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Trans-disciplinary research in synthesis of grass pollen aerobiology and its importance for respiratory health in Australasia

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HIGHLIGHTS

- The Australian Aerobiology Working Group engaged in trans-disciplinary research.
- The Group analysed available pollen count data sets from Australia and New Zealand.
- The analysis revealed biogeographical diversity in airborne pollen types.
- There were regional and seasonal variability in airborne grass pollen levels.
- Pollen monitoring aids management of current and future patient exposure to grass pollen allergy triggers.

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ABSTRACT

Grass pollen is a major trigger for allergic rhinitis and asthma, yet little is known about the timing and levels of human exposure to airborne grass pollen across Australasian urban environments. The relationships between environmental aeroallergen exposure and allergic respiratory disease bridge the fields of ecology, aerobiology, geospatial science and public health.

The Australian Aerobiology Working Group comprised of experts in botany, palynology, biogeography, climate change science, plant genetics, biostatistics, ecology, pollen allergy, public and environmental health, and medicine, was established to systematically source, collate and analyse atmospheric pollen concentration data from 11 Australian and six New Zealand sites. Following two week-long workshops, post-workshop evaluations were conducted to reflect upon the utility of this analysis and synthesis approach to address complex multidisciplinary questions.

This Working Group described i) a biogeographically dependent variation in airborne pollen diversity, ii) a latitudinal gradient in the timing, duration and number of peaks of the grass pollen season, and iii) the emergence of new methodologies based on trans-disciplinary synthesis of aerobiology and remote sensing data. Challenges included resolving methodological variations between pollen monitoring sites and temporal variations in pollen datasets. Other challenges included "marrying" ecosystem and health sciences and reconciling divergent expert opinion. The Australian Aerobiology Working Group facilitated knowledge transfer between diverse scientific disciplines, mentored students and early career scientists, and provided an uninterrupted collaborative opportunity to focus on a unifying problem globally. The Working Group provided a platform to optimise the value of

Abbreviations: ACEAS, Australian Centre for Ecological Analysis and Synthesis; ASCIA, Australasian Society of Clinical Immunology and Allergy; TERN, Terrestrial Ecosystem Research Network.

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large existing ecological datasets that have importance for human respiratory health and ecosystems research. Compilation of current knowledge of Australasian pollen aerobiology is a critical first step towards the management of exposure to pollen in patients with allergic disease and provides a basis from which the future impacts of climate change on pollen distribution can be assessed and monitored.

1. Introduction

Across Australasia; Australia and New Zealand, grass pollen is the major outdoor aeroallergen source. Although the prevalence and morbidity of hay fever and asthma in Australia and New Zealand are among the highest globally (Asher et al., 2006), the precise factors influencing airborne pollen concentration in Australasian cities are not well understood. This knowledge gap arises in part because of the complex trans-disciplinary nature of the processes that link grass flowering and the release of pollen from anthers, to the dispersal away from the source on wind currents to urban environments where sensitive individuals are exposed to allergenic pollen. Clearly, environmental, ecological, geospatial and meteorological factors will all affect local airborne grass pollen levels. Whilst other airborne pollen types and other taxa, including fungal spores, are also important for allergic respiratory disease in susceptible individuals, we focused on grass pollen because of the high frequency of patient sensitisation to grass pollen. In anemophilous plants, wind borne pollen is the vector for delivery of allergen components to the respiratory mucosa. Therefore, we investigated the aerobiology of grass pollen in Australasia to improve understanding of exposure patterns in those susceptible to grass pollen allergy.

The Australian Aerobiology Working Group was funded by the Australian Centre for Ecological Analysis and Synthesis (ACEAS; http://www.aceas.org.au/) and was supported within the Terrestrial Ecosystem Research Network (TERN) established by the Australian Government through the National Collaborative Research Infrastructure Strategy (NCRIS). The ACEAS funding supported two one-week workshops in March and November of 2013. The Australian Aerobiology Working Group consisted of experts in botany, ecology, palynology, biogeography, biostatistics, climate change science, plant genetics, pollen allergy, public and environmental health, and medicine from 15 academic or government research institutes from Australia, New Zealand, France, Germany and the USA. There were 19 participants in all, 16 of whom attended one of the workshops and 11 of whom attended both. The primary focus of the research was aerobiology in Australia but this was extended to include New Zealand where possible. In this paper we describe the context for the Australian Aerobiology Working Group research (Section 2), provide an overview of the Australian Aerobiology Working Group outcomes (Section 3), reflect on the benefits and challenges of the Australian Aerobiology Working Group experience (Section 4), and discuss future trans-disciplinary aerobiology research challenges and opportunities (Section 5).

