REVIEW ARTICLE

The Wellington Asthma Research Group house dust mite studies—an update

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ABSTRACT

House dust mites produce allergens which cause asthma symptoms in susceptible individuals. The Wellington Asthma Research Group has conducted many studies on house dust mites and its allergens since 1994. We have previously published a review of those published studies from 1994 to 2006. This review article updates subsequent house dust mite articles from the Wellington Asthma Research Group from 2007 to present, many of which contains new and novel information.

Keywords: Asthma, house dust mite, *Dermatophagoides,* allergens, indoor environment.

N Z J Med Lab Sci 2021; 75: 00-00

INTRODUCTION

New Zealand has one of the highest rates of allergic asthma in the world and, compared to other countries, is more severe (1). In a longitudinal birth cohort study from Dunedin, sensitisation to house dust mites (HDM) was a significant risk factor for the development of asthma in childhood (2). We have previously shown that the IgE antibody response to high levels of HDM in the indoor environment in New Zealand could contribute to the increased prevalence and severity of asthma here (3). HDM have also been implicated in atopic eczema and allergic rhinitis.

HDM are 8-legged arthropods, translucent, 0.2-0.3mm in length, have a life cycle of 65-100 days, absorb and loose moisture through their skin, and feed predominantly on skin scales and some moulds. Optimum temperature and relative humidity for growth and reproduction is 18-24^{o}C and 75-80%, respectively. HDM produce a number of allergens which are predominantly excreted in their faeces (4). One HDM can produce about 20 faecal pellets per day and in its lifetime will have produced about 2,000 faecal pellets.

The main HDM species in New Zealand is *Dermatophagoides pteronyssinus* (Figure 1) and was first described in New Zealand in 1971 by Cornere in this journal (5). In other, mainly drier, countries the dominant HDM species is *D. farinae* while *Blomia tropicalis* is mainly found in sub-tropical and tropical areas. In the indoor environment HDM are abundant in carpets, upholstery, mattresses, and bedding. For instance, a used mattress can contain between 100,000 and 10 million HDM.

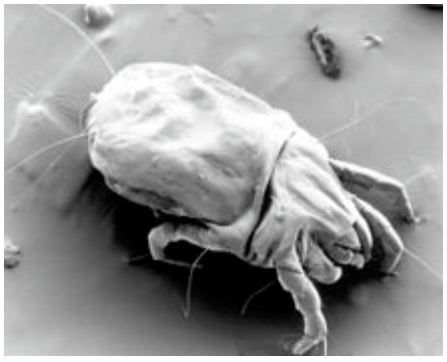

Figure 1. Electorn microscopy image of the HDM, *Dermatophagoides pteronyssinus.*

D. pteronyssinus produces a major group 1 allergen termed Der p 1. This allergen has a Cysteine protease structure with proteolytic activity which can cleave tight junctions of epithelial cells in the lung thus presenting the antigen to dendritic cells resulting in the production of specific IgE. Der p 1 in vacuumed dust samples is generally measured by double monoclonal antibody ELISA and expressed as µg Der p 1/ g dust. New Zealand has some of the highest Der p 1 levels in the world (6) due to extensive use of carpeting and a moist temperate climate, conducive for HDM proliferation.

The Wellington Asthma Research Group (WARG) was established in 1994. Among clinical and epidemiological studies, WARG's other main focus has been on HDM allergens in the indoor environment and its role in asthma and allergic diseases. Subsequently, studies on other allergens (cat, dog, mouse, rat, and cockroach) plus bacterial endotoxin and fungal ß-glucan have been conducted. We have previously described the HDM studies conducted and published by WARG from 1994 to 2006 (7). This review article is an update on further HDM studies by WARG since then to present time.

