

REVIEW

Pollen allergy in South Africa

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Introduction

South Africa has a microcosm of diverse climatic regions and distinct vegetative biomes [1]. Climatic conditions include Mediterranean, sub-tropical, tropical, semi-desert and desert conditions and most areas have a summer rainfall. There are humid coastal areas, dry inland areas, low lying and elevated areas. These different conditions have important and variable effects on the production and dispersal of pollen. Consequently the prevalence and aetiological agents of pollen allergy vary in the different regions of South Africa.

The Fynbos of the Cape, for example, represents one of the richest floral kingdoms of the world, with over 2622 species found in a relatively small area [2]. In spite of abundant pollen production, Fynbos is a most infrequent cause of pollen allergy in this region because the sticky pollen is largely insect pollinated. Pollinosis in the Cape usually results from grass or tree pollen.

South Africa also has a very extensive grassland comprising over 957 (10%) of the known grass species worldwide [3]. Three hundred and twenty-nine of these species are endemic. In addition to a rich indigenous repertoire of grasses there has been the introduction of 115 naturalized grass species, and deliberate planting of many tree species from Europe, America and Australia. Accidental contamination of grain and other imports has also introduced several alien weed species.

Thus, atopic individuals living in South Africa are exposed to a wide range of different indigenous and alien pollen, in addition to indoor allergens such as house dust mites, moulds, cat and dog dander.

Pollen allergy in South Africa usually manifests as seasonal or perennial rhinitis or conjunctivitis. Pollen allergy is an unusual cause of asthma in the region.

Literature review

Pollen allergy was first documented in South Africa by Potts in the first quarter of this century [4,5,6]. His observations of respiratory allergy to *Schinus molle*, introduced from South

America, led to the conclusion that this largely insect-dispersed pollen was subject to new conditions in South Africa and thereafter became allergenic. Here it was planted mostly in dry and hot areas of the country where the pollen rapidly became desiccated and powdery. In this form it was easily wind dispersed, and thus became a problem. Pirie, in 1928 [7], and later Watt in 1937 [8] tested and confirmed clinical sensitivity to various pollen types. In 1941 Davidson reported the clinical significance of diurnal variation in anthesis of different grasses [9].

From the mid-1940s and for the following 30 years, Ordman almost single-handedly investigated both pollen and fungal allergy in Southern Africa [10–16]. He worked throughout the region, from what was then Southern Rhodesia (Zimbabwe) to the Cape, from Windhoek in the old South-West Africa (Namibia) to Natal. He concluded that grass pollen and the fungal spores of *Cladosporium* were the principal causes of seasonal respiratory allergy in this region.

In the mid-1980s renewed interest in pollen allergy was sparked, possibly by the arrival of the volumetric sampler. Potter *et al.* [17–19] examined the issue from the clinician's point of view, while others addressed pollen prevalence from a botanical viewpoint [20–24].

Occurrence of pollen allergy

Combining data from pollen prevalence studies with clinical observations has confirmed that abundance of a particular pollen species is not the only determinant of clinical sensitivity. Although pollen allergy occurs commonly in the South African population, very interesting regional differences have been noted. These differences are not only due to climatic and regional variations in pollen production but are also influenced by factors such as ethnicity, urbanization and the mode of cultivation [19]. For example, pollen-induced allergic rhinitis has been noted to be uncommon in rural people living in a traditional grassland environment and a common problem in the urban situation. However, with modernization of rural populations this distinction is becoming less clear.

Pollen allergy is more common in the grassland areas where symptoms are almost perennial but seasonal

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pollinosis is also seen, particularly in the Cape. The variable influences of environmental factors and cultivation on the possible allergenicity of a grass species in the African context was illustrated by recent studies of the allergenicity of Kikuyu grass (*Pennisetum clandestinum* [19]). In this report it was noted that the production of pollen by Kikuyu grass is low in the rural environment where the grass is allowed to grow long, and propagated by rhizomatous propagation, but that pollen production is greatly increased in an urban environment where the grass is mowed or cut frequently. Furthermore, since Kikuyu is used more extensively in Gauteng than in the Cape, it is our impression that Kikuyu grass allergy is more common in that province.

