

Natural variation in mite antigen density in house dust and relationship to residential factors

J. KUEHR, T. FRISCHER*, W. KARMAUS†, R. MEINERT, R. BARTH, S. SCHRAUB, A. DASCHNER, R. URBANEK* and J. FORSTER

University Children's Hospital, Freiburg, Germany, *University Children's Hospital, Vienna, Austria and

†NORDIG Institute for Health Research and Prevention, Hamburg, Germany

Summary

To investigate the year-to-year variation of mite antigen density (*Der p* I, *Der f* I) in dust from mattresses and the relevance of residential factors for antigen load, information derived from an epidemiologic study including two surveys carried out in the households of a cohort of elementary school children ($n = 1291$) was analysed.

When considering residences with measurements taken in both years in question ($n = 1050$), rank-correlation indicated a predominance of stability for both antigens (*Der p* I: $r_s = 0.82$, $P = 0.0001$; *Der f* I: $r_s = 0.72$, $P = 0.0001$). Using multiple regression analyses, significant associations between antigen concentrations and a variety of residential factors were found. Use of a blanket of animal hair, use of a cover or underblanket, wet spots in the bedroom, higher relative humidity and a low storey level were significantly associated with increased concentrations of *Der p* I, whereas inverse relationships between this antigen and room temperature, number of persons per m^2 as well as use of underfloor heating were seen. Regarding *Der f* I, older mattresses, use of a cover or underblanket, higher weight of sampled dust, high educational level and higher ratio of inhabitants per m^2 were significantly associated with increased concentrations of the antigen. On the other hand, lower *Der f* I concentrations were found when interior sprung mattresses were used and when the mattress was 'treated regularly'.

In conclusion, two measurements, 1 year apart from each other, show that stability of mite antigen concentrations predominated. Our data suggest that allergic patients should be advised against living in lower storeys and damp homes and to use a newer or encased mattress and to give preference to a residence with underfloor heating.

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Introduction

Forty years after the statement that mites are the source of house dust allergen, an effective confirmation introduced more intensive research on the family of Pyroglyphidae [1,2]. Since then, antigens excreted in the faeces of house dust mites have been identified as worldwide common inhalant allergens triggering perennial asthma in large groups of patients [3]. The medical importance of mites stimulated numerous investigators to explore mite-related environmental conditions [4–12]. In all these studies mite counts were ascertained [4–12], whereas only in some was additional information using allergen load

available [7,10]. Furthermore, some reports on seasonal variation have been published [8,10] but, to our knowledge, none focusing on year-to-year stability in a given environment. As one option for allergen exposure assessment the 'Report of a second international workshop' on dust mite allergens and asthma recommends expressing results as mass of antigen per mass of dust [13]. To specify antigen exposure by this means, information regarding long-term variation within places of mite infestation is required. Furthermore, the dependence of antigen density on residential factors is of importance. Objectives of the present article were year-to-year variation of mite antigen density (major allergen I of *Dermatophagoides pteronyssinus* (*Der p* I) and *D. farinae* (*Der f* I)) in mattresses and the relevance of residential factors for the antigen load.

Correspondence: Dr J. Kuehr, University Children's Hospital, Mathildenstrasse 1, D-79106 Freiburg, Germany.

Information derived from an epidemiological study including two surveys carried out in the same large population-based sample was analysed.

Materials and methods

Population

Data were collected in a longitudinal study designed to assess risk factors for allergy and asthma in children. In order to obtain a population-based sample of school children in the study region, which includes three mainly urban areas (Freiburg, Loerrach/Weil, Kehl), all parents whose children started elementary school in 1989 were invited to participate. The study was approved by the local ethical committee and also by local school authorities. Initially, questionnaires were distributed to 2604 families and were returned by 70% ($n=1812$) of the parents [14]. In the course of the study, in addition to the use of questionnaires, the families' residences were visited twice in order to ascertain environmental conditions and to take dust samples for mite antigen measurements.

Questionnaire

A first standardized questionnaire was filled out in spring 1990, on average 10 months prior to the first household visit. A second and third questionnaire were administered 1 and 2 years later, respectively. Variables recorded were: individual room heaters; underfloor heating; wet spots in the bedroom; storey; age of the building; detached family house; inhabitants per m^2 ; dog or cat kept as pets; educational level (highest level achieved at school by father or mother).

