Review Article

A NEW SOUTH AFRICAN POLLEN NETWORK (SAPNET)

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ABSTRACT

For the last few decades, pollen counts in South Africa have been available only for Cape Town. There has been little monitoring of the pollen in the rest of the country and, for some South African cities, there are no published data at all. In order to address this deficit, a national pollen-monitoring project for South Africa was established in August 2019 under the direction of the Allergy and Immunology Unit at the University of Cape Town Lung Institute. Burkard volumetric spore traps were positioned on rooftops in six of the nine provinces of South Africa. As a result, regional pollen counts, updated weekly, are available for allergists and all healthcare professionals who treat allergy (see http://www.pollencount.co.za/). The preliminary findings presented in this article highlight the different seasons and pollen spectra observed from each sampling site as a consequence of substantial variation in biomes and climates between the sites.

Keywords: New South African Pollen Network, SAPNET, pollen counts

INTRODUCTION

In the Northern Hemisphere, networks of pollen-monitoring stations have been established so that pollen concentrations in the atmosphere are available to allergists, allergy sufferers and travellers. In South Africa, pollen and fungal spores have been sporadically measured in Gauteng, KwaZulu-Natal and Mpumalanga. There are many myths about airborne pollen. A common belief is that once pollen-monitoring data are available for one year, pollen calendars can be constructed and will be reliable for several decades thereafter. In fact, the seasons differ in timing and quantity year on year and this is illustrated in a comparison of the variation in the shape of the grass-pollen seasons in Cape Town between 1997 and 2001 (see Figure 1).

When regimes for grass desensitisation are planned, immunotherapy must be scheduled during the months when grass-pollen counts are low. In temperate climates, the grass-flowering season may be long, with only a small window of low grass concentrations. Thunderstorm asthma (TA) could occur in South Africa and cities deemed to be at risk should be monitored. Climate change in the Southern Hemisphere might cause seasons to extend or advance, which could prolong the flowering season for allergenic plants, and increasing temperatures might favour opportunistic allergenic weed growth. The regional pollen counts in seven cities in South Africa are providing us with a variety of information.

POLLEN SEASONS

Clinicians now have access to the flowering seasons and the identity of the major pollen allergens, to which their patients are exposed in their city, so that they can choose the appropriate pollen and fungal-spore testing panels for skin-prick and specific IgE tests.

IMMUNOTHERAPY

Desensitisation to aeroallergens such as grass pollen must be scheduled for the months when there are the least number of grass-pollen grains in the atmosphere. It is essential for the clinician to know the months when grass-pollen counts will be low in a calendar year so that grass-sensitive patients can be safely immunised; this will now be possible in seven cities around South Africa.

THUNDERSTORM ASTHMA

In South Africa, many regions have long grass-flowering seasons, especially the temperate grassland areas. The grasslands occur in summer rainfall areas where late afternoon thunderstorms commonly occur. In the early summer, the pollen-release cycle of grasses may coincide with the season when thunderstorms are frequent.

In Australia, the asthma deaths and large numbers of hospital emergency room admissions that occurred in Melbourne in