The extent of grassland and grass-dominated savanna in South Africa, and indeed in the African sub-continent, underpins the necessity for further studies of this nature.

Current investigations of pollen allergy in South Africa are focusing on the allergenicity of native taxa. This aspect is of concern as both testing and treatment kits are imported into the country from the Northern Hemisphere. Even though indigenous taxa apparently share some allergenicity with Northern Hemisphere taxa, the clinical significance of the known cross-reactivity with indigenous species is, as yet, unclear.

Even though grasses share allergenicity, the degree of cross-reactivity becomes less as the grasses become further removed taxonomically. African grasses belong largely to the sub-families Chloridoideae and Panicoideae, while Northern Hemisphere grasses are predominantly members of the Pooideae.

Figure 1 indicates the location of vegetation zones in South Africa. A large portion of the area occupied by grassland covers the province of Gauteng. It is here that almost one-third of the country's population is to be found.

Even though fairly densely urbanized, grass is still very common. In Gauteng and throughout the country, lawns form an extensive part of suburbia, and grass covered sports fields abound. *Pennisetum clandestinum* and several species of *Cynodon* are favoured for these purposes. Veld grasses occur not only in the countryside but also in towns, wherever there is vacant land. The nature of wind-dispersed grass pollen, being light and powdery, aerodynamic and produced in profusion by these plants, means that the population is constantly exposed to this allergen.

Added to these considerations is the fact that wherever agriculture replaces natural grassland, the crops that are cultivated are generally also members of the Poaceae. Even the sub-tropical region of the East Coast is not exempt, because here sugar cane farming with *Saccharum* is intensive.

As a result of such a profusion of grasses, the effective pollen producing season of the grasses is very long, due to the extended flowering season produced by many months of warm temperatures. Where irrigated, grasses will start flowering as soon as Winter frosts have stopped, usually around the end of July, and continue right through until the first frosts fall again in the beginning of June. This means that for 10 months of the year, consecutively flowering grass species produce pollen. Much of what is known about pollen distribution in South Africa has been obtained from regional pollen studies using 7-day Burkard samplers co-ordinated by Cadman [23,24] and Berman [18]. Data from these studies are summarized for the four main pollen producing regions in South Africa as follows:

Grassland

Pollen calendars of two sites are shown in Figures 2 and 3, namely Johannesburg and Vanderbijlpark. These cities,

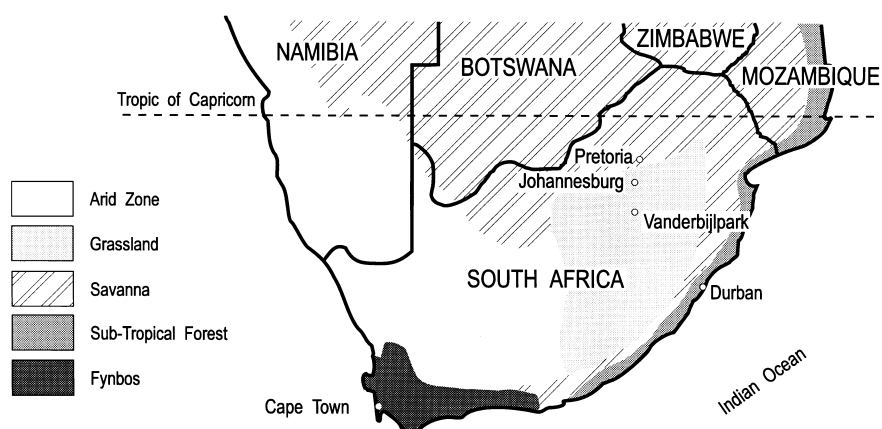


Fig. 1. Major vegetation zones of South Africa.