THE WELLINGTON ASTHMA RESEARCH GROUP HOUSE DUST MITE STUDIES

Although children spend a significant amount of time indoors in the home environment, similarly a significant amount of time indoors occurs in pre-school and school environments where children could be significantly exposed to HDM allergens, although generally at lower levels than is found in the home environment (8). A large majority of children in New Zealand attend day care centres and kindergartens before starting school. In 2007 we conducted a study of HDM allergen (as well as cat, dog and cockroach allergens, and bacterial endotoxin) in 18 kindergartens and 18 day-care centres. Der p 1 levels were much lower in these pre-school centres than in the domestic environment, however, some individual levels were high enough to potentially cause symptoms in HDM sensitised children (9).

We subsequently determined HDM allergen levels in primary schools. Vacuumed dust samples were collected from 136 classrooms in 12 primary schools and analysed them for Der p 1 as well as allergens from cat, dog, cockroach, cow, horse, and peanut (10). No classroom returned a HDM allergen that has been associated with symptoms in HDM sensitised individuals (≥ 10 µg Der p 1/g dust). The low levels of Der p 1 in primary schools are most likely due to the absence of carpets and the daily cleaning of floor surfaces.

WARG has collaborated with research groups in Korea and Taiwan to ascertain indoor HDM allergen levels in those countries. Vacuumed dust samples were collected from floors

and mattresses in 100 homes in Cheonan, Korea and analysed them for group 1 allergens from *D. pteronyssinus* (Der p 1) and *D. farinae* (Der f 1). Der p 1 levels were very low compared to much higher Der f 1 levels. We concluded that *D. farinae* is most likely the dominant HDM species in Cheonan, Korea (11).

In collaboration with Taiwanese colleagues, HDM allergens were determined in homes of 120 asthmatic children in central Taiwan (12). Collected dust samples from mattresses and pillows were analysed for HDM allergens from *D. pteronyssinus* (Der p 1), *D. farinae* (Der f 1), and *Blomia tropicalis* (Blo t 5). Blo t 5 was detected in 9.3% of pillows and 82.2% of mattresses, Der p 1 in 95.8% of pillows and of 93.2% mattresses, and Der f 1 in 82.2% of pillows and 83.1% of mattresses. Additionally, HDM allergen levels were significantly lower from the bamboo side of 67 mattresses, compared to the inner sprung mattress side. We advised that in countries with more than one dominant HDM species to measure all HDM allergens to obtain a truer index of HDM allergen exposure.

In Korea, charcoal pillows have been used to alleviate asthma symptoms; however, these claims have not been substantiated. The effect of activated charcoal on HDM in culture was tested by inoculating live HDM on culture media containing increasing amounts of activated charcoal (13). There was a dose dependant effect of activated charcoal on the survival of the HDM. Activated charcoal offers a new promising method for HDM control. Subsequently the effects of activated charcoal impregnated fibres on HDM survival was tested by adding 100 live adult HDM (*D. pteronyssinus*) to eight culture dishes containing HDM food and activated charcoal fibres (14). All HDM instantly attached to the activated charcoal fibres and started to shrink almost immediately and after some three hours all HDM were dead. Activated charcoal fibres incorporated into mattresses and bedding have the potential to control HDM in the bedroom.

Soft toys are known to harbour HDM. HDM allergens, as well as cat and dog allergens, were determined by collecting dust samples through vacuum cleaning soft toys and mattresses of 40 Taiwanese children (15). All soft toys and mattresses had detectable HDM allergens (Der p 1 + Der f 1) with soft toys containing about three times higher levels of HDM allergens than mattresses. Levels of HDM allergens on soft toys could be of importance to HDM sensitised children.

Sleeping with soft toys is a significant risk factor for sensitisation to HDM in infants. The effects of three HDM control measures were determined, namely freezing, hot tumble drying, and washing with water containing eucalyptus oil on the elimination of HDM from soft toys (16). Twelve soft toys in each HDM elimination group underwent either freezing overnight, hot tumble drying in a domestic clothes dryer for one hour, or washing in 0.2% to 0.4% eucalyptus oil. All three techniques were extremely efficient in eliminating HDM (>89%). Additionally, washing in eucalyptus oil also significantly reduced HDM allergen from the soft toys (HDM allergens are water soluble). These techniques give parents and caretakers of children effective methods of limiting children's HDM exposure.