Household visits, indoor conditions and interview

From December to April 1990/1991 (first survey) and in the same months 1991/1992 (second survey) the children's homes were visited by trained personnel ($n=10$) for dust sampling, measurement of temperature ($^{\circ}C$) and relative humidity (%), both taken in the bedroom (Testoterm, Germany), and for conducting interviews. The following variables were recorded during the household visit by means of a standardized interview: mattress on upper/lower level of a bunk bed; interior sprung mattress; blanket with animal hair; age of the mattress; mattress with underblanket or cover; woods, meadows, fields in the vicinity (500 m); stretch of water in the vicinity; use of humidifier in the child's room; regular treatment (turning over, ventilating, vacuum cleaning) of the child's mattress.

Dust sampling and antigen measurement

The dust was collected from the total area of the upper side of the mattress in a standardized manner using the

same device (collector and filter, ALK, Denmark) and the same type of vacuum cleaner (Miele, Germany) with an air flow of 56 l/s (specified by the manufacturer) for 5 min. The sample was transported to the laboratory immediately and stored at $-20^{\circ}C$ until it was extracted. Extraction (whole sample without removing larger particles) and quantification by ELISA were performed using species-specific antibodies to *Der p I* and *Der f I* (ALK, Denmark) according to the method described by Lau *et al.* [15]. The antigen concentration in the sample was calculated using a standard curve ranging between 1.6 and 400 ng/ml (ALK, Denmark; internal standards related to National Institute of Biological Standards and Control 82/518 [16]). The monoclonal antibody to *Der p I* (*Der f I*) used was Nhp5 (Nhf3) [17]. The intra-assay ($n=15$) and inter-assay ($n=23$) coefficients of variation ranged between 2.5% and 12%, and 3% and 12%, respectively. The assay sensitivity was 0.004 μg antigen per g of dust. The assay was carried out with three dilutions of the extracted sample (1:10, 1:50, 1:100), each in double control manner. The antigen concentration used for statistical analysis was the arithmetic mean of values in the linear section of the standard curve.

Statistical analysis

The degree of consistency of the antigen concentrations in 1990/1991 compared with those in 1991/1992 was assessed both graphically and by Spearman rank correlation. Median and 5–95% ranges of concentrations of both antigens were calculated, stratified for environmental variables. To explain concentrations, linear regression on environmental variables was applied. Besides the residential factors listed above (see questionnaire and interview), variables of interest were: month of sampling, town, weight of sampled dust, room temperature and relative humidity. Regression analysis of antigen concentrations measured in the first survey was performed in an explorative approach, striving for the most parsimonious model which is presented as the final model. This was achieved by a backward elimination strategy, keeping only factors which were significant at the ' $\alpha=0.1$ level'. The final explanatory model of the first survey was then applied to the concentrations measured in the second survey in order to check reliability of the previous explorative analysis. Range testing using the Scheffé test was performed for significant variables with more than two levels. In the linear regression of the second survey, subjects who moved to a new flat or changed their bed were not considered since new conditions had not been ascertained in detail. On account of potential observer effects, linear regression was carried out under control for the sampling persons. To achieve normal distribution for linear regres-

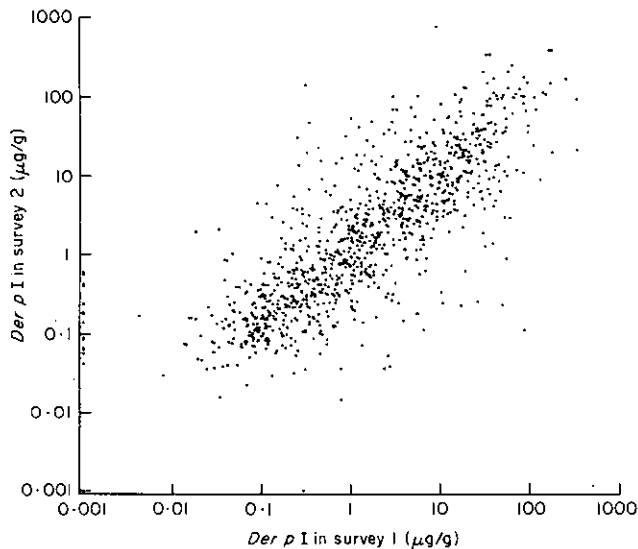


Fig. 1. *Der p I* concentrations in the second survey against the antigen density in the first survey ($n=1050$, $r_s=0.82$, $P=0.0001$).

