Original

Systematic variations in the appearance of house-dust mites (*Dermatophagoides* spp.), house mites (*Glycyphagus domesticus*) and of *Tarsonemus* sp. in dust samples from dwellings

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From the examination of 3303 dust samples collected 1984-1995 in the dwellings of Danish allergic patients the authors demonstrate a systematic variation in the weekly average concentration of mites during the year. The variation is interpreted as a nationwide, annual synchrony of the appearance of resting and active stages in the life cycles of the mites. From this *Dermatophagoides* spp. have four annual generations, *Glycyphagus domesticus* has three and *Tarsonemus* sp. has six annual generations. As resting stages are synchronous and underepresented in samples there is a risk of underestimating mite exposure when it is judged from single samples. The mattress samples had on the average 139 mites/0,1 g dust and in samples from floorings the figure was 69, but the dust from matresses in quantitatively a very small part of the dust from a dwelling and patient sampling time correlates with the population dynamics in floor dust. Therefore it is concluded that beddings is not the primary source of clinical relevant exposure to house dust mites. The concentration of house-dust mites in the patients dwellings was also associated with the age of the patients and increased with increasing number of persons in the households.

KEY WORDS: **House dust / House mites / Diagnosis / Allergy / Exposure / Synchrony.**

Variaciones sistémicas en la aparición de ácaros del polvo doméstico (*Dermatophagoides spp.*), ácaros domésticos (*Glycyphagus domesticus*) y *Tarsonemus sp.* en muestras de polvo de viviendas

A partir del estudio de 303 muestras de polvo recogidas entre 1984 y 1995 en los domicilios de pacientes alérgicos daneses, los autores demuestran una variación sistémica en la concentración media semanal de ácaros a lo largo del año. La variación se interpreta como una de orden sincrónico anual y nacional en la aparición de etapas activas y de reposo en los ciclos vitales de los ácaros. En función de esto, *Dermatophagoides* ssp. muestra cuatro generaciones anuales, *Glycyphagus domesticus* tres, y *tarsonemus* sp. seis. Dado que las etapas de reposo son sincrónicas y están subrepresentadas en las muestras, existe un riesgo de subestimación de la exposición a ácaros cuando se la evalúa a partir de muestras únicas. Las muestras procedentes de colchones tenían, por término medio, 139 ácaros por cg de polvo; en las muestras de polvo de suelo la cifra era de 69/cg, pero el polvo de los colchones es cuantitativamente una parte muy pequeña del total del polvo de una vivienda, y el tiempo de muestreo del paciente se correlaciona con la dinámica poblacional del polvo del suelo. Por consiguiente, se concluye que la colchonería no representa la fuente primaria relevante de exposición a ácaros del polvo. La concentración de ácaros del polvo doméstico en los domicilios de los pacientes estaba asimismo asociada con la edad de los propios pacientes y aumentaba en paralelo con el número creciente de individuos en la unidad doméstica.

PALABRAS CLAVE: **Polvo doméstico / Acaros domésticos / Diagnóstico / Alergia / Exposición / Sincronismo.**

INTRODUCTION

The diagnosis of house-dust mite allergy from anamnestic and clinical observations is often supported by analyses of dust from the patients home. Findings of mites or mite allergens relate the patients symptoms with actual exposure to relevant allergens in their own homes. This is

