The Study of Airborne Pollen Precipitation in the University of Nigeria (Nsukka) Botanic Garden

Njokuocha, R. C. and Ukeje, H. O.
Department of Botany, University of Nigeria, Nsukka, Nigeria

Corresponding author: Njokuocha, R. C., Department of Botany, University of Nigeria, Nsukka, Nigeria. Email: njokuwhyte66@yahoo.com Phone: 08045255455

Abstract

Indigenous and introduced trees as well as shrubs and herbs populate the Botanic Garden as well as the university environment. a study of the pollen rain within the garden was carried out using Tauber's trap. A total of 59 pollen types belonging to 38 plant families and consisting of 59 genera were identified. The pollen of trees reflects a minor proportion of the local tree species in the garden. Shrubs, herbs, weeds and climbers present in the garden exhibited major representation of their pollen influx than those from outside influx. Grass pollen grains were also richly represented. The pollen assemblage indicates that contributing trees and grasses were mainly from outside the Botanic Garden. Generally, the pollen rain was indicative of forest-savanna mosaic vegetation.

Keywords: Airborne pollen grains, Plant groups, Precipitation, Tauber's trap, Pollen influx.

Introduction

Pollen grains are released from the anthers in response to the need for reproduction by the numerous and diverse plant species inhabiting the various vegetations. Daily, millions of these pollen grains are injected into the air mass primarily to accomplish pollination of compatible plant species. However, those that fail in this fundamental role are precipitated by gravitational force or force of impaction (Tauber, 1977; Traverse, 1988) or by rain washout (Agwu, 1997; Njokuocha and Osayi, 2005). The height and distance attained by these pollen grains are influenced by a number of factors such as the speed of the wafting wind, among others (Lyon *et al.*, 1984; Khandelwal, 1988; Dupont and Agwu, 1991 and Dupont, 1993).

Because it is possible to identify the representative pollen types to the producing plants, the pollens are believed to reflect the floristic composition of their source areas despite the influences of long distance pollen transport. Usually in the interpretation of pollen assemblages one major assumption is that the abundance of pollen or group of pollen types represents the abundance of plants or group of plants that produce them. How correct such intuitive interpretation is depends on a number of factors, such as the knowledge of differential production and effective dispersal of pollen among the different plant species, especially between the anemophilous and entomophilous plants, and that of long distance pollen transport. From Traverse (1988) and Sugita (1994), it can be deduced that there is a relationship between modern and fossil palynoflora. That is why, to make a more accurate reconstruction of unknown past vegetation and appreciate the usefulness of fossil pollen, it is necessary to gain a better understanding of the present relationship between the plants that grow in an area and the resulting representative pollen rain. The benefit of such knowledge is that the interpretation of proxy fossil pollen assemblages will most likely draw information from the principles governing the relationship between the past and the present. Also, the modern pollen vegetation records may provide important analogues for the interpretation and responses of current vegetation to future environmental changes (Calleja and Campo, 1990; cf Sugita, 1994).

In the distribution and dispersal of pollen, significance has been attached to air current as an important means of pollen transport, especially in areas where the dominant pollen input is aeolian. According to Emberlin, *et al.* (1999), pollen transport by air flow over longer distances is likely to occur under a range of weather situations such as uplift and horizontal movement in convention cells and frontal storms, respectively. It has been reported that higher wind speeds results to increase in distance traveled by pollen (Lyon, *et al.*, 1984), while increased turbulence leads to greater impaction (Emberlin *et al.*, 1999) and precipitation of pollen. According to Naidina and Bauch (1999), it has been established that pollen transportation into deposits of various origin is principally governed by aerial transportation.

Variations also exist in the rate and amount of pollen grains precipitated periodically. Major flowering seasons, wind movement, rainfall, topography and dense vegetation cover are some of the identified factors that influence pollen precipitation (Tauber, 1977; Agwu, 1997 and Emberlin, *et al.*, 1999). Tauber (1977) and Markgraf (1980) reported that the major peaks of air borne pollen precipitation are the major flowering seasons and period of high rainfall.

During the flowering season of most plants, especially the anemophilous angiosperms, large quantity of pollen grains are produced in excess of their biological needs (Agwu, 1997). The entomophilous plants that normally dominate the component vegetation species of most tropical African regions have their pollen either absent or poorly represented in most pollen spectra (Elenga *et al.*, 2000). Low pollen production and poor aerodynamic properties of the pollen grains are partly responsible for the poor representation in pollen assemblages.