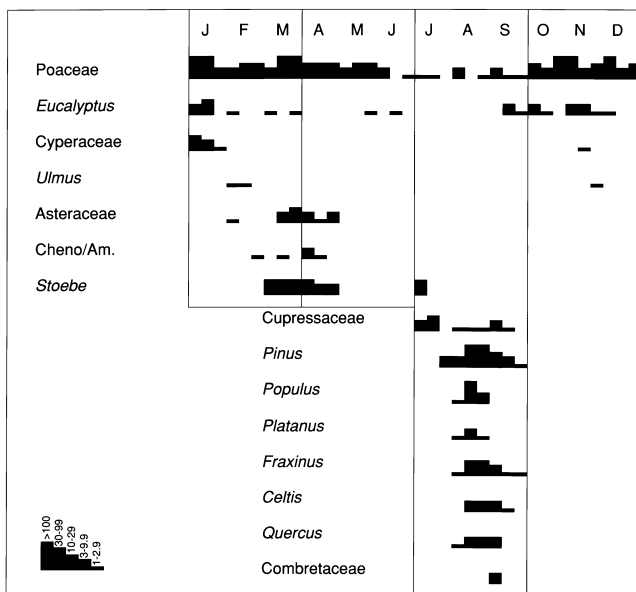


Fig. 2. Pollen calendar for Johannesburg.

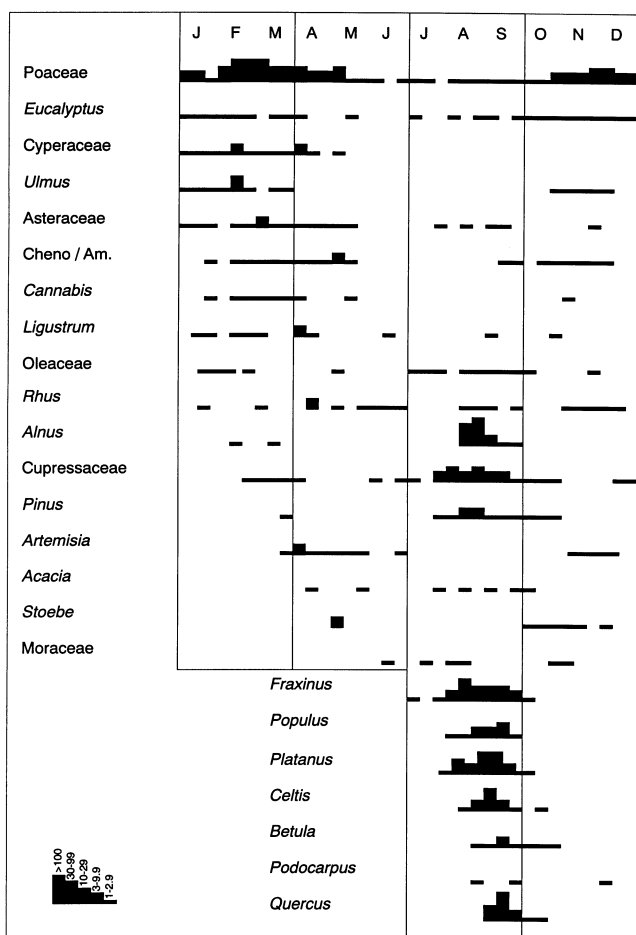


Fig. 3. Pollen calendar for Vanderbijlpark.

both in Gauteng, are about 100 km apart, and are similar in that they are each part of an industrial metropolis. Two sites were monitored in both Johannesburg and Vanderbijlpark, so that these two calendars represent composites of the data in each area.