2. Context of the Australian Aerobiology Working Group research

2.1. Burden of pollen allergy in Australia

The primary clinical manifestation of grass pollen allergy, allergic rhinitis, affects three million Australians (15% of the population) (AIHW, 2011). Allergic diseases have a high economic burden for society costing annually \$7.8 billion, including \$1.2 billion in direct medical costs in Australia (Cook et al., 2007). The increasing impact of allergic diseases is evident by the doubling of pharmacy wholesale purchases to \$226.8 million for hay fever drugs (oral anti-histamines and nasal corticosteroids) between 2001 and 2010 (AIHW, 2011). Allergic rhinoconjunctivitis is a seriously debilitating disease leading to poor quality of life and reduced productivity as well as contributing to other complications including asthma exacerbations (Walls et al., 2005; Bousquet et al., 2008; Meltzer et al., 2009). Airborne grass pollen levels have been positively correlated with symptoms of allergic rhinoconjunctivitis and anti-histamine use in patients with grass pollen allergy (Johnsen et al., 1992; Johnston et al., 2009; Medek et al., 2012). Allergic sensitisation to grass pollen can precede the development of allergic asthma in children (Hatzler et al., 2012) and airborne levels of grass pollen are associated with hospital admissions for asthma (Erbas et al., 2007a; Darrow et al., 2012). A causal relationship between grass pollen challenge and induction of allergic airway inflammation has been demonstrated (Suphioglu et al., 1992) and epidemics of grass pollen allergen-induced thunderstorm asthma are well documented in Australia and elsewhere (Hill et al., 1979; Celenza et al., 1996; Newson et al., 1998; Marks et al., 2001; Howden et al., 2011; Dabrera et al., 2013). Notably, 20% of patients presenting with acute thunderstorm asthma attacks had histories of allergic rhinitis without prior asthma (Waters et al., 1993). Emergency department presentations and admissions for acute episodes of asthma in children appear to be increasing during peak pollen season in Melbourne placing considerable burden on the child, family, community, health service provider and economy (Erbas et al., 2007a, 2012).

Treatment options for allergic rhinitis include pharmacotherapy to alleviate symptoms or allergen specific immunotherapy to ameliorate the underlying immunological processes. The later therapy provides a long lasting treatment with the benefit of reducing the long term financial burden of disease, acquisition of other allergies and progression to more severe disease (Rolland et al., 2010; Calderon et al., 2011). Knowledge of local current airborne pollen levels would empower patients to implement self-managed allergen avoidance strategies and provide a valuable resource for health professionals responsible for clinical management of patients with moderate to severe allergic rhinitis and asthma (Hill et al., 1979; Potter et al., 1991; Guillam et al., 2010; Erbas et al., 2013).

Elevated atmospheric grass pollen concentrations show strong consistent associations with allergic asthma symptoms and are the main trigger of primary care or emergency department attendance during grass pollen seasons (Erbas et al., 2012). Such seasonality is being shifted in inconsistent ways by climate change, expansion of urban areas and changes to farming practices in the rural fringe (Reid and Gamble, 2009; Beggs, 2010; Cecchi et al., 2010; Weber, 2012). Little research has been performed on the impact of climate change on grass pollen season timing and duration in Australasia. Moreover, direct and indirect effects of urban pollutants on allergen content, allergenicity and immunomodulation of pollen will additionally impact upon human respiratory health. Thus far we know very little of the interaction between consecutive days of high pollution and peak pollen periods.

Air pollutants including diesel exhaust particles and ozone (both in the atmosphere and in the lung) can directly interact with pollen, modify the allergen content and alter expression of genes encoding non-allergen components of pollen further influencing immunostimulatory properties of pollen (Diaz-Sanchez et al., 1997; Knox et al., 1997; Boldogh et al., 2005; Ghiani et al., 2012; D'Amato et al., 2013; Kanter et al., 2013).

In addition to allergic rhinitis and asthma, grass pollen allergy has been associated with atopic eczema (Eyerich et al., 2008) and eosinophilic esophagitis (Almansa et al., 2009; Moawad et al., 2010). Grass pollen exposure may affect other co-morbid conditions. Kim et al. (2010) examined The National Health and Nutrition Examination