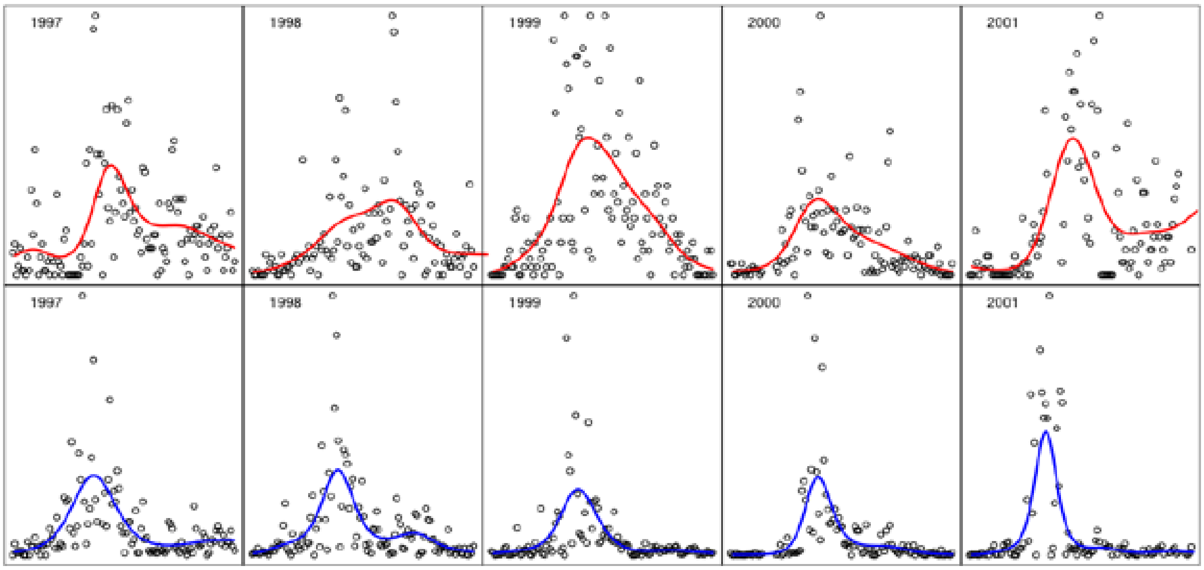

Figure 1: Cape Town grass-pollen distribution 1 September to 31 December 2011–2014 at Rondebosch (red smoothing line) and Table View (blue smoothing line). The smoothed lines are splines fitted in a negative binomial generalised additive model and they represent median pollen counts.

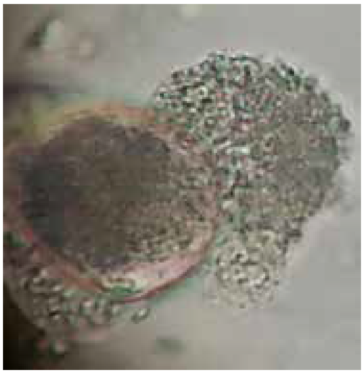

Figure 2: Degranulating grass-pollen grain trapped during a thunderstorm in Kimberley

November 2016[1] were the result of thunderstorms coinciding with high levels of ryegrass pollen in the atmosphere. The ryegrass pollen grains ruptured in response to osmotic shock that released millions of starch granules coated with the allergen, Lol p 5, into the atmosphere.[2] Compounding factors in this process are the meteorological variables: rain and humidity. The starch granules contained in the cytoplasm of grass-pollen grains are of small particle size: they are < 5 μm. These particles are tiny enough to reach the lower airways, triggering asthma with a specific name: 'thunderstorm asthma' (TA)(see Figure 2). TA occurs when large quantities of grass and/or fungal spores congregate in high concentrations at ground level following a thunderstorm.[3] Several of the new South African pollen-monitoring sites experience thunderstorms during the peak grass-pollen season – Johannesburg, Pretoria, Bloemfontein, Kimberley (see Figure 3) and Durban fall in this category, making TA a possible risk for the inhabitants of those cities. TA may also be triggered by fungal spores, notably *Alternaria alternata*. It has been shown that *Alternaria* extract administered after a ryegrass challenge significantly increases the number of bronchoalveolar lavage (BAL) eosinophils and lung inflammation in mice. This number was compared with the number of BAL eosinophils measured when *Alternaria* extract was given before priming with ryegrass extract.[4] An increase in asthma admissions to emergency rooms ascribed to TA has been reported in the cities of Australia, the United Kingdom, Italy, Canada, Saudi Arabia and Iran.[3] The greatest number of these incidents have been reported in the Southern Hemisphere cities of Australia. Identifying the fungal spores present in the air and measuring the fungal and grass concentrations would be essential should TA occur in South Africa.