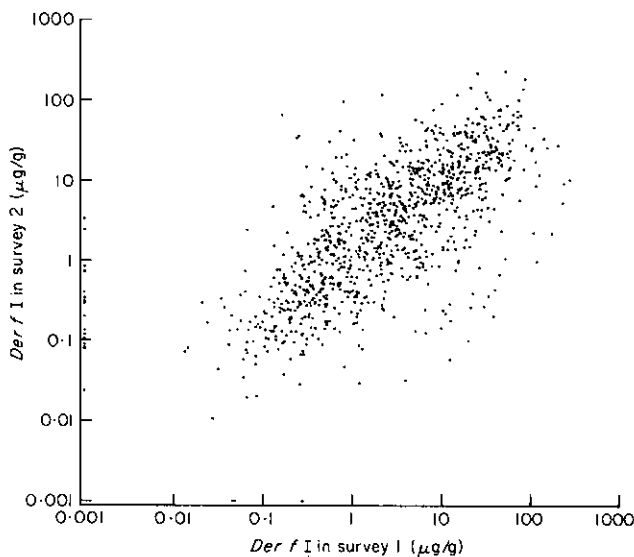


Fig. 2. *Der f I* concentrations in the second survey against the antigen density in the first survey ($n=1050$, $r_s=0.72$, $P=0.0001$).

sion, antigen concentrations were rank-transformed according to the method of Blom [18]. All analyses were carried out using the Statistical Analysis System.

Results

In the first survey ($n=1291$), the median (5–95% range) of the *Der p I* concentration was $1.35 \mu\text{g/g}$ (0.04 – $42.83 \mu\text{g/g}$)

and the median (5–95% range) of the *Der f I* concentration was $2.48 \mu\text{g/g}$ (0.08 – $45.7 \mu\text{g/g}$). In the second survey ($n=1192$ households), the median (5–95% range) of the *Der p I* concentration was $1.61 \mu\text{g/g}$ (0.08 – $62.58 \mu\text{g/g}$) and the median (5–95% range) of the *Der f I* concentration was $2.93 \mu\text{g/g}$ (0.11 – $43.85 \mu\text{g/g}$).

The agreement between mite antigen concentrations on the first and second survey for households with two measurements ($n=1050$) is shown for *Der p I* and *Der f I* in Figs 1 and 2. The *Der p I* concentrations of both surveys were significantly correlated ($r_s=0.82$, $P=0.0001$). A weaker relationship was found for *Der f I* ($r_s=0.72$, $P=0.0001$). In the second survey, an increase in *Der p I* (median: 20.1% increase in relation to the first measurement) as well as in *Der f I* concentrations (median: 13.7% increase) occurred. The change in the antigen concentration with regard to a classification is shown in Table 1. No change of the class was obvious for *Der p I* in 62% ($n=651/1050$) and for *Der f I* in 54.7% ($n=574/1050$). A decrease or increase of one class was seen in 32% ($n=336/1050$) for *Der p I* and in 37.6% ($n=395/1050$) for *Der f I*.

Of the 1050 households which could be visited in both surveys, a change concerning the child's bed was reported by 134 families (12.8%). In these dwellings a 3% increase in the *Der p I* concentration and a 4% decrease in the *Der f I* concentration were observed, on average (median). The distribution of temperature and relative humidity were similar in the first (mean/SD: temperature $18.1 \pm 2.3^\circ\text{C}$, relative humidity $45.5 \pm 8.4\%$) and second survey ($18.6 \pm 2.2^\circ\text{C}$, $43.6 \pm 7.4\%$). A weak positive correlation was seen between the surveys for temperature ($r=0.29$, $P=0.0001$) as well as for relative humidity ($r=0.26$, $P=0.0001$). The relationship between the mite antigen concentration (*Der p I*) and the residential factors is presented in Table 2. The use of a blanket of animal hair, use of a cover or underblanket, wet spots in the bedroom, higher relative humidity, a low storey level, and the town of Kehl were significantly associated with increased concentrations of *Der p I*, whereas the *Der p I* concentration showed an inverse relationship with room temperature and the number of persons per m^2 . These associations were again found when the final model of the first survey was applied to the second survey. Using range testing (Scheffé test) the negative association between storey and *Der p I* concentration was shown to be a consequence of differences between the higher storey levels (> 2) and level '0' as well as level '1'. Regarding the effect of 'town', the significant association was a result of differences between Kehl and both other cities. The negative association of *Der p I* concentrations and the use of underfloor heating was more strongly pronounced in the second survey, whereas the significance of the level of a bunk-bed and the rural surroundings of the residence (wood, meadow,

Table 1. Consistency of *Der p* I and *Der f* I concentrations between the first and second survey based on classification into four categories

Concentration ($\mu\text{g/g}$) in second survey	Concentration in the first survey							
	<i>Der p</i> I ($\mu\text{g/g}$)				<i>Der f</i> I ($\mu\text{g/g}$)			
	<0.4 <i>n</i> =333 (%)	≥ 0.4 –2 <i>n</i> =266 (%)	≥ 2 –10 <i>n</i> =226 (%)	≥ 10 <i>n</i> =225 (%)	<0.4 <i>n</i> =208 (%)	≥ 0.4 –2 <i>n</i> =268 (%)	≥ 2 –10 <i>n</i> =296 (%)	≥ 10 <i>n</i> =278 (%)
<0.4	72.1	19.6	5.3	2.7	63.9	17.2	3.4	4.3
≥ 0.4 –2	21.6	53.0	16.4	2.7	27.4	41.4	20.6	6.1
≥ 2 –10	4.8	20.7	51.3	26.2	6.7	32.5	51.0	25.2
≥ 10	1.5	6.8	27.0	68.4	1.9	9.0	25.0	64.4

fields) was diminished in the second survey.

