

AN OVERVIEW OF THE INDIGENOUS AND ALIEN ALLERGENS OF SOUTHERN AFRICA

Paul Potter, FCP(SA), MD

Department of Medicine, Groote Schuur Hospital

Allergy Diagnostic & Clinical Research Unit, University of Cape Town

Correspondence

Prof. Paul Potter, email paul.potter@uct.ac.za

ABSTRACT

Since the allergens causing clinical disease in Southern Africa were first identified in 1956 there has been a steady rise in the prevalence of allergic diseases in all populations. Although initial allergens were found to represent alien or introduced species, e.g. Bermuda grass, maize, lucerne, it later became apparent that indigenous allergens were also allergenic. Other major alien allergens which were imported into our region include oak, plane, pine and eucalyptus trees, the American, German and Oriental cockroaches, and fruits, e.g. kiwi and olive.

The first truly African indigenous pollen allergen to be characterised was kikuyu grass (*Pennisetum clandestinum*) followed by buffalo grass (*Stenotaphrum secundatum*). Subsequently indigenous food allergens identified and characterised include abalone (*Haliotis midae*), cobra venom (*Hemachatus hemachatus*), mopane worms (*Imbrasia belina*), Rhodesian flame lily, *Locusta migratoria* and the African penguin (*Spheniscus demersus*). Several indigenous food sources are suspected to be causing food allergies in Botswana and are currently being investigated for allergenicity.

In addition to the indigenous allergens described in this overview, South African researchers have also contributed to investigating and understanding the immunogenicity of other 'global allergens' such as Imbuia wood, verbena hybrida and *Anisakis*. The database of the aerobiology of the region shows a wide diversity of pollen and mould allergens.

South Africa has a vast ethnic, genetic and cultural diversity of its peoples, our flag of many colours being symbolic not only of our 'rainbow nation' but of our vast diversity of allergens. Superimposed on a mix of ethnic diversity (Oriental, European, Indian and African), we live in a land of diversified climate zones, or 'biomes', which are the habitat of a huge variety of flora and fauna. During the past 50 years, westernisation of most of South Africa has imposed changes on host-gene-environmental interactions, which have unleashed epigenetic changes in host immune responses, from 'tolerance' to environmental agents, to 'hypersensitivity' or allergy to previously tolerated environmental proteins, several of which are indigenous to the African continent.

For centuries, allergies were not known among the indigenous people of South Africa and even in recent times, when Bushmen living in the Kalahari in the traditional way participated in a health survey in 1989, no allergic diseases were reported.¹ In most regions of typical rural South Africa, where people live in the traditional thatched African hut (surrounded by grapes, chickens, goats, fungal spores and cow allergens), allergies are still very uncommon. In this traditional environment, parasite infestation (e.g.

schistosomiasis and *Ascaris* roundworms) stimulates IgE production, but does not inhibit the production of specific IgE to environmental allergens, but does reduce the expression of skin-prick test positivity and allergic disease phenotypes.

The first identification of a specific allergen in South Africa by Ordman² was in 1956 and Voorhorst *et al.*³ confirmed in 1964 that *Dermatophyoides pteronyssinus* was an environmental 'factor' causing asthma. Since these key publications, the field of allergy has mushroomed in our region, both in the number of individuals in the population affected (up to 25% or 12 million in South Africa) and in the variety of allergens, 'alien', 'global' and 'indigenous', causing common and sometimes life-threatening allergic diseases in our population.

CLASSIFICATION OF ALLERGENS OF SOUTH AFRICA

Allergens now prevalent in South Africa may be classified into 3 main groups (see Table I).

Group A: Global. These allergens are present worldwide, but studies of local distribution and immune responses in Southern African subjects have

been published in the past 15 years. Many of these allergens have been ‘introduced’ to South Africa, mainly through trade but also by the ‘settlers’, e.g. oak and plane (e.g. importation of grains, contaminated by alien pollens). These include many food allergens.