The predominant natural grasses of this region are *Hyparrhenia* spp., *Themeda triandra*, *Eragrostis* spp., *Sporobolus* spp., *Trachypogon spicatus* and *Aristida* spp. The Compositae *Stoebe vulgaris* and *Helichrysum kraussii* are common. The pollen calendars show two annual peaks, the first in early Spring and the second in Mid-Summer. Pollen of the Spring peak is derived mainly from alien trees brought into the country predominantly from the Northern Hemisphere. This was a trend initiated in the early colonial period at the end of the last century, when settlers found the treeless environment hostile and uncomfortable. Exotic trees were planted not only for shade, but extensive tracts of land were given over to plantations of *Pinus* and *Eucalyptus* for use in the gold mines and other industries.

Dominant trees of the Spring peak are *Fraxinus*, *Pinus*, *Populus*, *Platanus*, *Alnus* and *Celtis*. The family Cupressaceae flowers somewhat earlier and is recognized in South Africa as a late Winter allergen. Of the above only *Celtis* is native to the country, and even then the total pollen count for this taxon includes the Asian alien *C. sinensis*, extensively grown in parks and gardens. The Spring season is very intense but short, with the peak lasting for about a fortnight only. This contrasts with the Northern Hemisphere where spring flowering occurs over a period of about 6 weeks. The reason for this short pollen season is probably the speedy onset of high temperatures, encouraging rapid blooming.

The Summer peak at both sites is dominated by grass pollen, which is also the single most important component of the total annual pollen spectrum. The only other allergenic summer pollen of significance is that of *Ulmus*, with a short spike in December. The calendars effectively highlight the length of the Summer season.

A comparison of the pollen calendars for Johannesburg and Vanderbijlpark indicates that even though these towns are very similar in all respects, including vegetation and land-use, the calendars are not identical. This highlights the variability of the pollen spectrum on a regional scale, where the localized presence of specific taxa can introduce bias to the atmospheric sampling regime.

A further factor which is not apparent from the averaged data of the pollen calendars is annual variation in pollen counts. Dramatic inter-annual differences can occur, and these have been related to variations in annual rainfall [24]. Drought years are strikingly reflected. For example, the highest daily grass count recorded at Vanderbijlpark in 1991 was 261 m^{-3} , while the corresponding figure for 1992 was only 28 m^{-3} . Such anomalies mean that the value of a pollen

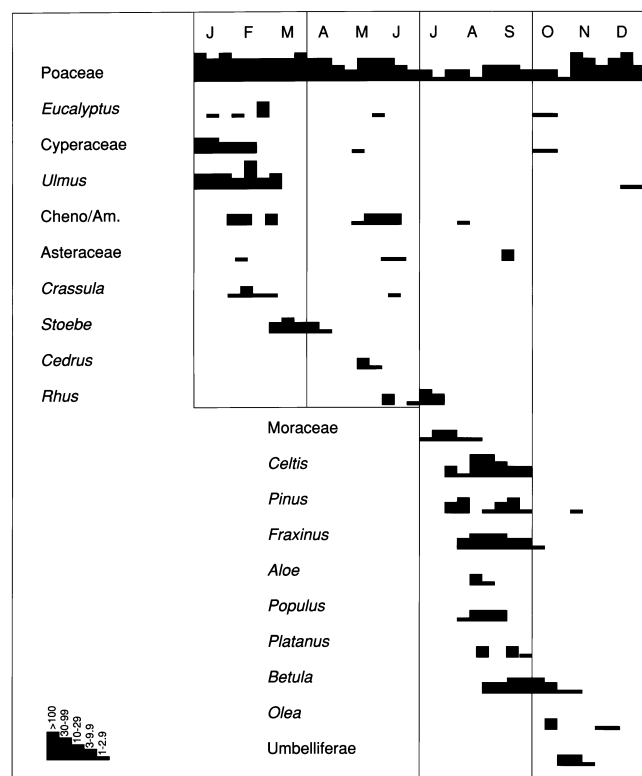


Fig. 4. Pollen calendar for Pretoria.

calendar lies not in the absolute counts, but rather in the trends of pollen incidence which are indicated.

