

REGIONAL-SPECIFIC POLLEN AND FUNGAL SPORE ALLERGENS IN SOUTH AFRICA

Dilys Berman, BA Hons

Allergy Diagnostic & Clinical Research Unit, University of Cape Town Lung Institute, Cape Town

Correspondence

Dilys Berman, e-mail dilys.berman@gmail.com

ABSTRACT

The selection of skin-prick and ImmunoCAP radioallergosorbent test (RAST) testing panels for tree, grass, weed and fungal spore aeroallergens is an easier task when pollen and fungal spore levels for the particular geographic area are accessible to the allergologist. In South Africa, long-term pollen and fungal spore level information exists for the Western Cape, where several areas in the greater Cape Town Metropole have been monitored. In Gauteng, sporadic pollen sampling studies have been carried out in the vicinity of Johannesburg and Pretoria. In KwaZulu-Natal, short-term studies have sampled airspora in Durban and Richards Bay, and a 3-year pollen and fungal spore assessment has been conducted in Secunda, Mpumalanga. These findings are examined in relation to the choice of allergen testing panels. There are vast unsampled areas of South Africa, containing major cities, where the major pollen allergens and their levels in the atmosphere are not known, and in addition, there is great variation in climate across these areas. Climate dictates the vegetation biome as well as the flowering times of allergenic plants. Guidelines for the selection of allergen testing panels in clinical settings, where no pollen monitoring exists, are discussed.

HISTORICAL BACKGROUND

David Ordman, who pioneered the study of environmental aeroallergens in South Africa from 1945 to 1972, outlined many of the environmental problems relating to aeroallergens in different regions of Southern Africa (South Africa, Zimbabwe and Namibia) providing a solid research base.¹⁻⁶ The discovery of the house-dust mite provided evidence for his observation that house dust at the coast was more allergenic than dust from houses inland, as house-dust mites prefer humid conditions.⁵ Ordman's examination of the incidence of allergic disease in population samples in urban vs rural environments in the same ethnic group were illuminating.⁵ Evidence-based studies in the second half of the twentieth century confirmed his theories.^{7,8}

His examination of the allergenicity and flowering times of grasses, such as *Hyperrhenia hirta*, which he noted as 'the dominant grass found east of the Drakensberg escarpment' or *Themeda triandra*, found west of the Drakensberg mountains² were expanded by Potter *et al.*⁹ and Prescott *et al.*¹⁰ who demonstrated IgE activity reactivity in >90% of patients tested for the African grass *Pennisetum clandestinum* (kikuyu), which was introduced from East Africa. Their work was expanded to study the indigenous grass, *Stenotaphrum secundatum* (buffalo grass) which grows in many coastal areas on the east coast of South Africa, and *Eragrostis curvula*, a pasture grass that is widespread in South

Africa. Ordman identified allergenic trees, such as *Cupressus* (cypress) and *Schinus molle* (Brazilian pepper tree) and his understanding of the influence of climate on respiratory disease established the groundwork for aerobiology and the identification of specific pollen and fungal spore allergens in South Africa.

WESTERN CAPE POLLEN SAMPLING STUDIES

Emeritus Professor Eugene Weinberg, who was head of the Allergy Clinic at Red Cross Children's Hospital for three decades, reintroduced pollen sampling to the Western Cape in 1973. He established a pollen and fungal spore monitoring programme at the School of Child and Adolescent Health, Department of Paediatrics, University of Cape Town. This monitoring system was set up to identify the allergenic pollen and fungal spores in the ambient air, and to measure the levels and assess the seasonality of the aeroallergens that triggered symptoms in his allergic patients. The range of pollens and fungal spores that the unit has been able to identify is shown in Table I. On his retirement, the pollen sampling programme was supported by Professor Paul Potter, head of the Allergy Diagnostic and Clinical Research Unit, at the University of Cape Town Lung Institute, using a volumetric spore trap, sited initially at the Land Survey Building in Mowbray and later at the South African Astronomical Observatory, in the suburb which bears its name.

Table I. Pollen grains & fungal spores identified by light microscopy

Pollen grains		Fungal spores
Cyperaceae	Ericaceae	<i>Alternaria</i>
Poaceae	Euphorbiaceae	Ascospores
Restionaceae	Iridaceae	<i>Aspergillus/Penicillium</i>
<i>Typhus</i>	Juncaceae	Basidiospores
<i>Acacia</i>	Liliaceae	<i>Bispora</i>
<i>Betula</i>	Loranthaceae	<i>Chaetomium</i>
Cupressaceae	Malvaceae	<i>Cladosporium</i>
Hippocastinaceae	Myricaceae	<i>Curvularia</i>
Moraceae	Oenotheraceae	<i>Epicoccum</i>
Myrtaceae	Oxalidaceae	<i>Nigrospora</i>
Oleaceae	<i>Plantago</i>	<i>Fusarium</i>
Pinaceae	Polygonaceae	<i>Helminthosporium</i>
Podocarpaceae	Polypodiaceae	<i>Leptosphaeria</i>
<i>Platanus</i>	Proteaceae	<i>Periconia</i>
<i>Populus</i>	Ranunculaceae	<i>Pithomyces</i>
<i>Prosopis</i>	Rosaceae	<i>Pleospora</i>
<i>Rhus</i>	<i>Rumex</i>	<i>Puccinia</i>
<i>Quercus</i>	Rutaceae	Rusts
Salicaceae	Solanaceae	Smuts
<i>Ulmus</i>	<i>Taraxacum</i>	<i>Spegazzinia</i>
<i>Casuarina</i>	Thymelaceae	<i>Stemphyllium</i>
Amaryllidaceae	Tiliaceae	<i>Tetraploa</i>
Asteraceae	Umbelliferae	<i>Torula</i>
Boraginaceae	Urticaceae	Mildew
Bruniaceae	<i>Parietaria</i>	
Caryophyllaceae		
Chenopodiaceae		

RONDEBOSCH SAMPLING SITE (1973-2007)

This aeroallergen monitoring programme, was set up at Red Cross Children's Hospital in Rondebosch, primarily for the benefit of the patients attending the Allergy Clinic at the hospital, but the findings were shared with the other academic hospitals in the Western Cape.

