

Distribution of *Dermatophagoides* mite (Acari: Pyroglyphidae) antigens in homes of allergic patients in Japan

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ABSTRACT

Dust samples collected in 61 homes of patients with mite allergies and 11 homes of non-allergic people as controls were examined for antigen levels of *Dermatophagoides farinae* Hughes and *Dermatophagoides pteronyssinus* (Trouessart) to reveal the current distribution of allergenic mites in homes in Japan. Patient homes had higher antigen levels than control homes in comforters and pillows but not in futons, carpets, tatamis and wooden floors. Samples with antigen levels of $\geq 10 \mu\text{g m}^{-2}$ were more frequent in and around summer (approximately April–October) than other seasons of the year in most materials and the differences between patient and control homes in comforters and pillows observed in yearly totals was also observed during this period. Wooden structures showed higher antigen levels than concrete structures in comforters, futons, pillows, carpets and tatamis in patient homes. Mite contamination in patient homes in relation to environmental factors was discussed.

Key words: Arachnida, allergy, house dust mites, distribution.

INTRODUCTION

Mite allergy caused by *Dermatophagoides farinae* Hughes and *Dermatophagoides pteronyssinus* (Trouessart) is an increasing hygienic concern in many countries of the world including Japan (Oshima, 1967; Voorhorst *et al.*, 1967; Maunsell *et al.*, 1968; Miyamoto *et al.*, 1968). Although therapy of patients with mite allergy is mainly done by treatment with anti-allergic medicine, another effective way is to keep patients from exposure to mite allergens, e.g. by the removal of allergens from the environment of patients (Burr *et al.*, 1980; Platts-Mills *et al.*, 1982; Murray and Ferguson, 1983). Physicians usually advise patients to do thorough

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and regular cleaning of carpets, tatamis, futons and other bedclothes, the major sources of allergens in homes in Japan. Therefore, it is important to show the current situation of mite distribution in homes of patients, compared with the situation in homes of non-allergic people, in order to evaluate home sanitation.

On the basis of the above background, we carried out a large-scale survey of mite distribution over a year in homes of patients with mite allergy as well as homes of non-allergic individuals as controls. In order to facilitate the testing of allergenic mites in dust samples, we employed a simple enzyme-linked immunosorbent assay (ELISA; Konishi and Uehara, 1990) for quantifying an antigen ubiquitously distributed in *Dermatophagoides* mite bodies; this antigen is a suitable target for immunoassay replacing the conventional counting method. We report here that patient homes had higher antigen levels than control homes in bedclothes, such as comforters and pillows.

MATERIALS AND METHODS

Homes of patients and non-allergic people

A total of 61 asthmatic patients consisting of 41 adults and 20 children were chosen from the Departments of Internal Medicine and Pediatrics of three hospitals. The patients had an allergy against *Dermatophagoides* mites as serodiagnosed by the radioallergosorbent test. Eleven homes of non-allergic people were used as controls.

The materials used for the survey in patient homes were the bedclothes (comforters, futons and pillows) of the patient's use and floorings (carpets, tatamis and wooden floors) of bedrooms, children's rooms and/or living rooms where the patients spent most of the time at home. Comparative materials were chosen in the control homes. A set of Japanese futons used for bedding includes two pieces put over and underneath the body: the former is designated as a comforter and the latter as a futon. Painted wooden floors and tiled floors were used in some homes and these floors, which are not considered as mite habitats, were included in wooden floors.

The homes surveyed included those made of wood and concrete. The majority of wooden structures were detached houses and the majority of concrete structures were apartment houses. For comparison of the wooden and concrete structures, only wooden detached houses and concrete apartment houses were used.

Dust collection and measurement of mite antigens

Dust samples were collected from a 1 m² area of the materials for 1 min using vacuum cleaners fitted with a collection apparatus which separates fine dust containing the mite body and pieces (Konishi and Uehara, 1994). This 1 m² area was primarily selected from the middle of the material. When the total surface area was less than 1 m² (for pillows), dust samples were collected from a whole surface over 1 min. Dust samples were collected every month throughout 1 year, primarily from the same locations each time.

