ORIGINAL ARTICLES AAEM

Ann Agric Environ Med 1998, 5, 73–85

THE ALLERGENIC ACAROFAUNA OF HOUSE DUST FROM DWELLINGS, HOSPITALS, LIBRARIES AND INSTITUTES IN UPPER SILESIA (POLAND)

Krzysztof Solarz

Department of Biology and Parasitology, Silesian Medical Academy, Katowice, Poland

Solarz K: The allergenic acarofauna of house dust from dwellings, hospitals, libraries and institutes in Upper Silesia (Poland). *Ann Agric Environ Med* 1998, **5**, 73-85.

Abstract: A survey of dust samples from dwellings, hospitals and some public utilities (libraries, institutes) in several Upper Silesian towns was undertaken to determine the prevalence, number and species of mites. Total seasonal dynamics of dust mite species of the family *Pyroglyphidae* in dust from beds, floors/carpets and upholstery furniture in dwellings was analysed. Over a 4-years period, 402 dust samples were studied: 238 samples from dwellings, 122 samples from hospitals, 14 from libraries and 28 from institutes. Mites were present in 51.3%, 50.0%, 21.3% and 17.9% of dust samples from dwellings, libraries, hospitals and institutes, respectively. Generally, they were found in 160 samples (39.8%) out of 402 examined. The majority of mites (96.0%) were found in samples from the dwellings, especially in dust from upholstery furniture, couches, sofas and beds. More than 30 mite species were found of which the most abundant and common were pyroglyphids, especially *Dermatophagoides pteronyssinus* and *D. farinae*. The pyroglyphid mites constituted 89.2%, 78.9% and 57.5% of a total count of mites collected from dwellings, libraries and hospitals, respectively, and were not found in institutes. *D. pteronyssinus* was the dominant, especially in libraries and hospitals, however, in dwellings *D. farinae* was more abundant per 1 gram of dust as the former species. Another pyroglyphid mite, *Euroglyphus maynei*, occurred in very small numbers. The highest mite densities per gram of dust were noted in dwellings and libraries. A mean number of mites per 1 gram of dust from dwellings was 73.7 ± 182.9 (range 1.0 - 1560.0), whereas mean values of indoor relative humidity and temperature were 64.5% RH and 22.7°C, respectively. The low mean indoor relative humidity of ambient air, resulted in the relatively low mite frequency (only about 51.3% of samples were positive for mites) and density detected in the dwellings.

Address for correspondence: Krzysztof Solarz, PhD, Department of Biology and Parasitology, Silesian Medical Academy, Medyków 18, 40-752 Katowice, Poland.

Key words: ***Acari*, acarofauna, dwellings, public localities, house dust mites, allergy, house-dust-mite atopy, *Pyroglyphidae, Acaridae, Glycyphagidae.***

INTRODUCTION

Mites occurring in house dust, especially several species from the family *Pyroglyphidae* (*Astigmata*), are considered as a main cause of house dust atopy [10, 35, 48, 50]. In 1964, for the first time, Voorhorst *et al.* [47] reported that house dust contained mites of the genus *Dermatophagoides* and suggested that these were the source of the house dust allergen. Many-faceted studies of house dust mites of the *Pyroglyphidae* family have been continued since 1964 in many countries of the world, including the surveys on their taxonomy and fauna, biology and ecology, epidemiology, allergenicity and control [4, 10, 15, 33, 34, 35, 43, 48, 50]. Three mite species, namely *Dermatophagoides pteronyssinus*, *D. farinae* and *Euroglyphus maynei* are most often and most abundantly found in house dust throughout the world [4, 15, 19, 21, 32, 34, 35]. These mites are the major sources

Received: 23 February 1998
Accepted: 9 April 1998

of indoor inhalant allergens causing both the sensitisation of atopic subjects and asthmatic attacks in patients [4, 14, 19, 35]. They have therefore been studied recently as causative agents of atopic diseases in humans, known in medicine as house-dust-mite allergy [1, 4, 32, 34, 35, 38, 44]. These diseases are atopic asthma, atopic dermatitis (eczema) and allergic rhinitis [14].

In Poland, knowledge of their occurrence in house dust is still poor and the number of faunistic surveys on dust acarofauna is low [11, 41]. Thus, such surveys are needed in Poland, especially in the Upper Silesian region, where air pollution may have a stimulating efect on the sensitisation of human beings with house dust allergens [27]. It is also known that the cases of asthma and rhinitis caused by house dust are not rare in our country [37].

The aim of this work was to study:

1) the occurrence, prevalence and species composition of mite fauna in house dust samples from dwellings, hospitals and other public localities (libraries, institutes);

2) levels of house dust infestation with mites and seasonal variation in mite abundance in particular sites of dwellings examined;

3) the main habitats of house dust mite occurrence and breeding in dwellings examined;

4) influence of air temperature and humidity, and some other environmental factors, on abundance and frequency of house dust mites, especially pyroglyphid mites.

MATERIALS AND METHODS

The study was carried out from 30 December 1981 to 14 September 1986 in Katowice district (Upper Silesia, Poland). A total of 402 house dust samples were examined, including 238 samples from dwellings, 122 from hospitals, 14 from libraries and 28 from institutes (Tab. 1).

Dust from flats was taken from floors, carpets, couches, beds and upholstery furniture, in 41 dwellings situated mainly in Katowice and Sosnowiec, but also in Tarnowskie Góry, Bytom, Zabrze, Chorzów, Gliwice, Mysłowice, Dąbrowa Górnicza and Ogrodzieniec.

The samples of dust from hospitals were vacuumed in 8 hospitals located in Katowice and Sosnowiec, always from 2 sites: floor and patients' mattress.

In two libraries samples were taken by vacuuming floors (coverings, carpets), upholstery chairs and arm-chairs, blinds, desks, book-shelves and books.

In the case of institutes, dust samples were obtained from floors from 13 laboratories and 6 offices of Departments of Medicine Theory and Central Experimental Husbandry of the Silesian Medical Academy in Katowice-Ligota.

The samples were taken with a portable car vacuum cleaner (Model #126, Predom Zelmer, Rzeszów, Poland), on a specially constructed dust trap filter attached to the end of the hose of the cleaner. At each sampling site, a surface area of $1m^2$ was vacuumed for 1 min. Next, samples of dust were weighed in a 150 ml beaker and analysed for mites as described by Arlian *et al.* [9], with some modifications. The samples were suspended in saturated NaCl with few drops of soap, stirred with a magnetic stirrer ATM, type MM 5, and held for 24 hours of floatation. After this time, supernatants were filtered through filter paper and rinsed with distilled water. Sediments were for the second time suspended in NaCl saturated solution and the procedure was repeated at least three times. Material retained on the filter was stained with crystal violet and repeatedly washed in distilled water. The filters with material retained were placed in Petri dishes and poured over with saturated NaCl solution. The surface of the liquid and the surface of the filter paper were carefully examined for mites under a binocular stereomicroscope, starting 1–2 hours after pouring. All mites were mounted in Hoyer's medium on slides, and the species and life stage determined with the aid of a compound microscope. When the samples were taken, air temperature and relative humidity in each dwelling were measured and noted. Relative humidity was monitored with a hair hygrometer. Mite density was calculated as the number of specimens per 1 gram of dust of samples positive for mites. The weight of samples ranged from 0.2 to 1.0 gram.

Table 1. Number of samples examined from dwellings, hospitals, institutes and libraries, and number of mites isolated.

Sampling sites	Total samples		Positive samples			Number of mites		
	Number of samples examined	Percent of total samples examined	Number of samples positive for mites	Percent of total count of samples	Percent of total mite positive samples	Number of mites isolated	Percent of total count of mites	Mean number of mites per one sample
Dwellings	238	59.2	122	51.3	76.3	1861	96.0	7.8
Hospitals	122	30.3	26	21.3	16.2	40	2.0	0.3
Institutes	28	7.0	5	17.9	3.1	19	1.0	0.7
Libraries	14	3.5	7	50.0	4.4	19	1.0	1.4
Total	402	100.0	160	39.0	100.0	1939	100.0	4.8

Table 2. Mean numbers of mites per 1 gram of dust in samples from particular sites in examined dwellings, hospitals, institutes and libraries.

