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Annual Records of Airborne Pollen of Poaceae in Five Areas in Lagos, Nigeria

TIWALADE ADEYEMI ADENIYI, PETER ADEGBENGA ADEONIPEKUN & JAMES DELE OLOWOKUDEJO

Laboratory of Palynology/Paleobotany, Department of Botany, University of Lagos, Akoka, Lagos State, Nigeria

Abstract
Poaceae pollen grains are known to be highly allergenic and they are potential causes of allergic respiratory diseases. In order to investigate the incidence of airborne Poaceae, and contribute to current trends in the development of aeropalynology/allergy studies in Nigeria, five highly populated locations in Central Lagos State, Surulere, Ebute-Metta, University of Lagos, Bariga and Gbagada, were sampled. Gravimetric aerosamples were collected monthly from January 2013 to December 2014. The lowest count in 2013 was recorded in the Ebute-Metta area (179), while the highest in 2013 was recorded in Gbagada (564). In 2014, the Surulere area (282) had the lowest count while Bariga (671) had the highest. The locations have similar monthly pollen distribution pattern but different peak months. Generally, Poaceae pollen counts were lowest in the months of June and July. These are therefore the safest months for Poaceae pollen hypersensitive individuals in the study areas. Relative humidity was the most important meteorological parameter with significant correlations in Ebute-Metta and Bariga locations. Results from this work will form the basis for a forecast service required to inform and educate the general public and allergy sufferers about Poaceae pollen distribution in Lagos State.

Keywords: *aeropalynology, allergy, hypersensitive individuals, meteorological factors*

Poaceae is a large and ubiquitous family of monocotyledonous flowering plants with more than 10 000 domesticated and wild species making it the fifth largest plant family (Burkill 1985). Grasslands are estimated to compose 20% of the vegetation cover of the Earth. Poaceae also populate many other habitats, including wetlands, forests and tundra (Martin & Brian 2007). Verma (2009) and Gonsalves (2010) remarked that domestication of poaceous cereal crops such as maize (corn), wheat, rice, barley and millet makes Poaceae the most economically important plant family, providing forage, building materials (bamboo, thatch) and fuel (ethanol), as well as food.

Grasses are commonly found worldwide and have been implicated as being the commonest airborne pollen in Australia and New Zealand (Haberle et al. 2014), Europe (Emberlin et al. 1993, 1994; Riberio et al. 2003; Rizzi-Longo et al. 2007; Kasprzyk & Walanus 2010; Kizilpinar et al. 2011; Fernández-Rodríguez et al. 2015; Myszkowska et al. 2015; Ugolotti et al. 2015), India (Singh et al. 2003; Chauhan & Goyal 2006; Mahney and Chaurasia 2008; Singh & Marthur 2012), North America (Kosisky et al. 2010), South Africa (Berman 2007), Morocco (Aboulaich et al. 2013), Egypt (El-Ghazaly & Fawzy 1988) and Nigeria (Njokuocha 2006; Adeniyi et al. 2014; Adeonipekun et al. 2016; Ezike et al. 2016).

The grass pollen season lasts long due to the occurrence of various grass species with different flowering times (Kasprzyk & Walanus 2010). The characteristics of the main parameters of grass pollen seasons (start, end, duration, peak value, peak date, seasonal pollen index [SPI]) and predictive models for the season parameters have been presented in the temperate regions (Emberlin et al. 1993, 1994; Cassagne et al. 2008; Smith et al. 2009; García-Mozo et al. 2010; Kasprzyk & Walanus 2010; Piotrowska

Correspondence: Tiwalade Adeyemi Adeniyi, Laboratory of Palynology/Paleobotany, Department of Botany, University of Lagos, Lagos, Nigeria. E-mail: *dessytwa@yahoo.com*

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2012; Fernández-Rodríguez et al. 2015; Myszkowska et al. 2015). This information is not readily available in Africa. In Nigeria, there are no specific aerobiological studies on Poaceae pollen as seen in other European and American regions. The works of Njokuocha (2006), Adeonipekun et al. (2016) and Ezike et al. (2016) recorded the presence of Poaceae pollen in dominant amounts in the air. However, they did not specifically discuss the Poaceae pollen season peaks or correlation coefficients with weather parameters which would have helped in developing forecast models. This has created several limitations in understanding the pollen seasons and predictive models of these notorious allergens.