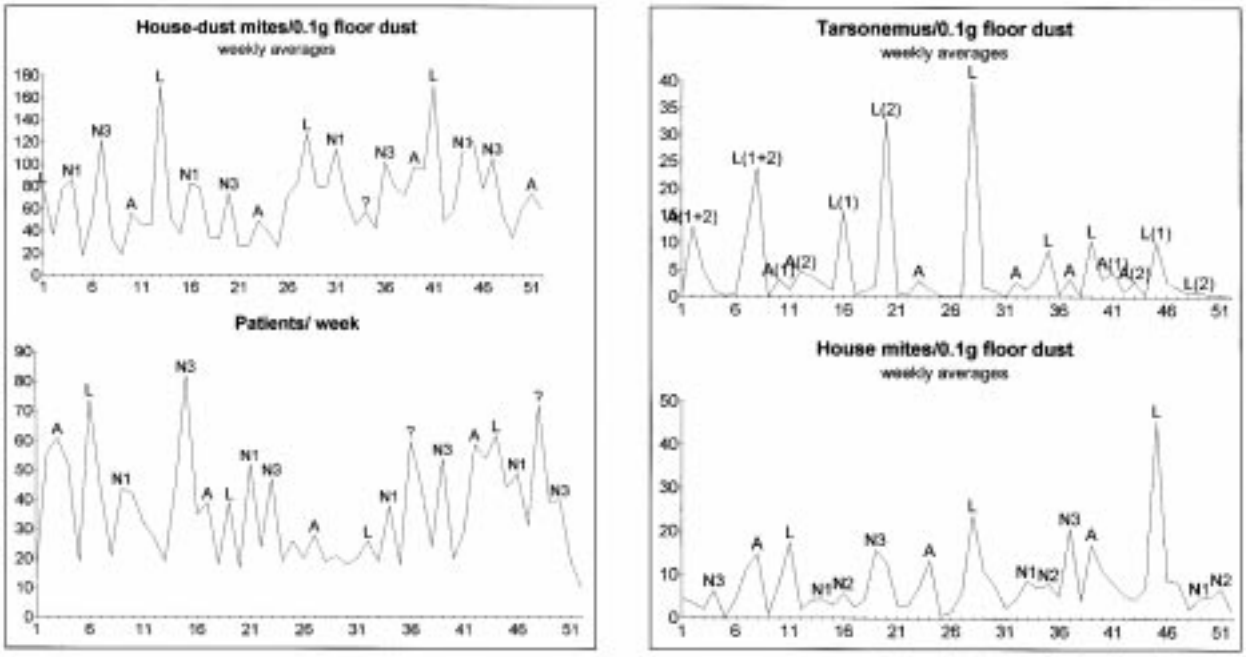

Fig. 1. Systematic variations in weekly averages of the concentration of mites in dust samples from the floor can be read as succesive, active stages in the ife cycles of mites. Tentatively the same peaks as for house-dust mites can be read from the number of samples received for examination some few weeks later indicating a possible relation to disease activity. Low peaks in week 26-33 were due to summer vacation for schools etc. in Denmark. A supernumerous peak appeared in patients in week 36, corresponding to wek 34 in House-dust mites from floorings. This peak was also clearly indicated in week 33 in samples from matresses (not shown). Another supernumerous peak in patients in week 48 could be a response to the larval peak (week 45) in *Glycyphagus domesticus. Tarsonemus* sp. showed only consequent synchrony in the summer months. The larval concentration in week 28 was 113/0,1 g. but has been shown as 40 in this figure. In the figures stage names of mites are abbreviated: E (egg), L (larva), N1 (protonymph), N2 (deutonymph), N3 (tritonymph) and A (adult).

done as a clinical routine when deciding whether or not to offer specific therapy as preventive measures or hyposensitizacion to the patient. One of us (JK) used counting of mites in dust from the patients dwellings as part of the routine clinical diagnostic work, initially for his own patients, but from 1984 offered as a service for allergologists.

Environmental findings of house-dust mites are usually described by means of statistical terms (standard deviations of aritmetic or geometic averages). However, if the material is comprehensive, it is possible alternatively to describe the systematic variations from suitable groupings of aritmetic averages. Systematic variations cannot be distinguished from rare statistical events, but with disregard of such events they form the basis of biological modelling. On this background it was recently proposed[1] to interpret systematic seasonal variations in countings of storage mites as representing synchronyzed stages of the mites own life cycles.

A knowledge of the systematic variations and their background is essential for the general understanding of the phenomenon of mites in house-dust samples. This knowledge can further be related with the housing conditions of each single patient and thus provide a more adequate background for the environmental part of the diagnosis. We have analyzed the routine mite countings from patients dwellings for possible systematic variations related to season and to the age of the patients and the present work show the most illustrative part of the results.

MATERIALS AND METHODS

Patients suspected of house-dust mite allergy were instructed to collect dust samples from their mattress and bedroom floor to evaluate their present exposure to house-dust mites. Samples were incubated with lactic acid, coloured with Lignin Pink, and subsequently examined by x 25. From the message of results for each patients sample were extracted: The age of the patient, the day of the mesagge (usually only a few days after the examination of the samples), origin of sample (mattress, bedroom floor or living room floor) and the number of *Dermatophagoides* spp., *Tarsonemus* spp. and storages mites counted in 0.1 g. of dust. No consequent identification to the level of species were done, but from casual identifications were observed the house mites, *Glycyphagus domesticus*, as being the most frequent representative of the storage mites. Only complete sheets of informations were included and a spreadsheet of 3303 dust analyses were analyzed. Copy of this file can be obtained from the authors. The results were from February 1984 to February 1995. For survey see Table I. A table of a persons age and the average number of persons in his household for the general Danish population of 1st January 1990, was calculated for the authors by Danmarks Statistik. Stage nomenclature in mites follow Hughes 1976[2].