CLIMATE CHANGE

Increased CO_2 concentrations attributable to human beings and changes in rainfall and temperature enhance the growth of some plants. This has been demonstrated by controlled studies of the growth of the allergenic invasive weed, *Ambrosia artemisiifolia*, or ragweed.[5] The pollen production of allergenic plants in South Africa could increase, or the length of the season for flowering plants could be extended, as a result of changes to the long-term averages caused by human activities. Baseline studies are necessary to compare long-term pollen records with modern pollen atmospheric concentrations; for example, such a study was undertaken in the Natal Drakensberg.[6] In South Africa it is now possible to record and compare pollen seasons in many regions. In time, these modern pollen records may be compared with fossil-pollen assemblages from palynological core analyses. Fossil-pollen assemblages have been constructed from coring in the south-western Cape,[7] from the identification of pollen fossilised in Hyrax (rock rabbit or *dassie*) middens[8] and from a site near Bloemfontein.[9]

A POLLEN WEBSITE MAKES POLLEN COUNTS ACCESSIBLE

To ensure that current pollen counts are easily available to all South Africans, an informative pollen website is updated each week so that the most recent pollen and fungal spore concentrations may be easily accessed by both medical professionals and the public. The SA Pollen Network (SAPNET) measures and reports the daily pollen count in Bloemfontein, Cape Town, Durban, Johannesburg, Kimberley, Port Elizabeth and Pretoria. The pollen and fungal spore mean daily concentrations are expressed as the number of pollen grains or fungal spores found in one cubic metre air per 24-hour period. This is the only source for accurate weekly pollen data in South Africa and the information may be found at http://www.pollencount.co.za/.

CLIMATE ZONE AND VEGETATION DIVERSITY IN SOUTH AFRICA

Pollen and fungal spores in the air are strongly influenced by the vegetation and the climate, or by long-term weather patterns. Day-to-day weather variations in the vicinity of the spore trap directly influence the concentrations of fungal spores in the air, especially rainfall, temperature, humidity, sunshine hours, and wind speed and direction. The seven cities listed above were chosen as each one is a major city with a large population within one of the nine provinces of South Africa (two of them in Gauteng province). The cities are situated in different vegetation biomes and there are distinct differences in the weather patterns of each city (see Figure 3).

South Africa has more climate zones than most other African countries; it also has unique topographical features such as long mountain ranges, which act as physical barriers to airborne pollen, and long coastlines. The coastlines differ: the Indian Ocean, with its warm Agulhas current, flanks the east coast, whereas the Atlantic Ocean, with its cold Benguela current, sweeps north along the west coast. This combination of factors has given rise to nine major vegetation biomes that vary considerably, from arid desert to Mediterranean. These are:

- the Mediterranean climate in the Western Cape, with its misty mountains and unique fynbos (needle-like) vegetation;
- the Highveld, where Pretoria and Johannesburg are situated, is on the land plateau in the central areas of the country, yet the climate of these two cities differs owing to the differences in altitude and mean temperature;