Poaceae pollen grains are usually spheroidal or ovoidal and their microscopic size and exine wall facilitate their dispersal. Their notoriety, ubiquity and copious productivity therefore make their monitoring necessary due to their impact on human health. The present study therefore analyses the prevalence of Poaceae pollen in order to: (i) characterise its spatial distribution in the study areas; (ii) recognise the pollen seasons; (iii) deduce the effect of meteorological parameters on the Poaceae pollen in the air; (iv) assess the level of exposure of inhabitants in study areas.

Material and methods

Study area

Lagos State is the most populated state in the country. It is situated in south-western Nigeria and has a humid tropical climate characterised by two wet (April to July and October and November) and two dry (August, and December to March) seasons (Ogundele 2012). Mean annual rainfall varies between 1381.7 mm and 2733.4 mm with an average of 2500 mm while monthly rainfall ranges between 25 mm to over 400 mm. Maximum temperature ranges between 29 °C and 34 °C and minimum ranges between 24 °C and 28 °C. Relative humidity is high throughout the year (above 70%) (Ogundele 2012).

The sampling areas for this study are located within the Lagos metropolis (Central Lagos State). The five sampling locations are within three local government areas. They are: Shomolu (consisting of University of Lagos, Gbagada and Bariga), Lagos Mainland (Ebute-Metta) and Surulere (Surulere) Local Governments (Figure 1). Shomolu Local Government is dominated by herbs of *Alchornea cordifolia* Mull. Arg., *Amaranthus*, *Gomphrena*, trees of *Elaeis guineensis* Jacq., *Cocos nucifera* L., *Mangifera indica* L., *Casuarina equisetifolia* L. and *Terminalia catappa* L., grasses such as *Panicum maximum* Jacq., *Axonopus compressus* (Sw.) P. Beauv., *Cynodon dactylon* (L.) Pers., *Pennisetum purpureum* Schumach., numerous plantations of vegetables (*Amaranthus*, *Celosia*) and weeds of Cyperaceae (Adeniyi et al. 2014). Most of the diverse flora in this area is found in the University of Lagos campus, Akoka. Many people from various parts of the State and across the country visit this area for educational, business and social purposes (Adeniyi et al. 2014). Lagos Mainland Local Government sampler location, Ebute-Metta, is on the border between Lagos Island and the mainland. The most significant

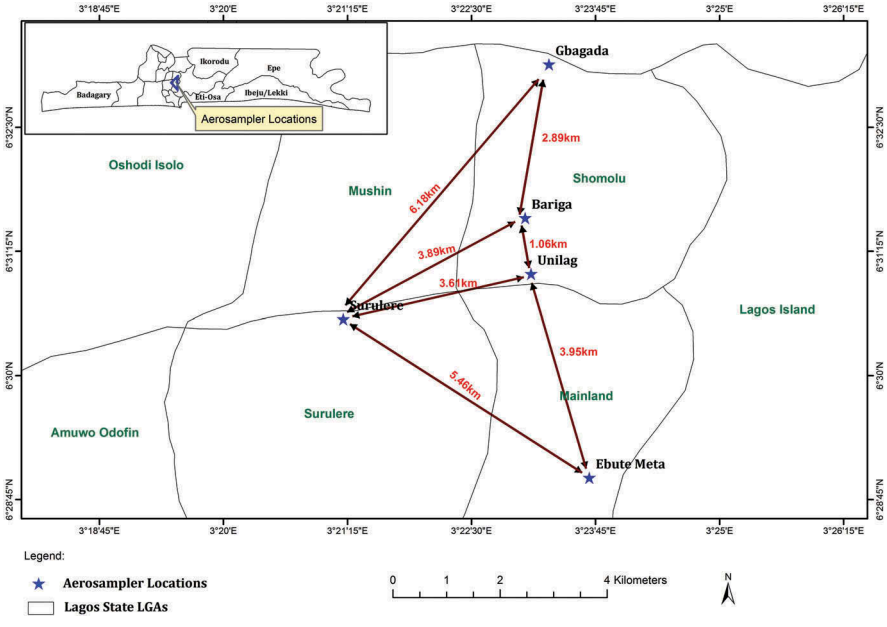

Figure 1. Sampling areas for this study.