Antigen levels contained in extracts from fine dust fractions were measured by ELISA using a monoclonal antibody against a *D. farinae* antigen (Konishi and Uehara, 1990) and were expressed as antigen equivalent in $\mu\text{g m}^{-2}$ of surface area. Antigen levels were semi-quantitatively classified as scores of - (normal, $< 10 \mu\text{g m}^{-2}$), + (high, $10\text{--}50 \mu\text{g m}^{-2}$) and ++ (extremely high, $\geq 50 \mu\text{g m}^{-2}$). A soluble antigen prepared from whole *D. farinae* mite bodies was used as a reference standard in this assay. The *D. farinae* antigen detected by this assay is cross-reactive to the equivalent antigen contained in *D. pteronyssinus* and the antigen level of $10 \mu\text{g}$ obtained with our reference antigen corresponds to approximately 100 mites of either *D. farinae* or *D. pteronyssinus*.

Statistical analysis

The significance of difference was evaluated by the Mann-Whitney *U*-test and a one-way analysis of variance (ANOVA) for antigen levels and the chi-square test or the Fisher's exact probability test for scores (Ichihara, 1990).

RESULTS

Antigen distribution

Antigen levels of 3724 dust samples collected in patient and control homes were compared in each material (Fig. 1). The mean antigen levels of comforters and pillows obtained from patient homes were significantly higher than those obtained from control homes ($F = 4.65$, $p < 0.05$ with comforters and $F = 7.88$, $p < 0.01$ with pillows). No differences between patient and control homes were observed in futons, carpets, tatamis and wooden floors ($p > 0.05$). Analysis of data by the *U*-test indicated higher antigen levels of carpets obtained from control homes than from patient homes ($z = 3.42$, $p < 0.001$).

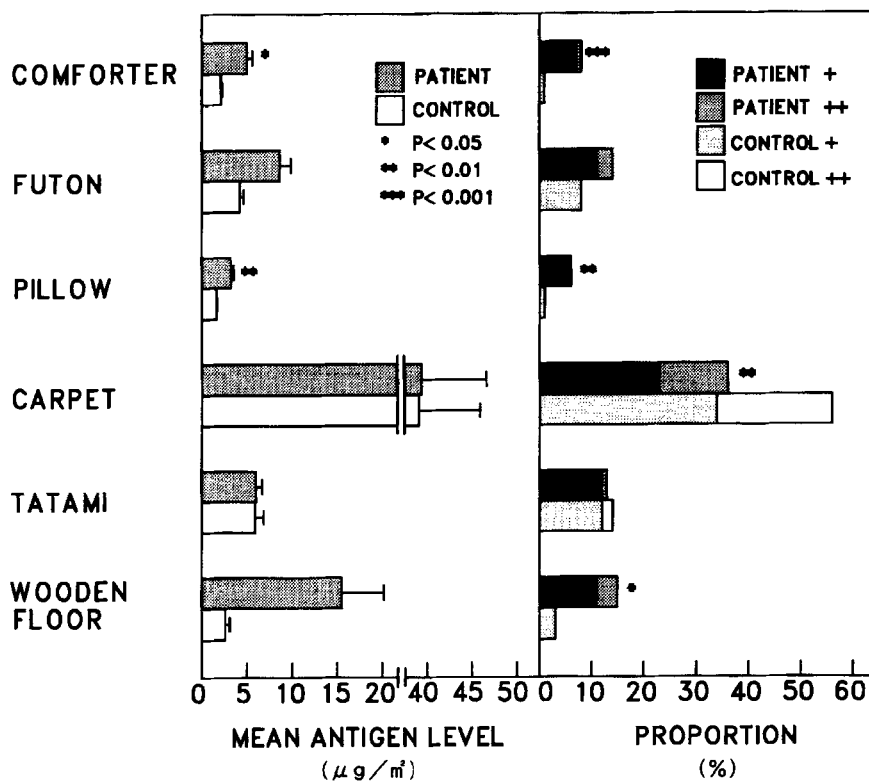


Fig. 1. Antigen distribution in patient and control homes. A comparison was made of the mean antigen levels (left) and the proportion of scores of + and ++ (right). Bars indicate standard errors. Asterisks indicate significant differences evaluated by a one-way ANOVA for mean antigen levels and the chi-square test or the Fisher's exact probability test for scores: * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$.