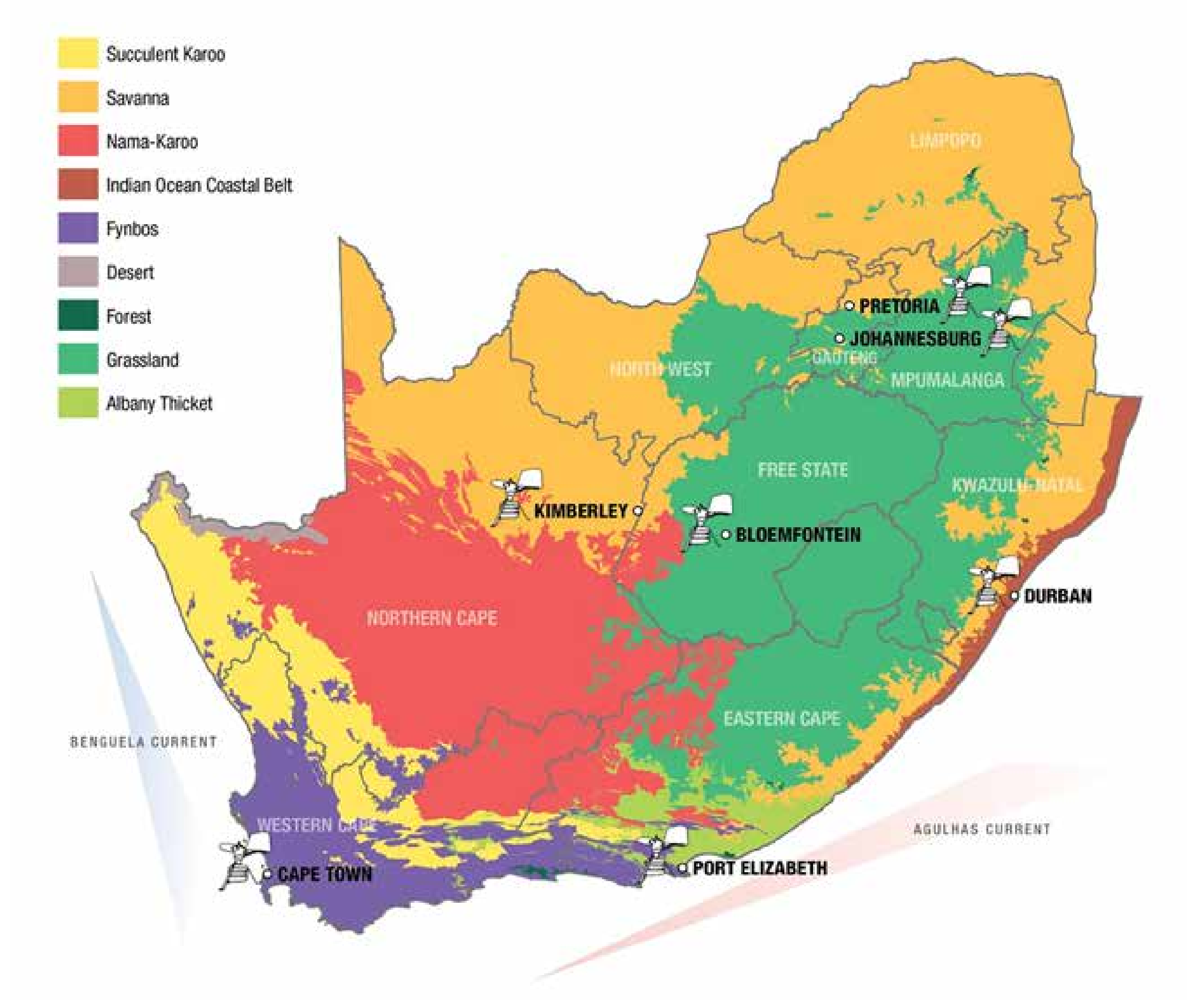

Figure 3: The biome map of South Africa shows the vegetation biomes. (The locations of the seven sampling sites that began in cities on 19 August 2019 are shown in bold letters.)

- Durban lies in a sub-tropical climate zone with high humidity;
- Kimberley's setting is the semi-arid Northern Cape;
- Bloemfontein, on the outskirts of the desert region, has a Steppe climate, with dry winters and a mean annual temperature below 18ºC;[10]
- Port Elizabeth has an Oceanic climate and the diverse vegetation of this site reflects its position between the summer and winter rainfall regions.

PRELIMINARY FINDINGS OF THE POLLEN-MONITORING NETWORK: THE FIRST SIX MONTHS

The most striking difference between the sites to date is the timing of the pollen seasons. The monitoring programme has not been operating long enough to define fully the tree, grass and weed seasons for each site, but it is already apparent that each site has its own unique pollen profile. Applying the pollen count in clinical practice is difficult without the guidance of a scale.[11] Burge suggested a range of separate measurements for fungal spores, grasses, trees and weed aeroallergens that correspond to exposure risk in a sensitised patient. This scale has been applied to the interpretation of pollen risk in this study. It is used by the US National Allergy Bureau.[12]

In this study we use an algorithm to calculate the intensity of the concentration which is linked to risk for symptoms. The website translates this into a 'traffic light' colour-coded result which is easy to read, ranging from 'very low' (which is colour-coded green) through shades of orange to red (which is 'very high').