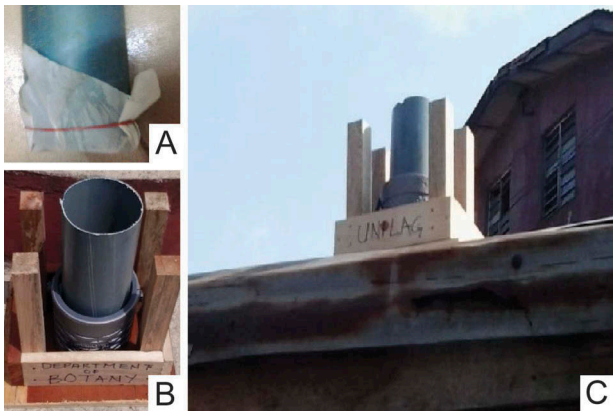

Figure 2. Modified Gbenga-2 aerosampler (Adeonipekun 2012). **A.** Sampler cylinder with 5 μm sieve. **B.** Sampler setup complete in UniLag. **C.** Mounted sampler on 2 m high shop in Ebute-Metta.

aspects of the flora are poorly managed ornamental plants, grasses and weeds. Many people visit Ebute-Metta to board diverse transport means (water, rail, road) which are readily available in the area. Surulere Local Government is a residential and commercial Local Government Area. Vegetation in the area is also depleted except for private parks and gardens around the array of housing estates.

Aeroflora sample collection

Five aerofloral samplers Gbenga-2, as constructed by Adeonipekun (2012), were used (Figure 2). The sampler uses the gravimetric principle of aerosampling. The sampler was constructed of a 10 cm diameter plastic cylinder with a height of 15 cm. A 5 μm sized mesh sieve was used in covering the base of the plastic cylinder with the aid of a band-like clamp. This setup was placed inside an open 12 cm diameter and 10 cm high food flask. The entire setup was placed in a wooden box to prevent it being dislodged by the wind. Fifteen millilitres of formaldehyde was added to 20 ml of glycerol and 10 ml of distilled water in the plastic cylinder of each sampler. The mixture in the cylinder was monitored every week to check its volume and assess if there was need to replenish during the dry season. The samplers were placed on the roof of a shop at about 2 m above ground level (Dola et al. 2004) in each sampling location. Samples were collected monthly from January 2013 to December 2014. Daily sampling using Hirst type volumetric samplers would have given a more accurate interpretation of the pollen season, but the fact that regular electricity is not guaranteed makes the use of this type of sampler unsuitable for this work in Nigeria. Moreover, the monthly replacement of the micron-sized sieve mesh and the ability of the sampler to avoid flooding during heavy rainfall makes the gravimetric method practical and affordable.

Sample preparation and analysis

Upon the removal of the plastic cylinder, the sediment was carefully washed into plastic vials with formaldehyde. Standard palynological preparation technique was adopted where the sediments were acetolysed according to Erdtman (1969). The resulting residue was washed with distilled water and stored in a vial with a known volume of glycerine (0.2 ml). Twenty microlitres of the residue was dropped on a microslide and covered with a coverslip. Nail polish was used to seal the edges of the coverslip. Two slides were prepared and studied from each residue (Adeonipekun & John 2011). Only Poaceae pollen were counted on the total surface area of the two slides.

Data collection and analysis

Meteorological data was collected from the Nigerian Meteorological Agency, Nigeria for the studied months (Table I). With the use of IBM SPSS computer program, non-parametric statistical analysis by Spearman's rank correlation test was applied to determine the relationship between monthly Poaceae pollen concentrations and meteorological parameters and its significance.

Results

A total of 1851 Poaceae pollen were recorded in all locations in 2013 while 1892 were recorded in 2014. The lowest count in 2013 was recorded in the Ebute-Metta area (179), while the highest in 2013 was recorded in Gbagada (564). In 2014, the Surulere area (282) had the lowest count while Bariga (671) had the highest (Figure 3). In UniLag and Gbagada, Poaceae pollen counts were higher in 2013 (556 and 564, respectively) than 2014 (279 and 377, respectively) whereas in Surulere, Ebute-Metta and Bariga, pollen counts were higher in 2014 (282, 283 and 671, respectively) than 2013 (229, 179 and 323, respectively).

Major and minor peaks in Poaceae pollen seasons varied with sampling location and year. In Surulere, the major Poaceae pollen peak was in December and the minor peak was in October in 2013, while the major peak was in January and the minor peak was in March in 2014. In Ebute-Metta, the major Poaceae pollen peak was in December and the minor peak was in January in 2013 while the major peak was in

Table I. Meteorological parameters for 2013 and 2014 in Lagos State.