The comparison between the materials provided showed that carpets had significantly higher antigen levels than other materials in patient homes ($F = 124.06$, $p < 0.001$: $z = 7.82$, $p < 0.001$) and control homes ($F = 29.79$, $p < 0.001$: $z = 9.45$, $p < 0.001$). The mean antigen level of wooden floors was higher than those of other materials in patient homes ($F = 7.81$, $p < 0.01$).

Analysis of scores indicated that the proportion of samples with scores of + and ++ was higher in patient homes than in control homes in comforters ($p = 0.0005$), pillows ($p = 0.0033$) and wooden floors ($p = 0.043$). In contrast, the yearly proportion of carpets with scores of + and ++ from patient homes was lower than that from control homes ($\chi^2 = 10.67$, $p < 0.01$). The comparison between the materials provided showed

that carpets had higher proportions of samples with + and ++ than other materials in patient homes ($\chi^2 = 154.7$, $p < 0.001$) and control homes ($\chi^2 = 200.6$, $p < 0.001$).

Seasonal variation

Individual antigen levels were plotted every month to show seasonal variation. Figure 2 shows an example obtained with carpets as a representative material. Most samples had antigen levels of $< 10 \mu\text{g m}^{-2}$ throughout the year in both patient and control homes, but some samples with higher antigen levels were observed predominantly in and around summer (approximately April–October).

The monthly means of antigen levels obtained with each of the six materials from patient and control homes are depicted in Fig. 3. Overall, the mean antigen levels were relatively high between April and October. In materials that showed mean antigen levels of $\geq 10 \mu\text{g m}^{-2}$ in any

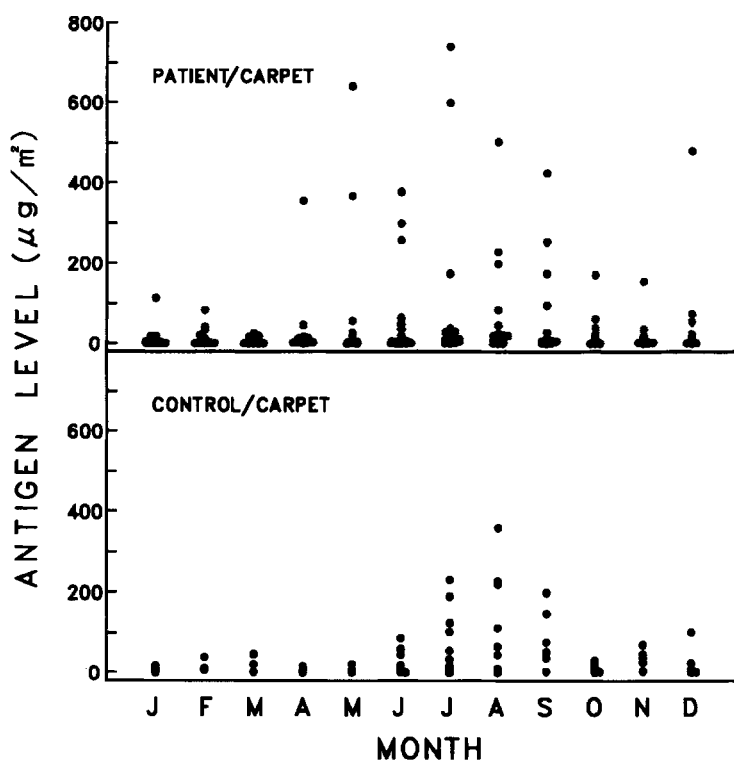


Fig. 2. Monthly variation in individual antigen levels obtained with carpets from patient and control homes.