	Mean number of mites/gram of dust $\bar{x}$ ± SD (range)						
Sampling sites	Bed dust	Carpet dust	Floor dust	Upholstery furniture	Book-shelves and books	Desks	Total
Dwellings	75.7 ± 209.6 (1.0-1560.0)	31.0 ± 64.7 (1.0-315.0)	4.9 ± 4.0 (1.0-13.3)	132.2 ± 190.1 (1.0-733.0)	ND	ND	73.7 ± 182.9 (1.0-1560.0)
Hospitals	37.8 ± 31.8 (2.0-100.0)	ND	23.8 ± 25.9 (1.0-100.0)	ND	ND	ND	30.0 ± 29.8 (1.0-100.0)
Institutes	ND	ND	4.8 ± 6.5 (1.0-16.0)	ND	ND	ND	4.8 ± 6.5 (1.0-16.0)
Libraries	ND	6.0[a]	ND	205.0 ± 195.0 (10.0-400.0)	325.0 ± 75.0 (250.0-400.0)	7.7 ± 6.7 (1.0-14.3)	154.5 ± 175.6 (1.0-400.0)

Key: [a] single sample only; ND - not determined.

Results from dwellings were analysed using χ^2 test, Student's *t*-tests and the *Pearson's* correlation test.

This material from the years 1981–1986 (not published to date) was the subject of a Ph.D. dissertation [40] and was recently thoroughly and supplementary analysed.

RESULTS AND DISCUSSION

Overall results

The overall results obtained are presented in Tables 1 and 2. Of a total of 402 dust samples examined, 160 (39.8%) were positive for mites (Tab. 1). The mites occurred most frequently and numerously in dwellings (51.3% of samples) and libraries (50%), while they were less frequent and abundant in hospitals (21.3%) and institutes (17.9%) (Tables 3, 4, 5 and 6).

A total of 1939 mite specimens were collected, of which about 96% was found in dwellings, whereas only 2.1% in hospitals (Tab. 1). The remaining 1.9% of mites was found in libraries and institutes (Tab. 1). The dwellings showed also the highest mean number of mites per one sample (Tab. 1).

The mites belonged to 4 orders, 15 families, 27 genera and 32 species (of which 31 are identified to species level), excluding unidentified specimens from *Oribatida*, *Tarsonemida*, *Gamasida* and *Cheyletidae* (*Actinedida*) (Tables 3-6).

Dust mites from the family *Pyroglyphidae* were the dominants (1698 specimens) and constituted 87.6% of a total count of mites obtained in this study. Most frequent and abundant were two species, *D. pteronyssinus* and *D. farinae*. The first was the numerically dominant, especially in libraries and and hospitals (Tables 4-7). The second, except in libraries, occurred in higher concentrations per 1 gram of dust (Tables 7, 10 and 11).

Highest mite concentrations were found in dust from book-shelves (in libraries), upholstery furniture (in dwellings and libraries) and beds (in dwellings and hospitals) (Tab. 2).

Mite fauna in dwellings

Diversity and composition of mite species. Among 238 samples examined from dwellings, only 122 (51.3%) were positive for mites. A total 1861 specimens of these arachnids were isolated from these samples. The species composition of domestic acarofauna in dust samples from dwellings is listed in Table 3. As this Table shows, the most abundant and most frequent were members of the family *Pyroglyphidae*, mainly two species: *D. pteronyssinus* and *D. farinae*. The pyroglyphid dust mites were found in 105 dust samples from dwellings (44.1% of the total of samples from dwellings and 86.1% of samples with mites from dwellings).

Thus, approximately 44.1% of the examined samples from dwellings contained at least one species of the family *Pyroglyphidae*, but only 19.3% of the samples contained exclusively one species from this family. Of all 122 samples positive for mites, 51 (41.8%) were inhabited by *D. pteronyssinus* and *D. farinae*, and only 7 samples (5.7%) by both of these species and *E. maynei* (Tab. 8). All the samples with *E. maynei* and a single sample with *Gymnoglyphus longior* were also coinhabited by *D. pteronyssinus* and *D. farinae* (Tab. 8). All these combinations of the pyroglyphid mite species composition which were observed in dust samples from dwellings, are listed in Table 8. This comparison excludes mites from other families.

Most of the pyroglyphid mites found in dwellings belonged to the genus *Dermatophagoides* (86.5% of a total mite population from dwellings). Fourty six samples (37.7% of mite positive samples) were inhabited by a single species from this genus, with 22 samples (18.0%) containing only *D. pteronyssinus* and 24 samples (19.7%) containing only *D. farinae* (apart from the other, non-pyroglyphid mites) (Tab. 8). Among 51 samples coinhabited by both *D. pteronyssinus* and *D. farinae*, in 17 (33.3%) samples *D. farinae* was found as the dominant, whereas *D. pteronyssinus* only in 14 (27.5%) samples. In the remaining 20 (39.2%) samples both of these mite species occurred in equal or similar numbers (Tab. 8).

Table 3. Species list, dominance and occurrence of mites found in dust samples from Upper Silesian dwellings.

Mite taxa	Dominance		Occurrence		Mite taxa	Dominance		Occurrence	
	Total mites	Percent of the total	Number of samples	Percent of total samples		Total mites	Percent of the total	Number of samples	Percent of total samples
A C A R I	1861	100.00	122	51.26	*Cheyletus eruditus*	11	0.59	7	2.94
ASTIGMATA					*Ch. schneideri*	1	0.05	1	0.42
Pyroglyphidae	1660	89.19	105	44.12	*Cheyletus* spp.	31	1.67	14	5.88
Dermatophagoides pteronyssinus	839	45.08	81	34.03	*Cheyletia papillifera*	1	0.05	1	0.42
D. farinae	748	40.19	83	34.87	**other cheyletids** (unidentified)	7	0.38	6	2.52
Dermatophagoides spp. (unidentified)	23	1.24	11	4.62	***ORIBATIDA***				
Euroglyphus maynei	49	2.63	7	2.94	***Haplochthoniidae***	4	0.22	1	0.42
Gymnoglyphus longior	1	0.05	1	0.42	*Haplochthonius simplex*	4	0.22	1	0.42
Acaridae	31	1.67	22	9.24	***Cosmochthoniidae***	1	0.05	1	0.42
Tyrophagus putrescentiae	21	1.13	12	5.04	*Cosmochthonius* sp.	1	0.05	1	0.42
Acarus siro	6	0.33	6	2.52	***Oppiidae***	1	0.05	1	0.42
A. siro **complex** (unidentified)	3	0.16	2	0.84	*Ramusella (R.) clavipectinata*	1	0.05	1	0.42
Rhizoglyphus robini	1	0.05	1	0.42	**other oribatids** (unidentified)	2	0.11	2	0.84
Glycyphagidae	22	1.18	11	4.62	***GAMASIDA***				
Gohieria fusca	11	0.59	7	2.94	***Laelapidae***	7	0.38	4	1.68
Glycyphagus domesticus	1	0.05	1	0.42	*Hypoaspis aculeifer*	3	0.16	1	0.42
Glycyphagus spp. (unidentified)	4	0.22	2	0.84	*Androlaelaps casalis*	4	0.22	3	1.26
Lepidoglyphus destructor	1	0.05	1	0.42	***Aceosejidae***	5	0.27	5	2.10
Lepidoglyphus sp. (hypopi)	5	0.27	1	0.42	*Blattisocius keegani*	3	0.16	3	1.26
Saproglyphidae	3	0.16	2	0.84	*Lasioseius berlesei*	2	0.11	2	0.84
Nanacarus minutus	3	0.16	2	0.84	***Ameroseiidae***	1	0.05	1	0.42
Anoetidae (hypopi)	2	0.11	2	0.84	*Ameroseius plumosus*	1	0.05	1	0.42
TARSONEMIDA					***Macrochelidae***	2	0.11	1	0.42
Tarsonemidae	46	2.47	11	4.62	*Macrocheles glaber*	2	0.11	1	0.42
Pygmephoridae	1	0.05	1	0.42	***Phytoseiidae***	9	0.48	3	1.26
ACTINEDIDA					*Phytoseius macrophilis*	1	0.05	1	0.42
Cheyletidae	51	2.74	24	10.08	**other phytoseiids** (unidentified)	8	0.43	2	0.84
					other gamasids (unidentified)	13	0.71	8	3.36

From 30 samples (24.6% of the samples with mites) only mites of the genus *Dermatophagoides* were isolated; in 17 samples (13.9%) it was *D. pteronyssinus* and in 13 (10.7%) - *D. farinae*. Generally, the mite *D. pteronyssinus* was slightly more abundant than *D. farinae*, whereas the latter species occurred a little more frequently (Tab. 3). *E. maynei* was distinctly less abundant and frequent, and *G. longior*, the last found member of the family *Pyroglyphidae* was represented only by a single tritonymph (Tab. 3).