Group B: True indigenous Southern African allergies. These are due to novel African species (or allergens) which only occur naturally in Southern Africa, which may cross-react with ‘non-African’ counterparts. In some cases these have completely unique or ‘novel’ allergenic epitopes. Several of these have been identified and reported in recent years. A broad classification of our indigenous allergens with typical examples is shown in Table I. This list is not exhaustive as many other novel allergens less commonly encountered are being identified as new cases are investigated immunologically in more depth.

Group C: Characterised in South Africa. Allergens found naturally globally but on which important basic research or significant studies on the characterisation of allergenicity or distribution has been performed by South African researchers, e.g. Bermuda grass, *Anisakis*, Imbuia wood, verbena allergens and spider mites. Allergens identified by the Burkard spore trap have a unique aerobiological distribution in Southern Africa and have been studied in detail for many years. These are listed in the accompanying article by Dilys Berman in this issue of the journal.

A discussion of all the allergens of Southern Africa including all of our ‘global’ or ‘indigenous’ species is beyond the scope

of this article. This article however highlights interesting, or unusual aspects and emphasises the South African research studies relating to our ‘indigenous’ and our global allergens, focusing particularly in some detail on local studies of the new recently described ‘truly’ African allergens.

Regarding testing for allergens in Southern Africa, commercial skin-prick tests (ALK-Abello, Stallergenes) or ImmunoCAP (Thermo Fisher) allergens are available and appropriate for all of the group A ‘worldwide’ allergens, but are not available for nearly all of the group B ‘indigenous’ African allergens, for which in-house extracts or Western blotting techniques are utilised for diagnostic purposes. Standardised tests for most of the group B allergens have yet to be developed. An indigenous African research laboratory is essential to elucidate the molecular basis of these allergies.

HOUSE-DUST MITES

House-dust mites are recognised as a major cause of persistent allergy in South Africa in patients with rhinitis, asthma and atopic dermatitis. Historical aspects and prevalence in the region was reviewed in detail by Potter *et al.* in 1996⁴ with solid evidence by Van Niekerk *et al.*⁵ showing that the prevalence of sensitivity to house-dust mite has increased in urbanised Xhosas to the extent that up to 80% of 200 children at a Cape Town paediatric allergy clinic are sensitised to house-dust mites.⁶ Although high levels of house-dust mite were reported in the coastal regions of Southern Africa (>10 µg/g dust Der p 1)⁴ and extremely high levels along the Namibian coast (more than 100 µg/g dust at Oranjemund and Swakopmund) (Christo Buys – personal communication), Steinman *et al.*⁷ found that westernisation and urbanisation within traditionally rural areas of the Eastern Cape had led to increased levels of dust-mite sensitisation in children.

Table I. Classification of Southern African allergens		
Group A	Global	Occur naturally worldwide Several are ‘introduced’ species Confirmed to be allergenic in Southern African subjects Characterised mainly in other parts of the world
Group B	Truly indigenous	Only occur naturally in Southern Africa Identified as ‘novel’ African allergens May ‘cross-react’ with similar non-African species Characterised in South Africa
Group C	Global but significant characterisation by South African researchers	Occurring in other parts of the world as well as South Africa Major understanding of their allergenicity or distribution (e.g. aeroallergens) elucidated by and contributed to by South African researchers

Jooma *et al.*⁸ reported a seasonal variation in Der p 1 levels in a study of 60 homes (bedding and carpets) on the Cape Peninsula, peaking between April and November with the lowest levels found in January and February. In Gauteng patients from the South African highveld appeared to be sensitised even at low levels of mite exposure⁴ and Seedat *et al.*⁹ recently reported that 46% of patients in Bloemfontein were sensitised to house-dust mites, with sensitisation being significantly more common in patients who had previously lived at the coast. House-dust mite sensitisation also occurs in tropical island areas of Southern Africa and in Harare, Zimbabwe. Although the major species causing sensitisation are *D. pteronyssinus* and *D. farinae*, *Blomia tropicalis* sensitisation occurs in about 40% of mite-sensitive subjects.