Savanna

Data for Pretoria are presented in the pollen calendar (Figure 4). Although Pretoria is situated on the boundary between the grassland and the savanna biome, the pollen sampler was sited in Pretoria North, where the vegetation is totally savanna. In addition, the prevailing wind direction from North-North-West blows directly from the savanna across the path of the sampler.

The natural vegetation comprises an open savanna with a fairly dense, tall grassveld. Dominant grasses are *Cymbopogon plurinodis*, *Themeda triandra* and *Hyparrhenia* spp. Savanna elements include several species of *Acacia*, *Rhus*, and *Grewia*, *Celtis africana*, *Pappea capensis*, *Burkea africana*, *Dombeya rotundifolia* and *Ziziphus mucronata*.

The pollen calendar is not dissimilar to that of the grassland biome, showing the same annual distribution with Spring and Summer peaks. Grass is again the dominant taxon, while exotic pollen is again evident in Spring. Of interest is the paucity of pollen of indigenous savanna tree

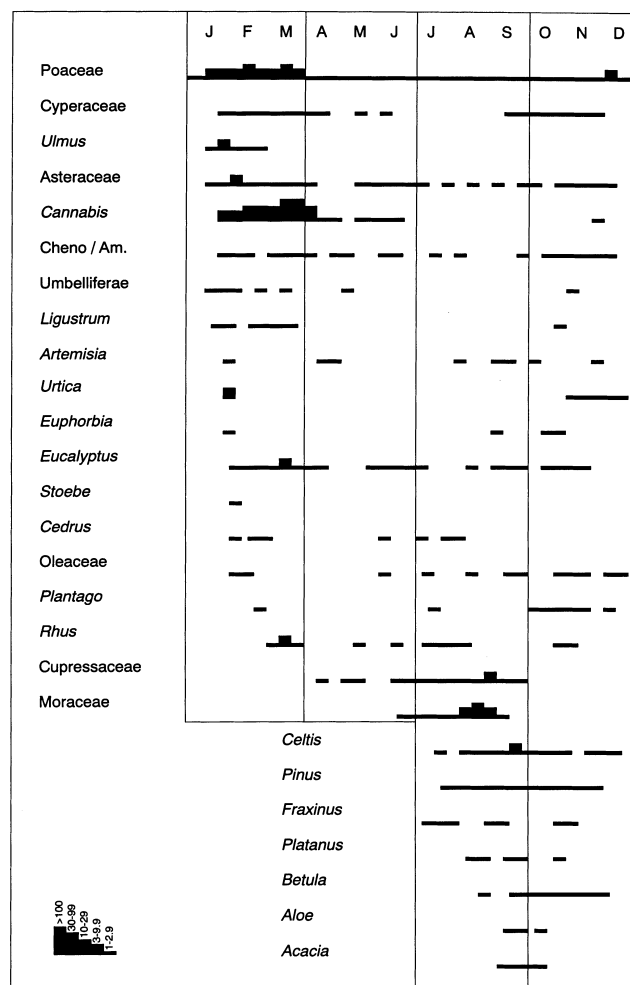


Fig. 5. Pollen calendar for Durban.

and shrub elements. The reason for this near absence is that most savanna taxa are insect pollinated, rather than wind pollinated, so that less pollen is produced by the plants. The little which is produced is heavy and sticky, and not easily airborne. Of the above taxa, only *Celtis* and *Rhus* are wind pollinated, and then *Rhus* only partly. *Celtis* would again include the exotic *C. sinensis*.