Regarding *Der f* I (Table 3), older mattresses (Scheffé test: > 24 months *vs* ≤ 24 months), the use of a cover or underblanket, a higher weight of sampled dust, educational level (Scheffé test: low level *vs* medium and *vs* high level) and a higher ratio of inhabitants per m^2 were significantly associated with increased concentrations of the antigen in both surveys, whereas December as the month of sampling was important only in the first measurement (Scheffé test). On the other hand, lower *Der f* I concentrations were found in the case of using interior sprung mattresses and of 'regular treatment' of the mattress.

Discussion

Knowledge about the natural variation of mite allergen exposure is of interest for clinical as well as scientific purposes. In contrast to former papers this article presents the data of two surveys carried out in the same large population-based sample. Firstly, the year-to-year variation of antigen concentrations in house dust and secondly the relevance of residential factors for the antigen load originating from two commonly found dust mite species were investigated. The results of the first survey analysing the antigen concentration in an explorative manner were checked using the data derived from the second survey.

Year-to-year variation

The relatively high level of stability found (Figs 1 and 2) was not expected since the measurement itself was based on a complex procedure, and numerous conditions in a dwelling are subject to spontaneous changes. However, since the first antigen concentration did not completely

agree with the second measurement (*Der p* I: $r_s = 0.82$, *Der f* I: $r_s = 0.72$), conditions interfering with stability should be considered in addition to pure measurement error.

Firstly, the median (5–95% range) of the intra-household coefficients of variation was 49% (4–131%) for *Der p* I and 56% (5–135%) for *Der f* I. Thus, inter-survey variation can be explained only in part by inter-assay variation (3–12%).

Secondly, measurement of 'antigen mass per mass of dust' was used arbitrarily to enable exposure assessment in risk and avoidance studies [15, 19–21]. However, factors determining the amount of antigen need not be the same as those contributing to the presence of dust. Thus, an increase in dust not in parallel with the change in antigen production can in part explain variation in the 'antigen mass per mass of dust'. In particular, the proportion of coarse fibres and particles in the sample must be regarded as an important mass factor. By using a filter paper (retaining $\geq 95\%$ of particles $> 1 \mu\text{m}$) within the collector device and eluting the whole dust sample, we tried to establish control for this point in the present study.

Thirdly, seasonal differences between the summer and autumn of 1990 compared with these seasons in 1991 could have been a partial cause for the year-to-year variation observed. Following the relatively [15,22] high allergen concentrations in the first survey ($> 2 \mu\text{g/g}$: 43.8% of households regarding *Der p* I and 54.1% regarding *Der f* I), the further increase in concentrations in the second survey for both antigens might be a consequence of even more 'favourable' conditions from winter 1990/1991 to summer 1991, compared with the previous year. Regarding fluctuations within one sampling period, in comparison with the literature [8,10], only a minor month-to-month variation of mite antigen load could be seen in our study region. A significant deviation occurred for *Der f* I in December 1990 compared with

Table 2. Relationship between *Der p* I concentrations ($\mu\text{g/g}$ dust) and residential factors based on median, quantiles and analysis of variance (*P*-value)