RESULTS

Stage synchrony

For each week of the year, all years combined, the average concentration of the three kind of mites in the dust samples from floors was calculated and a number of peak concentrations appeared throughout a year (Fig. 1). Provided that inactive stages of the mites appeared in reduced numbers in the samples or were overlooked by the examination of samples, then the sequences of peaks might represent synchronized, active stages. They were interpreted as larger sequences representing full life cycles in correspondance with the known biology[2] of the mites in question. For the duration of stages in *Dermatophagoides* spp. a control was made with data derived from Furumizo's observations[3] of the duration of active and resting stages

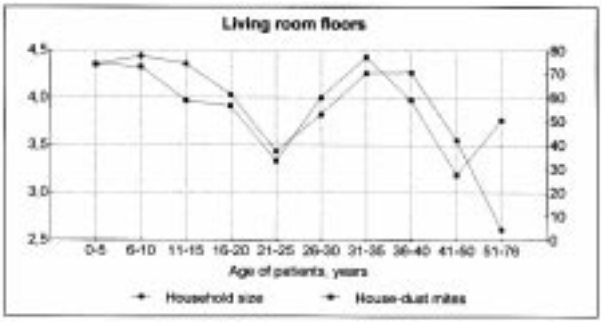

Fig. 2. The average concentration of house-dust mites in dust samples from floorings show systematic variation with the age of the patients. A similar variation exists for the (statistically) average number of persons in the patients household versus the age of the patients. This associates the concentration of mites with household size rather than with the age of the patients.

in individually observed specimens of *D. farinae*. In *G. domesticus* we compaired with stage duration from known cases of synchrony[1]. Corresponding systems of peaks was represented for the dust samples from mattresses but the systematic variation was not as illustrative. Fig. 1 shows that the house-dust mites have 4 annual generations. The house mite had 3 generations and *Tarsonemus* sp. 6 in the course of a year.

Synchrony of active mites versus frequency of dust sample examinations

If patients in general seek medical help because they were challenged by high concentrations of house-dust mites in their homes, this might also be reflected in the season, the applied for help due to worsening of their symptoms. As allergen exposure is expected to come in bursts with the peak occurences of active mites during the year, we tried (tentatively) to relate the weekly frequency of dust sampling (i.e. frequency of patients) with the supposed exposure to house dust-mites a few weeks before (the average concentration of mites in dust samples from floorings). The weekly frequencies of patients (Fig. 1) showed peaks similar to those in the floor dust samples and approximately 3-6 weeks delayed to the latter and with a relatively low sampling rate in the period of summer holiday (week 24-32).

Patient age and mite concentration

The average concentration of house-dust mites showed a decrease with increasing age of patients (Fig. 2) up to 25 years of age, then the average increased, but in older groups of age another decrease was observed. The age of a patient could be a determinant for the concentration of mites because age can be statistically connected with the number of persons in a household. Not knowing this for the patients in our material we used the calculated average household size connected with the age of a statistical person being a member of the Danish population. From Fig. 2 and Table II there is a remarkable close correspondance between household size and concentration of house-dust mites. No such correspondance was found for the concentrations of house mites or for *Tarsonemus* sp.

DISCUSSION

The large number of samples made it possible to describe in detail even minor variation in the ocurrence of mites in relation to season, age of patients and assumed household size. However, as the material was not collected for scientific purpose, there are some disadvantages connected with the power of conclusions. The sampling was performed by the patients themselves and patient selection was not standardized. Therefore the results presented should be seen as a possible biological model for the occurrence of mites in human dwellings, its significance and possible clinical implications to be elucidated in future studies.

From Fig. 1 the single active stages of house-dust mites, house mites or of *Tarsonemus* spp. was present for few days only and then they were more or less absent from the dust samples for weeks, probably because the resting stages adhere to surfaces[4] and/or are more difficult to collect by the vacuum cleaner. This underlines the difficulty[5] of associating mite exposure at one single time (the day of sampling or of sample examination) with the patients symptoms in a few weeks or months before or after.

Exposure assessments could possibly improve from repeated dust collection on different days with the inclusion of potential peak periods. This goes for allergen analyses too because the production of allergens comes in bursts when active specimens are present and produce fecal pellets, the source[6] of group I allergens. The synchrony of stages also imply that seminal fluid, which[7] may be the origin of group II allergens in *Dermatophagoides*, is produced in significant amounts for only short periods four times a year, i.e. corresponding to the peak appearance of synchronous adult males. As allergens from house-dust mites may be extremely stable under normal domestic circumstances[8] the present knowledge of the week number with increased production may provide a sound basis for the planning of removal strategies.

Much attention has been devoted to the mites in beddings. Our results indicate, that beddings is quantitatively a secondary source of exposure. The annual average of weekly averages was 139 mites/0.1 g. dust from mattress surfaces and 69 mites/0.1 g. or floor dust (Table I). Thus the average concentration from mattresses was on an

Table I.