COCKROACH ALLERGIES

Three species of cockroach are found in Southern Africa. *Blatella germanica* is the commonest and most widely spread, especially inland,⁹ whereas *Periplaneta americana* and the Oriental cockroach are more frequently encountered at the coast, particularly reported from the KwaZulu-Natal coast, from the Durban area.¹⁰ Isolated cockroach monosensitisation is rare in South Africa, but has been noted in Gaborone, Botswana. Cockroach sensitivity is invariably seen in patients who are polysensitised to house-dust mites and fungal spores.

FUNGAL ALLERGENS

In 1991 Potter *et al.*¹¹ in a large study of over 1 800 subjects found a significant clustering of the immune responses of South African allergic subjects to *Cladosporium*, *Alternaria* and *Aspergillus*. Sensitisation to *Aspergillus*, *Alternaria* and *Cladosporium* is common in polysensitised allergic subjects⁶ but occasionally patients are identified who are only sensitised to *Alternaria alternata*. Seasonal variations in fungal spore counts have been reported by Berman⁶ and depending on the siting of the Burkard spore trap, some areas of the Cape Peninsula have unusually high exposure to specific fungal spores, such as *Curvularia*.¹²

GRASS POLLENS

A total of 947 indigenous and 115 naturalised grass species in Southern Africa produce an abundance of pollen in the grassland and savannah biomes of Southern Africa, but fortunately for allergists there is a fair amount of cross-reactivity between the major grass pollens, for diagnostic purposes particularly, but also for selection of immunotherapy vaccines. Therefore for testing and immunotherapy Bermuda grass (*Cynodon dactylis*) (an imported species) and rye grass (*Lolium perenne*) specific

IgE testing is adequate for most grass-allergy sufferers, unless they have unusual presentations and are test-negative in the face of convincing history, when indigenous grass pollen sensitivity should be explored.

In one study at the University of Cape Town 90% of grass-pollen-allergic subjects were sensitised to Timothy grass (*Phleum pratensis*) although this grass does not occur naturally, but contains cross-reactive epitopes, recognised by most of our grass-allergic subjects. *Eragrostis* produces vast quantities of pollen and is a strong inducer of specific IgE, shown on Western blotting.

The first 'African' grass to be characterised (in 1993) was kikuyu grass (*Pennisetum clandestinum*) (Fig. 1a), to which 43% of grass-sensitised individuals in the Western Cape were found to be sensitised.¹³ This was followed by the identification of significant allergen sensitisation (80%) to buffalo grass (*Stenotaphrum secundatum*), (Fig 1b) the second African grass to be characterised.¹⁴ Characterisation of the alien Bermuda grass pollen had been conducted as early as 1977.¹⁵ The grasses of the Pooideae (rye, Timothy) and Chloridoideae (Bermuda) are available as vaccines. Grasses of the Panicoideae (e.g. buffalo grass, kikuyu grass, maize) may also be important in some subjects.

In Australia Johnson grass (Panicoideae) is very important and this group may be more important in South Africa than previously recognised. Pollen vaccines are available for maize (*Zea mays*), an important aeroallergen in farm growing areas of Southern Africa, the Free State and Zimbabwe. Sublingual immunotherapy (SLIT) for maize pollen was one of the first SLIT double-blind placebo-controlled studies, showing significant efficacy, by Van Niekerk *et al.* as early as 1987.¹⁶

ALLERGY TO ANIMAL DANDER OR PROTEINS

As in other westernised countries, allergy to household cats and dogs is commonly encountered. Allergy to rabbit and rat urine is commonly encountered in laboratory workers and less commonly to horses in farmers, equestrians and veterinarians. Very recently (SJ Kung and PC Potter – paper in preparation) specific IgE sensitisation has been confirmed in two isolated cases, in patients who encountered allergies when exposed to African antelope in game reserves (e.g. wildebeest and impala). Studies of the allergens responsible are currently in progress at the University of Cape Town Lung Institute, Allergy Diagnostic & Clinical Research Unit. Similar reactions have been reported in the UK in individuals handling fallow deer.