Approximately 44.3% of all samples positive for mites contained only the pyroglyphid dust mite species, and 41.8% were coinhabited also by other non-pyroglyphid mite species. Only 13.9% of the samples contained exclusively mites from other groups.

Apart from the pyroglyphid mites, the significant element of the dust acarofauna in the Upper Silesia region are members of the families *Cheyletidae* (*Actinedida*) (especially *Cheyletus* spp.), *Tarsonemidae* (*Tarsonemida*), *Acaridae* (*Astigmata*) (especially *Tyrophagus putrescentiae* and *Acarus siro*) and *Glycyphagidae* (*Astigmata*) (mainly *Gohieria fusca*). A total of 24 species of mites from 22 genera, 13 families and 4 orders (*Astigmata*, *Actinedida*, *Oribatida* and *Gamasida*) were determined in dwellings, that indicates the high diversity of mite species (Tab. 3).

Among the 122 samples positive for mites, 43 (35.2%) were inhabited by a single mite species, 41 (33.6%) were coinhabited by 2 mite species, 21 (17.2%) - by 3 species,

Table 4. Species list, dominance and occurrence of mites found in dust samples from Upper Silesian hospitals.

Mite taxa	Dominance		Occurrence	
	Total mites	Percent of the total	Number of samples	Percent of total samples
A C A R I	40	100.0	26	21.3
ASTIGMATA				
Pyroglyphidae	23	57.5	19	15.6
Dermatophagoides pteronyssinus	17	42.5	15	12.3
D. farinae	4	10.0	4	3.3
Euroglyphus maynei	2	5.0	2	1.6
Acaridae	6	15.0	4	3.3
Acarus siro	1	2.5	1	0.8
Tyrophagus putrescentiae	2	5.0	2	1.6
T. perniciosus	2	5.0	1	0.8
Caloglyphus berlesei	1	2.5	1	0.8
Glycyphagidae	1	2.5	1	0.8
Gohieria fusca	1	2.5	1	0.8
Suidasiidae	2	5.0	2	1.6
Suidasia pontifica	2	5.0	2	1.6
Psoroptidae	1	2.5	1	0.8
Otodectes cynotis	1	2.5	1	0.8
TARSONEMIDA				
Tarsonemidae (unidentified)	2	5.0	1	0.8
ACTINEDIDA				
Cheyletidae (unidentified)	1	2.5	1	0.8
GAMASIDA				
Laelapidae	1	2.5	1	0.8
Androlaelaps casalis	1	2.5	1	0.8
Aceosejidae	1	2.5	1	0.8
Blattisocius keegani	1	2.5	1	0.8
other gamasids (unidentified)	2	5.0	1	0.8

Table 5. Species list, dominance and occurrence of mites found in dust samples from libraries.

Mite taxa	Dominance		Occurrence	
	Total mites	Percent of the total	Number of samples	Percent of total samples
A C A R I	19	100.0	7	50.0
ASTIGMATA				
Pyroglyphidae				
Dermatophagoides pteronyssinus	12	63.16	5	35.71
D. farinae	3	15.79	3	21.43
Acaridae				
Tyrophagus palmarum	1	5.26	1	7.14
other acarids (unidentified)	1	5.26	1	7.14
oribatids (unidentified)	2	10.53	1	7.14

9 (7.4%) - by 4 species, 5 (4.1%) - by 5 species. Moreover, three single samples (2.5%) with complexes of 6 (0.8%), 7 (0.8%) and 8 species (0.8%) were collected.

In the samples with single mite species there most frequently occurred *D. pteronyssinus* (17 samples, 39.5%) and *D. farinae* (13 samples, 30.2%). Within the samples coinhabited by 2 species of mites, 16 combinations of the species composition were stated, and most frequently occurred the mixed populations of both dominants, *D. pteronyssinus* and *D. farinae* (22 samples, 53.7% of samples with 2 species of mites).

Among samples infested by 3 mite species, 33.3% constituted the samples with *D. pteronyssinus, D. farinae* and *Cheyletus* sp. (7 samples), and 19.05% the samples with both of dermatophagoid mites and with 1 species of gamasid mites (4 samples - with *Blattisocius keegani, Androlaelaps casalis, Lasioseius berlesei* and *Ameroseius plumosus*, respectively). Moreover, 10 combinations of 3 mite species represented by single samples were found. The samples with 4 species (9 combinations) most frequently were coinhabited by pyroglyphids (*D. farinae*, *D. pteronyssinus* and *E. maynei*) with 1 species of tarsonemid, cheyletid, glycyphagid or gamasid mites, whereas the samples with 5 species - by *D. pteronyssinus, D. farinae, T. putrescentiae, Cheyletus* sp. and an unidentified gamasid mite. Only the remaining 19 samples were coinhabited exclusively by non-pyroglyphid mites showing 10 combinations of species composition, including 5 combinations with 1 species (*T. putrescentiae, G. fusca*, unidentified *Tarsonemidae, Pygmephoridae* and *Gamasida*), 4 combinations of 2 species (2 unidentified species of tarsonemid mites, *T. putrescentiae* and unidentified tarsonemid mite species, *T. putrescentiae* and *A. siro* complex, unidentified *Gamasida* and *Oribatida*) and 1 combination of 4 species (*A. siro, R. robini, G. fusca, B. keegani*).

Fluctuations of mite densities. Influence of indoor air temperature and relative humidity. Mean densities of mites in beds, upholstery furniture and floor dust are compared in Tables 2 and 7. The number of total mites per 1 gram of dust varied in dwellings from 1.0 to 1560.0 (Tab. 2). The mean number of mites per 1 gram of dust was highest in dust from upholstery furniture, followed by beds, and the lowest in dust samples from not carpeted floors (Tables 2 and 7).

Numbers of total mite populations or particular pyroglyphid mite species varied from one town to another, from one dwelling to another in the same town, and from one locus to another within the same dwelling, at various seasons of the year. These fluctuations are illustrated in Figures 1–3, for beds, upholstery furniture

Table 6. Species list, dominance and occurrence of mites found in dust samples from institutes.

Mite taxa	Dominance		Occurrence	
	Total mites	Percent of the total	Number of samples	Percent of total samples
A C A R I	19	100.0	5	17.86
ASTIGMATA				
Acaridae				
Acarus siro	1	5.26	1	3.57
Tyrophagus putrescentiae	1	5.26	1	3.57
T. longior	1	5.26	1	3.57
Kuzinia sp. (hypopus)	1	5.26	1	3.57
ACTINEDIDA				
cheyletids (unidentified)	5	26.32	1	3.57
GAMASIDA				
Laelapidae				
Androlaelaps casalis	2	10.52	1	3.57
Hypoaspis sp.	1	5.26	1	3.57
Phytoseiidae (unidentified)	1	5.26	1	3.57
other gamasids (unidentified)	6	31.60	2	7.14

and floor dust, respectively, also in relation to changes of indoor air ambient relative humidity and temperature.

D. farinae was most abundant per 1 gram of dust among mites collected from dwellings. On average it was twice as abundant as *D. pteronyssinus* in dust from floors and upholstery furniture (Tab. 7). In dust from beds *D. farinae* occurred most numerously during spring and summer, whereas *D. pteronyssinus* in summer and autumn, both species in periods when peaks of indoor air ambient humidity were noted (Fig. 1). In floor dust and the dust from upholstery furniture *D. farinae* was most abundant in summer and autumn months (Figures 2 and 3).

Generally, the pyroglyphid mites were most abundant in dust samples in periods from July to September, when the most favourable indoor humidities were noted (Figs 1-3).

Statistical analysis. The difference between numbers of *D. pteronyssinus* and *D. farinae* per gram of dust was not significant for all kinds of samples (*t*-test, $p \geq 0.05$).

Significant relationships were found between the numbers of mites per gram of dust (for both dominant species, *D. pteronyssinus* and *D. farinae*) and the temperature and RH values (separately for floor dust, bed/mattress dust and dust from upholstery furniture). In all these cases χ^2 was ≥ 99.99 ($p < 0.0001$).