Sub-tropical region

The pollen calendar for Durban, situated on the East Coast of the country, is shown in Figure 5. The natural vegetation of the narrow coastal belt is a short but dense evergreen forest, dominated by *Millettia caffra*, *Strelitzia nicolai*, *Brachylaena discolor*, *Ensete ventricosum* and *Ficus natalensis*. In parks and gardens both native and alien sub-tropical plants are found, and include *Palmae*, ornamentals such as *Plumeria* spp., *Spathodea campanulata* and *Delonix*

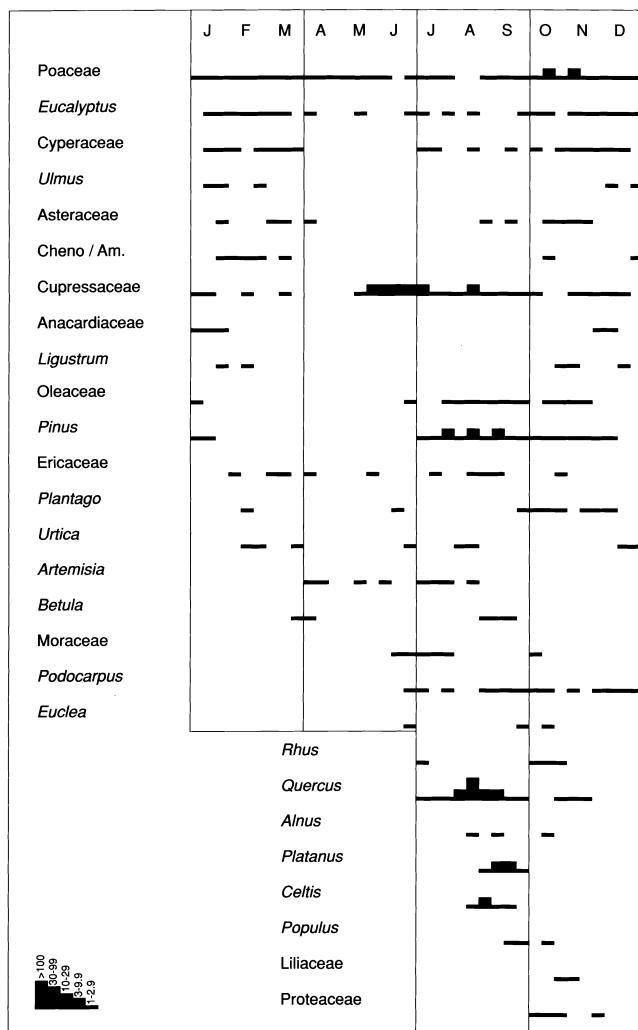


Fig. 6. Pollen calendar for Cape Town.

regia, as well as fruit trees, e.g. *Carica papaya*, *Musax paradisiaca* and *Mangifera indica*. The coastal forest is bordered by a scrubby thornveld, where tall grasses such as *Themeda triandra*, *cymbopogon validus* and *Digitaria* spp. are interspersed with *Acacia karoo*.

The basic pattern of Spring and Summer peaks is again seen in the pollen calendar, with grass the dominant pollen type. The major contributor to the Spring peak is Moraceae, introduced from Asia but now naturalized over large areas. The temperate Northern Hemisphere trees still feature, but far less in this pollen calendar than in the previous three.

Summer grass pollen is heavily augmented by that of *Cannabis*, flowering in late Summer. This exotic is clandestinely and extensively cultivated wherever the authorities can be evaded. The total lack of sub-tropical pollen is also attributable to the predominance of insect-pollinated taxa.

Fynbos

The calendar for Cape Town (Figure 6) is a composite of two sites that were monitored in the area.

The unique natural vegetation of the South-Western Cape is Macchia, locally named Fynbos. It consists of a great diversity of plants of which the Proteaceae, Ericaceae, Iridaceae and Asteraceae are well represented families.

The pollen calendar shows *Quercus*, *Platanus* and some *Pinus* peaking in the spring, while Cupressaceae flowers from winter through to spring. *Quercus robur* thrives in the Mediterranean climate of the South- Western Cape, and is abundant in Cape Town, but the trees are confined to certain suburbs. The result is that, even though this is a wind-pollinated taxon, the effective pollen rain varies considerably from one district of Cape Town to another. This is also partly due to the local topography, with Table Mountain acting as a barrier to air currents. Nevertheless, residents may live in one area and work in another, thereby emphasizing the importance of detailed investigative questioning by the clinician.