Fig. 1a. Kikuyu grass (*Pennisetum clandestinum*).



Fig. 1b. Buffalo grass (*Stenotaphrum secundatum*).

Recently a case of allergy to ingestion of the skin of porcupine (the largest known rodent) has been identified (C van Rooyen, B Fenemore and PC Potter – paper in preparation). Allergy to aerosolised cobra (rinkhals) (Fig. 2) venom was reported by Prescott and Potter¹⁷ in a snake handler at the Johannesburg Zoo. The major allergens in snake venoms were identified as phospholipases. This was the first report in the published literature of allergy to snake venom via the aerosolised route.

ALLERGY TO BIRDS

Allergy to hen egg is one of the commonest sensitivities encountered in young children with atopic dermatitis. Individuals who keep birds such as budgies, parrots, pigeons and cockatiels may also be sensitised, and commercial tests are available to detect specific IgE to these birds.

In 2012 a patient who developed asthma and conjunctivitis as a result of IgE sensitisation to African penguin proteins was reported at the South African Allergy Congress in Cape Town and at the European Academy of Allergy and Immunology Congress in Milan in 2013 (PC Potter, B Fenemore, L Foot – paper in preparation).¹⁸ The patient was an animal behaviourist who cared for a penguin colony at a Cape Town aquarium (Fig. 3) who became sensitised to penguin serum and mucus proteins by close exposure, in an enclosed environment. This is the first case in the international literature of immunologically confirmed sensitisation to penguin serum and mucus proteins.

TREE ALLERGENS

Southern Africa does not have vast, dense areas of forest as are encountered in Europe and North America, and tree



Fig. 2. Cobra (*rinkhals*).

pollinosis is uncommon in most regions. However, Johannesburg is the most heavily tree-planted city in South Africa, mainly by alien trees (such as pines, oaks, planes, eucalyptus trees), but also *Acacia* species and other African trees, and tree pollinosis is not uncommon in Johannesburg, in spring.

In the Western Cape, plane and oak trees are the most common cause of short-lived allergy symptoms, which occur in August and early September, each year.¹⁹ Although the *Acacia* trees are widespread in Southern Africa very few cases of apparent pollinosis are encountered. Allergy to alien Australian wattle trees, which are fairly widespread, is also very uncommon.

In Namibia, however, intense allergies are encountered to mesquite (Christo Buys – personal communication) particularly around Windhoek. Birch pollinosis (common in Europe) is not seen in South Africa, and therefore the oral allergy syndrome profile related to birch sensitisation is also rare. Oral allergy syndrome related to prunes and the gourd family (e.g. melon, watermelon and other summer fruits) is more common in Southern Africa.



Fig. 3. African penguin (*Spheniscus demersus*).

WEED AND FLORAL POLLENS

Fortunately South Africa does not have ragweed, so this important northern hemisphere pollinosis is not encountered. Sensitisation to English plantain, *Cosmos* and khakibos is found, but since pollination tends to take place out in the veld, they do not appear to pose significant clinical problems and patients are treated symptomatically, rather than by immunotherapy. The Cape fynbos produces sticky pollen and is not a source of allergenicity (i.e. Proteaceae, *Erica* and restios). Most garden flowers are alien and tend to produce pollen for very brief periods and are seldom a cause of clinical symptoms, although some subjects react to the fragrances (e.g. jasmine).

OCCUPATIONAL ALLERGIES

In addition to the typical occupational allergies experienced in industry in industrialised nations of the world, unusual and unique occupational allergies have been reported from South Africa.