Year	Months	Temperature (°C)	Average rainfall (mm)	Relative humidity (%)	Wind speed (km/h)
2013	January	28	6.7	76	6
	February	29	0.5	78	7
	March	29	2.4	80	8
	April	28	3.5	82	7
	May	27	6.4	85	6
	June	27	1.5	87	7
	July	26	3.3	90	9
	August	29	2.4	86	8
	September	27	3.8	89	11
	October	27	2.2	85	7
	November	28	5.9	85	6
	December	27	2.6	82	7
	Mean	27.67	3.43	83.75	7.42
2014	January	28	2.5	80	9
	February	28	2	80	8
	March	28	0.6	79	12
	April	28	4.5	82	8
	May	28	5.7	85	7
	June	27	4.4	88	6
	July	26	6.5	89	8
	August	25	3.5	88	8
	September	26	4.7	88	8
	October	27	1.9	85	8
	November	28	2.9	84	6
	December	29	5.7	84	5
	Mean	27.33	3.74	84.33	7.75

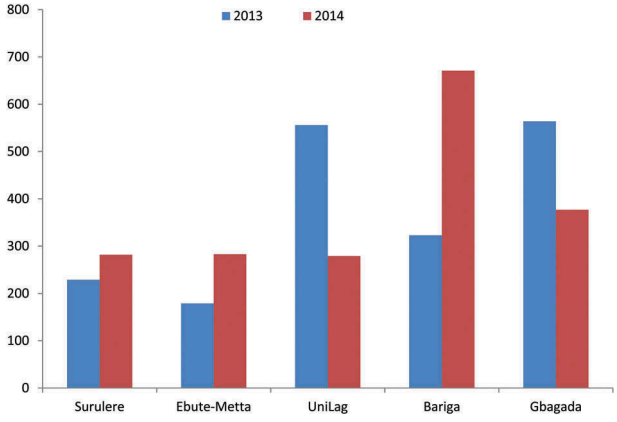

Figure 3. Poaceae pollen count in five regions in Central Lagos State.

January and the minor peak was in March in 2014. In UniLag and Gbagada, the Poaceae pollen major peak was in October and the minor peak was in December in 2013, while the major peak was in March and minor peak was in January in 2014. In Bariga, the major Poaceae pollen peak was in January and the minor peak was in December in 2013 while the major peak was in March and the minor peak was in January in 2014. Despite these dissimilarities in peak seasons, the lowest pollen counts were however recorded in June and July for all the sampled areas (Figure 4).

The year 2013 recorded its highest temperature (29 °C) in February, March and August, while 2014 recorded its highest (29 °C) in December. Lowest temperature values for both years were recorded in August 2014 (25 °C). Average annual temperature was higher in 2013 (27.67 °C) than 2014 (27.33 °C). As expected, there was more precipitation and higher relative humidity in 2014 (3.74 mm; 84.33%) compared to 2013 (3.43 mm; 83.75%). February was the driest month of 2013 (0.5 mm rainfall) while March recorded the least rainfall in 2014 (0.6 mm). Highest rainfall values were recorded in January 2013 (6.7 mm) and July 2014 (6.5 mm). July 2013 and 2014 recorded the highest relative humidity (90% and 89%, respectively) while January 2013 recorded the least (76%). Wind speed values were highest in September for 2013 (11 km/h) and March for 2014 (12 km/h). The annual average wind speed was higher in 2014 (7.75 km/h) than 2013 (7.42 km/h) (Table I).

Temperature and wind speed had insignificant positive correlations with Poaceae pollen counts in all locations ($p \leq 0.05$). Rainfall had negative insig-