month, the maximum level was concentrated in July–September. One-way ANOVA showed that carpets of patient homes had higher mean antigen levels between May and September than other months ($F = 6.35$, $p < 0.05$). Similarly, seasonal variation was observed in patient homes with tatamis (June–September versus other months; $F = 10.23$, $p < 0.01$) and wooden floors (August and September versus other months; $F = 8.66$, $p < 0.01$). Control homes showed higher mean antigen levels between July and September than other months in carpets ($F = 23.85$, $p < 0.001$) and tatamis ($F = 14.95$, $p < 0.001$). Analysis of data by the U -test indicated higher antigen levels between April and October than other months in futons ($z = 2.47$, $p < 0.05$), carpets ($z = 2.98$, $p < 0.01$) and tatamis ($z = 4.77$, $p < 0.001$) in patient homes.

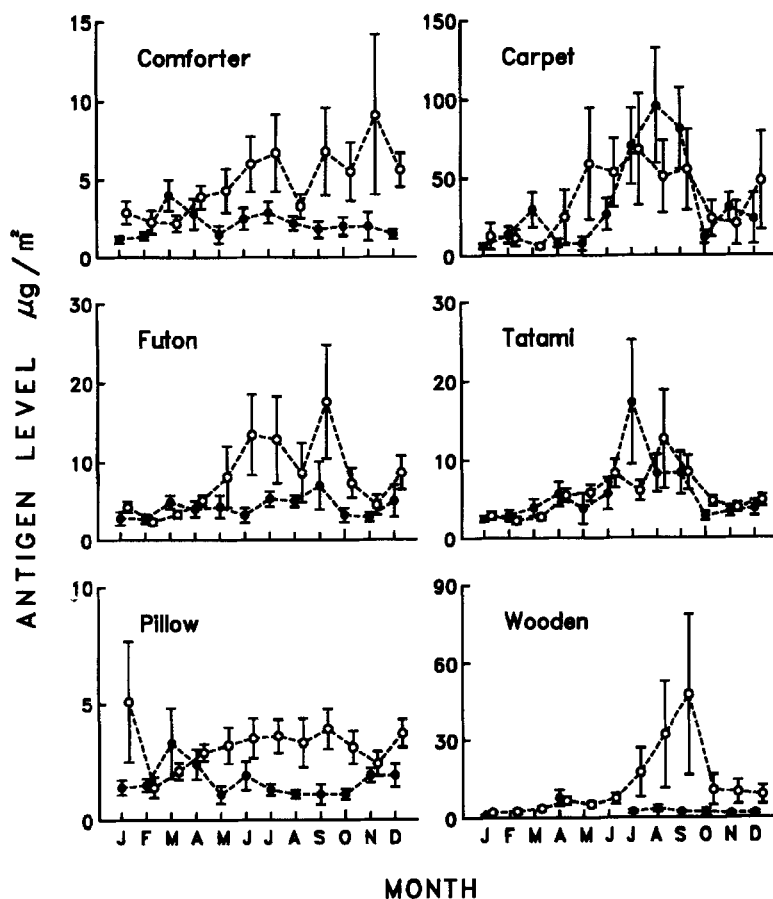


Fig. 3. Monthly variation in mean antigen levels of six indicated materials in patient homes (open circle) and control homes (closed circle). Bars indicate standard errors.

The comparison of patient and control homes in antigen levels obtained in April–October indicated that patient homes had higher levels than control homes in pillows ($F = 9.12$, $p < 0.01$; $z = 2.19$, $p < 0.05$). No differences between patient and control homes were observed with other materials nor with pillows in other months ($p > 0.05$).