Mattresses are a significant source of HDM and their allergens (6). HDM sensitised individuals are usually advised to use occlusive covers to limit exposure, however, these covers are not cheap. Therefore, the use of regular vacuum cleaning of mattresses on HDM allergen levels was investigated (17). Twenty volunteers vacuumed their mattresses daily for eight weeks and dust samples were analysed for the HDM allergens Der p 1 and Der f 1 at two weekly intervals. Regular vacuum cleaning of mattresses significantly reduced HDM allergen content by an average of 85% (as well as bacterial endotoxin and fungal ß-glucan) after eight weeks of regular vacuum cleaning and is a practical and cheaper option to reduce exposure to HDM allergens.

Bedding dust is a mixture of many components, including HDM allergens and bacterial endotoxin. When sensitized subjects are exposed to both endotoxin and HDM allergens, a synergistic effect takes place resulting in significantly augmented inflammatory responses. the effect of endotoxin in bedding dust on the allergenic effect in HDM sensitized patients was determined (18). Twenty-nine HDM sensitized patients were skin pricked and allergen patch tested against a sterile solution of their bedding dust and against a Der p 1 solution containing the same concentration of Der p 1 as their bedding dust solution. No significant difference in the resulting wheal sizes resulted suggesting that bedding dust does not appear to contain factors that influence skin prick or atopy patch responses to HDM.

Der p 1 is generally measured in vacuumed dust samples in studies of HDM allergens. It has been argued that this might not be reflective of what is air born and thus inhaled and therefore, some studies have used the technique of electrostatic cloths as a proxy of inhaled allergen exposure (19). A study was undertaken to determine whether HDM allergen (and cat allergen and endotoxin) were detectable in electrostatic cloths dust collectors (20). Der p 1 levels from electrostatic cloths, bedroom floor and mattress dust samples from 60 homes were compared. We could only detect Der p 1 (by an enhanced ELISA method) in 15% of the electrostatic cloths and there was no correlation between those electrostatic cloths and corresponding floor and mattress dust Der p 1 levels. The cat allergen cat allergen, Fel d 1, was detectable in all electrostatic cloths most likely due to its great aerodynamic properties. Electrostatic cloths, together with reservoir dust sampling, could be a unique method for estimating airborne HDM and cat allergen and provide an additional measure of allergen exposure.

In conclusion, the WARG studies on HDM and their allergens (total of 41 publications from 1994 to 2020) have provided valuable, and at times new and novel findings, that have contributed to the world literature. Some of our findings have resulted in recommendations and advice. For instance, the Asthma and Respiratory Foundation of New Zealand recommends the use of feather fill bedding over synthetic fill bedding for HDM sensitised asthmatics based on our previously published studies showing that feather bedding has significantly lower HDM allergen levels than synthetic bedding (21,22), which is most likely due to the tighter weave of feather bedding covers that occlude HDM penetration (23).

ACKNOWLEDGEMENTS

I wish to acknowledge present and past members of the Wellington Asthma Research Group, particularly Professor Julian Crane, Dr Kristin Wickens, and Dr Penny Fitzharris. Also, thanks to my Korean and Taiwan colleagues, especially Professor Hae-Seon Nam and Dr Francis Wu. The HDM studies of WARG were supported by grants from the Health Research Council, Lotteries Health, Child Health Foundation, Wellington Medical Research Foundation, and the University of Otago.