Factor	Bivariate analysis							Analysis of variance	
	Survey 1990/1991				Survey 1991/1992			1990/1991 (<i>n</i> = 1096)	1991/1992 (<i>n</i> = 829)
	<i>a</i>	<i>n</i>	Median	5-95%	<i>n</i>	Median	5-95%	<i>P</i> -value	<i>P</i> -value
Bed									
Lower level of a bunk-bed	No	1182	1.2	0.04-41.8	1094	1.6	0.08-62.6	0.0223	0.0605
	Yes	103	3.7	0.10-56.1	96	1.8	0.13-67.2		
Interior sprung mattress	No	454	1.2	0.05-29.2	357	1.5	0.08-37.4	—	—
	Yes	747	1.3	0.04-49.4	594	1.5	0.07-86.4		
Blanket of animal hair	No	405	1.1	0.04-30.7	315	1.3	0.07-48.9	0.0153	0.0358
	Yes	848	1.5	0.05-54.2	659	1.7	0.08-78.1		
Age of the mattress	≤ 12 months	185	0.8	0.03-31.3	38	1.4	0.08-37.1	0.0684	0.51
	13-24 months	176	1.0	0.05-41.4	142	0.9	0.07-72.7		
	> 24 months	892	1.5	0.05-48.7	851	1.6	0.08-60.3		
Cover or underblanket	No	664	1.1	0.04-38.8	542	1.0	0.07-60.3	0.0016	0.0259
	Yes	619	1.8	0.07-49.2	513	2.3	0.09-59.7		
Regular treatment	No	317	1.2	0.05-52.2	376	1.3	0.07-47.9	—	—
	Yes	969	1.5	0.04-41.9	813	1.8	0.08-74.2		
Weight of sampled dust								—	—
Bedroom									
Underfloor heating	No	1187	1.5	0.05-44.6	1053	1.7	0.08-62.6	0.0320	0.0002
	Yes	50	0.7	0.05-22.1	36	0.4	0.01-12.3		
Wet spots	No	1209	1.3	0.04-41.7	1115	1.5	0.08-57.0	0.0025	0.0001
	Yes	52	5.0	0.08-95.5	39	13.7	0.09-126		
Temperature								0.0001*	0.0001*
Relative humidity								0.0001†	0.0007†
Building, outdoor									
Storey	0	18	7.2	0.17-112	11	11.5	0.44-253	0.0001	0.0001
	1	711	1.7	0.06-54.6	624	2.4	0.09-83.0		
	2	129	1.3	0.04-37.1	111	1.1	0.08-38.2		
	> 2	365	0.8	0.04-35.0	331	0.9	0.07-25.8		
Town	Freiburg	695	0.9	0.04-38.8	654	1.0	0.07-48.9	0.0001	0.0001
	Loerrach/Well	294	1.4	0.04-39.3	294	1.9	0.07-78.1		
	Kehl	302	3.0	0.11-56.9	244	3.9	0.13-98.9		
Wood, meadow, field in vicinity	No	238	0.9	0.04-37.9	187	0.9	0.08-37.1	0.0267	0.0644
	Yes	1053	1.5	0.05-45.5	843	1.8	0.08-67.2		
Month of sampling	Dec	38	3.7	0.17-95.5	76	1.2	0.08-35.0	—	—
	Jan	372	1.5	0.09-52.5	323	1.9	0.08-93.7		
	Feb	397	1.2	0.04-36.9	353	1.9	0.09-62.6		
	Mar	362	1.3	0.03-44.6	439	1.5	0.08-57.6		
	Apr	122	1.1	0.02-35.8	0	—	—		
Education, crowding									
Educational level of parents	Low	379	1.8	0.04-48.7	351	2.3	0.08-85.7	—	—
	Medium	366	1.3	0.04-41.2	346	1.8	0.09-62.6		
	High	523	1.1	0.05-41.7	372	1.3	0.07-45.3		
Persons/m ²								0.0428*	0.0001*

For analysis of variance a backward modelling strategy was employed in the first survey and the final model (including factors with significance $\alpha < 0.1$) was applied to the second survey. The analyses of variance were carried out under control of the sampling person.

* Negative association. † Positive association.

Table 3. Relationship between *Der f1* concentrations ($\mu\text{g/g}$ dust) and residential factors based on median, quantiles and analysis of variance (*P*-value)

