (Figure 1). Correlation between airborne pollen concentrations of some allergic types and allergy-related cases showed that there was a strong positive significant correlation between *Prosopis africana* pollen and bronchitis, conjunctivitis, dermatitis, and rhinitis; strong positive significant correlation between the pollen of *Casuarina equisetifolia* and hay fever; strong positive significant correlation between the pollen of *Ceiba pentandra* and allergy as well as upper respiratory tract

infections (Table 2). Furthermore, correlation analysis also revealed that there was a strong negative significant correlation between the pollen of *Aspilia africana* with dermatitis and hay fever; *Tridax procumbens* with dermatitis, *Bombax buonopozense* with bronchitis and dermatitis as well as *Azadirachta indica* pollen with hay fever (Table 2).

Medical records showed that a total of 3,826 patients were diagnosed of seven allergy-related cases with the highest cases of 924 and 875 recorded in October and July respectively (Table 2); and this coincides with the period where allergic airborne pollen grains were most abundant in the studied area (Table 1). In this study, out of 3,826 patients diagnosed of 7 allergy-related cases, the highest reported allergy prevalence were diagnosed for upper respiratory tract infection and hay fever in which 1,684 patients were diagnosed with symptoms of upper respiratory tract infection and 1,323 for hay fever followed by dermatitis (355), conjunctivitis (198), rhinitis (116), bronchitis (76) and naso-bronchial allergy (74) respectively (Table 2). For example, the highest reported monthly allergy-related case was diagnosed for hay fever in July and October with a total of 812 and 508 patients respectively and the least recorded in November and December with 2 and 1 patient respectively (Tables 2).

TABLE I: ALLERGIC POLLEN TYPES DOMINANT IN AKOKO ENVIRONMENT (OCTOBER 2016 TO SEPTEMBER 2017)

Pollen types	Octob er	Novemb er	Decemb er	Januar y	Februa ry	Marc h	Apr il	Ma y	Jun e	Jul y	Augu st	Septemb er	Total	Mean counts±S E	Plant Form
Poaceae	3109	3892	4145	1679	594	551	567	889	699	703	565	3418	20,811	86.71±5.74	Herb
<i>Alchornea cordifolia</i>	15	847	497	196	99	202	99	56	29	7	14	65	2,126	9.25±1.21	Shrub
<i>Aspilia africana</i>	415	446	31	66	18	10	4	17	20	39	104	77	1,247	5.19±1.06	Herb
<i>Casuarina equisetifolia</i>	719	14	23	27	17	61	31	110	34	33	90	33	1,192	4.99±0.99	Tree
<i>Tridax procumbens</i>	255	478	19	85	11	5	9	9	11	42	100	68	1,092	4.55±1.26	Herb
<i>Prosopis africana</i>	0	0	0	215	291	131	0	0	0	0	0	0	637	2.65±0.45	Tree
<i>Amaranthaceae</i>	26	28	24	16	11	158	35	53	26	9	3	26	415	1.73±0.29	Herb
<i>Cyperaceae</i>	19	13	12	10	9	17	10	116	42	25	22	26	321	1.33±0.18	Sedges
<i>Bombax buonopozense</i>	25	11	6	3	4	0	12	17	13	-	3	17	111	0.43±0.09	Tree
<i>Delonix regia</i>	3	17	0	2	0	0	23	6	0	10	1	0	62	0.26±0.07	Tree
<i>Cocos nucifera</i>	0	0	5	2	5	15	5	10	2	0	0	0	44	0.18±0.05	Tree
<i>Azadirachta indica</i>	0	2	9	0	0	5	6	1	7	5	6	2	43	0.18±0.05	Tree
<i>Carica papaya</i>	0	0	0	0	0	0	0	0	0	0	11	31	42	0.17±0.05	Herb
<i>Justicia</i> spp.	1	5	0	0	0	4	1	3	4	1	2	0	21	0.09±0.03	Herb
<i>Ricinus communis</i>	0	0	0	0	0	0	8	6	3	0	0	0	17	0.07±0.03	Shrub
<i>Ceiba pentandra</i>	0	3	0	2	0	2	7	1	0	0	0	0	15	0.06±0.02	Tree
<i>Ipomoea</i> spp.	0	4	0	0	2	0	0	0	0	0	0	0	6	0.02±0.01	H/climber
<i>Acacia</i> spp.	0	0	0	0	0	0	0	0	0	3	0	0	3	0.01±0.01	Shrub
TOTAL	4587	5760	4771	2303	1061	1161	817	1294	890	877	921	3763	28,205		

