

# Measurement of Indoor Airborne Mite Allergens

Masahiro Sakaguchi<sup>1</sup>

## ABSTRACT

To evaluate the extent of exposure to airborne mite allergens, we measured major mite allergens in indoor environments with an immunoassay using allergen-specific antibodies. The levels of mite allergens trapped by the sampler were measured with a highly sensitive immunoassay. We found heavy exposure to mite allergens from bedding during sleep. Bedding is likely one of the major reservoirs of mite allergens. When the used bedding was replaced with new allergen-free bedding, we detected a decrease in the airborne allergen levels. The use of new bedding seems to be an effective countermeasure against airborne mite allergen exposure.

## KEY WORDS

airborne allergen, allergen avoidance, bedding, house dust, mite

## INTRODUCTION

Dust mites are a major source of allergens in house dust.<sup>1</sup> It has been well established that two species of mite genus *Dermatophagoides*, *D. pteronyssinus* and *D. farinae* are important sources of house dust allergens.<sup>1,2</sup> Immunoassays of *Dermatophagoides* mite group 1 (Der 1) and group 2 (Der 2) allergens, which are major allergens, are commonly used in studies of mite allergen levels and mite avoidance measures.<sup>2</sup>

It is known that airborne allergen levels are very high under disturbed conditions such as bedmaking or vacuuming using a vacuum cleaner without a filter.<sup>2-5</sup> Conventional air samplers are too noisy to be operated for a long period inside houses. Furthermore, assay methods for allergens have not been sensitive enough to detect airborne allergens in such relatively calm environments such as living rooms. We have overcome these difficulties by using low-noise or personal air samplers and a more sensitive immunoassay, and hence could measure mite allergen levels in the air of houses.

## FLOOR DUST ALLERGENS IN LIVING ROOMS AND BEDDING DUST ALLERGENS IN BEDROOMS

Dust samples from the floor and Japanese quilts (futon) were obtained from 10 families, selected without regard to the children's allergy histories, living in concrete apartments in a public housing area.<sup>5</sup> Each family consisted of one couple with one or two children who were 0-4 years old.

Figure 1 shows the levels of floor dust allergens in the living room. The levels of Der 1 and Der 2 in the floor dust were 2,040 and 2,690 ng/g fine dust, respectively. The levels of these allergens in the futons were 35,500 and 28,200 ng/g fine dust, respectively, which is more than 10 times higher than in floor dust. These findings suggest that bedding is a major reservoir of mite allergens.

## AIRBORNE ALLERGENS IN LIVING ROOMS AND BEDROOMS

A low-noise portable air sampler (KI-636, Dylec, Tokyo, Japan) was used for collection of airborne particles. During operation, the noise levels were less than 50 dB.<sup>5</sup> The levels of airborne mite allergens were measured by a highly sensitive immunoassay.<sup>6,7</sup> To assess the extent of natural exposure to mite aller-

<sup>1</sup>Laboratory for Allergy Regulation, Research Center for Allergy and Immunology, RIKEN (The Institute of Physical and Chemical Research), Kanagawa, Japan.