RONDEBOSCH POLLEN LEVELS

Grass was found to be the major aeroallergen in this area, which had a short tree season (August-October). Major tree pollen loads were found to be *Platanus* (plane) and *Quercus* (oak) with low levels of *Ulmus* (elm), *Myrtus* (eucalyptus) *Olea* (olive), *Cupressus* (cypress) *Pinus* (pine) and *Casuarina* pine. There were occasional low counts for *Acacia*, *Betula* (birch) *Populus* (poplar) and *Salix* (willow). Weed pollen levels were rarely significant and included: *Plantago* (English plantain), *Myrica* (sweet gale), *Chenopod*

(goosefoot), *Urtica* (nettle) and *Taraxacum* (dandelion). Very low levels were recorded for fern spores (*Polypodium*), *Rumex* (Polygonaceae) and *Oenothera* (evening primrose). The typical Cape *fynbos* was represented by low background counts of *Erica* (heather), Asteraceae (daisy family) and occasional *Protea* pollen grains.

RONDEBOSCH FUNGAL SPORE LEVELS

Fungal spore counts were variable and weather dependent but significant levels were consistently recorded for *Alternaria*, *Cladosporium* and *Epicoccum*. Ascospore levels peaked following rain and basidiospore levels rose in autumn months. The highest fungal spore levels were recorded during the spring and autumn seasons.¹¹

MOWBRAY SAMPLING SITE (2008-2009)

Similar findings to those from Red Cross Children's Hospital



Fig 1. The Burkard spore trap at the Land Survey Building site in Mowbray.

were recorded for this nearby site, the Land Survey Building (Fig. 1), which was deliberately chosen for continuity of the airspora levels.

MOWBRAY POLLEN LEVELS

In addition to the pollen allergens listed above, significant levels of *Rhus* (kareeboom) pollen were recorded. The grass pollen load appeared to be slighter than previously measured levels at the Rondebosch site, but this may have been attributable to meteorological conditions and as the spore traps were not run concurrently, grass levels at the two sampling sites could not be compared.

MOWBRAY FUNGAL SPORE LEVELS

The most important difference between this site and the other sites was the *Curvularia* peak each autumn when significant levels were seen for this genus (Fig. 2).¹²

OBSERVATORY SAMPLING SITE (2010 TO DATE)

OBSERVATORY POLLEN LEVELS

The most important difference regarding the pollen trapped at this site was that there was a longer tree pollen season with a larger tree pollen load. Significant levels for *Cupressus* (cypress), *Quercus* (oak), *Rhus* (kareeboom) and *Platanus* (plane) tree pollen were recorded, from early August until late October.

OBSERVATORY FUNGAL SPORE LEVELS

Observatory fungal spore levels were unremarkable and showed the usual increases for *Alternaria*, *Cladosporium* and *Epicoccum* that are usually seen during spring and autumn months. (D Berman - unpublished data).

TABLE VIEW SAMPLING SITE (1985 TO DATE)

The City of Cape Town added a pollen and fungal spore monitoring system to their Air Quality Monitoring Project in 1985 and this has been continued intermittently.

TABLE VIEW POLLEN LEVELS

In keeping with the climate of this West Coast sampling site, grass was the dominant pollen while the tree season was scant and fleeting (September-October). For the sampling

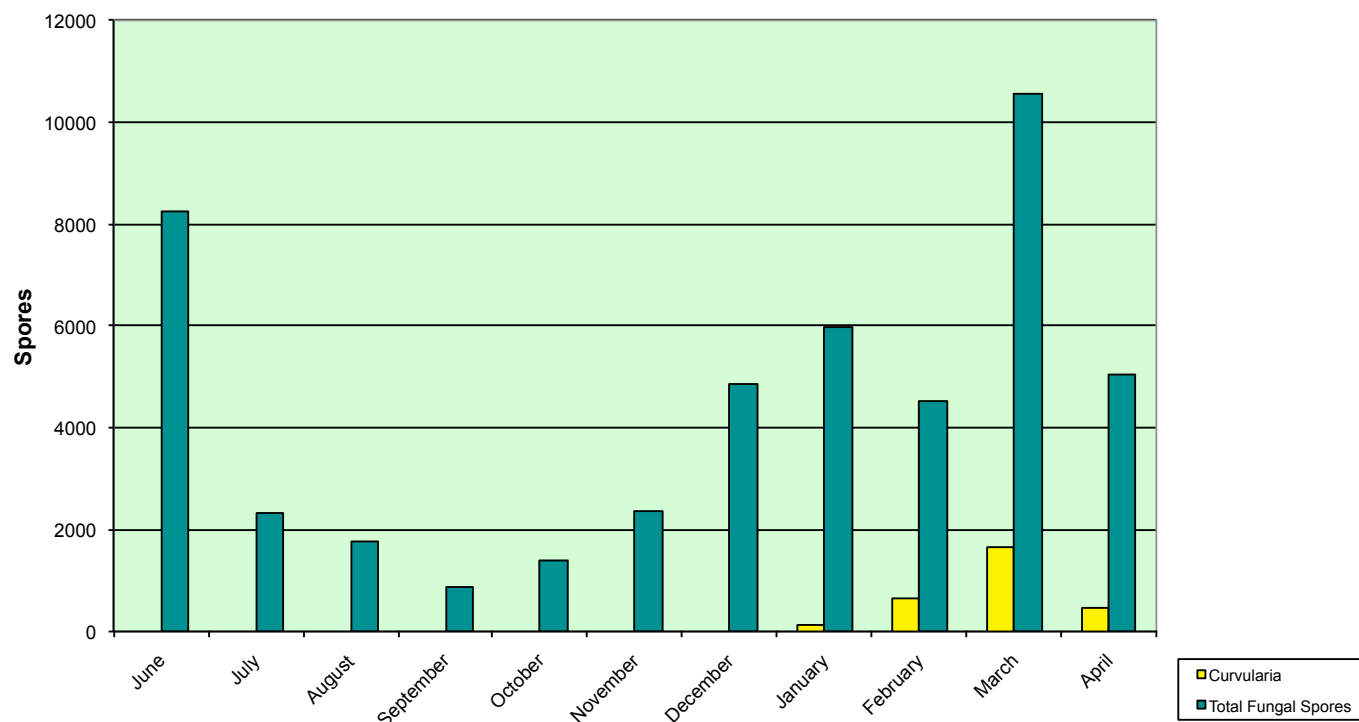


Fig. 2. Curvularia and total fungal spores for Mowbray 2008-2009.

years 1995-2003 the grass season began 2 weeks earlier at this site than at the inland sites. Weed pollen was not significant but higher scores for weeds were obtained from this coastal site when compared with the weed pollen levels at inland sampling sites.