Summary data from the seven spore traps between 19 August 2019 and 9 February 2020 have shown the following features:

SITE: CAPE TOWN, WESTERN CAPE

This is a winter rainfall area and the grasses peak ahead of those in the other cities currently being measured.

The tree season begins during the winter months when *Cupressus* (cypress) pollen appears in June, followed by *Acacia*, commonly *Acacia longifolia* in the Cape, *Casuarina* (beefwood), *Quercus* (oak), *Platanus* (plane), *Morus* (mulberry), *Myrtus* (eucalyptus), *Olea* (olive), *Pinus* (pine), *Podocarpus* (yellowwood), *Betula* (birch), *Populus* (poplar), *Morella* formerly *Myrica* (waxberry), *Searsia* (formerly *Rhus* (*kareeboom*), *Salix* (willow) and *Celtis* (white stinkwood).

The grass season usually begins in late September, when counts exceed 20 m^{-3}, peaking in October; but grass counts persist until March or April.

Weed concentrations are rarely > 10 m^{-3} in this region. *Plantago* (English plantain), *Taraxacum* (dandelion), Asteraceae (daisy and other shrubs) and Chenopodiaceae (goosefoot) appear in low concentrations.

Fynbos pollen is represented by *Erica* (heather) and *Protea*, two of the three dominant species for which fynbos vegetation is named.

Fungal spores peak in spring and autumn, but also at other times of the year when weather parameters are favourable. *Cladosporium*, *Alternaria* and *Epicoccum* increase to significant levels in October–December when temperatures rise in the spring.

SITE: PORT ELIZABETH, EASTERN CAPE

Very strong wind currents frequent this city, to such an extent that the wind vane has been ripped from the spore trap. The perennial rain and strong wind account for low pollen counts at this site.

The tree types include *Acacia* (wattle), Arecaceae (African palm), *Cupressus* (cypress), *Myrtus* (eucalyptus), *Olea* (olive), *Pinus* (pine), *Ulmus* (elm) and *Casuarina* (beefwood).

Weeds include Asteraceae (daisies), *Chenopod* (goosefoot), *Erica* (heather), *Euphorbia* (indigenous succulent), Iridaceae (iris, lily, *Gladiolus*), Rutaceae (rue or citrus family) and *Protea*.

Fungal-spore concentrations were low, but Ascospores increased frequently following rain. *Cladosporium* did not exceed 3 000 m^{-3}.

SITE: DURBAN, KWAZULU-NATAL

The most striking feature of the air spora at this site is the extremely high fungal-spore concentration that occurred from October: it exceeded 47 000 m^{-3} in November, coinciding with a tornado and heavy rainfall. *Alternaria* and *Epicoccum* concentrations of > 50 spores m^{-3} were recorded. *Cladosporium* concentrations > 3 000 spores m^{-3}.

Grass concentrations were < 20 m^{-3}, but large stands of grasses flower from January, which does not correlate with the scanty atmospheric concentrations – the high humidity levels may be inhibiting grass pollen in the ambient air.

Tree pollen identified included *Acacia* (wattle), *Betula* (birch), *Cupressus* (cypress), *Morus* (mulberry), *Myrtus* (eucalyptus), *Pinus* (pine), *Podocarpus* (yellowwood), *Platanus* (plane), *Searsia* (kareeboom), *Quercus* (oak) and *Ulmus* (white stinkwood).

Weed pollen comprised Asteraceae (daisy and other shrubs), Malvaceae (mallow family), *Plantago* (English plantain), Polypodiaceae (ferns) and *Urtica* (nettle).

Tree and weed pollen levels were insignificant.

SITE: JOHANNESBURG, GAUTENG

Fungal-spore concentrations were low at this summer rainfall site, but the rains were late and fungi require moisture to sporulate.

Tree pollen identified included *Acacia* (wattle), *Betula* (birch), *Casuarina* (beefwood), *Celtis* (white stinkwood), *Combretum* (bushwillow), *Cupressus* (cypress), *Erythrina* (coral tree), Fabaceae (jacaranda), *Fraxinus* (ash), *Morus* (mulberry), *Myrtus* (eucalyptus), *Olea* (olive), *Pinus* (pine), *Podocarpus* (yellowwood), *Platanus* (plane), *Populus* (poplar), *Searsia* (kareeboom), *Salix* (willow) and *Quercus* (oak).