It is worthy to note that cases of Conjunctivitis, Dermatitis, Rhinitis and Upper respiratory tract infection were reported all through the study period (October 2016 to

September 2017) whereas allergy was reported in other months of the study except March, April and June; Bronchitis were reported in all other months of study except

March while Hay fever was reported in the months of October, November, December and July only (Table 2). Highest reported cases of allergic manifestations were

recorded in the month of October while the least reported cases were recorded in August (Table 2).

TABLE II: SUMMARY OF ALLERGY-RELATED CASES RECORDED IN THE STUDY AREA (OCTOBER 2016 TO SEPTEMBER 2017)

Month	Allergy	Bronchitis	Conjunctivitis	Dermatitis	HF	Rhinitis	URTI	Total
October	21	13	21	43	508	8	310	924
November	2	17	45	68	2	23	166	323
December	8	11	25	54	1	16	270	385
January	21	7	21	35	0	13	411	508
February	7	5	11	17	0	8	33	81
March	0	0	9	13	0	5	65	92
April	0	5	6	22	0	3	98	134
May	4	1	9	24	0	6	131	175
June	0	1	5	29	0	12	17	64
July	3	1	14	11	812	7	27	875
August	3	2	11	7	0	3	21	47
September	5	13	21	32	0	12	135	218
TOTAL	74	76	198	355	1,323	116	1,684	3,826

LEGEND: HF: Hay Fever URT: Upper Respiratory Tract Infection

At the study locations (i.e Local Government Areas of study), Akoko North-East recorded 1,320 patients (812 in July and 508 in October) diagnosed for hay fever whereas Akoko South-West recorded 3 patients (2 in November and 1 in December) respectively.

Although this study did not extend to clinical immunological or sensitivity tests, some of the dominant aeropollen grains identified in this study have been proven to be perennial or seasonal causes of allergy (cf. Singh, 1987; Mishra *et al.*, 2002). In this study, eighteen (18) allergic pollen types were documented. These pollen types have also been reported in previous aerobiological studies in Nsukka (Agwu, 1997; Agwu *et al.*, 2004; Njokuocha and Osayi, 2005; Njokuocha, 2006), Port Harcourt (Agwu, 2001), Aguata (Njokuocha and Ezenwajiaku, 2010), Anyigba (Essien, 2014; Essien *et al.*, 2016), Ayetoro (Adeonipekun *et al.*, 2016); Abuja (Ezike *et al.*, 2016); Gbagada (Adeniyi *et al.*, 2018a); Jabalpur, Bengal, India (Chakraborty *et al.*, 2001; Mishra *et al.*, 2002).

Allergies are a heavy socio-economic burden worldwide. There is a deficit in public awareness, education and training on allergies; therefore, efficient preventive strategies are urgently needed.

However, in allergenicity studies, a vegetation reconnaissance of the sampled area is conducted to determine the dominant species within the region as it is in the present study. For example, *Alchornea cordifolia* pollen contains allergenic proteins and has been reported by Adeniyi *et al.* (2018b) to have a high allergenicity of 84% and this poses great risk to hypersensitivity individuals, especially those within close proximity to fresh water swamps, canals, wetlands, secondary forests and riverine forest where the plant has been seen to be dominant. Also, it's abundant/ cupious production of pollen grains, which are widely dispersed and often remains in the atmosphere throughout the calendar year poses another major risk. Because of this properties, the researcher suggests an integrated weed management approach for *Alchornea cordifolia*: the plant populations should be reduced to the barest minimum in urban canals/ swamps, and such area should be re-vegetated to allowed only the animal species to survive; *Alchornea cordifolia* should be allowed to remain in urban wetlands (where they certainly perform ecological functions) but they can be pruned regularly to prevent

flowering; cut/ thinned. *Alchornea cordifolia* plant should be disposed-of in an environmentally friendly manner (for instance, sold to medicinal practitioners, or used as compost) to prevent regrowth in another environment.