Baatjies and Jeebhay²⁰ have studied baker's asthma in the region in detail, and Jeebhay *et al.*²¹ have highlighted seafoods as important occupational allergens in the seafood

processing industry along the West Coast of the Western Cape. Studies of fruit farm workers in the Elgin area also identified allergy to spider mites (*Tetranychus urticae*) as an important occupational cause of allergic rhinitis²² in the farm workers.

Platinum salts are an important cause of IgE-mediated asthma in Southern African platinum mines.

Latex allergy is the most important occupational allergy in healthcare workers, with a prevalence ranging between 5% and 20% in South African hospitals, first reported by Potter *et al.*²³ and highlighted again in 2013 by Risenga *et al.*²⁴ The rights of healthcare workers in South Africa to a latex-powder-free environment have recently been highlighted in an editorial in the *South African Medical Journal*.²⁵

Healthcare workers are also being sensitised to chlorhexidine and to pharmaceuticals such as penicillin in the pharmaceutical manufacturing industry.

Asthma due to inhalation of the body parts and wing fragments of the African locust, *Locusta migratoria* (Fig. 4), found in students working in a University of Cape Town research laboratory,²⁶ improved significantly after the introduction of proper ventilation and restriction of exposure, through working in hoods with fume-appropriate air extractors. A similar improvement in occupational asthma was affected when the patient who developed penguin allergy¹⁸ at a Cape Town aquarium modified her exposure to aerosolised seafood, penguin faecal and mucus proteins, once the allergen had been identified.

Jeebhay *et al.*²⁷ also reported allergy to imbuia wood in a wood-processing worker.



Fig. 4. *Locusta migratoria*.

AFRICAN FOOD ALLERGENS

Food allergens causing allergies in young children, particularly those with atopic dermatitis, are similar to those causing allergies in other Western countries, the major allergens being egg, milk and peanut in infants and wheat, tree nuts and seafood allergens in older children and adults.

A Cape Town study by Zinn *et al.*²⁸ of 100 seafood-allergic adults highlighted the importance of mollusc allergy, as well as abalone (Fig. 5), as a novel allergen for the region. The allergen in the South African abalone (*Haliotis midae*) was subsequently characterised by Lopata *et al.*²⁹ Further studies of seafood allergy also identified alikreukel, African lobster (*Jasus lalandii*) and mussels as important seafood allergens in the Cape region. Patients have also been identified who have reacted to kingklip, Cape hake, prawns, snoek and red roman fish.



Fig. 5. Abalone (*Haliotis midae*).

Testing for crustacean allergy is conveniently screened by using the ImmunoCAP radioallergosorbent test (RAST) (Thermo Fisher) which is positive in over 90% of patients who are sensitive to crustaceans. Recent studies in 2012 by Gray and Kung³⁰ in 100 African children with atopic dermatitis have shown that sensitisation to food allergens is common, but challenge positive sensitivity was confirmed in less than 50% of cases tested in this way. Thus the significance of a positive food allergy, skin or blood test in children with atopic dermatitis should be investigated by open or closed 'challenge' by doctors trained in this technique.

An unusual clinical allergy, with confirmed specific IgE sensitivity to novel proteins confirmed on Western blotting, was also recently reported by Kung *et al.*³¹ to mopane

worms (*Gonimbrasia belina*). These are true novel African indigenous allergens which are commonly consumed in Zimbabwe, Botswana and northern areas of South Africa, for their high protein content and nutritional value. Kung has also identified patients with allergy to marula nut (paper in preparation), the African pear and black-eyed pea (Kung – personal communication). Immune investigation is in progress on these three novel African allergens, at the Indigenous Allergen Research Unit of the University of Cape Town. Allergy to an African wild fruit (*Strychnos madagascariensis*) is highlighted in her article on 'Allergy in Botswana' in this issue of *Current Allergy & Clinical Immunology*.