Survey of material 1984 - 1985	Dust samples from mattresses			Dust samples from floors		
Months of examination of samples	Jan. - June	July - Dec.	Jan. - Dec.	Jan. - June	July - Dec.	Jan. - Dec.
Number of samples	953	936	1,889	722	692	1,414
Samples/week av (s.d.)	36.6 (15.1)	34.7 (16.8)	35.6 (16.0)	27.8 (13.0)	26.6 (11.3)	27.2 (18.2)
Average age of patients, years	21.1	20.7	20.9	26.4	27.9	27.1
Dermatophagoides/0.1 g av (s.d.)	128.6 (36.2)	148.5 (57.3)	138.7 (49.2)	56.8 (33.8)	81.1 (30.5)	69.2 (34.4)
Glycyphagus domesticus/0.1 g av (s.d.)	5.0 (8.0)	6.7 (21.2)	5.9 (16.2)	6.0 (5.0)	9.5 (8.8)	7.8 (7.4)
Tarsonemus/0.1 g av (s.d.)	8.6 (13.2)	18.1 (59.8)	13.4 (43.9)	5.0 (8.0)	6.7 (21.2)	5.9 (16.2)
Mites/0.1 g dust	142.2	173.3	158	67.8	97.3	82.9
% Dermatophagoides	90.4	85.7	88.1	83.8	83.4	82.9
% Glycyphagus domesticus	3.5	7.2	5.4	8.8	9.8	9.4
% Tarsonemus	6.1	7.1	6.5	7.4	6.8	7.2

Table II.

Age groups (years)	Persons in households	Mattres samples N	Prevalence N/100,000	Dermatophagoides in 0.1 g dust		
				Mattress	Floor	Average
51 - 76	2.5 - 3.0	144	8.2	124.5	56.2	90.4
21 - 25	3.1 - 3.5	130	31.4	136	51.8	93.9
16 - 20, 26 - 30, 41 - 50	3.6 - 4.0	452	33.1	133.6	65.2	99.4
31 - 40	4.1 - 4.2	236	32.9	141.3	77	109.2
0 - 15	4.3 - 4.4	957	109.1	152.7	78.6	115.7

annual basis only twice that of the floors. The ave rages appeared as the sum of a background level with no visible sign of systematic variation and an amplitude. The amplitude between peaks and valleys was of the same size of order in both mattress and floor samples. Therefore the difference in average concentration from these locations was the difference in the background consisting of specimens maintaining an almost constant level all the year (live or dead specimens, or accumulated skins from the moultings).

Considering the total amount of allergens and mites in a patients dwelling the contribution from beddings is a very small part and consequently the most likely source of exposure and cause of symptoms is from other locations, i.e. floorings. Our tentative correlation between floor peaks and peaks in number of samples received throughout the year (Fig. 1) support this view with a delay indicating that peak occurrences of house dust mites on floorings may be the primary reason for the patients complaints. High counts due to background, however, may be found in mattress-samples in several cases, and as such investigation of mattress dust still serves as the best indicator of domestic exposure to mites. Samples from floorings, however, may seem more adequate for the assessment of the degree of exposure as the background is generally lower and countings may thus indicate a greater proportion of clinical relevant, active and allergen producing specimens.

Houses with low indoor air humidity during the winter season (45 % RH or below by 20 °C) showed[9] no significant concentration of house-dust mites the rest of the year despite high humidity in the summe and in the autumn. Our patients are not member of this group as they are patients mainly because they are exposed to high concentrations of house-dust mites in their homes all the year (Table I and Fig. 1). There was a small seasonal variation in the concentration of house-dust mites and of house mite with population increase in the autumn. This could be due to the lower indoor air humidity in the winter, causing an increase of mortality and consequently smaller populations in the spring. High autumnal concentrations of house-dust mites[10] and of house mites[1, 10] are known from Denmark, but was not found in the present material.

Allergy to house mites, *G. domesticus,* depends upon other kind of allergens and the presence of peak occurrences of house mites may be a challenge too, but we were unable to relate safely the appearance of patients to this. Patients allergic for house-dust mites do have a high prevalence for house mites[11] and a patients symptoms could be a combination of reactions to both kind of mites. House mites are, like the house-dust mites, present all the year. Quantitatively their low concentrations, compaired with *Dermatophagoides* spp., could be misleading. House mites may produce significant amounts of fecal pellets as they are larger than house-dust mites. The allergenic status of *Tarsonemus* sp. is unknown, but the fecal mass may be small as this species ingests fluid food only.

A threshold limit value (TLV) of exposure of 100 house-dust mites (or 2000 ng of *Der* I) per gram dust is well established in relation to development of mite sensitization and current mite allergy in previous healthy individuals and presumably also to continued disease activity with exposure above the TLV. On the contrary the relation between individual patient exposure above the TLV and actual disease activity has hitherto proved to be weak or lacking. This may be due to assessments of exposure from dust samples without the present knowledge of the systematic variations in the findings. A better approach of assessing the degree of exposure might refer of the total mite population in a dwelling, with sampling of several sites and calculated to include both active and resting specimens of allergenic mites.

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