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REFERENCES

1. Asher MI, Montefort S, Björkstén B, et al. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys. *Lancet* 2006; 368(9537): 733-743.
2. Sears MR, Herbison GP, Holdaway MD, et al. The relative risks of sensitivity to grass pollen, house dust mite and cat dander in the development of childhood asthma. *Clin Exp Allergy* 1989; 19(4): 419-424.
3. Erwin EA, Wickens K, Custis NJ, Siebers R, et al. Cat and dust mite sensitivity and tolerance in relation to wheezing among children raised with high exposure to both allergens. *J Allergy Clin Immunol* 2005; 115(1): 74-79.
4. Tovey ER, Chapman MD, Platts-Mills TA. Mite faeces are a major source of house dust allergens. *Nature* 1981; 289 (5798): 592-593.
5. Cornere BM. The incidence of house dust mites in Auckland. *N Z J Med Lab Technol* 1971; 25(1): 7-9.
6. Wickens K, Siebers R, Ellis I, et al. Determinants of house dust mite allergen in homes in Wellington, New Zealand. *Clin Exp Allergy* 1997; 27(9): 1077-1085.
7. Siebers R, Wickens K, Crane J. House dust mite allergens and allergic diseases – the Wellington Asthma Research Group studies. *N Z J Med Lab Sci* 2006; 60: 49-58.
8. Salo PM, Sever ML, Zeldin DC. Indoor allergens in school and day care environments. *J Allergy Clin Immunol* 2009; 124(2): 185-192.
9. Oldfield K, Siebers R, Crane J. Endotoxin and indoor allergen levels in kindergartens and day-care centres in Wellington. *N Z Med J* 2007; 120 (1248): U2400.
10. Siebers R, Jones B, Bailey L, et al. Indoor allergen exposure in primary school classrooms in New Zealand. *N Z Med J* 2019; 132(1495): 42-47.
11. Nam HS, Siebers R, Lee SH, et al. House dust mite allergens in domestic homes from Cheonan, Korea. *Korean J Parasitol* 2008; 46: 187-189.
12. Wu FF, Siebers R, Chung CF, et al. Indoor allergens and microbial bio-contaminants in houses of asthmatic children in central Taiwan. *J Asthma* 2009; 46: 745-749.
13. Nam HS, Siebers RW, Lee SH, et al. Activated charcoal suppresses breeding of Dermatophagoides pteronyssinus, in culture. *J Korean Med Sci* 2007; 22: 231-233.
14. Nam HS, Lee SH, Choi YJ, et al. Effect of activated charcoal fibres on the survival of the house dust mite, Dermatophagoides pteronyssinus: a pilot study. *ISRN Allergy* 2012; article ID 868170: 3 pages.
15. Wu FF, Wu MW, Ting MH, et al. Cat, dog and house dust mite allergen levels on children's soft toys. *J Asthma* 2014; 51: 75-78.
16. Chang CF, Wu FF, Chen CY, et al. Effect of freezing, hot tumble drying and washing with eucalyptus oil on house dust mites in soft toys. *Pediatr Allergy Immunol* 2011; 22 (6): 638-641,
17. Wu FF, Wu MW, Pierse N, et al. Daily vacuuming of mattresses significantly reduces house dust mite allergens, bacterial endotoxin and fungal β-glucan. *J Asthma* 2012; 49: 139-143.
18. Smith C, Stanley T, Crane J, Siebers R. Do other components of bedding dust affect sensitisation to house dust mites? *ISRN Allergy* 2011; article ID 426941: 4 pages.
19. Sander I, Lotz A, Zahardnik E, Raulf M. Allergen quantification by use of electrostatic dust collectors (EDCs): influence of deployment time, extraction buffer, and storage conditions on the results. *Ann Occup Hyg* 2016; 60(7): 845-859.
20. Kristono GA, Shorter C, Pierce N, et al. Endotoxin, and cat and house dust mite allergens in electrostatic cloths and bedroom dust. *J Occup Environ Hygiene* 2019; 16: 89-96.
21. Kemp TJ, Siebers RW, O'Grady GB, et al. House dust mite allergen in pillows. *Br Med J* 1996; 313(7062): 916.
22. Mills S, Siebers R, Wickens K, et al. House dust mite allergen in individual bedding components in New Zealand. *N Z Med J* 2002; 115: 151-153.
23. Siebers R, Nam HS, Crane J. Permeability of synthetic and feather pillows to live house dust mites and house dust. *Clin Exp Allergy* 2004; 34(6): 888-890.