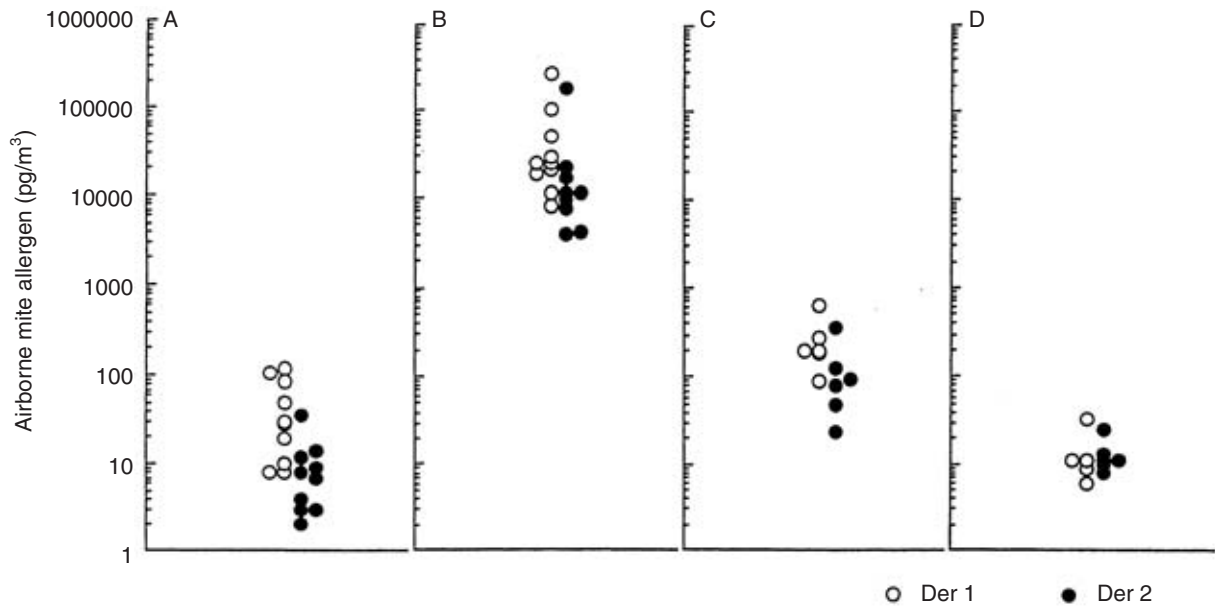
Correspondence: Dr. Masahiro Sakaguchi, Laboratory for Allergy Regulation, Research Center for Allergy and Immunology, RIKEN (The Institute of Physical and Chemical Research), 1-7-22

Suehiro-cho, Tsurumi-ku, Yokohama, Kanagawa 230-0045, Japan.

Email: msakaguc@rcai.riken.jp

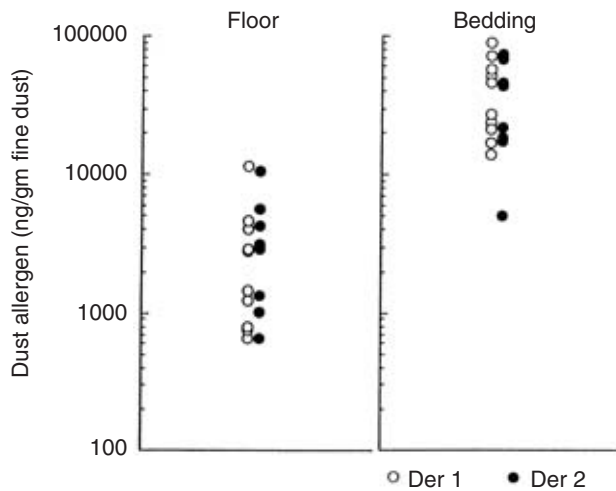
Received 15 January 2004.

©2005 Japanese Society of Allergology



**Fig. 2** Airborne mite allergen levels under various conditions. **A**, in the living room; **B**, in the bed room (bedmaking), **C**, during sleep (with used bedding); **D**, during sleep (with new bedding).

○, Der 1; ●, Der 2.

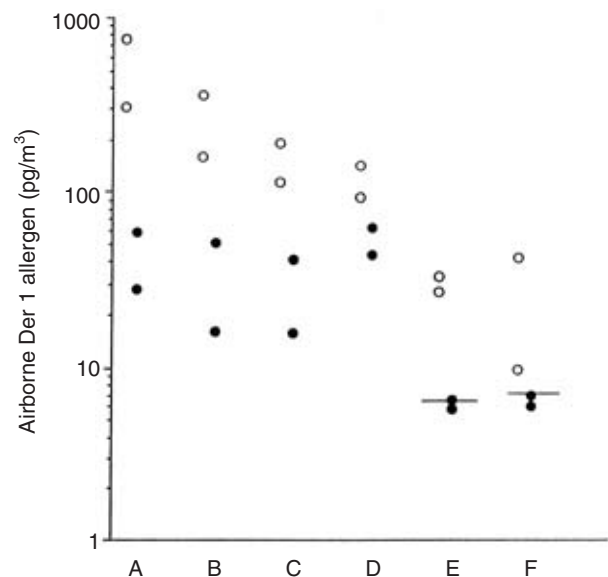


**Fig. 1** Mite allergen levels in dust from floor and bedding. Dust from the floor and futon was collected with a vacuum cleaner.<sup>5</sup>

○, Der 1; ●, Der 2.

gens, the exposure levels to Der 1 of individual inhabitants at home were measured with a personal air sampler and a highly sensitive immunoassay.