GROUP C: INTERNATIONAL ALLERGENS (EXPLORED BY SOUTH AFRICAN RESEARCHERS)

These are allergens that commonly cause allergies in Southern Africa, but are not naturally indigenous to the region. However, important elucidation of their allergenicity in case studies or formal research projects has been performed by South African researchers, and published mainly in international peer-reviewed journals.

- **Bermuda grass:** *Cynodon dactylon* was first identified by Ann Orren in 1977 and characterised as a major allergen in her MD thesis.¹⁵
- **Imbuia wood:** First identified as an occupational allergen by Mohamed Jeebhay and characterised and published in 1996.²⁷
- **Verbena hybrida:** First identified as a contact allergen by Paul Potter in a child who developed an anaphylactic reaction following contact and published in 1995.³²
- **Anisakis:** Allergenicity investigated in mouse models by Andreas Lopata, Natalie Nieuwenhuizen and others;³³ present in a high percentage of local fish, though clinical allergic manifestations appear to be uncommon in our region, for reasons still to be explored.
- **Spider mites:** Found to be allergenic in fruit farm workers in the Western Cape by Jeebhay *et al.*,²² although previously reported in Korea.
- **Aerobiological spectrum:** Studied in detail over a 30-year period by Dilys Berman. Subject of several reviews and a PhD thesis in progress.^{34,35} These are listed in detail in a table in her accompanying article.

Table II summarises some of the major allergens of South Africa.

Table II. Major allergens of South Africa*		
Group A Global & present worldwide	Group B True indigenous African allergens	Group C Global but characterised in South Africa
House-dust mites ^{2-5, 8, 9} <i>D. farinae</i> <i>D. pteronyssinus</i> <i>B. tropicalis</i> Cockroach species ¹⁰ <i>Blatella germanica</i> <i>Periplaneta americana</i> - Oriental cockroach Grass pollen species ⁶ - Bermuda grass¹⁵ - Maize¹⁶ - Rye grass Floral pollen <i>Cosmos</i> Tree pollens ⁶ - Oak - Plane¹⁹ - Cyprus - Pine - Mesquite/<i>Prosopis</i> Animal dander - Cat - Dog - Cow - Horse - Rabbit - Rat - Hamster Fungal spores ^{11,12} <i>Aspergillus</i> <i>Alternaria</i> <i>Cladosporium</i> <i>Curvularia</i> <i>Botrytis</i> Occupational allergens - Latex^{23,24} - Chlorhexidine - Isocyanates - Spider mites²² - Baker's asthma (wheat flour, rye)²⁰ - Enzymes: papain, alpha-amylase, phospholipases Food allergens - Egg - Milk - Peanut³⁰ - Soya - Wheat - Banana - Avocado - Kiwi - Lentil - Gelatin - Fish: hake, salmon²¹ - Crustaceans: crayfish, shrimps, prawns - Molluscs: calamari, mussels	Grass pollens - Kikuyu grass¹³ - Buffalo grass¹⁴ <i>Eragrostis</i> species Tree pollens <i>Acacia</i> species Weed and floral pollen - Khakibos - Rhodesian flame lily³⁷ Food allergies - Abalone (<i>Haliotis midae</i>)²⁹ - Alikreukel - African rock lobster - Mopane worms³¹ - Marula nuts - African pear - Black-eyed pea - Mogwagwa wild fruit (<i>Strychnos madagascariensis</i>) Occupational - Platinum salts <i>Locusta migratoria</i>²⁶ Animal products - Cobra venom (rinkhals)¹⁷ - Wildebeest - Impala - African penguin¹⁸ - Porcupine	Grass pollens - Bermuda (<i>Cynodon dactylis</i>)¹⁵ Trees - Imbuia wood²⁷ Floral - Verbena hybrida³² Arthropod <i>Tetranychus</i>²² Parasite <i>Anisakis</i>³³ Aerobiological ^{34,35} See full table of fungal and pollen spores in accompanying article

* Note: This list is not exhaustive.