TABLE VIEW FUNGAL SPORE LEVELS

The fungal spore levels were moderate overall at this sampling site, with sporadic autumn and spring peaks for *Alternaria* and *Cladosporium* (D Berman – unpublished data).

POLLEN MONITORING IN GAUTENG ATMOSPHERIC POLLEN LEVELS

Ordman's aerobiological studies in Gauteng were extended by Cadman, who noted that the climate zone of this city is grassland, bordering savanna. Pretoria North is situated in the savannah belt. Despite the strong presence of northern hemisphere trees, which have been introduced and naturalised, the tree pollen season is short (October-November).¹³ Trees that make up the spring tree pollen peak in this region are the following taxa:

- *Fraxinus* (ash)
- *Pinus* (pine)
- *Populus* (poplar)
- *Platanus* (plane)
- *Alnus* (elder)
- *Celtis* (stinkwood)

It is not surprising that the dominant pollen allergen in the sampled areas of Johannesburg and Pretoria is grass. The season runs from October to March, peaking later than the Cape grass season, as would be expected in this summer rainfall area. Similarly to Cape Town, weed pollen was not significant although weed pollen allergens such as *Platanus* (English plantain) and *Tagetes minuta* (khaki weed) were present in the atmosphere.¹³ *Cosmos* pollen would be identified as Asteraceae, a constant background presence in pollen assemblages and pollen monitoring studies.

POLLEN RECORDS FROM KWAZULU-NATAL

Sampling sites have been set up in and around Durban and Richard's Bay in this subtropical region. These east coast towns enjoy milder temperatures, with abundant rainfall and increased relative humidity (RH) levels, and consequently higher perennial fungal spore levels were recorded. Grass was a dominant aeroallergen and the dominant tree pollen was found to be *Morus*. The dominant weed pollen was *Cannabis*. The levels of this taxon exceeded the grass pollen levels.¹⁴

THE MPUMALANGA POLLEN RAIN

A pollen sampling study was carried out in the vicinity of Secunda in this lowveld region, from 2006 to 2009, to assess the pollen and fungal spore content of the atmosphere. This area of Mpumalanga is characterised by flat grasslands which include *Themeda triandra* (thatching grass).²

GRASS POLLEN

In this summer rainfall region, grass pollen levels peaked in January and significant levels for grasses were recorded.

TREE POLLEN

Low tree pollen counts were obtained from this area which is characterised by scrub vegetation. Indigenous tree pollen is infrequently allergenic as trees are invariably insect- or bird-pollinated and the pollen is not windborne or produced in large amounts. The tree pollen load was dominated by alien trees such as plane, oak and eucalyptus.

WEED POLLEN

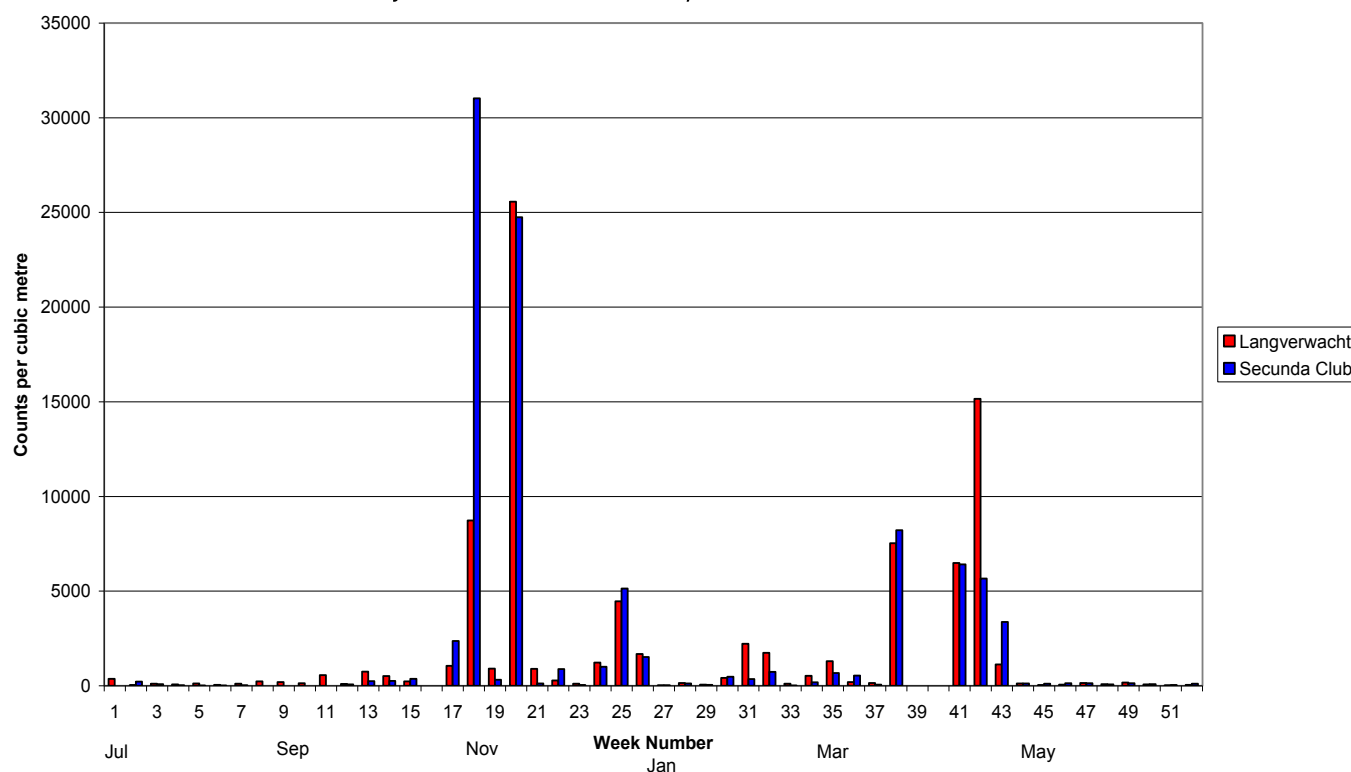
Weed pollen levels were low, but small peaks for Asteraceae were seen during the autumn months of March and April, probably contributed by *Cosmos*, which flowers in abundance in that region. The area around Secunda is often referred to as 'Cosmos country', because of the thickly massed fields of *Cosmos* (Fig. 3) that are found in the vicinity. *Cosmos* species belong to the Asteraceae family, introduced to South Africa from Mexico and naturalised.