Next, monthly differences were analysed with data expressed as the scores of antigen levels (Fig. 4). Samples of tatamis from patient homes showing scores of + and ++ appeared more frequently in April–October than in other months ($\chi^2 = 14.30$, $p < 0.001$). Other flooring of patient homes showed a higher proportion of samples with + and ++ between May and October (carpets: $\chi^2 = 4.29$, $p < 0.05$) and between April and September (wooden floors: $\chi^2 = 4.75$, $p < 0.05$) than other months. Bedclothes in patient homes had similar patterns; significant differences were observed in comforters in May–September ($\chi^2 = 3.87$,

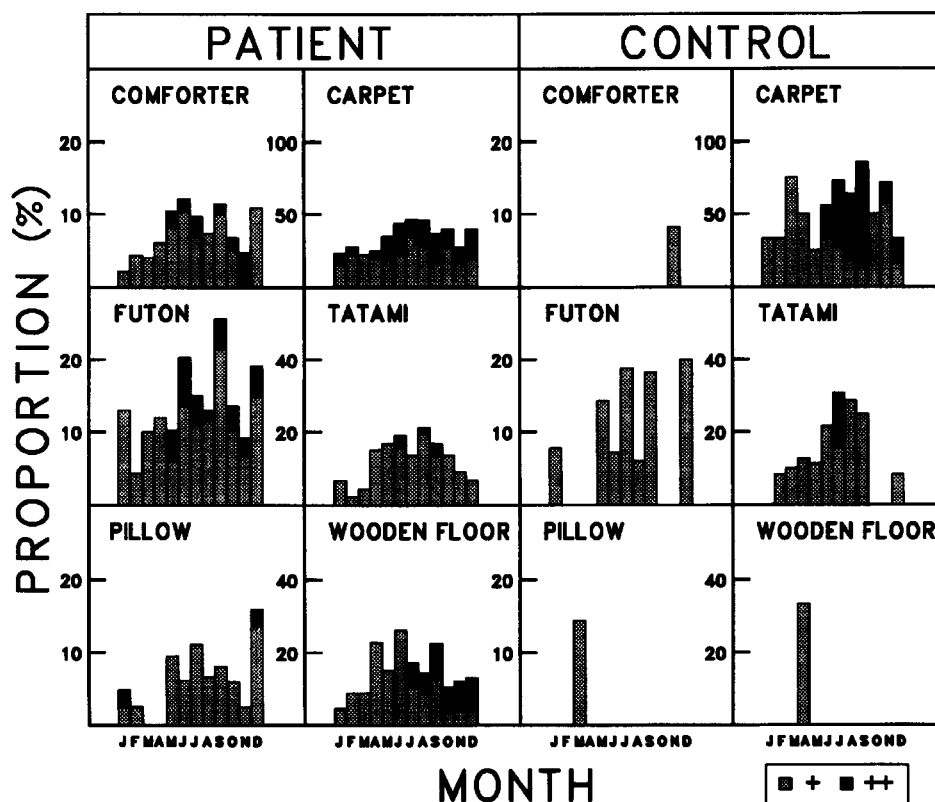


Fig. 4. Monthly variation in proportion of scores of + and ++ obtained with six indicated materials in patient and control homes.

$p < 0.05$) and in futons ($\chi^2 = 3.87$, $p < 0.05$) and pillows ($p = 0.0025$) in May–December. Floorings in control homes had a higher proportion of samples with + and ++ between June and September for carpets ($\chi^2 = 21.17$, $p < 0.001$) and tatamis ($\chi^2 = 12.45$; $p < 0.001$).

The comparison of patients and control homes in scores obtained in and around summer provided higher proportions of samples with + and ++ in patient homes than in control homes in comforters ($p = 0.0006$) and pillows ($p = 0.0038$) in April–October in wooden floors in May–October ($p = 0.041$). Carpets showed a higher proportion of + and ++ in control homes than in patient homes in April–October ($\chi^2 = 6.56$, $p < 0.05$), consistent with the result obtained with yearly totals (Fig. 1). However, data obtained from those materials in November–March did not provide significant differences between the patient and control homes ($p > 0.05$).