CONCLUSION

In Southern Africa we encounter patients with a full range of allergies, from those seen commonly in most westernised countries to novel and unique African allergies, several of which have been reported internationally and some of which are still being characterised in university academic allergy research units. Much can be learned about the interplay between environments, epigenetics, parasites, urbanisation, Western style living and the expression of clinical allergy by studying allergies in the Southern African region. It is important therefore that the limited research facilities we have for the characterisation and elucidation of these fascinating and informative novel allergens, and for the investigation of our patients with 'new' or unexpected allergens, should be conserved and expanded.

Declaration of conflict of interest

Prof Paul Potter has been a recipient of research funds from the Allergy Society of South Africa (ALLSA), the National Research Foundation (NRF), the Medical Research Council (MRC) and ALK-Abello, and has conducted clinical trials for GlaxoSmithKline (GlaxoWellcome), UCB, MSD, Uriach, Astra-Zeneca, Leti, Stallergenes, Schering-Plough, Parexel, Triclinium and Novartis.

REFERENCES

- O'Keefe SJD, Lavender S. The plight of modern Bushmen. *Lancet* 1989;ii:255-257.
- Ordman D. The ultimate factor in perennial respiratory allergy. *Int Arch Allergy Appl Immunol* 1956;9:129-145.
- Voorhorst R, Spijksma-Boezeman MIA, Spijksma FTA. Is a mite (*Dermatophyoides* sp) the producer of house dust allergen? *Allergy Asthma* 1964;10:329-334.
- Potter PC, Davis G, Manjra A, Luyt D. House dust mite allergy in Southern Africa: historical perspective and current status. *Clin Exp Allergy* 1996;22:132-137.
- Van Niekerk C, Shore C, Weinberg EG. The house dust mite and childhood asthma in the Cape Peninsula. *S Afr Med J* 1977;25:70-75.
- Potter PC, Berman D, Toerien A, Malherbe D, Weinberg EG. Clinical significance of allergen identification in the Western Cape. *S Afr Med J* 1991;79:80-84.
- Steinman HA, Donson H, Kowalski M, Toerien A, Potter PC. Bronchial hyperreactivity and atopy in Xhosa and white children cross a gradient of environments from rural to urban. *Paediatric Allergy and Clinical Immunology* 2003;14:383-393.
- Jooma OF, Weinberg EG, Berman D, Manjra A, Potter PC. Accumulation of house dust mite Der p 1 levels on mattress covers. *S Afr Med J* 1995;10:1002.
- Seedat RY, Claassen J, Claassen AJ, Joubert G. Mite and cockroach sensitisation in patients with allergic rhinitis in the Free State. *Current Allergy & Clinical Immunology* 2009;22(2):81.
- Lopata AL, Jeebhay MF, Groenewald M, Manjra A, Du Toit G, Sibanda EN. Sensitisation to three cockroach species in South Africa. *Current Allergy & Clinical Immunology* 2005;18(2):22-25.
- Potter PC, Juritz J, Little F, McCaldin M, Dowdle EB. Clustering of fungal allergen specific IgE antibody responses in allergic subjects. *Ann Allergy* 1991;66:149-153.
- Berman D. The curious case of *Curvularia* in Cape Town. *Current Allergy & Clinical Immunology* 2009;22(2):82.
- Potter PC, Mather S, Lockey P, Ainslie G, Cadman A. IgE specific immune responses to an African grass kikuyu *Pennisetum clandestinum*. *Clin Exp Allergy* 1993;25:5881-5886.
- Prescott R, Potter PC. Allergen specificity and cross reactivity of buffalo grass (*Stenotaphrum secundatum*). *S Afr Med J* 2001;91:237-243.