Therefore, to appreciate this pollen-vegetation representation relationship, a study was conducted in the small enclosure of the Botanic Garden of the University of Nigeria as a first step in understanding the pollen-vegetation representation relationship prevalent in the Nsukka environment. The aim of the study was therefore to ascertain the relationship between pollen precipitation and major vegetation composition of the Botanic Garden of the University of Nigeria, Nsukka.

Material and Methods

The study was carried out with Tauber's pollen trap (Tauber, 1974) which is a passive sampler. Basically, the sampler is a cylindrical container closed at the top by an aerodynamically circular-shaped lid with a circular opening (5cm in diameter) at the apex. Through this opening airborne particles precipitating from the air enter the sampler and become trapped in a liquid medium consisting of a mixture of glycerol, formalin and phenol (10: 5: 1) that act as a bactericide.

The sampler was mounted in the western end of the Botanic Garden and samples were collected every month for a period of nine month from December 2000 to August 2001. The precipitates in each sample were concentrated by centrifugation at 2000 revolutions per minute for 10 minutes. The precipitates were treated with 10% Hydrofluoric acid for 3 days to digest siliceous materials. The precipitates were subsequently subjected to acetolysis treatment adopted from Moore and Webb (1978).

The pollen residues obtained were diluted in glycerol in specimen bottles. Routine counting and identification was done using a binocular microscope. Two specimen slides were studied per sample and the average obtained by extrapolation to give the number of palynomorphs counted. The spores of fungi and pteridophytes were grouped under fungal spores and pteridophyte spores, respectively. The unidentified pollen grains were grouped under varia/indeterminate.

The Botanic Garden where the study was conducted covers an area of about 6,838m^2 and was partitioned into 6 units and the qualitative floristic inventories of the major plants in the garden were taken on basis of habits: trees, shrubs, herbs, weeds and climbers. Emphasis was placed on the plants that have attained flowering stage. The different pollen types of the different plant species were compared only for presence or absence with the qualitative floristic inventories of the major plants in the garden so as to assess the differential pollen type representation. The vegetation and climate of Nsukka have been widely published in Agwu (1997) and Agwu, *et al.* (2004).

Results and Discussion

The botanic garden is composed of a mixture of different plant species majority of which are typical of a Mosaic Savanna and Lowland Rainforest species. The preliminary inventory of the vegetation components revealed about 37 Families of flowering plants excluding the pteridophytes and gymnosperm (Tab. 1). These are composed of diverse tree, shrubs, herbs, weeds and grasses most of which are characteristic of Forest Savanna and Mosaic Farmland species intermingled with introduced plant species. The analysis of the pollen precipitation shows that the pollen types identified do not reflect adequately the vegetation characteristics of the garden, an indication that the pollen influx were derived from both the immediate and surrounding vegetations (Tab. 2).

The tree pollen types that dominate the pollen assemblage reflect only a minor proportion of the local tree species. Of the 31 tree pollen types counted, only 11 tree types were derived from the garden, the remaining 20 pollen types were transported from outside. But the tree inventory shows that 34 trees that have attained flowering stage were counted, showing that 23 trees were not represented in the pollen spectra (Tab. 1). Among these trees are *Treculia africana, Mangifera indica, Cola* sp., *Adenanthera pavoniana, Gambeya albidum, Piliostigma thonningii, Azadirachta indica, Amphimas* sp, *Senna siemae, S. siberiana, Afzelia africana, Persea americana* and *Cussonia barteri.*

The tree pollen types transported from outside the garden include *Ceiba pentandra, Spondias mombin, Casuarina equisetifolia, Lophira lanceolata, Syzygium guinense, Milicia excelsa, Irvingia wombolu* and *Pinus* sp. Comparable results have also been obtained by Elenga *et. al.* (2000), Jolly *et al.* (1996), cf Dodson (1992) and Agwu *et al.* (2004). It has been reported that the prevailing wind regime during the period of main pollen release influence the kind and quantity of pollen in the air (cf Naida and Bauch, 1979; Tauber, 1977; Dupont and Agwu, 1991; Hoogiemstra *et al.*, 1986). Trees inhabiting open forest are most likely to have their pollen transported farther before they are precipitated, especially the anemophilous taxa (Tauber, 1977). However, in contrast, Jolly *et al.* (1996) in their work reported that in densely forested environments, numerous common canopy trees (entomophilous trees) were under-represented or absent in pollen assemblage, thereby showing a poor reflection of the pollen rain in relation to the floristic diversity of the forests.