FUNGAL SPORES

The major aeroallergens for this study were fungal spores, particularly *Epicoccum*, *Alternaria* and *Cladosporium*. This lowveld area experiences high RH, which frequently exceeds 90%. When this high RH coincides with temperatures that are >20°C, ideal conditions for the proliferation of fungal



Fig 3. *Cosmos*.

July 2006 - June 2007: *Cladosporium* Counts at each siteFig 4. Annual *Cladosporium* levels (weeks) from Mpumalanga sampling sites.

spores occur. The highest fungal spore counts were recorded in February when counts $>30\,000/\text{m}^3$ for *Cladosporium* were recorded (Fig. 4). This is in keeping with findings from other countries, where *Cladosporium* is often the dominant fungal spore.

GUIDELINES FOR THE SELECTION OF AEROALLERGEN TESTING PANELS

AEROALLERGEN TESTING IN A NEW CLINICAL SETTING

It is difficult to select allergens for testing in a new environment. Ideally, skin testing profiles are selected, based on pollen monitoring records from the region. These pollen counts indicate the important pollen and fungal spore levels in the atmosphere as well as the months of the year when the aeroallergens peak. It is sensible to choose testing panels for aeroallergens based on the experience of allergologists in other regions of Southern Africa. A thorough knowledge of the seasonality of the major trees, grasses and weeds of the new study area is helpful. In cities, the allergenic pollen load has invariably been composed of alien pollen from northern hemisphere trees, which have been introduced and naturalised, particularly *Platanus* (plane) and *Quercus* (oak), but also *Olea* (olive). *Olea europaea* and *Olea capensis* are found in the Western Cape and the pollen may be an important allergen in areas where olives are cultivated, such as in Paarl.

SUMMARY OF SUGGESTED GUIDELINES FOR THE CHOICE OF POLLEN/FUNGAL SPORE TESTING PANELS IN A NEW ALLERGY CLINIC

1. If no pollen monitoring data exist for a new clinic, select pollen and fungal spore allergens that have been found to be important allergens in other regions of Southern Africa, i.e. with a similar biome to the new clinic.
2. Audit the frequency of aeroallergen-specific sensitivity from positive skin-prick or ImmunoCAP RAST testing in the new clinic. This may prove useful when diagnosing patients with symptoms of seasonal allergic rhinitis.
3. Set up contact with staff members of the Botany Department of the nearest university, technikon, botanical garden, parks and forest department or garden plant nursery. This will be invaluable when identifying allergenic plants, or plants that may cause contact dermatitis in your area. Pollen flowering calendars are a very useful guide and are usually available from local botanists or botanical garden bookstores.
4. If there is a municipal air pollution department, a mutually beneficial relationship may develop between the staff of the allergy clinic and the air pollution personnel, in assessing triggers for seasonal allergy.
5. Take note of the local vegetation and record the flowering times of trees, weeds and grasses in the new area.

6. Note the weather patterns in your region. Weather parameters that influence pollen counts include the rainy season, humidity levels, temperature fluctuations and wind speed and direction.
7. If large, important sporting events, especially running and cycling marathons, are held in your region, it is important to be informed about the seasonal allergens that may trigger symptoms of allergy in these elite athletes, so that they may be able to take appropriate and permitted medications.
8. Consider adding *Zea mays* to the testing panel in farming areas where maize is grown. It is interesting that sugar cane pollen does not appear to be allergenic.

POLLEN CALENDAR

Figure 5 summarises in calendar form the pollen frequencies from the regional sampling sites.

DISCUSSION

In Europe, pollen calendars are constructed for the benefit of travellers who suffer symptoms of seasonal allergic rhinitis. It has not yet been possible to design a comprehensive pollen calendar for South Africa because of the dearth of sampling sites in this country; however, pollen calendars of allergenic plants should be constructed when aerobiological studies are unavailable for a particular region.

Declaration of conflict of interest

The author declares no conflict of interest.

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Pollen sampling site	Pollen type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Western Cape	Tree												
	Grass												
	Weed												
Gauteng	Tree												
	Grass												
	Weed												
KwaZulu-Natal	Tree												
	Grass												
	Weed												
Mpumalanga	Tree												
	Grass												
	Weed												

Fig 5. Calendar of pollen from South African sampling sites.

ALLERGY IN BOTSWANA

Shiang-Ju Kung, MD, FAAP^{1,2}

Loeto Mazhani, MD¹

Andrew P Steenhoff, MD, FAAP, FCPaed(SA)^{3,4}

¹ Department of Paediatrics, University of Botswana, Gaborone, Botswana

² Division of Allergy & Immunology, Children's Hospital of Philadelphia, Philadelphia, USA

³ Division of Infectious Diseases, Children's Hospital of Philadelphia, USA

⁴ Botswana-UPenn Partnership, Gaborone, Botswana

Correspondence

Shiang-Ju Kung, e-mail: Shiang-ju.kung@mopipi.ub.bw or thesteenhoffs@msn.com.