Factor	Bivariate analysis							Analysis of variance	
	Survey 1990/1991				Survey 1991/1992			1990/1991 (<i>n</i> = 1096)	1991/1992 (<i>n</i> = 829)
	<i>a</i>	<i>n</i>	Median	5-95%	<i>n</i>	Median	5-95%	<i>P</i> -value	<i>P</i> -value
Bed									
Lower level of a bunk-bed	No	1182	2.5	0.08-45.7	1094	2.9	0.10-42.9	—	—
	Yes	103	2.5	0.05-45.5	96	3.7	0.17-52.0		
Interior sprung mattress	No	454	3.0	0.09-45.5	357	4.5	0.13-50.8	0.0079	0.0019
	Yes	747	2.1	0.07-48.0	594	2.7	0.10-39.4		
Blanket of animal hair	No	405	1.7	0.06-51.6	315	2.5	0.10-45.8	—	—
	Yes	848	2.7	0.08-41.8	659	3.5	0.12-42.2		
Age of the mattress	≤ 12 months	185	0.6	0.01-12.3	38	1.1	0.12-36.2	0.0001	0.0001
	13-24 months	176	1.0	0.07-23.3	142	0.9	0.11-22.5		
	> 24 months	892	3.8	0.11-55.5	851	4.3	0.11-46.1		
Cover or underblanket	No	664	2.2	0.07-42.9	542	2.7	0.10-40.8	0.0031	0.0293
	Yes	619	2.9	0.08-51.6	513	3.6	0.13-45.8		
Regular treatment	No	317	2.9	0.16-51.2	376	3.6	0.13-47.9	0.0418	0.0563
	Yes	969	2.2	0.07-45.0	813	2.6	0.09-41.5		
Weight of sampled dust								0.0003†	0.0002†
Bedroom									
Underfloor heating	No	1187	2.6	0.08-46.9	1053	3.1	0.11-42.9	—	—
	Yes	50	2.7	0.03-46.8	36	4.5	0.03-62.4		
Wet spots	No	1209	2.6	0.08-46.9	1115	3.1	0.11-44.1	—	—
	Yes	52	2.0	0.06-36.3	39	1.3	0.07-30.6		
Temperature								—	—
Relative humidity								—	—
Building, outdoor									
Storey	0	18	2.0	0.00-57.2	11	0.6	0.03-29.6	—	—
	1	711	2.7	0.08-51.7	624	4.1	0.10-49.0		
	2	129	2.3	0.07-41.8	111	2.1	0.17-33.1		
	> 2	365	2.3	0.11-38.1	331	2.3	0.13-36.1		
Town	Freiburg	695	2.7	0.11-45.7	654	2.8	0.13-40.5	—	—
	Loerrach/Weil	294	2.4	0.07-51.6	294	3.0	0.10-47.9		
	Kehl	302	2.1	0.06-35.0	244	3.6	0.10-45.3		
Wood, meadow, field in vicinity	No	238	1.8	0.07-41.8	187	1.9	0.07-40.2	—	—
	Yes	1053	2.6	0.08-46.9	843	3.5	0.13-45.3		
Month of sampling	Dec	38	7.3	0.34-81.5	76	3.1	0.08-47.9	0.0028	0.52
	Jan	372	2.7	0.08-58.3	323	2.4	0.09-36.4		
	Feb	397	2.3	0.06-38.8	353	2.6	0.12-52.0		
	Mar	362	2.3	0.08-33.2	439	3.9	0.12-42.4		
	Apr	122	1.9	0.09-33.0	0	—	—		
Education, crowding									
Educational level of parents	Low	379	1.4	0.04-34.7	351	1.7	0.08-35.0	0.0002	0.0010
	Medium	366	2.6	0.10-41.8	346	3.4	0.11-42.9		
	High	523	3.3	0.14-48.9	372	3.7	0.14-50.0		
Persons/m ²								0.0709†	0.0032†

For analysis of variance a backward modelling strategy was employed in the first survey and the final model (including factors with significance $\alpha < 0.1$) was applied to the second survey. The analyses of variance were carried out under control of the sampling person.

† Positive association.

February, March and April (Scheffé test). Therefore, our data suggest a similar antigen level at the same place in the same season.

Finally, changes in residential conditions and in the behaviour of the participants must be considered. In several households residential factors had changed between the first and the second dust sampling. For instance, new bedding was obtained for the child (12.8%) and families moved to other residences (3.2%). However, when the result of the antigen concentration in the first survey was communicated to the families, the second sample had already been taken. Moreover, no attempt had been undertaken by staff working on the study to initiate changes in housing conditions. On the other hand, the parents had been informed about their child's sensitization to mite allergen found in skin-prick testing on average 10 months prior to the respective household visit [14]. The concentration of *Der p* I (median in first survey) in families with children sensitized to *D. pteronyssinus* ($n=74$) was $1.55 \mu\text{g/g}$, and was $2 \mu\text{g/g}$ if the child had been additionally diagnosed as asthmatic ($n=26$), whereas the median concentration was $1.3 \mu\text{g/g}$ in children with neither sensitization nor asthma ($n=988$). Decreasing *Der p* I concentration (median: -5%) were seen in sensitized asthmatics, in contrast to an increasing density in the healthy subpopulation (median: $+23\%$). In affected children, therefore, avoidance measures were likely to have caused, on average, a year-to-year decrease of the antigen load.

Residential factors

Although ecological conditions affecting the living insect need not necessarily influence mite antigen load to the same extent, in principle, an indirect effect of environmental factors on antigen production is likely. Most of the effects on the mite antigen load suggested by the explorative analysis of the first survey were of statistical significance again in the models based on the second cross-section. However, association of environmental factors and antigen concentrations should not be extrapolated to an ecological level. With regard to this, our findings appear to be limited.