Comparison of wooden and concrete structures

A total of 1467 data from patient homes and 312 data from control homes were grouped according to the structure of the homes to show the effect of the homes on mite growth (Fig. 5). The mean antigen levels observed in wooden structures were higher than those in concrete structures in futons ($F = 4.00$, $p < 0.05$), carpets ($F = 10.55$, $p < 0.01$) and tatamis ($F = 4.79$, $p < 0.05$) from patient homes and in futons ($F = 5.39$, $p < 0.05$) and tatamis ($F = 4.05$, $p < 0.05$) in control homes. Analysis of data by the *U*-test indicated higher antigen levels in wooden structures than in concrete structures with futons ($z = 2.55$, $p < 0.05$) and pillows ($z = 2.00$, $p < 0.05$) in patient homes and futons ($z = 2.67$, $p < 0.01$) in control homes.

The comparison between patient and control homes indicated that antigen levels of patient homes were higher than those of control homes in comforters ($F = 4.67$, $p < 0.05$; $z = 2.00$, $p < 0.05$) and pillows ($F = 4.03$, $p < 0.05$; $z = 2.54$, $p < 0.05$) from wooden structures and in comforters from concrete structures ($F = 13.74$, $p < 0.001$; $z = 3.22$, $p < 0.01$), whereas carpets of concrete structures showed higher antigen levels in control homes than in patient homes ($F = 13.91$, $p < 0.001$; $z = 4.03$, $p < 0.001$).

The analysis of data expressed as the scores of antigen levels provided a higher proportion of samples with + and ++ in wooden structures than in concrete structures in comforters ($p = 0.014$), pillows ($p = 0.032$), carpets ($\chi^2 = 18.81$, $p < 0.001$) and tatamis ($p = 0.013$) in patient homes. Differences between patient and control homes were observed in carpets ($\chi^2 = 12.42$, $p < 0.001$) in concrete structures.

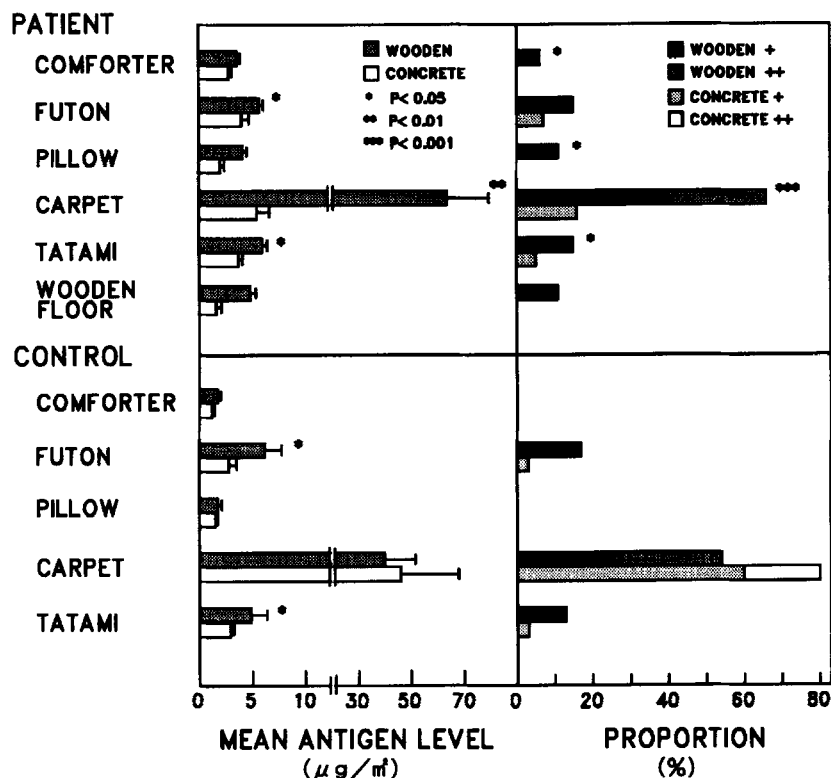


Fig. 5. Comparison of wooden and concrete structures in mean antigen levels (left) and proportions of scores of + and ++ (right). Bars indicate standard errors. Asterisks indicate significant differences evaluated by a one-way ANOVA for mean antigen levels and the chi-square test or the Fisher's exact probability test for scores: * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$.