ABSTRACT

Introduction. Unlike South Africa and Zimbabwe, allergen sensitisation patterns are unknown for Botswana. Skin-prick test (SPT) results for Gaborone are reviewed. **Methods:** SPTs from an allergy practice included trees, grasses, weeds, moulds, cat, dog, dust mites and cockroach. Food SPTs were conducted when clinically indicated. **Results:** In 126 patients, median age was 7.8 years (interquartile range (IQR) 3.4-16.3 years), with male predominance (56%); 68% were atopic - 72% were sensitised to aeroallergens, 15% foods and 13% both. Top aeroallergen sensitisations were: Bermuda grass (41%), Timothy grass (33%), maize pollen (32%), *Alternaria* (28%), English plantain (25%) and acacia tree (21%). Less common were: dust mite (14%), pets (14%), and cockroach (10%). Peanut and egg allergy were common food allergies (10%). Novel food allergies included mopane worm and mogwagwa. Frequent clinical presentations were rhinitis (70%), asthma (42%) and eczema (30%). Rhinitis patients were significantly grass allergic (Bermuda $p<0.01$, Timothy $p=0.04$, maize pollen $p<0.01$). Asthmatics were more likely to be cockroach ($p=0.02$) or *Aspergillus* ($p<0.01$) allergic. Conjunctivitis was significantly linked to Bermuda grass ($p<0.001$), maize ($p<0.01$) and acacia tree pollen ($p=0.02$) allergy. **Conclusion:** Bermuda grass allergy is common in Botswana, but dust mite sensitisation is infrequent. Peanut and egg were the most common food allergies. Novel food allergens were identified.

INTRODUCTION

Botswana is a land-locked country, surrounded by South Africa (south), Namibia (west), Zambia (north) and Zimbabwe (north-east). Relatively little is known about allergic conditions in Botswana. Only one previous study outlines adult respiratory conditions in Botswana and found that in 1997, asthma contributed 1.5% of outpatient consultations and 0.7% of inpatient mortality.¹ There are no data on other allergic conditions in Botswana, especially pertaining to allergen sensitisation patterns. The latter have been established for some neighbouring countries, such as South Africa²⁻⁴ and Zimbabwe.⁵ Because of the geographical proximity, the general assumption has been that Botswana would display a similar sensitisation pattern, yet this has never been investigated. Our primary objective is to describe aeroallergen and food sensitisation patterns for Gaborone, Botswana. Secondary objectives include description of the spectrum of atopic diseases, correlating clinical significance of particular allergen sensitisations and reporting of novel indigenous food allergens.

METHODS

A retrospective descriptive study was conducted at a private allergy practice in Gaborone over 16 months, from October

2008 to February 2010. Gaborone is Botswana's capital city and a third of the country's population live within 100 km of the city. As this was the only allergy practice in Botswana during this period, patients with suspected allergies were referred for assessment from as far as 1 000 km away.

Included were all patients who underwent skin-prick test (SPT) to either aeroallergens and/or food allergens. The decision to perform SPT was based on evidence elicited from clinical history that suggested an allergic trigger for the clinical presentation of an atopic disorder (such as asthma, rhinitis, atopic dermatitis or food allergy). The allergens that were tested varied depending on the clinical indication. For children under 3 years of age, a modified panel was used, as indicated by allergen exposure. This was often limited to indoor allergens, such as moulds, pets and dust mites. For those 3 years and older, a full aeroallergen panel was used. In the latter group, mould was the only exception which was tested as a mixture, individual moulds, or both. Food allergy testing was only performed if any one of the following criteria was satisfied: (i) history consistent with an IgE-mediated reaction; (ii) previous documented positive tests of specific IgE (either by SPT or serum specific IgE); (iii) suspected food trigger in a child with moderate to severe eczema.

MATERIALS

Standardised allergen extracts (ALK-Abelló, Madrid, Spain) were used for food (cow's milk, soya, egg white, wheat, peanut) and aeroallergens. Aeroallergens included plane tree (*Platanus acerifolia*), oak tree (*Quercus ilex*), acacia tree (*Robinia pseudoacacia*), Bermuda grass (*Cynodon dactylon*), Timothy grass (*Phleum pratense*), maize pollen (*Zea mays*), English plantain (*Plantago lanceolata*), moulds (mix – *Alternaria*, *Chaetomium*, *Cladosporium fulvum*, *Fusarium*, *Alternaria alternate*, *Aspergillus fumigatus*), cat, dog, dust mites (*Dermatophagoides* mix – *D. farinae*, *D. pteronyssinus*; *Blomia tropicalis*) and cockroach (*Blattella germanica*).

For other food allergens, fresh food and the prick-prick method (pricking the food with the lancet, then pricking the skin with the lancet) were used.⁶ Foods tested included fish, shellfish, local fruit (mogwagwa) and mopane worm (rehydrated dried caterpillar).

TECHNIQUE

A stainless steel lancet (ALK-Abelló, Madrid, Spain) was used for the skin prick, technique as described by the practice parameter.⁶ All tests were compared to positive (histamine) and negative control (glycerinated saline), and a positive test was defined as a wheal size 3 mm greater than the negative control at 15 minutes.⁶ SPT were all performed and interpreted by the same author, who is a board-certified allergist (SJK).

STATISTICAL ANALYSIS

The cohort was described using summary statistics, utilising parametric or non-parametric techniques as appropriate. For each allergen (e.g. Bermuda grass), the frequency of a positive test was reported among those who were tested. For each clinical syndrome (e.g. asthma), the frequency of a positive result for each relevant specific allergen test was reported. For each clinical syndrome and a specific allergen, a 2x2 table was constructed and the proportion of a positive specific allergy test among those with the syndrome (cases) was compared to the frequency of a positive allergy test among those without the syndrome (controls) using the chi square test. Data were analysed using STATA version 9.2 (College Station, TX, USA). Significance was defined as $p < 0.05$.

ETHICS

Approval was obtained from the Botswana Ministry of Health Research Unit.

RESULTS

DEMOGRAPHICS

A total of 126 patients were included in the study. The median age was 7.8 years with a range of 3 months to 51 years (interquartile range (IQR) of 3.4-16.3 years) (Fig. 1). There was a male predominance (56%). Race breakdown was as follows: black African 69%, Caucasian 17%, Asian 9% and multiracial 5%.