The shrubs, herbs, weeds and climbers in the garden exhibited major representation in the pollen influx, though the number of pollen types of each plant group does not reflect quite accurately the diverse species composition and dominance in the garden. Among the shrubs represented in the pollen spectra are Euphorbia sp, *Montandra guineensis, Costus afar, Nauclea latifolia, Cnestis ferruginea* and *Protea angolensis;* herbs, weeds and climbers include *Senna* spp, *Sida acuta, Gloriosa superba, Ipomoea involucrata, Cyperus, Aneilema, Mimosa pigra,* Amaranthaceae/Chenopodiaceae and Asteraceae complex (*Aspilia africana, Emilia sonchifolia, Vernonia* sp, *Chromolaena odorata, Argeratum conyzoides, Gutenbergia* sp). The shrubs, herbs, weeds and climbers not represented were *Bryophyllum, Rauvolfia vomitoria, Alamanda cathateica, Costus afar, Ricinus communis,*

Table 1: Pollen spectra and vegetation representation relationship among plant groups in the Botanic Garden, University of Nigeria, Nsukka

Plant Groups	Pollen Assemblage (Pollen Types)	Vegetation Inventory	Outside Pollen Influx
Family	Number of Families - 39	Number of Families- 37 (presently identified)	
Trees	31 pollen types identified	34 trees counted (11 trees represented in pollen spectra and 23 not represented)	11 pollen types from outside
Shrubs	9 pollen types identified	18 shrubs counted (9 shrubs not represented)	3 pollen types from outside
Herbs	7 pollen types identified	10 herbs counted (3 herbs not present in pollen spectra)	-
Climbers	4 Pollen types	10 herbs counted (3 herbs not present in pollen spectra)	-
Weeds	8 pollen types identified, others grouped under Asteraceae and Amaranthaceae/Chenopodiaceae	Numerous (not classified)	Outside pollen influx possibly few
Poaceae (Grasses)	Poaceae pollen highly represented	Poaceae plants not numerous	Outside pollen influx most probably contributed highly

Table 2: List of some important ecological plant species in pollen spectra, vegetation inventory and outside pollen influx compared for their presence or absence in the study of pollen rain in the Botanic Garden, University of Nigeria, Nsukka

Taxa	Pollen spectra	Vegetation composition	outside pollen influx
Acidanthera sp	+	-	-
Adansonia digitata	+	+	-
Adenium sp	-	+	-
Adnanthera pvoniana	-	+	-
Afzelia africana	-	+	-
Albizia sp	+	+	-
Alchornea cordifolia	+	-	+
Amaranthaceae/ Chenopodiaceae	+	+	-
Amphimas sp	-	+	-
Anacardium occidentale	+	+	-
Aneilema sp	+	+	-
Asteraceae	+	+	+
Azadirachta indica	-	+	-
Bombax buonopozense	+	-	+
Bridelia ferruginea	+	+	-
Casuarina equisetifolia	+	-	+
Ceiba pentandra	+	+	-
Celtis sp	+	-	+
Cissus quadrangularis	-	+	-
Clerodendron sp	+	+	-
Cnestis ferruginea	+	+	-
Costus afar	+	+	-
Crotalaria erinaceus	-	+	-
Cussonia barteri	-	+	-
Cyperus sp	+	+	-
Dialum guinense	+	-	+
Dracaena arborea	+	+	-
Elaeis guineensis	+	+	-
Erythrina sigmiodes	-	-	+
Euphorbia sp	+	+	-
Gambeya albidum	-	+	-
Gloriosa superba	+	+	-

Table 2 continues

Hymenocardia acida	+	-	+
Ipomoea involucrata	+	+	-
Jatropha curcas	+	+	-
Lagostroemia indica	-	+	-
Landolfia owariensis	-	+	-
Lonchocarpus inermis	-	+	-
Lophira sp	+	-	+
Mangifera indica	-	+	-
Milicia excelsa	+	-	+
Mimosa pigra	+	+	-
Montandra guineensis	+	-	+
Moringa oleifera	-	+	-
Nauclea latifolia	+	+	+
Olax sp	+	-	+
Oreodoxa regia	+	+	-
Pentaclethra macrophylla	+	-	+
Persea americana	-	+	-
Phyllanthus sp	+	+	-
Piliostma thonningii	-	+	-
Pinus sp	+	-	+
Palisota hirsuta	-	+	-
Poaceae	+	+	+
Poinciana regia	+	+	-
Protea angolensis	+	+	-
Pterocarpus erinaceus	+	+	-
Quisqualis indica	-	+	-
Rauvolfia vomitoria	-	+	-
Ricinus communis	-	+	-
Senna hirsuta	+	+	-
Senna spp	+	+	-
Sesbania sp	+	-	+
Sida acuta	+	+	-
Spondias mombin	+	-	+
Syzygium guineense	+	-	+
Tectona grandis	+	+	-
Terminalia spp	+	+	-
Tetracera affinis	+	-	+
Treculia africana	-	+	-
Irvingia wombolu	+	-	+
Zanthoxylum zanthoxyloides	+	-	-
Zygophyllum sp	+	+	-