Alchornea cordifolia

Amaranthaceae

Aspilia africana

Casuarina equisetifolia

Ceiba pentandra

Delonix regia

Cyperaceae

Poaceae

Plate 1: Photomicrograph of Some Selected Aeropollen grains

i. Comparison between Pollen counts and Allergy prevalence

v. Comparison b/w Pollen counts and Hay fever prevalence

ii. Comparison b/w Pollen counts and Bronchitis prevalence

vi. Comparison b/w Pollen counts and Rhinitis prevalence

iii. Comparison b/w Pollen counts and Conjunctivitis prevalence

vii. Comparison b/w Pollen counts and Upper respiratory tract infection prevalence

iv. Comparison b/w Pollen counts and Dermatitis prevalence

i. Monthly abundance of Poaceae pollen

Fig. 1: Comparison of Pollen counts with Allergy-related cases: (i) Allergy (ii) Bronchitis (iii) Conjunctivitis (iv) Dermatitis (v) Hay fever (vi) Rhinitis (vii) Upper respiratory tract infection

ii. Monthly abundance of Casuarina equisetifolia pollen

iii. Monthly abundance of Alchornea cordifolia pollen

iv. Monthly abundance of Cyperaceae pollen

(v): Monthly abundance of Amaranthaceae pollen

Figure 2: Monthly abundance of pollen of (i) Poaceae (ii) Casuarina equisetifolia (iii) Alchornea cordifolia (iv) Cyperaceae (v): Amaranthaceae

In this study, a total of 28,205 pollen counts belonging to eighteen (18) dominant allergic aeropollen types were documented (Table 1). Highest pollen counts of 5,760 and 4,771 were recorded in November and December respectively and lowest pollen counts of 877 and 817 were recorded in the months of July and April (Table 1). These predominant pollen types include those of Poaceae, *Alchornea cordifolia*, *Aspilia africana*, *Casuarina equisetifolia*, *Tridax procumbens*, Amaranthaceae and Cyperaceae among others. For example, Poaceae (with 20,811 pollen grains) is the major pollen contributor; recorded the highest pollen grains count of 4,145 and 3,892 in December and November and the lowest pollen grain count of 551 in March while *Alchornea cordifolia* with 2126 pollen grains recorded its highest pollen counts of 847 and 497 in November and December and the lowest pollen grain count of 7 in July (cf. Table 1). *Aspilia africana* with 1,247 pollen grains counts recorded the highest pollen count of 446 and 415 in December and October and the least pollen count of 4 in April while *Tridax procumbens* with 1,092 pollen grains recorded its highest pollen counts of 478 in October and the least pollen grain count of 5 in March respectively. The plant family Amaranthaceae with 414 pollen grains counts recorded the highest pollen count of 158 in March and the least pollen count of 3 in August whereas the plant family Cyperaceae with 321 pollen grains recorded its highest pollen counts of 116 in May and the least pollen grain count of 9 in February respectively (Table 1).

These dominant pollen types had different peaks of abundance in the atmosphere. *Casuarina equisetifolia* contributed a total of 1,192 pollen counts in this study and its pollen grains peaked in the month of October (Figure 2i). Njokuocha (2006) recorded *Casuarina equisetifolia* peak month in Nsukka in September 1993, Adeonipekun *et al.* (2016) and Ezike *et al.* (2016) recorded no dominance of *Casuarina equisetifolia* pollen while Adeniyi *et al.* (2018a) recorded *Casuarina equisetifolia* pollen grains peak in October 2013 and November 2014. There are variations in the peak month of *Casuarina equisetifolia* pollen in different region and different years in Nigeria which were attributed to weather conditions and surrounding vegetation (Morton, 1980). The general trend observed is that *Casuarina equisetifolia* pollen peaked during the months of September to November.