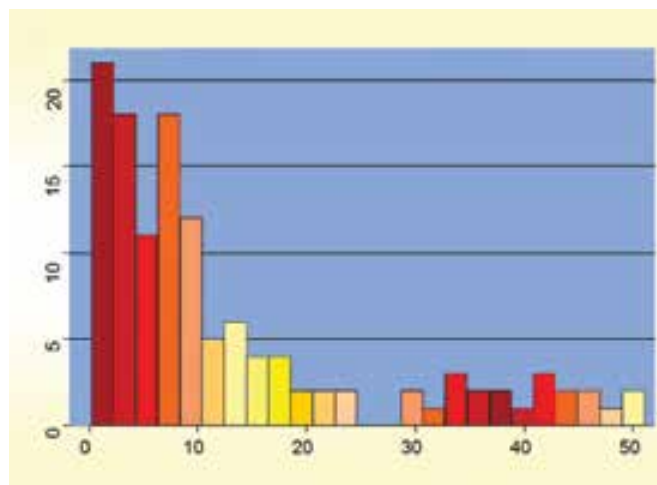


Fig. 1. Age distribution in years (n=126).

CLINICAL PRESENTATION

Of the group, 65 (52%) had only a single allergic diagnosis on presentation, while the remainder suffered from multiple atopic disorders. The most common clinical presentations were rhinitis (70%) and asthma (42%), followed by atopic dermatitis (30%), food allergy (20%), conjunctivitis (21%) and angio-oedema (6%).

ALLERGEN SENSITISATION

SPTs were positive in 86 (68%) of the group. Of those who were sensitised, 62 (72%) were allergic only to aeroallergens, 13 (15%) to food, and 11 (13%) to both aeroallergens and food. Almost half (48%) of the atopic patients were polysensitised.

- Aeroallergens (Table I): grass pollen was the most common offending allergen (41%), followed by mould (28%), weed (25%) and trees (21%). Household pets, dust mites and cockroaches were less common sensitisers.
- Food allergens (Table II): of the 5 most common food allergens encountered in westernised children, peanut and egg were the most common allergens in this cohort. Only one of two adults who had skin testing for both fish and shellfish was sensitised. Novel food allergens that were positively tested included mopane

worm and mogwagwa. Clinical details of the patients are outlined in Table III. Of those who were sensitised to foods, 17 (71%) had concurrent atopic dermatitis. Only 2 (8%) of the food allergy patients were adults; the remainder were younger than 18 years of age.

SIGNIFICANT CORRELATION BETWEEN SPT POSITIVITY AND CLINICAL DIAGNOSIS

Patients with certain clinical allergic disorders were more likely to be sensitised to specific allergens (Table IV). In particular, asthmatics were more likely to be allergic

Table I. Aeroallergen SPT results

Type of aeroallergen	Total tested	SPT positive	% positive
Grass			
Bermuda	104	43	41
Timothy	104	34	33
Maize pollen	103	33	32
Moulds			
Alternaria	101	28	28
Mould mix	78	16	21
Aspergillus	100	11	11
Weed			
English plantain	103	26	25
Trees			
Acacia	103	22	21
Plane	103	17	17
Oak	103	10	10
Animals			
Cat	113	16	14
Dog	115	16	14
Mites			
Dustmite mix	114	16	14
Blomia tropicalis	102	4	4
German cockroach	104	10	10

SPT – skin-prick test.

Table II. Food allergy SPT results

Food tested	Total tested	SPT positive	% positive
Egg white	18	12	67
Peanut	19	12	63
Cow's milk	13	3	23
Wheat	10	1	10
Soya	11	1	9
Shellfish/fish*	2	1	50
Mopane worm*	2	2	100
Mogwagwa*	1	1	100

*Food was directly used, not standardised extract

SPT – skin-prick test.

Table III. Details of patients with food allergy to novel allergens

Patient	Implicated food	Age/gender	Reaction	Other clinical diagnoses	SPT result
1	Mopane worm	15-year-old male	Anaphylaxis (dyspnoea, wheeze, palatal pruritus, urticaria, tongue & lip swelling)	Allergic rhinitis Infantile eczema	Positive to trees, grass, dust mites, weed, cockroach Wheal of 7 mm to reconstituted dried mopane worm
2	Mopane worm	39-year-old male	Throat and palatal itching, urticaria	Allergic conjunctivitis	Positive to dust mites (mixture and Blomia) Wheal of 3 mm to reconstituted dried mopane worm
3	Mogwagwa	13-year-old female	Anaphylaxis (tongue swelling, throat closure, dyspnoea, generalised pruritus)	Atopic dermatitis	Positive to trees, grasses Wheal of 7 mm to fresh mogwagwa fruit

SPT – skin-prick test.

Table IV. Correlation between allergic conditions and allergen sensitisations

Allergic condition	Allergen sensitisation	Allergen exposure in subjects <i>with</i> condition	Allergen exposure in subjects <i>without</i> condition	<i>p</i> value
Asthma	Cockroach*	8/48 (17%)	2/56 (4%)	0.02
	<i>Aspergillus</i> *	9/45 (20%)	2/55 (4%)	<0.01
	<i>Alternaria</i>	16/46 (35%)	12/55 (22%)	0.14
Rhinitis	Bermuda grass*	40/84 (48%)	3/20 (15%)	<0.01
	Timothy grass*	31/83 (37%)	3/21 (14%)	0.04
	Maize pollen*	31/83 (37%)	2/20 (10%)	<0.01
	<i>Alternaria</i>	25/81 (31%)	3/20 (15%)	0.16
Conjunctivitis	Bermuda grass*	21/27 (78%)	22/77 (29%)	<0.001
	Maize pollen*	15/27 (56%)	18/76 (24%)	<0.01
	Acacia tree*	10/27 (37%)	12/76 (16%)	0.02

*Significant relationship between allergen sensitisation and clinical condition ($p < 0.05$)

to cockroach ($p = 0.02$) and *Aspergillus* ($p < 0.01$); rhinitis sufferers to Bermuda grass pollen ($p < 0.01$), Timothy grass pollen ($p = 0.04$), and maize pollen ($p < 0.01$) and conjunctivitis patients to Bermuda grass, maize or acacia tree pollen ($p < 0.001$, < 0.01 and 0.02 respectively). All egg-allergic patients were children with atopic dermatitis.