Caesalpinea pulcherima and *Paullinia pinnata* (Tab. II). In previous studies conducted in the garden and university environment by Agwu (1997), Agwu et al. (2004), Agwu and Osibe (1992) and Njokuocha and Osayi (2005), these plants were well reflected in the pollen spectra, particularly the plants whose pollen are readily dispersed by wind.

The Poaceae that are dominating plant in Nsukka environment are copious producers of pollen from both wild and cultivated plants. The quantity of Poaceae pollen input counted in comparison to the standing grass community shows that a high proportion of the pollen influx must have come from outside the garden. Among the component members of this Poaceae family characteristic of Nsukka environment are *Andropogon tectorum, Loudetia arundinacea, Panicum maximum, Schizachyrum brevifolium, Anthephora ampulacea, Hyparrhenia barteri, Eragrostis aegyptiaca* and *Pennisetum purpureum,* among others.

A significant proportion of these pollen grains were derived from 38 families of flowering plants (29 dicotyledons and 8 monocotyledons) and one Gymnosperm. Of these families 20 and 38 pollen types were identified to the generic and specific levels, respectively (Tab. 1). In this work and others conducted in Nsukka by Agwu and Osibe (1992) and other places (Elenga *et al.*, 2000; Tauber, 1977 and Dodson, 1982), the result shows that the pollen assemblage reflects a dominance of the tree taxa when compared to the pollen representative of shrubs, herbs, weeds and climbers in the same vegetation site. This difference in the representative pollen of some plants and the vegetation composition of an area are attributed to a number of factors, such as the inhomogeneity in the flowering periodicity of the plant species and unequal pollen production.

In tropical regions of Africa, notable variations exist in the quantity of pollen production and dispersal between different plant species particularly between the entomophilous and anemophilous species (Agwu, 1997). The result of this work shows that there are some plants that are prominently present in the garden but because they are low pollen producers their pollen are either not represented or are poorly represented in the pollen spectra counted. These include such entomophilous taxa as *Amphimas, Piliostima thonningii, Rauvolfia vomitoria, Adasonia digitata, Mangifera indica, Trelizia, Cissus quadrangularis, Cussonia barteri, Senna siberiana* and *Afzelia* Africana. The absence of such taxa in the pollen assemblage cannot be correctly regarded as absence of the plants. In contrast, some plants that exhibit high pollen production and effective dispersal, mainly anemophilous plants such as *Elaeis guineensis, Terminalia ivorensis, Casuarina equisetifolia* and *Albizia* are well represented (Tab. II). If the pollen of such plants are absent in a pollen spectra it strongly suggests their absence in the vicinity of the site, while their low percentage may reflect long distance transport (Elenga *et al.*, 2000).

The import of such an evaluation is that the interpretation of modern pollen assemblage calls for caution and requires good knowledge of the vegetation physiognomy of the study area or region. This particularly becomes more imperative when dealing with fossil pollen assemblage that draws its interpretation from the principles governing modern pollen-vegetation-climatic relationships (Calleja and Campo, 1990; Sugita, 1994). The differences observed however, between pollen spectra and vegetation inventory can be attributed partly to the fact that pollen types of certain families such as Asteraceae, Amaranthaceae /Chenopodiaceae, Poaceae and Combretaceae /Melastomataceae cannot be readily identified to the generic or specific level. Also the lumping of some pollen grains into varia/indeterminata as a result of difficulty of identification is equally a contributing factor. However, despite these identification difficulties, the limitations of the sampler and open nature of the garden vegetation that permits in and out flow of pollen grains, the result generally still reflects the diversity and characteristic forest savanna and mosaic farmland vegetation of the garden.

Conclusion: This study, which was carried out to ascertain the relationship between pollen precipitation and the quantitative floristic composition of the plants in the garden, indicate that marked difference exists in the observed relationship. Consequently, in interpreting modern pollen assemblages, caution should be exercised.