DISCUSSION

Previous surveys of mite counts or allergen levels in dust samples have indicated significant differences between homes of allergic patients and non-allergic people (Korsgaard, 1982; Turner *et al.*, 1988; Harving *et al.*, 1993) or non-significant differences (Takaoka *et al.*, 1977; Pauli *et al.*, 1993). At present, patients are well educated about mite allergies and are also advised by doctors on how to eliminate allergens from the environment. Therefore, it is likely that patient homes will not show higher mite levels than homes of normal people, even though patient homes did have higher mite levels before the patients developed allergic symptoms. In particular, carpets and tatamis have been generally known as important

habitats of allergenic mites and have been objects for patients to take a special care of. Our results concerning the mean antigen levels of floorings indicated no significant differences between patient and control homes (Fig. 1) or, rather, control homes showed higher mite levels in carpets than patient homes when analysis was done with proportions of scores (Figs 1 and 4) and when homes made of concrete were grouped (Fig. 5). However, antigen levels of bedclothes, such as comforters and pillows, were significantly higher in patient homes than in control homes, in both analysis using mean antigen levels and scores (Fig. 1). Ordinary control measures for comforters and futons taken by people, including exposure to the sun and cleaning, may not effectively and practicably remove mites from these materials.

Carpets showed the highest mean antigen levels among materials in patient and control homes (Fig. 1), suggesting that carpets are the major source of allergen. However, carpets originally have a role in absorbing dusts and the airborne allergens in rooms with carpets may not be directly related to the allergen level shown in the dust collected from carpets using a vacuum cleaner (Price *et al.*, 1990). Therefore, bedclothes, another well-known habitat of allergenic mites, may be a more important source of allergen than carpets, since patients have close contact with bedclothes apparently for a longer period.

Higher antigen levels of comforters and pillows in patient homes than in control homes (Fig. 1) may indicate some environmental factors involved in the mite growth characteristic of patient homes. Primarily, mite growth is affected by temperature, humidity, supplement of feed (human dander) and place suitable for growth (Natuhara, 1989). Structure, age and floor levels of homes mainly relate to temperature and humidity and the density and age of people living in the homes mainly relate to supplement of feed. A temperature of 25°C and a relative humidity of 75–80% are the most suitable conditions for growth of *D. farinae* and *D. pteronyssinus* (reviewed by Natuhara 1989). In relation to these factors, seasonal variation in mite density have been reported (Murray and Zuk, 1979; Arlian *et al.*, 1982; Takaoka and Okada, 1984; Platts-Mills *et al.*, 1987). Our result also indicated higher antigen levels in April–October, in particular in the hot and humid season between June and September (Figs 2–4). Furthermore, significant differences between patient and control homes in comforters, pillows and carpets observed in yearly totals were accounted for by the difference in data obtained in April–October.

Wooden detached houses had higher antigen levels than concrete apartment houses (Fig. 5). This result was inconsistent with the earlier

reports stating that the concrete structure provided higher mite levels than wooden structures (Uchikoshi *et al.*, 1982) and more children positive for the IgE antibody to *Dermatophagoides* mites were observed in concrete structures than in wooden structures (Osaka *et al.*, 1985) in relation to the higher humidity in concrete than wooden structure. Our result may be partly explained by more recent reports revealing the difference in humidity according to floor levels of homes in high-rise apartments: the abundance of *D. pteronyssinus* decreased with the increase in the floor level (Suto *et al.*, 1991, 1992). Furthermore, current wooden homes seem to be good at keeping indoor humidity as high as concrete homes. Because of the difference in antigen levels between wooden and concrete homes, higher antigen levels in patient homes than in control homes (Fig. 1) may be partly attributed to a higher proportion of wooden structures (68%) than the concrete structure (32%) in patient homes compared with a lower proportion of the wooden structure (40%) than the concrete structure (60%) in control homes. However, higher mean antigen levels in patient homes than control homes were still observed in comforters and pillows from wooden structures and in comforters from concrete structures (Fig. 5), indicating some other factor(s) involved in the difference in mite levels in patient and control homes. We are currently studying mite distribution in public facilities to assess their hygienic situation and also to further clarify the nature of mite contamination in the human environment.

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