DISCUSSION

Two-thirds of the patients who presented to a private allergy practice in Gaborone, Botswana and underwent SPT were found to be atopic. As anticipated, the most common sensitising agents were aeroallergens (85%) rather than

foods (19%); however, 13% of patients were sensitised to both aeroallergens and foods.

The most common aeroallergen sensitisation was to Bermuda grass (41%), with slightly lower rates to Timothy grass (33%) and maize pollen (32%). Although only three species of grass pollen were tested, there is significant cross-reactivity between Timothy grass and Bermuda to other local grass species such as kikuyu grass, buffalo grass and *Eragrostis*.⁷ Unfortunately, because local grass species extracts are not commercially available, these could not be tested. The sensitisation rate to grass pollen overall is

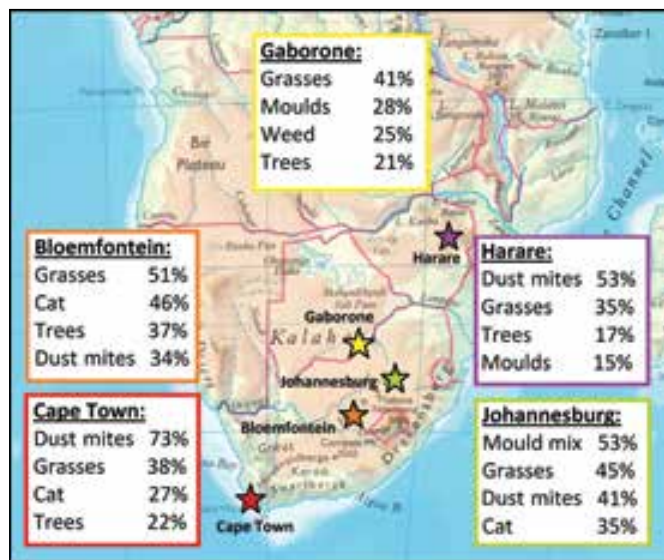


Fig. 2. Common allergens in southern Africa by geographical area.

similar to Johannesburg (45%),⁴ Cape Town (38%)³ and Harare (35%),⁵ but less than in Bloemfontein (51%) (Fig. 2).² Within our population, Bermuda grass pollen sensitisation was significantly associated with allergic rhinitis, as has been demonstrated in Arizona, a similar semi-arid region in the USA.⁸ In addition, Timothy grass and maize pollen sensitisations were also significantly associated with rhinitis. As has been seen in other countries, allergic conjunctivitis was significantly associated not only with Bermuda grass, but also with maize and acacia tree pollen sensitisation.⁹⁻¹¹

Alternaria mould allergy (28%) was the next most common aeroallergen in Gaborone, almost double that seen in Harare (15%).⁵ This was however similar to *Aspergillus* sensitisation in Bloemfontein (20%),² and less than mould allergy among asthmatics in Johannesburg (53%).⁴ This phenomenon of increased mould sensitisation in semi-arid or desert conditions has been noted elsewhere in the world, e.g. the USA,⁸ Australia¹² and Kuwait.¹³ Among our cohort, *Aspergillus* sensitisation was noted more frequently in asthmatics, but this was not the case for *Alternaria*. In other settings, *Alternaria* sensitisation in children has been linked to development of asthma,⁸ as well as to increased bronchial hyper-responsiveness.¹² The absence of this finding in our cohort may be due to the small sample size and needs to be explored in future studies.

Interestingly, dust mite sensitisation was relatively uncommon (14%) in our cohort, unlike in Bloemfontein (34%),² Johannesburg (41%),⁴ Harare (53%)⁵ and Cape

Town (73%).³ Dust mite survival relies on high humidity to prevent dehydration, since their body composition is 70-75% water.¹⁴ The critical relative humidity essential for dust mite survival is 55-73%, and the ideal temperature range is 15-35°C.¹⁵ Dust mites die from dehydration if the relative humidity is maintained below 51%.¹⁵ In Gaborone, minimum temperatures are 22°C in January to 7°C in July, and maximum temperatures are 30°C in January and 20°C in July.¹⁶ Average daily relative humidity is 43-76% in January and 30-72% in July.¹⁶ Hence, the environment is not suitable for dust mite survival. The low prevalence is similar to rates noted in a semi-arid region of Arizona in the USA.⁸ However, the higher prevalence of dust mite sensitisation in other comparable climates may be related to increased indoor relative humidity through the use of indoor air conditioners, evaporative coolers or poor air ventilation.^{13,15,17}

Pet allergy, to cat and dog (14% respectively), was also relatively uncommon in our study. It is unclear if this was related to less pet ownership or to different home practices, such as keeping pets outside the house. This warrants further investigation in future studies.

Cockroach sensitisation was only noted in 10% of our cohort, which is less than the prevalence of 30-70% worldwide, 40% in Western Cape and Natal, 38% in Bloemfontein and 32% in Gauteng.¹⁸⁻²⁰ Although all three species of cockroach (German (*Blattella germanica*), American (*Periplaneta americana*) and oriental (*Blatta orientalis*)) are found in South Africa,¹⁸ we only tested for German cockroach, for three reasons. Firstly, sensitisation to German cockroach predominates at higher altitudes (Pretoria and Harare), whereas all three species are important in the coastal regions of Cape Town and Durban.¹⁸ Secondly, the German cockroach is found within the home in Gaborone, but the American cockroach usually resides outside the abode, within the water drainage system and sewerage pipes.²¹ Lastly, there was no commercial allergen extract to American and oriental cockroach at the time the study was conducted. The lower prevalence of cockroach sensitisation in Gaborone is similar to rates of 16-17% noted in a larger epidemiological study in children from Eastern and Western Cape.¹⁸ Interestingly, monosensitisation to cockroach (in the absence of sensitisation to dust mite or grass pollen), is said to be rare in South Africa,²⁰ yet was present in 30% (3 of 10) of our cockroach-allergic patients. As has been established in USA inner-city populations, cockroach sensitisation in our cohort was significantly associated with the clinical diagnosis of asthma.^{22,23}



Fig. 3. Mopane worms, served either as a dried snack (left) or cooked as a stew (right).