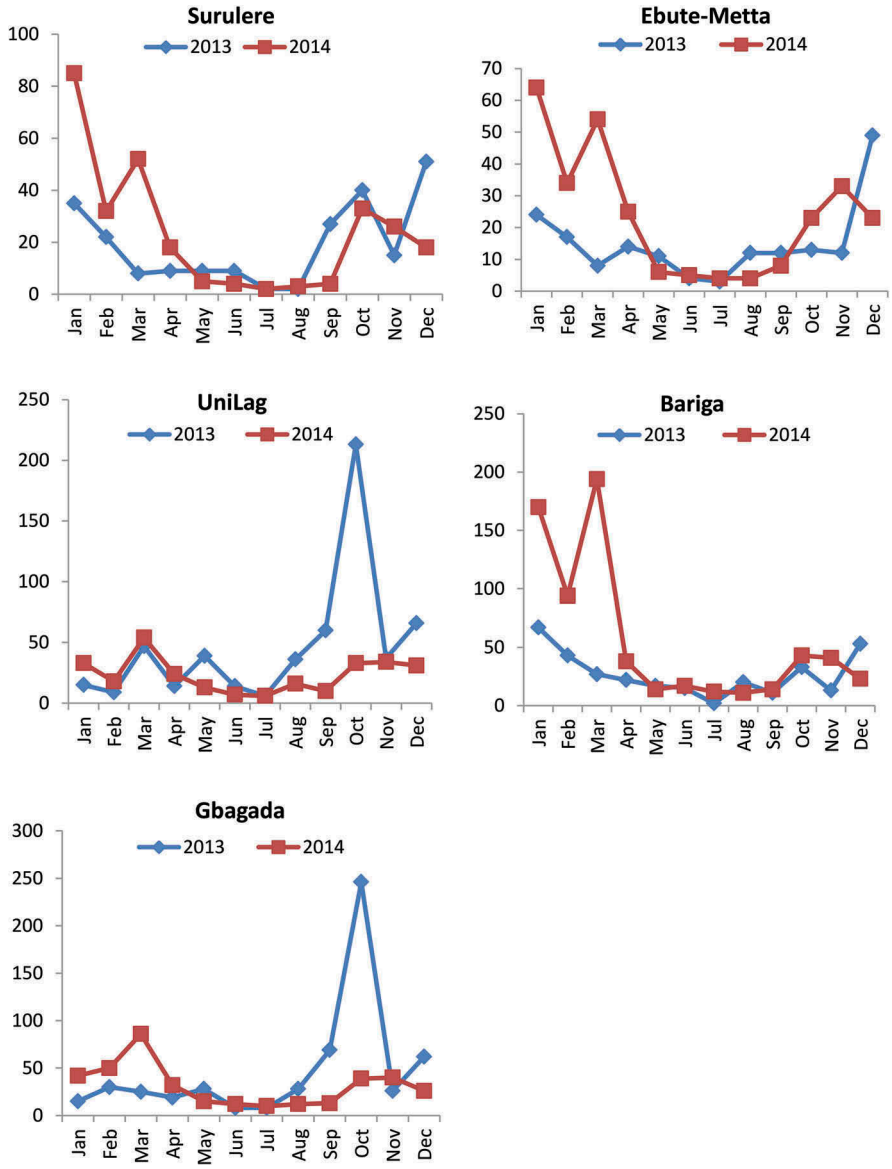

Figure 4. Monthly Poaceae pollen distribution of five regions in Central Lagos State.

nificant correlation with Poaceae pollen counts in all locations ($p \leq 0.05$). Poaceae pollen counts in all locations had negative correlations with relative humidity and this was significant in Surulere, Ebute-Metta and Bariga ($p \leq 0.05$). Poaceae pollen counts in Bariga and Ebute-Metta had significant negative correlation with relative humidity (Table II).

Table II. Correlation coefficients between Poaceae pollen counts and meteorological parameters.

	Meteorological parameters			
Locations	Temperature (°C)	Rainfall (mm)	Relative humidity (%)	Wind speed (km/h)
Surulere	0.2137	−0.3711	−0.5606	0.2944
Ebute-Metta	0.3217	−0.3573	−0.6202*	0.2770
Unilag	0.0162	−0.2372	−0.0358	0.0636
Bariga	0.282	−0.4245	−0.6360*	0.4762
Gbagada	0.0148	−0.3325	−0.1028	0.1659

*Correlation is significant at the 0.05 level.

Discussion

This is the first time that several pollen traps were placed in Lagos within a small radius to study variations in Poaceae pollen. A total of 1851 (2013) and 1892 (2014) Poaceae pollen were recorded, which is much lower than what Adeonipkeun et al. (2016) recorded in Ayetoro, south-western Nigeria (7276) using a similar sampler and located within the same geopolitical zone (south-western Nigeria). This may be due to the urban environment of the study area compared to the rural and agricultural environment sampled by Adeonipekun et al. (2016) with more abundant vegetation. Dominant Poaceae in the studied areas of the present work include: *Panicum maximum*, *Cynodon dactylon*, *Pennisetum purpureum* Schumach., *Sporobolus* sp. and *Axonopus compressus.*

In the present study it was also found that though the five studied locations were very close spatially (within 8 km radius), different grass pollen counts were recorded. This can be attributed to the different vegetation of the locations. The high counts of grass pollen in Gbagada and Bariga may be attributed to the gardens and parks around these locations. Hence, they are marked as the highest risk sites for allergy sufferers. High human population density in the Ebute-Metta region is greatly responsible for reduction in vegetation cover which was ultimately reflected in the low grass pollen abundance in the area. This location is recommended as a low risk region for Poaceae pollen allergy sufferers in Lagos. The highly diverse vegetation nature in UniLag seems to account for the relatively moderate counts. However, the highly populated built-up residential nature of Surulere that is characterised with choice tree gardens accounted for the low count in this area.