The results of the Pearson's test for correlation between the densities of both dominant species in dust and the RH and temperature values were as follows:

- between *D. pteronyssinus* and RH in beds/mattresses: middle positive correlation, r = 0.34;
- between *D. pteronyssinus* and RH in upholstery furniture: middle negative correlation, r = - 0.44;
- between *D. pteronyssinus* and RH in floor dust: low negative correlation, r = - 0.09;
- between *D. pteronyssinus* and temperature in beds/ mattresses: very low negative correlation, r = - 0.057;
- between *D. pteronyssinus* and temperature in upholstery furniture: low positive correlation, r = 0.12;
- between *D. pteronyssinus* and temperature in floor dust: high negative correlation, r = - 0.76;
- between *D. farinae* and RH in beds/mattresses: middle positive correlation, r = 0.41;
- between *D. farinae* and RH in upholstery furniture: low positive correlation, r = 0.16;
- between *D. farinae* and RH in floor dust: middle positive correlation, r = 0.42;
- between *D. farinae* and temperature in beds/mattresses: very low positive correlation, r = 0.095;
- between *D. farinae* and temperature in upholstery furniture: low positive correlation, r = 0.17;
- between *D. farinae* and temperature in floor dust: middle positive correlation, r = 0.49.

Of all these relationships, only the high negative correlation between *D. pteronyssinus* and temperature in floor dust was statistically significant ($p < 0.01$).

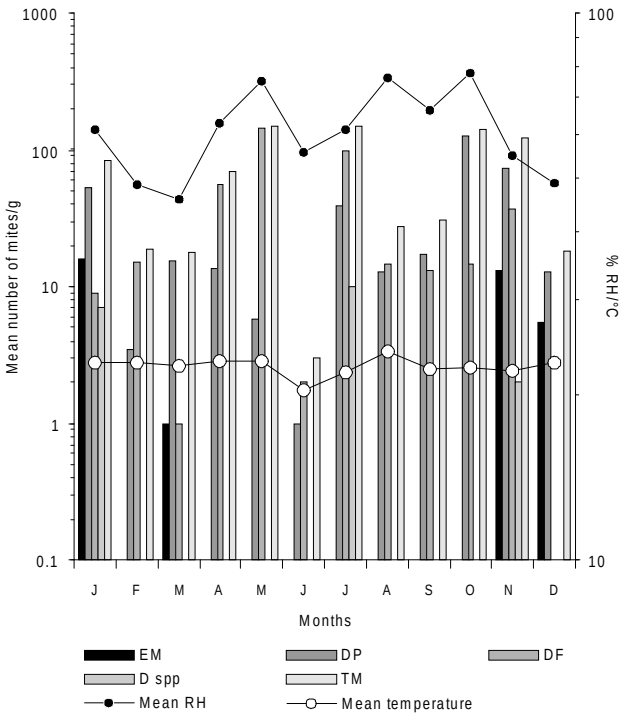

Figure 1. Annual dynamics of pyroglyphid mite species (mean number of mites per 1 gram of dust) in pooled bed/mattress dust samples from examined dwellings and mean values of relative humidity and temperature. Key: EM - *Euroglyphus maynei*; DP - *Dermatophagoides pteronyssinus*; DF - *D. farinae*; D spp - *Dermatophagoides* spp.; TM -total mites; RH - relative humidity.

Total age structure of pyroglyphid mite species. Total age structure of *D. farinae* populations in dwellings was characterised by the dominance of protonymphs and adults, while in *D. pteronyssinus* - by the dominance of adults and tritonymphs, and a low number of protonymphs (Fig. 4).

Discussion of the results from dwellings. These results correspond well with literature data. As indicated by a review of the literature, 32-100% of homes and dwellings or dust samples analysed are positive for both pyroglyphid or other house dust mites (known as domestic mites). In surveys where a qualitative estimate of the total mites per sample of dust has been made, about 43-100% were pyroglyphids or they were the dominant mite species [2, 8, 10, 21, 22]. In the case of mite density, the number of mites per gram of dust may range from a few to 16000 and more, although the results of the surveys are difficult to compare and evaluate because of a lack of standardisation of both dust collecting methods and reporting procedures [8, 10, 19, 22, 34, 50]. It has been shown, however, that occurrence and abundance of house dust mites may vary in particular topographical regions and are associated to a large degree with climate of a region, especially with outdoor and indoor humidity [28, 42]. The mean concentration of mites in examined samples and mite frequency was at the lower end of the published range for more humid regions [6, 19, 22, 23, 30, 38], and was comparable with some European results from France and Holland [10]. In Denmark, for example, Hallas and Korsgaard [22] found average concentrations of mites approximately ten times higher than those actually observed in the Upper Silesia region.

The observed fluctuations of mite densities in dwellings throughout the year and higher abundance in summer/autumn months (Figures 1–3), are consistent with most of the literature data from temperate climate regions [9, 10, 16, 17, 19, 48, 50].

Ratios of numbers of the particular pyroglyphid dust mite species, especially *D. pteronyssinus* to *D. farinae*, are different in separate regions of the world. Critical factors influencing their occurrence and abundance are mainly relative humidity and temperature of both outdoor and indoor air [10, 16, 19, 21, 23, 28, 42]. Within the wide zone of temperate climate *D. pteronyssinus* is the most common and dominant species at the seaside or in lowland, with more humid region climate. By contrast, *D. farinae* is more common and abundant in areas with a dry continental region climate (intercontinental and alpine regions) [3, 10, 16, 31, 42].

It is commonly known that optimal temperature is higher (25–30°C) and optimal humidity is lower (50-75% RH) for *D. farinae* than for *D. pteronyssinus*. The former species appears to survive better in dryer habitats than the latter. In contrast, lower temperature (15-20°C) and higher humidity (75–80% RH) favours *D. pteronyssinus* in mixed laboratory cultures [3, 5, 16, 20, 29]. The results actually obtained are distinctly consistent with these laboratory data only in the case of dust from floors

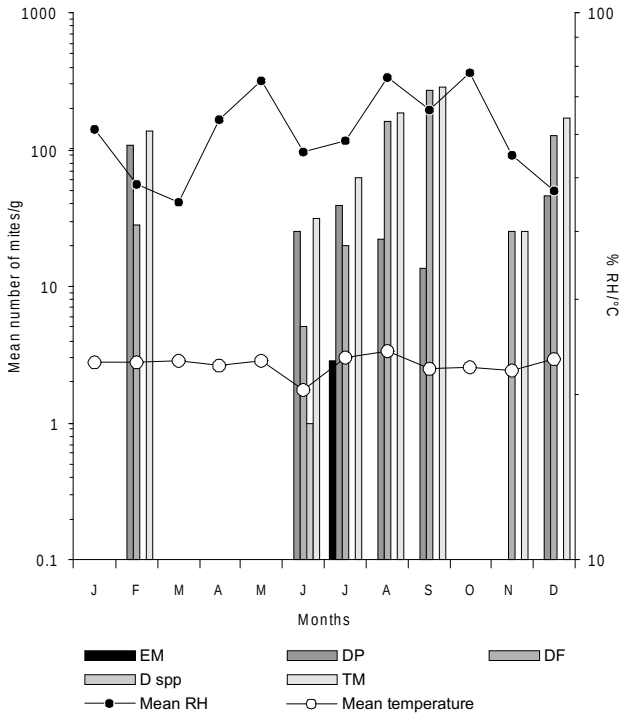

Figure 2. Annual dynamics of pyroglyphid mite species (mean number of mites per 1 gram of dust) in pooled dust samples from upholstery furniture in examined dwellings and mean values of relative humidity and temperature. Key: EM - *Euroglyphus maynei*; DP - *Dermatophagoides pteronyssinus*; DF - *D. farinae*; D spp - *Dermatophagoides* spp.; TM - total mites; RH - relative humidity.