Regarding food allergy in our cohort, 24 (19%) were found to be sensitised to food allergens. Although the definitive diagnosis of food allergy traditionally relies on a positive double-blinded placebo-controlled food challenge, the presence of sensitisation to the food allergen (either by SPT or serum specific IgE test) in the presence of a convincing clinical history may be confirmatory for IgE-mediated food allergy.²⁴ In our cohort, food challenges were not conducted, but the SPTs were only performed when the history was consistent with an IgE-mediated mechanism. This rate of food allergy is higher than that in the USA, where 6% of children and 3.7% of adults are food allergic,²⁴ probably because of a selection bias in the patients (those presenting specifically for allergy evaluation) and the small sample size.

Nonetheless, in our cohort the most common food allergies were to egg white (10%) and peanut (10%). Milk (2%), wheat (1%) and soya (1%) allergy were less common.



Fig. 4. Mogwagwa (*Strychnos madagascariensis*).

All those who tested positive for these foods were children. In addition, all egg-allergic patients had atopic dermatitis. The higher rate of egg and peanut allergy is similar to findings in a cohort of eczematous children from Cape Town who underwent food challenges. The most common food allergies were peanut (26%), egg (24%), fish (3%) and milk (2%).²⁵ One adult in our cohort was found to be allergic to fish and shellfish by SPT to the fresh food. This is consistent with other countries, where shellfish and fish are among the most common food allergens in adults.²⁴

Two novel indigenous food allergens were also identified by SPT, namely mopane worm (Fig. 3) and mogwagwa (Fig. 4). Mopane worm is the larva of the mopane emperor moth (*Imbrasia belina*).²⁶ This caterpillar lives almost exclusively on the leaves of mopane trees (*Colophospermum mopane*), found only in south-central Africa, at elevations of 300-1000 m, with low to moderate rainfall of 400-1 000 mm rainfall per annum (Fig. 5).²⁷ Harvesting is seasonal and includes hand-picking the caterpillar, followed by degutting. It is then boiled and dried. It is eaten later as a dried snack, or as a stew.²⁷ Owing to the high protein content (56.8 g per 100 g – approximately three times that of beef per unit weight), mopane worms form an important part of the rural indigent diet of Botswana.²⁷ They are also valued as delicacies by the wealthier population and are widely exported. Two patients had positive SPT to mopane worm in our cohort. Details and further work-up for one patient has been published.²⁸ Prior to this, the only reported food allergy to mopane worm was in a 36-year-old non-atopic woman from Botswana who had angio-oedema, pruritic rash and hypotension after ingestion of 20 g mopane worms.²⁹ Further testing was not conducted and history was atypical since angio-oedema persisted for 4 days after the event.



Fig. 5. Geographical distribution of mopane (*Colophospermum mopane*)²⁷ and mogwagwa (*Strychnos madagascariensis*) trees.³³

The other novel indigenous food allergen was mogwagwa (*Strychnos madagascariensis*). We report the first-ever patient with food allergy to this wild fruit. Mogwagwa is one of 16 edible wild fruits that have been described for Botswana.³⁰ Other names include: black monkey orange (English); swartklapper (Afrikaans); morapa (Northern Sotho); nkwaka (Tsonga); mogorwagorwana (Tswana); mukwakwa (Venda); umkwakwa (Zulu).³¹ The plant is found not only in Botswana, but throughout South Africa (Limpopo, North-West, Mpumalanga, Swaziland and KwaZulu-Natal). Although originally from Madagascar, this plant is also found in Malawi, Mozambique, Zambia, Zimbabwe and Tanzania (Fig. 5).^{32,33} The fruit is smooth and hard, and ripens to yellow, containing tightly packed seeds which are surrounded by an edible pulp.^{30,31} Besides consumption of the fruit pulp, in South Africa (KwaZulu-Natal) other parts of the plant are used for medicinal purposes: the leaves and fruit sap for topical treatment of sores;³⁴ and the root, bark and leaves for making a drink to treat diarrhoea.³⁵ Intriguingly, this plant is also poisonous, containing strychnine compounds in the pip, and curare in the bark.³¹ The plant has been used for poison fishing,³⁶ as well as tick control among livestock.³⁷

The most common clinical allergic manifestation of all patients presenting to our practice was rhinitis, followed by asthma. These findings are similar to cohorts in Zimbabwe

and South Africa,^{2,5} but the percentages in this Botswana cohort are higher. This may be due to a relative selection bias compared to the Zimbabwe and South African cohorts, since this study was at a single private practice where cost implications of the SPT may have self-selected for only testing those subjects with more serious or bothersome symptoms.

CONCLUSION

The allergen sensitisation pattern in Gaborone, Botswana differs significantly from those of the neighbouring countries (Fig. 2). Grass allergy is the most common, with prevalence rates similar to South Africa and Zimbabwe. Mould allergy, especially to *Alternaria*, occurred in just under a third of patients. Unlike surrounding countries, dust mite allergy was uncommon. The last two findings are more consistent with semi-arid regions in the USA. Asthmatics in Botswana were more likely to be sensitised to cockroach and *Aspergillus*, whereas rhinoconjunctivitis was linked to Bermuda grass sensitisation. Food allergy occurred most commonly to egg white and peanuts. Novel food allergens were identified in this cohort – mopane worm and mogwagwa. This study highlights the importance of studying allergen sensitisation for each country individually, since there are important regional differences that may occur as a result of different climatic environments, cultural practices or diet.

Acknowledgements

The authors would like to thank Thamani Mazhani for cooking and photographing the mopane worm stew. A big vote of thanks also goes to ALLSA for their support of allergy ventures in Botswana. Last, but not least, we would like to warmly thank Professor Paul Potter for his continued support and encouragement that have made further investigation of the novel indigenous food allergens possible.

Declaration of conflict of interest

The authors declare no conflict of interest.

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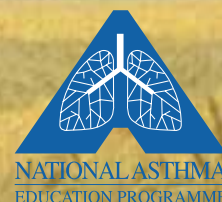
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