As recorded by Njokuocha (2007) and Adeonipekun et al. (2016) in Nigeria Poaceae pollen occurred throughout the year also over the study areas. Also in sub-tropical India, it was recorded all year round (Singh et al. 2003; Chauhan & Goyal 2006; Mahney & Chaurasia 2008). Hence, according to Mahney and Chaurasia (2008), no definite pollen season for Poaceae can be demarcated because their plants exhibit flowering throughout the year and keep on contributing pollen grains to the atmosphere.

Earlier studies of Emberlin et al. (1990, 1993, 1994) and Szczepanek (1994) noticed this phenomenon when they recorded the presence of grass pollen for many months beyond the pollen season, though the pollen count was low. They suspected most of the grains probably came from re-deposition. Similar results were obtained in this work because beyond the pollen peak there was a gradual reduction in Poaceae pollen to a minimum in June and July before the gradual start of the season again which was dependent on location. According to Njokuocha (2007), these minimum values were recorded from May to August in Nsukka; Adeonipekun et al. (2016) recorded them in April in Ayetoro while Ezike et al. (2016) recorded the lowest values from March to May in Abuja all within Nigeria. In sub-tropical countries such as India, it was recorded in June (Singh et al. 2003; Chauhan & Goyal 2006; Mahney & Chaurasia 2008). However, in the temperate regions, different months for minimum values were recorded. In Italy, (Rizzi-Longo et al. 2007), Spain (Recio et al. 1998), and Turkey (Altintas et al. 2004; Kizilpinar et al. 2011), minimum values were recorded from November to February which coincides with their winter season.

Szczepanek (1994) also distinguished two groups of taxa of different courses of pollen seasons. The first group comprises of taxa whose pollen season is characterised by compact single-peak seasons. The second group comprises taxa whose pollen seasons are long and show many peaks in subsequent years including grasses. The second group was observed in this work. The peak pollen months varied in the different areas and in each year in this study due mainly to different local vegetation types. In 2013, Bariga recorded the earliest major peak period in January. Gbagada and Unilag had similar major peaks in October while Surulere and Ebute-Metta recorded the latest major peak in December. In 2014, Surulere recorded the earliest major peak period in January; this was also similar in Ebute-Metta. This could be as a result of their December peaks in 2013, indicating a continuation of the pollen season across two years. However, they had varying minor peak months; Ebute-Metta recorded a late minor peak in December while Surulere was in October. Bariga, Gbagada and UniLag had similar major peaks in March. Similarities and differences were observed when these pollen season peaks were compared to other works in Nigeria. The major and minor peaks were recorded at November and December in south-eastern Nigeria (Njokuocha, 2007), November and March in south-western Nigeria (Adeonipekun et al. 2016), and October and September in north-central Nigeria (Ezike et al. 2016). The reason for this could be attributed to variances in vegetation types and composition as well as frequency of data collection and the regional climatic variation. In other parts of the world such as sub-tropical India, the major peak season was from September to October while minor peak was from March to April (Singh et al. 2003; Chauhan & Goyal 2006; Mahney & Chaurasia 2008). However, in the temperate regions as reported, only a major peak was recorded between May and July in Italy (Rizzi-Longo et al. 2007), Spain (Recio et al. 1998), and

Turkey (Altintaş et al. 2004; Kizilpinar et al. 2011), and this period coincides with their summer season.

As indicated by the results of previous workers, multiple and accumulated weather parameters and aerobiological monitoring for a long period is necessary for a complete understanding of the relationship between meteorology and aerobiology as evident from the various insignificant statistical correlations from this work. Nevertheless, this work is the first to report a two year aeropollen data collection and study in Nigeria.

Conclusion

Poaceae pollen counts in the air of Central Lagos State recorded the lowest values in the months of June and July which happen to be the wettest months. Analysis of the Poaceae pollen distribution in different regions varied according to human population and their standards of living as well as vegetation structure with its floristic composition. It was shown that the highest exposures are in Gbagada and Bariga, but a moderately high value was also recorded in UniLag making these areas the highest risk for grass pollen hypersensitive individuals. The lowest exposures were in Ebute-Metta and Surulere marking those areas a relatively low risk for grass pollen hypersensitive individuals.

Disclosure statement

No potential conflict of interest was reported by the authors.

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