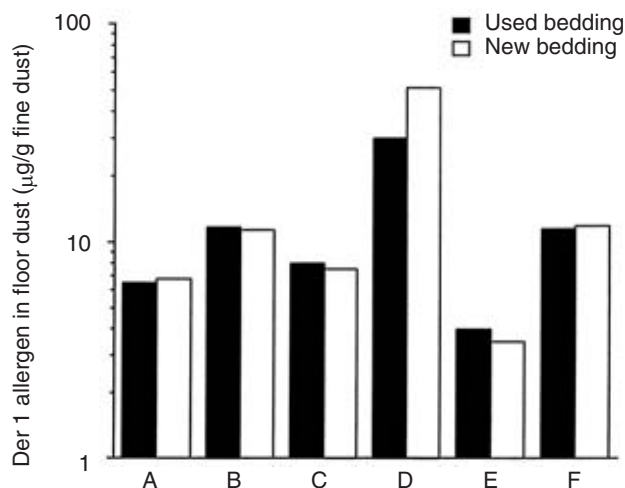
Figure 2 shows the levels of airborne allergens in the living rooms and bedrooms. The airborne allergen levels of Der 1 and Der 2 in the living rooms were very low, 29.5 and 6.3 pg/m<sup>3</sup>, respectively (Fig. 2A).<sup>5</sup> In another study, the airborne levels of mite allergens in the living rooms were very low.<sup>8</sup> Air sampling in the bedrooms was conducted under disturbed condi-



**Fig. 3** Exposure to airborne mite allergen before and after changing to new bedding. Mean air sampling times (mean  $\pm$  SD) were: **A**, 43.5  $\pm$  7.9 hours; **B**, 54.5  $\pm$  8.2 hours; **C**, 57.1  $\pm$  8.2 hours; **D**, 49.9  $\pm$  4.4 hours; **E**, 61.4  $\pm$  7.4 hours; **F**, 50.5  $\pm$  3.0 hours.

○, Used bedding; ●, New bedding; -----, Detectable level.

tions: 5–10 min of bedmaking (unfolding and shaking two sets of sheets, blankets and futons according to the routine in each home). The airborne allergen levels of Der 1 and Der 2 in the bedrooms were very high, 3,900 and 12,600 pg/m<sup>3</sup>, respectively (Fig. 2B).



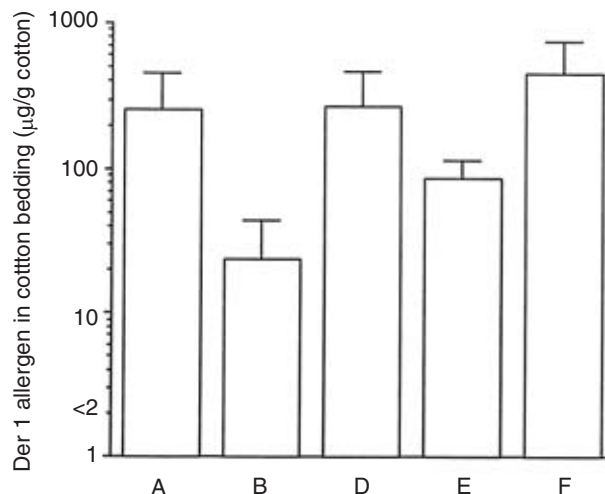
**Fig. 4** The levels of floor dust allergens in the bedroom before and after changing to new bedding. The types of material on the bedroom floors were as follows: **A**, carpet; **B**, straw matting (tatami in Japanese); **C**, carpet; **D**, wooden flooring; **E**, straw matting; **F**, carpet.

Air sampling was done twice in the bedrooms during sleep: in the first sampling, all families slept with their used bedding; in the second sampling, all slept with new bedding.<sup>9</sup> Figure 2C shows the levels of airborne allergens during sleep with the used bedding. The levels of Der 1 and Der 2 were 223 and 87.1 pg/m<sup>3</sup>, respectively. When new bedding free of mite allergens was used, the airborne allergens during sleep were greatly decreased to 11.5 and 12.0 pg/m<sup>3</sup> (Fig. 2 D). These findings indicate that the airborne allergens during sleep are generated from used bedding. Bedding appears to be a major reservoir of mite allergens. We believe that the use of new bedding is an effective countermeasure to reduce airborne mite allergens.