The summer pollen load in this region is very small, and confined to low grass counts. Of this, *Stenotaphrum secundatum* (Buffalo grass), a popular lawn grass in the south-western Cape, is an important allergenic component [25].

Once again, the indigenous vegetation, a very rich and varied one, is almost totally lacking from the pollen spectrum, notwithstanding the fact that one of the pollen samplers was sited in the Garden of the National Botanical Institute at Kirstenbosch, which is dedicated to the preservation and cultivation of Fynbos. This is, as above, partly due to the entomophilous nature of most taxa within the Fynbos. An exception is found in *O. europaeae*, for which counts are considerably less than those in European Mediterranean countries where this pollen is a serious cause of allergy. It seems that the local variety, which is in fact *O. europaeae* ssp. *africana* and which is not commercially grown, produces fewer flowers than the cultivated variety.

The count for Cupressaceae may include pollen of the indigenous *Widdringtonia*, but these trees are far less abundant than alien taxa of this family. Similarly, the count for Poaceae may include the family Restionaceae, because these two families have very similar pollen. They were not separated in this study which was limited to the light microscope analysis of non-acetolysed pollen.

The winter rainfall regime of the area partially excludes the alien tree taxa typical of the summer rainfall areas of the country, although they still occur in smaller numbers. The grass pollen peak is also lower than that of the summer rainfall regions.

Clinical implications

In the first completed study of native plants, it was found that the ubiquitous African grass, *Pennisetum clandestinum*, displayed some cross-reactivity with *Cynodon dactylon* (Bermuda grass), but in addition also contained species-specific allergens [19]. IgE binding to 48 kDa and 70 kDa proteins could not be inhibited by pre-absorption with *Cynodon dactylon* pollen extract.

A problem facing allergists in South Africa is to select the most important of the abundant grass pollen procedures for detailed immunological studies at the present time. This is of particular relevance to the selection of appropriate grass pollen immunotherapy vaccines. Kikuyu, *Themeda*, Buffalo and *Eragrostis* grass pollen are currently under detailed investigation for allergenicity.

Although the obvious choice for a candidate allergen is to select a species which is an abundant pollen producer, abundance of pollen is not necessarily the most important factor affecting allergenicity among African grasses. This has recently been illustrated in our local studies of thatch grass, *Hyparrhenia hirta* [26]. Although it is the most abundant pollen producer in the grassland around Gauteng, we have not been able to demonstrate specific IgE responses to aqueous extracts of this grass using Western blotting, in grass-sensitive patients. Bermuda grass has long been identified as an important grass allergen in South Africa [18] and in one study [26] over 95% of grass allergic individuals in the Transvaal and 80% of grass allergic subjects in the Cape had IgE antibodies to it.

A clear understanding of the immunological relationships between the allergenic epitopes of tribes of both the Panicoideae and Chloridoideae sub-families appears to be of great importance for allergy sufferers in Southern Africa, since pollen is produced by many members of these sub-families over vast areas for many months of each year. The allergens of Bermuda grass pollens were first identified and characterized in South Africa by Orren in 1977 [27]. Sequence data recently available on the major allergens of Bermuda grass [28] and its physicochemical and immunochemical characterization will be of great assistance in evaluating the allergenicity of other species in the Chloridoideae sub-family in Southern Africa.

One species currently under consideration is that of *Stenotaphrum* (Buffalo grass) [25]. Buffalo grass is an indigenous coastal grass but also cultivated inland. We have found that 40% of grass allergic subjects in the Cape react to Buffalo grass and further studies of its allergenicity are in progress.

The *Eragrostis curvula/chloromelas* complex is a Southern African grass with abundant pollen. Prescott *et al.* [25] have observed that it induces strong single

specific IgE responses using Western blotting and readily releases histamine for sensitized basophils. *Eragrostis* also belongs to the Chloridoideae sub-family. The IgE responses to *Eragrostis* are to a 32kDa allergen, probably a Group 1 allergen (Prescott 1996, personal communication).