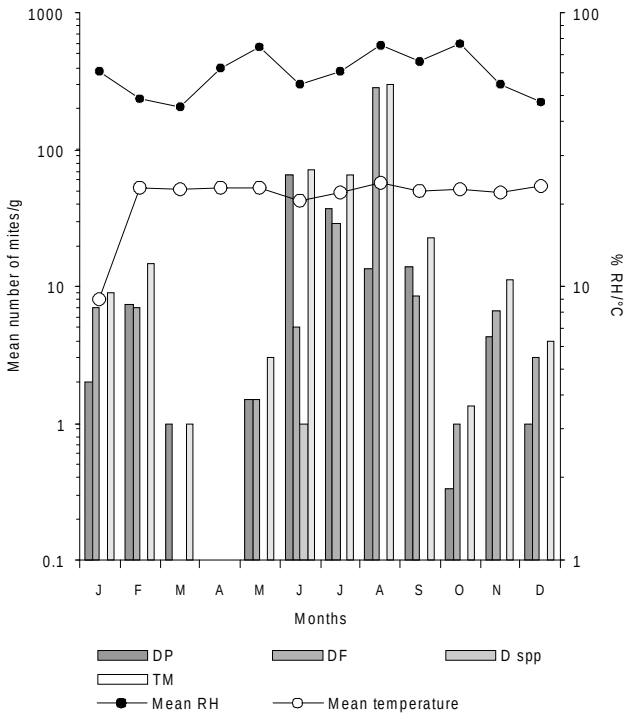

Figure 3. Annual dynamics of pyroglyphid mite species (mean number of mites per 1 gram of dust) in pooled floor/carpet dust samples from examined dwellings and mean values of relative humidity and temperature. Key: DP - *Dermatophagoides pteronyssinus*; DF - *D. farinae*; D spp - *Dermatophagoides* spp.; TM - total mites; RH - relative humidity.

Table 7. Mean numbers of pyroglyphid mites per 1 gram of dust and mean values of relative humidity and temperature in the examined dwellings.

Habitat	Mite species	Mean number/g x ± SD (range)	Median (number/gram)	Mean RH x ± SD (range)	Median RH (% RH)	Mean temp. (°C) $\bar{x}$ ± SD (range)	Median temp. (°C)
Beds	DP	36.21 ± 62.71 – (1.0-350.0)	15.0	59.1 ± 11.03 – (42.0-84.0)	56.0	22.2 ± 1.64 (18.0-24.5)	22.0
Mattresses	DF	41.59 ± 76.21 (1.0-380.0)	15.7	62.02 ± 8.46 (46.0-82.0)	63.0	21.9 ± 1.86 (18.2-24.5)	22.0
Bedding	EM	10.31 ± 10.19 (1.0-29.0)	5.6	52.25 ± 0.75 (51.5-53.0)	52.3	22.25 ± 0.25 (22.0-22.5)	22.3
Upholstery furniture	DP	53.67 ± 108.87 (1.0-29.0)	22.5	56.36 ± 6.98 (47.0-68.0)	56.0	23.41 ± 0.69 (18.2-27.0)	23.5
	DF	107.91 ± 185.75 (5.0-733.3)	27.0	58.77 ± 7.52 (46.0-73.0)	61.0	23.61 ± 1.91 (18.8-27.0)	23.9
	EM	2.88 ± 1.88 (1.0-4.76)	2.9	59.67 ± 4.03 (54.0-63.0)	62.0	22.5 ± 1.47 (20.5-24.0)	23.0
Floor dust	DP	13.96 ± 18.46 (1.0-64.0)	4.3	67.44 ± 8.99 (51.0-83.0)	65.0	20.87 ± 1.73 (18.0-24.5)	20.6
Carpets	DF	26.89 ± 63.42 (1.0-286.7)	6.0	61.67 ± 11.36 (50.0-81.0)	56.0	22.14 ± 1.31 (18.2-24.5)	22.0

Key: RH = Relative Humidity; temp. = temperature; DP = *Dermatophagoides pteronyssinus*; DF = *D. farinae*; EM = *Euroglyphus maynei*.

(Tables 7 and 8). The climate of these niches may be considered as closer to the room climate than the microclimate on used upholstery furniture or in beds [9, 10]. In some samples the occurrence and dominance of *D. pteronyssinus* was associated with higher relative humidity (65-84% RH) and lower temperature (18-24°C), whereas the dominance of *D. farinae* with lower humidity (50-65% RH) and higher temperature (18-27°C), but generally, this relationship was clearly visible only in the case of a total of the samples of floor dust (Tables 7 and 8). Therefore, the middle negative correlation between *D. pteronyssinus* and RH in dust from upholstery furniture, actually observed, is astonishing.

During most of the year, the mean monthly indoor relative humidity of ambient air in the examined dwellings did not exceed 65%. In winter months (December, February, March) it dropped to 42-50% RH. Throughout the rest of a year it ranged mainly between 50 and 84% RH. The high humidity (from 80 to 87%) was noted only in few cases during some short periods of a year (May, August, September and October). Mean annual humidity of ambient air in the examined dwellings was 64.5 ± 12.4% RH (range 42-87% RH, median = 64.6% RH) and the mean temperature was 22.7 ± 1.8°C (range 18-27°C, median = 23°C). These data explain the high densities of *D. farinae* in the total of dwellings examined (Tab. 7) consistent with results of other Silesian surveys [25, 26, 42].

E. maynei is usually less abundant in dust samples than *D. pteronyssinus* and *D. farinae*, but in some favourable indoor conditions under high constant humidity (80-85% RH) and milder temperatures it may predominate and occurs more frequently [12, 13, 15, 20, 42, 46]. This mite appears to be less able than *D. pteronyssinus* to withstand low humidity [12, 13]. It has a higher critical equilibrium activity (CEA) than *D. pteronyssinus* and is confined to more damp habitats [12, 13]. In Silesian dwellings, the humidity levels rarely reached the optimal scope for this mite (Tab. 8) but even at high humidity (80-87%) *E. maynei* was not found. Seven samples which contained these mites were taken from old couches (n=4) and upholstery sofas (n=3) in dwellings heated with stoves, located in older buildings (Sosnowiec, Chorzów, Gliwice); the samples were collected in January (n=2), March (n=1), July (n=2), November (n=1) and December (n=1). Relative humidity in these dwellings ranged from 51.5 to 63% RH. It is possible that during the period from August to October, the humidity was higher. The observed predilection of *E. maynei* for bedding is consistent with data reported by Walshaw and Evans [49] from Liverpool, and Hart and Whitehead [23] from Oxfordshire who all found weak or no correlation between the numbers of *E. maynei* and relative humidity of a bedroom.

Mites from families *Glycyphagidae* and *Acaridae* are considered as much more sensitive to dessication than pyroglyphids [10, 19]. It was also suggested that some house dust mite species thrive in very damp conditions; this group include domestic acarids, glycyphagids (*L. destructor*, *G. domesticus*) and cheyletids (*Cheyletus* spp.). Therefore, the presence and abundance of these mite species can be used as an indicator of humid environments [19, 42]. For example, in Brazil and Costa Rica, the most abundant mites in house dust are

Table 8. Combinations of the occurrence of pyroglyphid mite species and mean values of relative humidity and temperature in the examined dwellings.

Habitats	Pyroglyphid mites	Number[a] of samples	Percent of samples[b] with mites	Relative Humidity (% RH)			Temperature (°C)		
				x ± SD	Median	Range	x ± SD	Median	Range
Beds	DP solely	16	13.11	59.66 ± 12.49	56.0	42-84	22.46 ± 0.96	22.0	20.5-24.0
	DF solely	16	13.11	64.30 ± 4.06	64.0	60-72	21.72 ± 1.74	22.0	18.2-24.5
Bedding	DP+DF (DP>DF)	4	3.28	67.37 ± 13.74	68.0	51.5-82	23.45 ± 0.94	23.7	22.0-24.5
	DP+DF (DP<DF)	10	8.19	59.73 ± 11.33	56.0	46-82	22.49 ± 1.77	22.5	18.0-24.5
Couches	DP+DF (DP≅DF)	9	7.38	66.30 ± 9.48	64.0	56-81	22.02 ± 2.26	22.0	18.8-24.5
	DP+DF+EM	4	1.64	52.25 ± 0.75	52.25	51.5-53	22.25 ± 0.25	22.3	22.0-22.5
Floors	DP solely	3	2.46	69.33 ± 13.47	74.0	51-83	22.83 ± 2.72	23.5	18.0-24.0
	DF solely	4	3.28	58.25 ± 8.78	55.0	50-73	22.65 ± 1.48	22.8	20.6-24.5
	DP+DF (DP>DF)	5	4.1	64.70 ± 9.5	64.0	51.5-81	21.44 ± 1.89	22.5	18.2-23.5
Carpets	DP+DF (DP<DF)	3	2.46	54.66 ± 3.86	53.0	51-60	22.83 ± 0.62	23.0	22.0-23.5
	DP+DF (DP≅DF)	5	4.1	62.40 ± 10.05	56.0	54-81	22.44 ± 1.76	22.0	20.5-24.5
	DP+DF+GL	1	0.82	ND	ND	ND	ND	ND	ND
	DP solely	3	2.46	55.00 ± 9.27	50.0	47-68	22.60 ± 0.43	22.8	22.0-23.0
	DF solely	4	3.28	64.62 ± 7.96	67.0	51.5-73	24.20 ± 3.35	25.5	18.8-27.0
Upholstery	DP+DF (DP>DF)	5	4.1	58.00 ± 5.76	62.0	51-64	21.24 ± 2.03	20.5	18.2-23.5
furniture	DP+DF (DP<DF)	4	3.28	48.50 ± 2.50	48.5	46-51	24.42 ± 1.49	23.7	23.4-27.0
	DP+DF (DP≅DF)	6	4.92	61.33 ± 5.93	64.0	51-67	23.20 ± 1.26	23.5	20.5-24.0
	DP+DF+EM	3	2.46	59.67 ± 4.03	62.0	54-63	22.50 ± 1.47	23.0	20.5-24.0
Total pyroglyphid mites		105	44.12						