Reference

Agwu, C. O. C. (1997). Modern pollen rain in Nsukka: An indicator of the vegetation of Nsukka plateau. *Wurburger Geographische Arbeiten 92*: 97 – 115.

Agwu, C. O. C. (2001). A study of Niger Delta environment through airborne palynomorphs, PortHarcourt, Nigeria. *Palaeoecology of Africa 27*: 191 – 185.

Agwu, C. O. C. and Osibe, E. E. (1992). Airborne palynomorphs of Nsukka during the months of February-April, 1990. *Nigerian Journal of Botany 5*: 177 – 185.

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. *Journal of Biological Research and Biotechnology 2 (2):* 9 – 19.

Calleja, C. and Campo, E. V. (1990). Pluei pollinique le long d'un transect Atlantique Afrique-Bahamas. C. R. Academic Science Paris t. 310, *11*: 1321 – 1326.

Dodson, J. R. (1982). Modern pollen rain and recent vegetation history on Lord Howe Island: Evidence of human impact. *Review of Palaeobotany and Palynology 38*: 1 – 21.

Dupont, M. L. (1993). Vegetation zones in N.W. Africa during the Brunhes Chron. Reconstructed from marine palynological data. *Quaternary Science Review 12*: 189 – 202.

Dupont, M. L. and Agwu, C. O. C. (1991). Environmental control of pollen grain distribution patterns in the Gulf of Guinea and off-shore NW-Africa. *Geologische Rundschau 80 (3):* 567 – 589.

Elenga, H., de Namur, C., Vincens, A., Roux, M. and Schwartz, D. (2000). Use of plots to define pollen-vegetation relationships in densely forested ecosystems of Tropical Africa. *Review of Palaeobotany and Palynology 112*: 79 – 96.

Emberlin, J., Adams-Groom, B. and Tidmarsh, J. (1999). *A Report on the Dispersal of Maize pollen.* UK Soil Association, Uk, 21pp.

Hooghiemstra, H., Agwu, C. O. C. and Beug, H. J. (1986). Pollen and spore distribution in recent marine sediments: A record of NW-Africa seasonal wind patterns and vegetation belts. *"Meteor" Forsch-Ergebnisse* C *40*: 87 – 135.

Jolly, D., Burg, S., Bonnefille, R. and Roux, M. (1996). Representation pollinique de la foret dense humide du Gabon, tests statistiques. *Comptes Rendus de l'Academie des Sciences, Paris 322 (2):* 63 – 70.

Keay, R. W. J., Onochie, C. F. A. and Stanfield, D. P. (1960, 1964). *Nigerian Trees. Vols 1&2.* Nigerian National Press Ltd, Ibadan, Nigeria.

Khandelwal, A. (1988). Vertical Variation of Aerospora Concentration at Lucknow. *Geophytology 18 (2):* 173 – 185.

Lyon, F. L., Kramer, C. L. and Eversmeyer, G. M. (1984). Variation of airspora in the atmosphere due to weather conditions. *Grana 19*: 127 – 146.

Markgraf, V. (1980). Pollen dispersal in a mountain area. *Grana 19:* 127 –146.

Moore, P. D. and Webb, J. A. (1978). *An illustrated guide to pollen analysis.* Hodder and Stoghton, London.

Naidina, O. D. and Bauch, H. A. (1999). Distribution of pollen and spores in surface sediments of Laptevsea. In: Kassens, H. A., Eicken, H., Hubberten, H. W., Melles, M., Thiede, J. and Timokhov, L. (eds). *Land-Ocean Systems in the Siberian Artic: Dynamics and History.* Springer-Verlag, Berlin, 577 – 585.

Njokuocha, R. C. and Osayi, E. E. (2005). Airborne pollen and spore survey, in relation to allergy and plant pathogen. *Journal of Biological Research and Biotechnology 3* (*1*):

Sugita, S. (1994). Pollen representation of vegetation in quaternary sediments: theory and method in patchy vegetation. *Journal of Ecology 82*: 881 – 897.

Tauber, H. (1974). A static non-overload pollen collector. *New Phytology 73*: 359 – 369.

Tauber, H. (1977). Inverstigations of Aerial Pollen Transport in a Forested Area. *Dansk Botanisk Arkiv 32 (1):* 12 – 84.

Traverse, A. (1988). *Paleopalynology.* Unwin Hyman Ltd, London.