Amaranthaceae pollen grains peaked in the month of March (Figure 2v). Adeonipekun *et al.* (2016) recorded Amaranthaceae peak in Ayetoro in March 2011; Njokuocha (2006) recorded its peak month in Nsukka in January 1994; Ezike *et al.* (2016) recorded Amaranthaceae peak in Abuja in August 2011, while Adeniyi *et al.* (2018a) recorded its peak in October and January 2013. There are also variations in the peak months of Amaranthaceae pollen in different regions due to weather conditions 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.* (2017) for Poaceae pollen grains.

In this study, the monthly pollen abundance of Poaceae showed that the frequency increased greatly from September, reached its peak in November and thereafter declined progressively to a relatively low level from February (Figure 2i). Adeniyi *et al.* (2018a) recorded Poaceae peak months in Gbagada in October and March 2014; Adeonipekun *et al.* (2016) recorded Poaceae peak in Ayetoro in March 2011; Ezike *et al.* (2016) recorded Poaceae peak in Abuja in October 2011 while Njokuocha (2006) recorded Poaceae peak in Nsukka in November 1993. There are variations in the peak months of Poaceae pollen in different regions and different years in Nigeria which can be attributed to the weather 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. Similar finding was reported by Latorre and Belmonte (2004) who recorded Poaceae peak month in Catalonia (NE Spain) in May and August-September 2001.

Alchornea cordifolia had its peak in the months of November and December (Figure 2iii). Njokuocha (2006) recorded *Alchornea cordifolia* peak month in Nsukka in November 1993; Adeonipekun *et al.* (2016) recorded *Alchornea cordifolia* peak in Ayetoro in March 2011; Adeniyi *et al.* (2018a) recorded *Alchornea cordifolia* peak in Gbagada in October and February 2014 while Ezike *et al.* (2016) recorded *Alchornea cordifolia* peak in Abuja in November 2011. There were also variations in the peak months of *Alchornea cordifolia* pollen in different regions and different years in Nigeria which can also be attributed to weather conditions and surrounding vegetation peculiarities. However, the general trend observed is that *Alchornea cordifolia* pollen peaked during the dry months of October to November and February to March.

Cyperaceae pollen had its peak in May (Figure 2iv). Njokuocha (2006) recorded Cyperaceae peaked month in Nsukka in May 1993; Ezike *et al.* (2016) recorded Cyperaceae peak in Abuja in November 2011; Adeniyi *et al.* (2018a) recorded Cyperaceae peaked in October and March 2014 while Adeonipekun *et al.* (2016) recorded Cyperaceae peak in Ayetoro in February 2011. There are variations in the peak month of Cyperaceae pollen in different regions and different years in Nigeria which were most likely due to the weather conditions 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. Similar pattern of variations in peak of abundance were also observed for all the predominant allergic aeropollen documented in this study.

IV. CONCLUSION

Dominant aeropollen grains in the atmosphere of Akoko environment are those of *Acacia* sp., *Azadirachta indica*, *Bombax buonopozense*, *Carica papaya*, *Casuarina equisetifolia*, *Ceiba pentandra*, *Cocos nucifera*, *Delonix*

regia, *Ipomoea* sp., *Justicia* sp., *Prosopis africana*, *Ricinus communis* and those of the families *Amaranthaceae*/*Chenopodiaceae*, *Asteraceae*, *Cyperaceae* and *Poaceae*. These aeropollen grains statistically have a significant impact on the health of allergic individuals in the studied area, especially those with upper respiratory tract infection and hay fever symptoms. Adequate environmental monitoring through pollen rain analysis and avoidance of exposure to allergens during their season of prevalence are recommended for safety health and environmental sustainability. Extraction, isolation and quantification of allergenic proteins in the dominant pollen grains will provide baseline data for immunological research in the studied area.