As stated in the literature, the number of mites in house dust is related to the indoor and outdoor climate [7–9, 12, 23]. In addition, the mite antigen concentration (PI-equivalent) showed a positive correlation with the relative humidity of indoor air [7]. Summarizing numerous studies, a 'crucial influence' on growth of the house dust mite within dwellings has been ascribed to indoor air humidity [8,12]. In our study a significant positive association of relative humidity and antigen concentration was also obvious, however, only for *Der p* I (Table 2).

Relative humidity could be ascertained only as a point-measurement and it seems uncertain that one single ascertainment is representative. However, although the values of the first and second survey were only weakly correlated, the importance of 'relative humidity' was similar in the first and the second model. Some reports suggest that a sufficient level of relative humidity is beneficial for the *D. pteronyssinus* mite [24,25]. A positive association between bedroom humidity and mattress numbers of *D. pteronyssinus* has also been found [12].

In the present study, the antigen concentration originating from *D. pteronyssinus* was highest in Kehl (Table 2). All three study areas are situated in the Upper Rhine Valley. Regarding the relatively foggy area of Kehl, however, the vicinity of the Rhine, several channels and an industrial harbour together with local meteorological factors could contribute to special outdoor conditions. Thus, over a distance of about 150 km within a homogeneous geographical region, differences in outdoor conditions are apparently related to significant differences in *Der p* I (and not *Der f* I) concentrations.

The negative association of *Der p* I concentration and room temperature is in accordance with findings by others showing lower mite numbers in rooms with higher temperatures [9,12]. An effect on the indoor air climate which could be a secondary influence on mite infestation might be caused by the heating device used [12]. Since underfloor heating and also the storey may have an effect on the indoor climate and as *Der p* I shows dependency on climatic conditions, we believe that the negative association of *Der p* I concentrations and use of underfloor heating as well as higher storeys is a result of the corresponding indoor conditions.

In contrast to *Der p* I, the *Der f* I concentration was less affected by climate-related factors (temperature, humidity, town, storey). The weight of sampled dust was positively associated with the amount of antigen per g of dust (Table 3). Theoretically, if the dust weight increases, a relative decrease of antigen per g of dust (dilution) would be expected. On the other hand, a higher density of antigen would be found if dust weight represents a nutritional supply for the insects. Besides 'weight of sampled dust', the age of the mattress, high educational level and crowding are of statistical significance in both *Der f* I analyses (Table 3). As could be expected, the four predictors are in part related to each other. For example, in older mattresses, greater amounts of dust were sampled (age ≤ 12 months: median = 559 mg; 13 to 24 months: 657 mg; > 24 months: 773 mg).

The indoor as well as the outdoor climate form conditions which seem to be favoured by one mite species. Predominance of *Der p* I or *Der f* I, defined by a 10-fold higher concentration of one compared with another

antigen, was reported for about 70% of a sample of dwellings in north east Germany [15]. In our region such a 'co-predominance' is evident for more than half of the samples (57%). In about half of these mattresses, predominance of the same antigen is apparent in both surveys, whereas changes in predominance from one antigen to the other are rare (1%). Thus, it can be assumed that if more than one species finds sufficiently favourable regional outdoor conditions, indoor factors which assist or limit thriving might be decisive regarding the predominance of one mite species and its specific antigens.

As widely varying antigen densities within one and the same dwelling were reported only as an exception [10,15,21], we assume that our observations on the basis of dust samples from the mattress are generally relevant also for other mite foci in the residence. Thus an avoidance measure directed at the dwelling as a whole (e.g. higher storey, underfloor heating) may well be particularly effective, as all mite pockets (beds, carpets, upholstered furniture) in the residence are influenced by this. In contrast, measures aimed at one particular mite focus might have only a limited, local effect. Since for most asthmatic patients sensitized to dust mite allergens individual ways of allergen avoidance have to be found, some of the factors presented, for example avoidance of covers and underblankets, could find practical application.

Conclusion

Investigating the year-to-year variation of mite antigen load in households of a large population-based sample, stability of the measurement commonly used to assess mite allergen exposure was found. From our data identifying residential factors, which seem to be highly relevant for the degree of mite allergen exposure, we conclude that sensitized patients should be advised against living in lower storeys and rooms with wet spots, and to use a newer or encased mattress, giving preference to a residence with underfloor heating.