### MEASUREMENT OF AIRBORNE MITE ALLERGEN EXPOSURE IN INDIVIDUAL PERSONS

To assess the extent of natural exposure to mite allergens, exposure levels to Der 1 of individual inhabitants at home were measured with a personal air sampler and a highly sensitive immunoassay.<sup>10</sup> Furthermore, to evaluate the effects of new bedding (mite allergen-free) on reducing exposure to airborne mite allergens, the exposure levels before and after changing the used bedding to new were compared.

Small personal air samplers (MP-15CF; Shibata scientific, Tokyo, Japan) were carried by six young adults (subjects A to F), who were selected without regard to allergy history. The sampler (4.3 cm×11.5 cm×8.1 cm and 500 g in weight) with a vertical filter inlet has a constant flow-rate device and ensures a stable suction flow rate (1 liter/min) for 26 hours by



**Fig. 5** The levels of mite allergen in the cotton of used bedding. The beddings of subjects **A**, **B**, **D**, **E**, and **F** were made from cotton. The bedding of subject **C** was made from feathers.

batteries. The subjects went to universities or worked during the day. When they were away from home, the sampler was left behind with the switch off. Upon their return, it was carried again.

### PERSONAL EXPOSURE TO MITE ALLERGENS

The exposure levels to Der 1 were measured before and after changing the bedding (Fig. 3).<sup>10</sup> Before changing to new bedding, we conducted duplicate air sampling. The mean levels of exposure to Der 1 ranged from 29.6 to 485 pg/m<sup>3</sup> (geometric mean value, 102 pg/m<sup>3</sup>). After changing to new bedding, the mean levels of exposure to the mite allergen ranged from <6.00 to 52.2 pg/m<sup>3</sup> (geometric mean value, 19.9 pg/m<sup>3</sup>). No airborne mite allergens were detectable in the rooms of subjects E and F. In all persons, the levels of exposure to airborne Der 1 decreased. This is the first report to estimate mite allergen exposure to individual persons living under normal circumstances. The mean level of mite allergens was 102 pg/m<sup>3</sup>. Great variations in airborne allergen levels were observed between individuals. There was no correlation between mite allergen levels in the air and those in bedding cotton, cotton dust, and floor dust. In addition, no correlation was observed between the levels of Der 1 in carpets and the levels in air. Probably the human activity in the house that causes the allergens to float into the air varies between persons.

### MITE ALLERGEN LEVELS IN THE BEDROOM AND IN COTTON BEDDING

The Der 1 levels in bedroom floor dust were meas-

ured before and after changing to new bedding (Fig. 4). Dust was collected three times over a period of 2 weeks. The mean values of the allergen in floor dust before and after changing to new bedding were 10.4 and 11.3 µg/g fine dust, respectively, with no significant difference.

To evaluate the amount of Der 1 in bedding, we measured the levels of mite allergens in cotton bedding (Fig. 5). The levels of Der 1 in cotton bedding that had been used for more than 1 year ranged from 26.6 to 437 ng/g cotton (geometric mean value, 140 ng/g cotton). The levels of Der 1 in the cotton of new bedding were not detectable (<2 ng/g cotton). Subject C's bedding was made of feathers, so we measured the allergen levels from the bedding dust. The levels of mite allergens in the dust of subject C's bedding was very high (34.4 µg/g fine dust). In other bedding, the levels of Der 1 mite allergens from the dust were also very high, ranging from 16.4 to 115 µg/g fine dust (geometric mean value, 38.0 µg/g fine dust) (data not shown). The Der 1 levels in the dust of new bedding were not detectable (<20 ng/g fine dust).

There was no change in mite allergen levels in floor dust before and after the bedding change. Furthermore, there were high levels of mite allergen in the cotton of used bedding, but no detectable mite allergen in the cotton of new bedding. These results suggest that the decrease in airborne mite allergens depends on the use of new bedding free from mite allergens.