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REFERENCES

- Adeniyi, T.A., Adeonipekun, P.A. and Olowokedujo, J.D. (2018a). Comparative study of aeropollen and pollinosis cases. *Environmental Monitoring and Assessment*, 190: 562-572.
- Adeniyi, T.A., Adeonipekun, P.A., Olowokedujo, J.D. and Akande, I.S. (2018b). Allergenicity of dominant aeropollen in Nigeria. (Part 11). *Current Allergy and Clinical Immunology*, 31(3):178-183.
- Adeonipekun, P.A., Agbalaya, A.E. and Adeniyi, T.A. (2016). Aeropallynology of Ayetoro-Itele, Ota, South-West Nigeria: A preliminary study. In: R.Alabi and P.A. Adeonipekun (Eds.), *human Palaeoecology in Africa: Essays in honour of M.Adebisi Sowunmi*. University of Ibadan Press, Ibadan, Nigeria. Pp 130-153.
- Agwu, C.O.C. and Akanbi, T.O. (1985). A palynological study of honey from four vegetation zones of Nigeria. *Pollen et Spores*, 27:335-348.
- Agwu, C.O.C. (1997). Modern pollen rain in Nsukka: An indicator of the vegetation of Nsukka Plateau. *Wurzbürger Geographische Arbeiten*, 92:97-115.
- Agwu, C.O.C. (2001). A Study of Niger Delta Environment through air-borne palynomorphs, Port-Harcourt, Nigeria. *Palaeoecology of Africa*, 27:191-205.
- Agwu, C. O. C., Njokuocha, R. C. and Mezue, O. (2004). The study of airborne pollen and spores circulating at "head level" in Nsukka environment. *Bio-Research*, 2(2):7-14.
- Belmonte, J., Canela, M. and Guardia, R.A. (2000). Comparison between categorical pollen data obtained by Hirst and Cour sampling methods. *Aerobiologia*, 16: 177-185.
- Bhattacharya, K., Majumdar, M.R. and Bhattacharya, S.G. (2011). *A Textbook of Palynology (Basic and Applied)*. New Central Book Agency (P) Ltd., West Bengal, India. 352pp.
- Bonnefille, R. and Rioulet, G. (1980). *Pollen des savanna d'Afrique orientale*. Anatole Press, Paris, France. 140pp.
- Burge, H.A. and Rogers, C.A. (2008). Outdoor allergens. *Environmental Health Perspective*, 108:-655-368.
- Chakraborty, P., Gupta-Bhattacharya, S., Chowdhury, I., Majumdar, M.R. and Chanda, S. (2001). Differences in concentrations of allergenic pollens and spores at different heights on an agricultural farm in West Bengal, India. *Annals of Agriculture and Environmental Medicine*, 8:123-130.
- Daremborg, C. (1854). Allergic reactions. *Baillieara*, 1:549.
- Erdtman, G. (1969). *Handbook of Palynology*. Muntisguard, Copenhagen. 285pp.
- Essien, B.C. and Agwu, C.O.C. (2013). Aeropallynological study of Anyigba, Kogi State, Nigeria. *Standard Scientific Research Essays*, 1(13): 347-351.
- Essien, B.C. (2014). A comparative analytical study of airborne pollen grains, spores and other palynomorphs within Grimard Catholic hospital, Anyigba, Kogi State, Nigeria. *Scholarly Journal of Scientific Research and Essay*, 3(5): 56-60.
- Essien, B.C. and Aina, D.O. (2014). The role of airborne pollen grains of some angiosperms and fungal spores in allergic and pathogenic