- Orren A, Dowdle EB. Studies on Bermuda grass allergens. *S Afr Med J* 1977;51:586-591.
- Van Niekerk C, de Wet J. Efficacy of grass-maize pollen oral immunotherapy in patients with seasonal hay fever: a double blind study. *Clin Allergy* 1987;17:507-513.
- Prescott R, Potter PC. Hypersensitivity to aerosolised spitting cobra venom. *Ann Allergy Asthma Immunol* 2005;94(5):600-603.
- Potter PC, Fenimore B, Foot L. Specific IgE to African penguin serum and mucus proteins. Poster session: New perspectives in occupational allergy. Proceedings of the EAACI-WAO Congress, Milan, June 2013. Abstract No. 1284.
- Hawarden D, Baker S, Toerien A, et al. Aero-allergy in South African Olympic Athletes. *S Afr Med J* 2002;92(5):355-356.
- Baatjies R, Jeebhay MF. Baker's allergy and asthma: towards preventive strategies. *Current Allergy & Clinical Immunology* 2002;15(4):160-163.
- Jeebhay MF, Lopata AL, Robins TG. Seafood processing in South Africa - a study of working practices, occupational health services and allergic health problems in the industry. *Occup Med (Lond)* 2000;50:406-413.
- Jeebhay MF, Baatjies R, Chang YS, Kim YK, Kim YY, Lopata AL. Risk factors for allergy due to the two-spotted spider mite (*Tetranychus urticae*) among table grape farm workers. *Int Arch Allergy Immunol* 2007;144:143-149.
- Potter PC, Crombie Y, Marian A, Kosheva O, Maqula B, Schinkel M. Latex allergy at Groote Schuur Hospital: prevalence, clinical features and outcome for affected individuals. *S Afr Med J* 2001;91(9):760-765.
- Risenga SM, Shivambu GP, Rakgole MP, et al. Latex allergy and its clinical features among healthcare workers at Mankweng Hospital, Limpopo Province, South Africa. *S Afr Med J* 2013;103(6):390-394.
- Potter PC. Latex allergy: 'Plights, rights and fights'. *S Afr Med J* 2013;103(6):369-370.
- Lopata AL, Fenimore B, Jeebhay MF, Gade G, Potter PC. Occupational allergy in laboratory workers caused by the African migratory grasshopper *Locusta migratoria*. *Allergy* 2005;60(2):200-205.
- Jeebhay MF, Prescott R, Potter PC, Ehrlich RI. Occupational asthma caused by imbuia wood dust. *J Allergy Clin Immunol* 1996;97(4):1025-1027.
- Zinn C, Lopata AL, Visser M, Potter PC. The spectrum of allergy to South African bony fish (Teleostei): evaluation by DBPCFC. *S Afr Med J* 1997;87:146-152.
- Lopata A, Zinn C, Potter PC. Characteristics of hypersensitivity reactions and identification of a unique 49 kd IgE-binding protein (Hal-m-1) in abalone (*Haliotis midae*). *J Allergy Clin Immunol* 1997;100(5):642-648.
- Gray C, Kung SJ. Food allergy in South Africa: joining the food allergy epidemic? *Current Allergy & Clinical Immunology* 2012;25(1):24-29.
- Kung SJ, Fenimore B, Potter PC. Anaphylaxis to mopane worms (*Imbrasia belina*). *Ann Allergy Asthma Immunol* 2011;106(6):538-540.
- Potter PC. Immediate and delayed contact hypersensitivity to verbena plants. *Contact Dermatitis (UK)* 1995;33:343-346.
- Nieuwenhuizen N, Lopata AL, Jeebhay MF, De Broski H, Robins TG, Brombacher F. Exposure to the fish parasite *Anisakis* causes allergic airway hyperreactivity and dermatitis. *J Allergy Clin Immunol* 2006;117(5):1098-1105.
- Berman D. Pollinosis and the aerobiology of southern Africa. *Allergy Clin Immunol Int* 2000;60(2):258-259.
- Potter PC, Cadman A. Pollen allergy in South Africa. *Clin Exp Allergy* 1997;100:662-668.