Weeds were Asteraceae (daisy and other shrubs), Boraginaceae (herb), Caryophyllaceae, Apiaceae (parsley, carrot and celery family), *Erica* (heather), *Euphorbia* (indigenous shrubs), *Loranthus* (mistletoe), *Plantago* (English plantain), *Taraxacum* (dandelion), *Thymelaeaceae* (Daphne) and *Stoebe* (indigenous shrubs).

The highest tree-pollen concentrations were seen for plane trees from August to September. Plane pollen exceeded 300 m^{-3} but rapidly disappeared from the air after six weeks.

SITE: PRETORIA, GAUTENG

Grasses increased to daily concentrations of > 20 m^{-3} in mid-January.

Tree-pollen types at this site were *Acacia* (wattle), *Betula* (birch), *Cupressus* (cypress), *Morus* (mulberry), *Myrtus* (eucalyptus), *Olea* (olive), *Pinus* (pine), *Podocarpus* (yellowwood), *Platanus* (plane), *Populus* (poplar), *Searsia* (kareeboom), *Quercus* (oak), *Ulmus* (elm), *Celtis* (white stinkwood), *Combretum* (bushwillow), *Erythrina* (coral tree), Fabaceae (jacaranda) and *Fraxinus* (ash).

Weeds were Asteraceae (daisies and other shrubs), Caryophyllaceae, Chenopodiaceae (goosefoot), *Erica* (heather), *Loranthus* (mistletoe), *Plantago* (English plantain), Polygonaceae (*Rumex*), Polypodiaceae (ferns) and *Parietaria* (pellitory).

The pollen of insect-pollinated plants such as acacia and jacaranda is seldom found in quantity in the atmosphere. Pretoria is heavily planted with jacaranda trees and there are many of these trees in Johannesburg too, but the concentrations did not exceed 15 m^{-3} in either city.

SITE: KIMBERLEY, NORTHERN CAPE

The air spora were consistently low at this site in the semi-arid Northern Cape until the rainy season began in summer.

Grass concentrations increased rapidly in mid-January to > 30 m^{-3}. Degranulating grasses were observed on the strip on many of the days when rain and thunderstorms occurred.

The tree types were *Acacia* (wattle), *Betula* (birch), *Morus* (mulberry), *Cupressus* (cypress), *Searsia* (kareeboom), *Casuarina* (beefwood), *Celtis* (white stinkwood), *Myrtus* (eucalyptus), *Quercus* (oak), Olea (olive) and *Salix* (willow). Of the tree types, only olive exceeded 15 m^{-3}.

TABLE I: A COMPARISON OF TREE-POLLEN LOADS AT THE SAMPLING SITES, 19 AUGUST–9 FEBRUARY

Tree taxa		**Cape Town, Western Cape**	**Bloemfontein, Free State**	**Johannesburg, Gauteng**	**Pretoria, Gauteng**	**Durban, KwaZulu-Natal**	**Kimberley, Northern Cape**	**Port Elizabeth, Eastern Cape**
Scientific name	Common name	*n* = 4 683	*n* = 3 293	*n* = 3 146	*n* = 1 461	*n* = 260	*n* = 212	*n* =121
Acacia	wattle spp	4	32	2	10	8	2	11
Acer	maple	26						4
Arecaceae	palm	1				1		7
Betula	birch	26	20	147	64	87	18	4
Buddleja	butterfly bush		397					6
Casuarina	beefwood	8	42	8	15		4	4
Celtis africana	white stinkwood	47	1 331	2	8		27	
Combretaceae	bush willow		85	6	66			
Cupressaceae	cypress	2 465	166	222	46	24	10	8
Erythrina	coral tree			1				
Jacaranda mimosifolia	jacaranda			1	16			
Fagus	beech			1	1			
Fraxinus	ash	4		8	21	23	10	
Morus	mulberry	99	1	125	567	23	48	1
Myrtaceae	includes eucalyptus	108	179	100	104		9	16
Olea	olive	245	789	58	53	12	55	4
Pinus	pine	1 059	170	74	29	58	26	17
Platanus	plane	398	10	2 307	420	9	1	35
Podocarpus	yellowwood			30	10			
Populus	poplar	4		3	9	4		3
Prosopis	mesquite				4			
Quercus	oak spp	188	31	40	3	9	2	
Rhus/Searsia	Kareeboom		40	8	15	2		1
Salix	Willow	1		3				