Key: [a]including also samples contained other non-pyroglyphid mite specimens; [b]percent of the total count of samples positive for mites from dwellings including also non-pyroglyphid mites (n = 238); DP = *Dermatophagoides pteronyssinus*; DF = *D. farinae*; EM = *Euroglyphus maynei*: GL = *Gymnoglyphus longior*; > = prevalence of the first species; < = prevalence of the second species; ≅ = both species in almost equal numbers; ND = not determined.

glycyphagids and chortoglyphids or cheyletids while pyroglyphids occupy only third place [38, 45]. In humid geographic areas, most dwellings and houses contain pyroglyphid dust mites, whereas in dry areas, only a few homes contain these arachnids [3, 6, 10, 20, 23, 45]. Relatively low frequency of mites in a total of samples from examined dwellings and relatively lower abundance of glycyphagids, acarids, cheyletids and *E. maynei* mites could be related to low relative humidity observed in these dwellings [19]. In general, these mites are not as abundant and frequent in Europe as in the tropics [10, 19, 21, 22, 37, 41, 44, 50].

As observed from the results actually obtained, the main sites of mite occurrence in dwellings in the Upper Silesia region are padded plush upholstery furnitures, periodically used for sleeping, such as couches or sofas, then bed-mattresses and regularly used couches or sofas (Tab. 7).

In Europe, the most abundant mite populations were usually collected from bed mattresses [4, 10, 19, 22, 26, 42, 44, 50]. However, a greater abundance of mites in padded furnitures than in bed mattresses has been also frequently observed [19], for example in Israel [20] and in the USA (Ohio) [7, 8, 9].

Mite fauna in hospitals

The taxonomic position of mites found in hospitals is shown in Table 4, whereas Table 9 presents mite species found in particular hospitals examined. The total number of mites isolated from hospital dust samples and the number of samples positive for mites was distinctly lower than in dwellings. Mites (a total of 40) were collected only from 26 samples (21.3% of total samples from hospitals) of dust from floor (n = 15 samples) and patients' beds (n = 11 samples). Similarly to dwellings, the most abundant mites were members of the family *Pyroglyphidae*, which formed 57.5% of a total mite count from hospitals. The dominant species was *D. pteronyssinus* which constituted 42.5% of a total count. It was also the

Table 9. Domestic and other mites found in particular hospitals and wards examined.

Hospitals	Wards examined	Number of samples examined	Number of samples positive for mites (% of the total count)	Mite taxa
Childrens' Public Hospital in Sosnowiec	First Internal, Second Internal	17	4 (23.5%)	DP/SP/TP/CB/OC/ BK/tm
Municipal Hospital N^{o} 5 in Sosnowiec	Maternity	1	1 (100.0%)	DP
Central Clinical Hospital of Silesian Medical Academy in Katowice	Maternity, Neurological	17	4 (23.5%)	DP/EM/AS
The Mielęcki State Clinical Hospital in Katowice	Nephrological, Laryngological, Surgical, Ophthalmologic	32	4 (12.5%)	DP/DF
The First Clinic of Internal Diseases in Katowice	Internal, Haematological	10	4 (40.0%)	DP/TPu/chm
Specialist Hospital in Katowice	Surgical, Internal, Laryngological, Neurological	28	7 (25.0%)	DP/DF/EM/TPu/GF
Central Mining Hospital in Katowice-Ochojec	Urological, Cardiological	16	1 (6.25%)	DP
Municipal Hospital in Katowice-Szopienice	Internal	1	1 (100.0%)	DP/AC/gmu

Key: DP = *Dermatophagoides pteronyssinus*; DF = *D. farinae*; EM = *Euroglyphus maynei*; AS = *Acarus siro*; TPu = *Tyrophagus putrescentiae*; TP = *Tyrophagus perniciosus*; CB = *Caloglyphus berlesei*; GF = *Gohieria fusca*; SP = *Suidasia pontifica*; AC = *Androlaelaps casalis*; BK = *Blattisocius keegani*; OC = *Otodectes cynotis*; tm = tarsonemid mites; chm = cheyletid mite; gmu = gamasid mites unidentified.

Table 10. Abundance of pyroglyphid dust mite species in dust samples from hospitals examined.

Hospitals	Mean number of mites/gram of dust x ± SD (range)			
	D. pteronyssinus	*D. farinae*	*E. maynei*	Total mites[a]
Childrens' Public Hospital in Sosnowiec	1.0[b]	0.0[b]	0.0[b]	3.5 ± 1.5 (2.0-5.0)
Municipal Hospital N^{o} 5 in Sosnowiec	1.0[b]	0.0[b]	0.0[b]	1.0[b]
Central Clinical Hospital of Silesian Medical Academy in Katowice	8.3[b]	0.0[b]	20.0[b]	20.54 ± 10.2 (8.3-33.3)
Mielęcki Clinical Hospital in Katowice	24.82 ± 15.53 (10.0-50.0)	50.0[b]	0.0[b]	40.89 ± 34.83 (10.0-100.0)
First Clinic of Internal Diseases in Katowice	23.75 ± 10.82 (10.0-40.0)	0.0[b]	0.0[b]	35.0 ± 20.61 (10.0-60.0)
Specialist Hospital in Katowice	20.0[b]	0.0[b]	0.0[b]	20.0[b]
Central Mining Hospital in Katowice-Ochojec	34.4 ± 12.3 (20.0-50.0)	44.17 ± 35.85 (6.67-100.0)	6.7[b]	40.4 ± 34.8 (13.3-100.0)
Municipal Hospital in Katowice-Szopienice	1.0[b]	0.0[b]	0.0[b]	4.0[b]

Key: [a]including also other (non-pyroglyphid) mites; [b] single sample positive for the particular mite species.

most frequent and occurred in 15 samples (12.3% of total samples from hospitals) and in all hospitals examined. Among specimens of *D. pteronyssinus* the most abundant were tritonymphs and males; totally, 6 tritonymphs (35.3%), 5 males (29.4%), 3 females (17.6%), 2 protonymphs (11.8%) and 1 larva (5.9%) were isolated (Fig. 5). Among pyroglyphid mites, besides *D. pteronyssinus*, there were found specimens of *D. farinae* (1 protonymph, 1 tritonymph, 2 homeomorphic males) in 2 samples and *E. maynei* (only 2 females) in 2 dust samples (Fig. 5). Pyroglyphid mites occurred in 19 samples (15.6% of samples from hospitals and 73.1% of the samples positive for mites). In samples from beds these mites were found solely, with the exception of one sample of mattress dust, which was

Table 11. Abundance of mites per 1 gram of dust in libraries examined.