- infections in Anyigba, Kogi State, Nigeria. *International Journal of Advances in Medical Sciences and Biotechnology*, 2(3): 23-28.
- Essien, B.C., Ige, O.E. and Ekeyi, D. (2016). Recent pollen rain in Anyigba: an indicator of the vegetation of Kogi State, Nigeria. *World Journal of Biology and Medical Sciences*, 3(1):82-92.
- Ezike, D.N., Nnamani, C.V., Ogundipe, O.T. and Adekanmbi, O.H. (2016). Airborne pollen and fungal spores in Garki (North-Central Nigeria). *Aerobiologia*, 32: 697-707.
- Giesecke, T., Fontana, S.L., van der Knaap, W.O., Pardoe, H.S. and Pidek, I.A. (2010). From early pollen trapping to experiments to the Pollen Monitoring Programme. *Vegetational History and Archaeobotany*, 19:247-258.
- Ige, O.E. and Essien, B.C. (2019). Monitoring environmental change in Akoko North-East Local Government Area of Ondo State, Nigeria through pollen analysis. A paper presented at the 10th Palynological Association of Nigeria (PAN) Conference. Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria. 5th to 9th May, 2019.
- Levetin, E., Rogers, C.A. and Hall, S.A. (2000). Comparison of pollen sampling with a Bukard spore trap and a Tauber trap in a warm temperate climate. *Grana*, 39: 294-302.
- Marketos, S.G. and Ballos, C.N. (1982). Allergy. *Journal of Asthma*, 19: 263.
- Mishra, R.P., Singh, B. and Oommachan, M. (2002). Airborne pollen flora of Jabulur- the central India. *Aerobiologia*, 18: 73-81.
- Moore, P.D. and Webb, J.A. (1978). *An illustrated guide to pollen analysis*. Hodder and Stoughton, Kent-London. 133pp.
- Morton, J.F. (1980). The Australian pine or beefwood (*Casuarina equisetifolia* L.), an invasive weed tree in Florida. *Proceedings of the Florida State Horticultural Society*, 93: 87-95.
- Njokuocha, R.C. and Osayi, E.E. (2005). Airborne pollen survey in relations to allergy and plant pathogens in Nsukka, Nigeria. *Nigerian Journal of Biological Research and Biotechnology*, 3(1):77-84.
- Njokuocha, R. C. (2006). Airborne pollen grains in Nsukka, Nigeria. *Grana*, 45:73-80.
- Njokuocha, R.C. and Ezenwajiaku, T.E. (2010). Airborne pollen flora in Aguata Local Government Area, Anambra State, Nigeria. *Nigerian Journal of Botany*, 23(2): 211-224.
- Pardoe, H.S., Giesecke, T., van der Knaap, W.O., Svitavaska-Svobodova, H., Kvavadze, E.V., Panajiotidis, S., Gerasimidis, A., Pidek, I.A., Zimney, M., Swieta-Musznicka, J., Latalowa, M., Noryskiewicz, A.M., Bozilova, E., Tonkov, S., Filipova-Marinova, M.V., vvan Leeuwen, J.F.N. and Kalnipa, L. (2010). Comparing pollen spectra from Modified Tauber Traps and Moss samples: example from a selection of woodlands across Europe. *Vegetational History and Archaeobotany*, 19:271-283.
- Patton, M.Q. (1990). *Quantitative evaluation and research methods* (2nd Ed.). Sage Publications, Newbury Park, CA. 523pp.
- Richet, C.I. (1902). Anaphylaxie. Felix Alcan, Paris.1991. Quoted from 'Charles Robert Richet and some milestones in the history of allergies. Mazana, J. Ariamo, M.R. (Eds.). *Journal of Investigational Allergology and Clinical Immunology*, 1: 93.
- Shivanna, K.R. (2005). *Pollen biology and biotechnology*. Oxford & IBH Publishing Company, New Delhi. 301pp.
- Shubharani, R., Roopa, P. and Sivaram, V. (2013). Pollen morphology of selected bee forage plants. *Global Journal of Bio-Science and Biotechnology*, 2(1): 82- 90.
- Singh, A.B. and Rawat, A. (2000). *Aeroallergens in India*. In: *advances in allergy and asthma*. R. Prasad (Ed.), Shivam Publication, Lucknow, UP, India. Pp 23-46.
- Sowunmi, M.A. (1995). Pollen of Nigerian plants II. *Grana*, 34:120-141.
- Subiza, J., Masiello, M., Subiza, J.L., Jerez, M., Hinojosa, M. and Subiza, E. (1992). Prediction of annual variations in the atmospheric concentrations of grass pollen. A method based on meteorological factors and grain crop estimates. *Clinical and Experimental Allergy*, 22: 540-546.
- Tauber, H. (1974). A static non-overload pollen collector. *New Phytology*, 73:359-369.
- Tauber, H. (1977). Investigations of aerial pollen transport in a forested area. *Dansk Botanisk Arkiv*, 32(1):1-121.
- Thomas, F. and Leuschner, R.M. (2006). A change from grass pollen induced allergy to tree pollen induced allergy: 30 years of pollen observation in Switzerland. *Aerobiologia*, 16:407-416.