n = the total pollen sum for each taxon for the entire time period. The daily concentration is expressed as concentration/cubic metre/24-hour period and these scores were summed.

Weeds included Asteraceae (daisy and other shrubs), Polypodiaceae (fern), Chenopodiaceae (goosefoot), Euphorbia (indigenous shrub) and *Plantago* (English plantain) but did not exceed 10 m^{-3}.

SITE: BLOEMFONTEIN, FREE STATE

Grasses increased during September, exceeding 30 m^{-3}. From October until mid-January grasses were < 10 m^{-3}, when concentrations increased again to > 50 m^{-3}.

A six-week tree season began in September, when *Platanus* (plane), *Cupressus* (cypress), *Pinus* (pine), *Podocarpus* (yellowwood), *Betula* (birch), *Buddleja* (sagewood), Combretum (bushwillow), *Olea* (olive), *Celtis* (white stinkwood), *Myrtus* (eucalyptus), *Searsia* (kareeboom), Salix (willow), *Acacia* (wattle) and *Casuarina* (beefwood) exceeded 15 m^{-3}.

The weed concentrations were consistently < 10 m^{-3} and included Asteraceae (daisy and other shrubs), Boraginaceae (herb), *Chenopod* (goosefoot), *Erica* (heather), Euphorbia (indigenous shrub), *Plantago* (English plantain), Polygonaceae (Rumex), Polypodiaceae (ferns) and *Taraxacum* (dandelion). Four Buddleja species are found in South Africa. The flowers form dense heads and their flowering time is long, from August to March. It is difficult to identify them to species level using light microscopy. It is noted that *Buddleja glomerata* is known as *Karoo sagewood* or sneezebush/*niesbos.*

TREATMENT REGIMES FOR SEASONAL ALLERGY

Knowledge of the relevant airborne pollens and fungal spores is a valuable asset to the diagnosis and management of seasonal allergic diseases. SAPNET, through radio and media coverage advertising the weekly pollen counts, aims to create an awareness for seasonal allergy sufferers of the specific pollens of fungal triggers, seasons and symptoms. Similarly, an awareness of key local offending allergenic pollens and the timing of their flowering seasons can inform allergists or healthcare workers about which testing – either skin-prick or *in vitro* specific IgE – to use to identify the specific offending tree, grass, weed or fungal-spore allergenic sensitisations needed for a particular patient. This will in turn allow for optimal management strategies for seasonal allergies, which can include:

- advice on avoiding or restricting outdoor exposures during particular times of year when counts of offending allergens are high or very high;
- guiding the initiation of preventer therapies such as intranasal or inhaled steroids that need to be commenced 2–4 weeks prior to flowering seasons for optimal efficacy; and
- guiding the use of allergen-specific immunotherapies via either sublingual or subcutaneous routes, which may be curative for certain seasonal pollen or fungal allergens.

FUTURE RESEARCH

SAPNET hopes to extend its monitoring to include the provinces of Mpumalanga, Limpopo and North West. Palynologists collaborating in this pollen-monitoring project have already added to the study valuable insights to and provided assistance in identifying pollen. Further collaboration with clinicians, aerobiologists, palynologists, biosecurity and plant-health, and invasion specialists and climatologists in Australia and South America would provide the critical science about pollen and fungal aerobiology in the Southern Hemisphere and the impacts of climate change. This undertaking could produce data similar to those being generated in the countries of the Northern Hemisphere.

Figure 4: A robber fly that nicely illustrates insect pollination. Courtesy of Mark Berman.

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DECLARATION OF CONFLICT OF INTEREST

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