	Number of total mites per gram of dust	Number of DP per gram of dust	Number of DF per gram of dust	Relative humidity (% RH)	Temperature (°C)
$\bar{x} \pm SD$	154.5 ± 175.6	203.5 ± 175.1	20.3 ± 21.3	66.2 ± 8.01	24.2 ± 0.98
Median	14.3	200.0	10.0	60.0	25.0
Range	1.0-400.0	3.0-400.0	1.0-50.0	59.0-76.0	23.0-25.0

Key: DP = *Dermatophagoides pteronyssinus*; DF = *D. farinae*.

coinhabited also by *Suidasia pontifica*. Samples of floor dust contained, apart from pyroglyphids, also mites from other groups, which were, however, not numerous (Tables 4 and 9). Altogether, 17 mite species from 12 genera, 9 families and 4 orders were stated in hospitals (Tab. 4).

Mean number of mite specimens per 1 gram of dust from hospitals was 30.0 ± 29.8 and ranged from 1.0 to 100.0 (Tab. 2). The density of mites was higher in dust from beds than in dust from floors (Tab. 2).

Mean numbers of mites per 1 gram in particular hospitals are compared in Table 10. It appears that the mites occurred in highest densities in hospitals located in Katowice, namely in the Mielęcki Clinical Hospital, Central Mining Hospital (Katowice-Ochojec) and in the First Clinic of Internal Diseases (Tab. 10). Lowest numbers of mites per gram of dust were found in February, March, April and May (1.0-20.0), whereas the highest in samples collected in October (80.0-100.0). Samples without mites were collected mainly in seasons when buildings were heated (winter months). The results appertaining to the dynamics of mite numbers in hospitals are consistent with the fluctuations observed in dwellings, and also with literature data [10, 16, 17, 18, 42, 48, 50]. The cases of occurrence of non-pyroglyphid mites mainly in floor dust were previously reported [19], also in hospitals [24].

It is noteworthy that in dust from hospitals mites were less frequent and abundant compared to dwellings. These results correspond to data obtained by Colloff *et al.* [15] in Western Australia, where mite concentrations were significantly lower in a sanatorium (13 mites/gram of dust) than in patients' homes (170 mites/gram of dust). These results are also consistent with the data obtained in British hospitals [24, 36]. It was suggested [36] that frequent changing and washing of bed linen and brushing and cleaning of mattresses in hospitals (as observed in Cardiff, Wales, UK) are the main factors in preventing mite infestation.

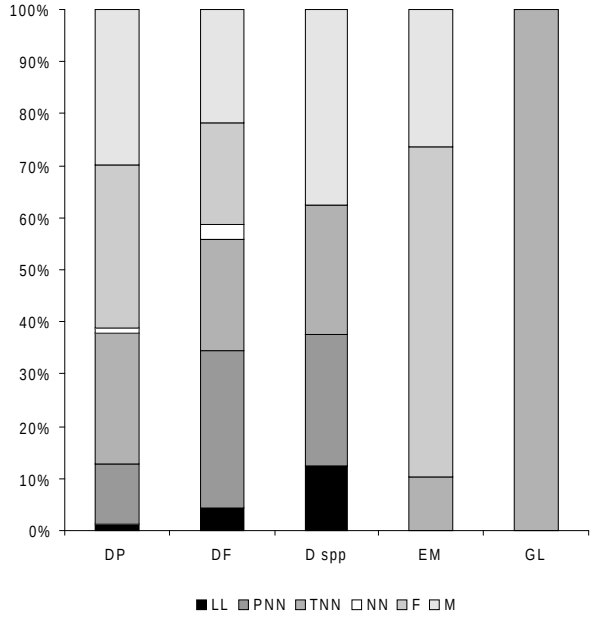

Figure 4. Age structure of populations of pyroglyphid dust mite species in a total of dust samples from the examined dwellings. Key: DP - *Dermatophagoides pteronyssinus*; DF - *D. farinae*; D spp - *Dermatophagoides* spp.; EM - *Euroglyphus maynei*; GL - *Gymnoglyphus longior*; LL - larvae; PNN - protonymphs; TNN - tritonymphs; NN - nymphs unidentified; F - females; M - males.

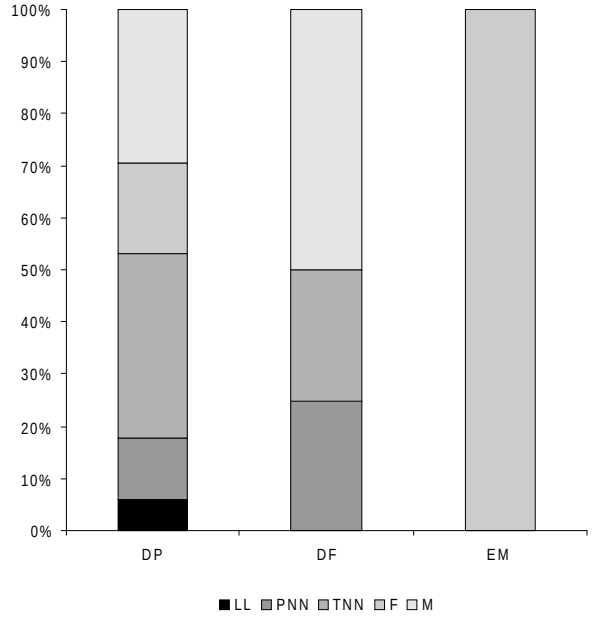

Figure 5. Age structure of populations of pyroglyphid dust mite species in a total of dust samples from the examined hospitals. Key: DP - *Dermatophagoides pteronyssinus*; DF - *D. farinae*; EM - *Euroglyphus maynei*; LL - larvae; PNN - protonymphs; TNN - tritonymphs; F - females; M - males.

Mite fauna in libraries and institutes

Half of the samples from libraries was positive for mites (Tables 1 and 5). The highest mite numbers per 1 gram of dust were isolated from samples of dust from book-shelves and upholstery chairs (Tab. 2). *D. pteronyssinus* was the dominant, constituting 63.2% of mites collected, and was found in 35.7% of the samples from libraries. This mite also occurred in tenfold higher numbers per gram of dust, than *D. farinae* (Tab. 11). The abundance of house dust mites collected from libraries (per 1 gram of dust from samples positive for mites) is compared in Table 11. It should be stressed that besides dwellings, the highest mite densities were noted in libraries. Therefore, a potential risk of an occupational exposure to dust mite allergens exists among librarians. It is also noteworthy that to the best of my knowledge libraries were actually examined for the first time for an occurrence of house dust mites or other allergenic mites.

In the samples of dust from institutes only non-pyroglyphid mites were found; 17.9% of these samples were mite positive (Tab. 6). The species list, abundance and occurrence of mites collected from libraries and institutes is presented in Tables 5 and 6.

Only floor dust samples were examined from institutes. This fact probably explains the occurrence of non-pyroglyphid mites, which are usually more common on floors than on upholstery furniture or in beds [19, 24].

REMARKS

Further studies are needed, particularly on seasonal dynamics and population structure in hospitals and other public localities in the Upper Silesia region, and also on the occurrence of dust and domestic mites in other regions of Poland. Large part of the territory of our country has not been examined for occurrence of house-dust mites, inclusive of pyroglyphid mite species. It seems true that the most common mites, *D. pteronyssinus* and *D. farinae* occur all over the country; probably the former is more frequent and abundant in the northern part of Poland, whereas the latter in the southern part of the country. This problem needs to be solved by further studies.

Acknowledgements

This study was possible thanks to the kind advice and great help of the late Professor Jan Rafalski, to whom this paper is dedicated. I owe to his kindness the identification of all mites from the orders *Gamasida* and *Oribatida*. I am also grateful to Professor Andrzej Szeptycki from Kraków for his critical review of the manuscript and to Professor Jacek Dutkiewicz from Lublin for helpful discussion.

REFERENCES

1. Abe T, Ishii A: Comparison of *Dermatophagoides pteronyssinus* allergens from culture medium extract and whole body extract by using the same probe of pooled human serum. *Allergy* 1987, **42**, 352-358.

2. Andersen A: Abundance and spatial distribution of house-dust mites in their natural environment (*Acari: Sarcoptiformes* and *Trombidiformes*). *Entomol Med* 1984, **52**, 25-32.

3. Arlian LG: Biology and ecology of house dust mites, *Dermatophagoides* spp. and *Euroglyphus* spp. (Airborne allergens). *Immunol Allergy Clin North Am* 1989, **9**, 339-356.