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References

- 1 Dekker H. Asthma and Milben. *Munch med Wschr* 1928; 75:515-6.
- 2 Voorhorst R, Spicksma FTM, Varekamp H, Leupen MJ, Lyklema AW. The house dust mite (*Dermatophagoides pteronyssinus*) and the allergens it produces: identity with the house dust allergen. *J Allergy* 1967; 39:325.
- 3 Platts-Mills TAE, de Weck AL. Dust mite allergens and asthma—A worldwide problem. *J Allergy Clin Immunol* 1989; 83:416-27.
- 4 Wharton GW. House dust mites. *J Med Entomol* 1976; 12:577-621.
- 5 Arlian LG, Brandt RL, Bernstein R. Occurrence of house dust mites, *Dermatophagoides* Spp (Acari: Pyroglyphidae), during the heating season. *J Med Entomol* 1978; 15:35-42.
- 6 Arlian LG, Bernstein IL, Gallagher JS. The prevalence of house dust mites, *Dermatophagoides* spp, and associated environmental conditions in homes in Ohio. *J Allergy Clin Immunol* 1982; 69:527-32.
- 7 Smith TF, Kelly LB, Heymann PW, Wilkins SR, Platts-Mills TA. Natural exposure and serum antibodies to house dust mite of mite-allergic children with asthma in Atlanta. *J Allergy Clin Immunol* 1985; 76:782-8.
- 8 Korsgaard J. House-dust mites and absolute indoor humidity. *Allergy* 1983; 38:85-92.
- 9 Vyszynski-Moher DL, Arlian LG, Bernstein IL, Gallagher JS. Prevalence of house dust mites in nursing homes in southwest Ohio. *J Allergy Clin Immunol* 1986; 77:745-8.
- 10 Platts-Mills TAE, Hayden ML, Chapman MD, Wilkins SR. Seasonal variation in dust mite and grass-pollen allergens in dust from the houses of patients with asthma. *J Allergy Clin Immunol* 1987; 79:781-91.
- 11 Walshaw MJ, Evans CC. The effect of seasonal and domestic factors on the distribution of *Euroglyphus maynei* in the homes of *Dermatophagoides pteronyssinus* allergic patients. *Clin Allergy* 1987; 17:7-14.
- 12 Hart BJ, Whitehead L. Ecology of house dust mites in Oxfordshire. *Clin Exp Allergy* 1990; 20:203-9.
- 13 Platts-Mills TAE. Dust mite allergens and asthma: report of a second international workshop. *J Allergy Clin Immunol* 1992; 89:1046-57.
- 14 Frischer T, Kuehr J, Meinert R, Karmaus W, Urbanek R. Relationship between exposure to dust mite allergen and bronchial response to exercise in schoolchildren sensitized to dust mites. *Pediatr Pulmonol* 1993; 16:13-18.
- 15 Lau S, Falkenhofst G, Weber A *et al.* High mite-allergen exposure increases the risk of sensitization in atopic children and young adults. *J Allergy Clin Immunol* 1989; 84:718-25.
- 16 Ford AW, Seagroatt V, Platts-Mills TAE, Lowenstein H. A collaborative study on the first international standard of *Dermatophagoides pteronyssinus* (house dust mite) extract. *J Allergy Clin Immunol* 1985; 75:676-86.
- 17 Lind P, Hansen OC, Horn N. The binding of mouse hybridoma and human IgE antibodies to the major fecal allergen *Der p 1* of *Dermatophagoides pteronyssinus*: relative binding site locations and species specificity studied by solid-phase inhibition assay with radiolabeled antigen. *J Immunol* 1988; 140:4256-62.
- 18 Blom G. Statistical estimates and transformed beta variables. New York: John Wiley & Sons, 1958.

- 19 Ehnert B, Lau-Schadendorf S, Weber A, Buettner P, Schou C, Wahn U. Reducing domestic exposure to dust mite allergen reduces bronchial hyperreactivity in sensitive children with asthma. *J Allergy Clin Immunol* 1992; 90:135-8.
- 20 Arshad SH, Matthews S, Gant C, Hide DW. Effect of allergen avoidance on development of allergic disorders in infancy. *Lancet* 1992; 339:1493-7.
- 21 Sporik R, Holgate ST, Platts-Mills TA, Cogswell JJ. Exposure to house-dust mite allergen (*Der p* I) and the development of asthma in childhood. A prospective study. *N Engl J Med* 1990; 323:502-7.
- 22 Schwartz B, Lind P, Lowenstein H. Level of indoor allergens in dust from homes of allergic and non-allergic individuals. *Int Arch Allergy Appl Immunol* 1987; 82:447-9.
- 23 Rijckaert G, van Bronswijk JEMH, Linskens HF. House-dust community (fungi, mites) in different climatic regions. *Oecologia* 1981; 48:183-5.
- 24 Arlian LG. Humidity as a factor regulating feeding and water balance of the house dust mites *Dermatophagoides farinae* and *D. pteronyssinus* (Acari: Pyroglyphidae). *J Med Entomol* 1977; 14:484-8.
- 25 Lang JD, Mulla MS. Abundance of house dust mites, *Dermatophagoides* spp. influenced by environmental conditions in homes in Southern California. *Environ Entomol* 1977; 6:643.

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