### CONCLUDING COMMENTS

In most areas of the world, house dust mites are the most important source of allergens in the indoor environment. Mite allergens are strongly associated with asthma, perennial rhinitis, and atopic dermatitis. There have been many studies of house-dust mite allergen control and avoidance.<sup>11-14</sup> In 1999, the American Academy of Asthma, Allergy and Immunology published a position statement that recommended indoor allergen avoidance as adjunctive therapy for patients with allergic asthma.<sup>13</sup> This statement indicated that the heaviest exposure occurs from bedding when the patient lies down to sleep, and that the avoidance measures for the bedroom are as follows: wash bedding, encase bedding, remove soft toys and small items from the bed.<sup>15-17</sup> This review suggests that the use of new bedding might be one of the most effective countermeasures for reducing airborne mite allergens.

### REFERENCES

1. Voorhost R, Spieksma-Boezeman MIT, Spieksma FTM. Is a mite (*Dermatophagoides* sp.) the producer of the house

- dust allergen? *Allergie Asthma* 1964;**10**:329-334.
2. Platts-Mills TAE, Thomas WR, Aalberse RC, Vervloet D, Chapman MD. Dust mite allergens and asthma: report of a second international workshop. *J. Allergy Clin. Immunol.* 1992;**89**:1046-1060.
3. Tovey ER, Chapman MD, Wells CW, Platts-Mills TAE. The distribution of dust mite allergen in the houses of patients with asthma. *Am. Rev. Respir. Dis.* 1981;**124**:630-635.
4. Swanson MC, Agarwal MK, Reed CE. An immunochromatological approach to indoor aeroallergen quantitation with a new volumetric air sampler: studies with mite, roach, cat, mouse, and guinea pig antigens. *J. Allergy Clin. Immunol.* 1985;**76**:724-729.
5. Sakaguchi M, Inouye S, Yasueda H, Irie T, Yoshizawa S, Shida T. Measurement of allergens associated with dust mite allergy. II. Concentrations of airborne mite allergens (Der I and Der II) in the houses. *Int. Arch. Allergy Appl. Immunol.* 1989;**90**:190-193.
6. Yasueda H, Mita H, Yui Y, Shida T. Measurement of allergens associated with dust mite allergy. I. Development of sensitive radioimmunoassays for the two groups of *Dermatophagoides* mite allergens, Der I and Der II. *Int. Arch. Allergy Appl. Immunol.* 1989;**90**:182-189.
7. Yasueda H, Saito A, Akiyama K *et al.* Estimation of Der p I and Der f I quantities in the reference preparations of *Dermatophagoides* mite extracts. *Clin. Exp. Allergy* 1994;**19**:1030-1035.
8. Sakaguchi M, Inouye S, Irie T *et al.* Airborne cat (*Fel d* I), dog (*Can f* I), and mite (Der I and Der II) allergen levels in the homes of Japan. *J. Allergy Clin. Immunol.* 1993;**92**:797-802.
9. Sakaguchi M, Inouye S, Yasueda H, Shida T. Concentration of airborne mite allergens (Der I and Der II) during sleep. *Allergy* 1992;**47**:55-57.
10. Sakaguchi M, Inouye S, Sasaki R, Hashimoto M, Kobayashi C, Yasueda H. Measurement of airborne mite allergen exposure in individual persons. *J. Allergy Clin. Immunol.* 1996;**97**:1040-1044.
11. Tovey ER. Allergen exposure and control. *Exp. Appl. Acarol.* 1992;**16**:181-202.
12. Colloff MJ, Ayres J, Carswell F *et al.* The control of allergens of dust mites and domestic pets: a position paper. *Clin. Exp. Allergy* 1992;**22**:1-28.
13. Eggleston PA, Bush RK. Environmental allergen avoidance: an overview. *J. Allergy Clin. Immunol.* 2001;**107**:S403-S405.
14. Arlian LG, Platts-Mills TAE. The biology of dust mites and the remediation of mite allergens in allergic disease. *J. Allergy Clin. Immunol.* 2001;**107**:S406-S413.
15. McDonald LG, Tovey E. The role of water temperature and laundry procedures in reducing house dust mite populations and allergen content of bedding. *J. Allergy Clin. Immunol.* 1995;**96**:1010-1012.
16. Watanabe M, Sakaguchi M, Inouye S *et al.* Removal of mite allergens (Der I and Der II) from blanket: Comparison between washing in hot water and dry cleaning. *J. Allergy Clin. Immunol.* 1992;**90**:599-608.
17. Nishioka K, Yasueda H, Saito H. Prevention effect of bedding encasement with microfibre fibers on mite sensitization. *J. Allergy Clin. Immunol.* 1998;**101**:28-32.