4. Arlian LG: House-dust-mite allergens: A review. *Exp Appl Acarol* 1991, **10**, 167-186.

5. Arlian LG: Water balance and humidity requirements of house dust mites. *Exp Appl Acarol* 1992, **16**, 15-35.

6. Arlian LG, Bernstein D, Bernstein IL, Friedman S, Grant A, Lieberman P, Lopez M, Metzger J, Platts-Mills T, Schatz M, Spector S, Wasserman SI, Zeiger RS: Prevalence of dust mites in the homes of people with asthma living in eight different geographic areas of the United States. *J Allergy Clin Immunol* 1992, **90**, 291-300.

7. 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**, 527-532.

8. 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.

9. Arlian LG, Woodford PJ, Bernstein IL, Gallagher JS: Seasonal population structure of house dust mites, *Dermatophagoides* spp. (*Acari: Pyroglyphidae*). *J Med Entomol* 1983, **20**, 99-102.

10. Bronswijk JEMH van: *House Dust Biology (for Allergists, Acarologists and Mycologists).* NIB Publishers, Zoelmond 1981.

11. Chmielewski W: Mites (*Acarina*) in house dust of a basemat flat. *Proceedings of the Symposium on "Advances of Acarology in Poland", Siedlce, TN, September 26-27, 1995,* 205-209. Plant Protection Committee and Polish Academy of Science Press, Drukarnia ISK, Siedlce 1995.

12. Colloff MJ: Population studies on the house dust mite *Euroglyphus maynei* (Cooreman, 1950) (*Acari: Pyroglyphidae*). In: Schuster R, Murphy PW (Eds): *The Acari: Reproduction, Development and Life-History Strategies*, 497-505. Chapman and Hall, London 1991.

13. Colloff MJ: A review of the biology and allergenicity of *Euroglyphus maynei* (Cooreman, 1950) (*Acari: Pyroglyphidae*). *Exp Appl Acarol* 1991, **11**, 177-198.

14. Colloff MJ, Ayres J, Carswell F, Howarth PH, Merrett TG, Mitchell EB, Walshaw MJ, Warner JO, Warner JA, Woodcock AA: The control of allergens of dust mites and domestic pets: a position paper. *Clin Exp Allergy* 1992, **22**, **Suppl 2**, 1-28.

15. Colloff MJ, Stewart GA, Thompson PJ: House dust acarofauna and Der p I equivalent in Australia: the relative importance of *Dermatophagoides pteronyssinus* and *Euroglyphus maynei*. *Clin Exp Allergy* 1991, **21**, 225-230.

16. Dusbábek F: Population structure and dynamics of the house dust mite *Dermatophagoides farinae (Acarina, Pyroglyphidae)* in Czechoslovakia. *Folia Parasitol* (Praha) 1975, **22**, 219-231.

17. Dusbábek F: Dynamics and structure of mixed populations of *Dermatophagoides farinae* and *D. pteronyssinus. Recent Advances in Acarol* 1979, **2**, 173-177.

18. Dusbábek F: Present state of research on house dust mites (*Pyroglyphidae*) in the Czech Republic. *Wiad Parazytol* 1995, **41**, 337-342.

19. Fain A, Guerin B, Hart BJ: *Mites and Allergic Disease.* Allerbio, Varennes en Argonne 1990.

20. Feldman-Muhsam B, Mumcuoglu Y, Osterovich T: A survey of house dust mites (*Acari: Pyroglyphidae* and *Cheyletidae*) in Israel. *J Med Entomol* 1985, **22**, 663-669.

21. Hallas TE: The biology of mites. *Allergy* 1991, **46**, **Suppl 11**, 6-9.

22. Hallas TE, Korsgaard J: Systematic variations in the appearance of house-dust mites (*Dermatophagoides* spp.), house mites (*Glycyphagus domesticus*) and of *Tarsonemus* sp. in dust samples from dwellings. *Rev Esp Allergol Immunol Clin* 1997, **12**, 173-177.

23. Hart BJ, Whitehead L: Ecology of house dust mites in Oxfordshire. *Clin Exp Allergy* 1990, **20**, 203-209.

24. Hewitt M, Barrow GI, Miller DC, Turk F, Turk S: Mites in the personal environment and their role in skin disorders. *Br J Dermatol* 1973, **89**, 401-409.

25. Horak B: Preliminary study on the concentration and species composition of bacteria, fungi and mites in samples of house dust from Silesia (Poland). *Allergol Immunopathol* 1987, **15**, 161-166.

26. Horak B, Dutkiewicz J, Solarz K: Microflora and acarofauna of bed dust from homes in Upper Silesia, Poland. *Ann Allergy Asthma Immunol* 1996, **76**, 41-50.

27. Kiełczewski B: Parasitic arthropods under anthropopressure. *Wiad Parazytol* 1977, **23**, 3-7.

28. Korsgaard J: House-dust mites and absolute indoor humidity. *Allergy* 1983, **38**, 85-92.

29. Lang JD, Mulla MS: Distribution and abundance of house-dust mites, *Dermatophagoides* spp., in different climatic zones of Southern California. *Environ Entomol* 1977, **6**, 213-216.

30. Lang JD, Mulla MS: Seasonal abundance of house-dust mites, *Dermatophagoides* spp., in homes in Southern California. *Environ Entomol* 1978, **7**, 281-286.

31. Lascaud D: Etude ecologique des acariens pyroglyphides de la poussiere de maison dans la region Grenobloise. Approche qualitative et incidence de differents parametres: saisons, altitude, temperature et humidite relative, sur leur multiplication. *Ann Parasitol Hum Comp* 1978, **53**, 675-695.

32. Mosbech H: House dust mite allergy. Review article. *Allergy* 1985, **40**, 81-91.

33. Oshima, S.: Observations of floor mites collected in Yokohama.I. On the mites found in several schools in summer. *Jap J Sanit Zool* 1964, **15**, 233-244.

34. 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.

35. Pope AM, Patterson R, Burge H: *Indoor allergens. Assessing and Controlling Adverse Health Effects.* National Academy Press, Washington 1993.

36. Rao VRM, Dean BV, Seaton A, Williams DA: A comparison of mite populations in mattress dust from hospital and from private houses in Cardiff, Wales. *Clin Allergy* 1975, **5**, 209-215.

37. Rapiejko P: Profilaktyka alergicznego zapalenia błony śluzowej nosa i spojówek. *Terapia* 1997, **3**, 3-6.

38. Rosa AE, Flechtmann CHW: Mites of house dust in Brazil. *Internat J Acarol* 1979, **5**, 195-198.

39. Schou C, Lind P: The antigenicity of house dust mites. *Allergy* 1991, **46**, **Suppl 11**, 10-13.

40. Solarz K: Fauna alergogennych roztoczy (*Acari*) kurzu domowego w wybranych środowiskach Górnego Śląska. Thesis, Silesian Medical Academy, Katowice (Poland) 1987.

41. Solarz K: The actual data on the occurrence of pyroglyphid mites in Poland (*Astigmata: Psoroptidia: Pyroglyphidae*). *Abstracts of the 7th European Multicolloquium of Parasitology, Parma, Italy, September 2-6 1996*, 125. European Federation of Parasitologists, *Parassitologia* 1996, 38.

42. Solarz K: Seasonal dynamics of house dust mite populations in bed/mattress dust from two dwellings in Sosnowiec (Upper Silesia, Poland): An attempt to assess exposure. *Ann Agric Environ Med* 1997, **4**, 253-261.

43. Suggars AL: House dust mites: A review. *J Entomol Sci* 1987, **Suppl 1**, 3-15.

44. Tovey ER: Allergen exposure and control. *Exp Appl Acarol* 1992, **16**, 181-202.

45. Vargas MV, Mairena HA: House dust mites from the metropolitan area of San José, Costa Rica. *Internat J Acarol* 1991, **17**, 141-144.

46. Vobrázková E, Samšiňák K, Špičák V: Allergogenous mites (*Acari*: *Pyroglyphidae*) in private recreation houses. *Folia Parasitol* 1979, **26**, 343-349.

47. Voorhorst R, Spieksma-Boezeman MIA, Spieksma FTM: Is a mite (*Dermatophagoides* sp.) the producer of the house-dust allergen? *Allerg Asthma* 1964, **10**, 329-334.

48. Voorhorst R, Spieksma FTM, Varekamp H: *House-dust Atopy and the House-dust Mite.* Stafleu's Scientific Publishing Co, Leiden 1969.

49. 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.

50. Wharton GW: House dust mites. *J Med Entom* 1976, **12**, 577-621.