Although our studies of indigenous grasses have focused on species from the Panicoideae and Chloridoideae sub-families, grass pollens of the Pooideae sub-family are also clearly important allergens in South Africa. Eighty per cent of a cohort of grass allergic subjects were found to have strong IgE responses to Rye grass (*Lolium perenne*) pollen [18] and in one study of allergic subjects in the Cape Town region over 90% of the patients had positive RAST tests to Timothy grass (*Phleum pratense*). This was interesting because Timothy grass is not found in the Cape but contains cross-reacting elements for other grasses of the Pooideae which do occur in that region.

Grass pollen allergy is also well documented to maize (*Zea mays*) and sugar cane, both species from the Panicoideae sub-family. Unlike Australia, Canary grass does not appear to be an important cause of pollinosis in South Africa.

Allergy to weed and flower pollen is not common in South Africa although allergy to English plantain and to certain Compositae species, e.g. Cosmos is found. Ragweed is not found in South Africa. Allergy to *Tagetes minuta* (Khakibos) is common.

An important clinical characteristic of grass allergy in South Africa is that grass pollen allergic symptoms are often experienced over many months, in some areas up to 10 months in the year, due to the long grass season in some of the regions. Furthermore, certain grass species produce pollen intermittently several times during a Summer season. Some patients may experience a cyclical waxing and waning of symptoms during a 'season'. It is, as yet, not known in these patients to what extent relapses in symptoms are due to abundance of the same or related pollen or due to exposure to a different or unrelated pollen in a given locality.

Since most patients react to grasses for more than one grass sub-family, immunotherapy with a single grass pollen vaccine is only likely to benefit a few mono-sensitive individuals in this region. It is for this reason that detailed immunophenotyping and profiles of reactivity of all grass-sensitive patients to known grass allergens in the region is recommended before choosing a particular immunotherapy vaccine. In the work-up of such patients, specific IgE testing should include appropriate and representative elements of the indigenous grasses as well as those of well-characterized introduced species from the Pooideae sub-family (e.g. rye grass) and the Chloridoideae sub-family (e.g. Bermuda grass).

Regional flowering calendars have been compiled for

indigenous and alien species and have clarified important differences. These calendars are particularly useful in identifying the causes of tree and weed allergies, where immunological cross-reactivity between the species is uncommon. Correlating symptomatology with pollen peaks is highly informative. By contrast, for grass species the usefulness of flowering calendars will only become apparent once detailed immunological cross-reactivity of the different species has been elucidated. Grass pollen all appear very similar on the Burkard spore trap samples by light microscopy.

Tree pollen is also an important cause of pollen allergy in South Africa, but most of the identified tree allergies have allergenicity from introduced tree species, e.g. Oak, Ash, Plane and Cypress. Allergy to indigenous trees is largely confined to the *Acacia* species.

We have documented specific IgE responses to the Australian *Acacia longifolia* in a few tree-sensitive individuals but most of the trees in the savanna are insect pollinated and do not appear to be important allergens. Many patients believe they are allergic to the alien Port Jackson, an *Acacia* species introduced from Australia, which produces abundant yellow pollen in Mid-Spring in the Cape. Although we have identified weak but specific IgE responses to Port Jackson using Western blotting, the precise clinical significance of these responses has not yet been fully elucidated and detailed characterization of the allergens identified by specific IgE or their cross-reactivity has not as yet been conducted. Port Jackson flowers abundantly concurrent with the peak in tree and grass pollens.

A wealth of information has recently become available on the distribution, seasonality and relative abundance of pollen in South Africa as a result of regional pollen monitoring. Detailed studies of the sequences, T and B cell epitopes and the relative allergenicity of the indigenous pollen are now necessary for the development of more appropriate *in vitro* and *in vivo* diagnostic panels and for the rational development of effective immunotherapy vaccines.

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