ORIGINAL ARTICLES AAEM

Ann Agric Environ Med 2001, 8, 11–24

RISK OF EXPOSURE TO HOUSE DUST PYROGLYPHID MITES IN POLAND

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Solarz K: Risk of exposure to house dust pyroglyphid mites in Poland. *Ann Agric Environ Med* 2001, **8**, 11–24.

Abstract: During the period of 1989-2000, 335 house dust samples were collected from dwellings at 27 different localities in Poland. Mite allergen exposure was measured in house dust samples collected by performing of mite taxa determination and measuring of the mite allergen levels by a semiquantitative guanine method (Acarex® test). Mites were found in 158 of the samples examined (47.2%). A total 3,714 mites were isolated and 15 species identified, including four species from the family *Pyroglyphidae* (house dust mites). Among them, *Dermatophagoides farinae* (DF) was predominant (approximately 67% of the total count), followed by *D. pteronyssinus* (DP) (17.6%) and *Euroglyphus maynei* (EM) (1.6%). *Hirstia chelidonis* (HCh) was found for the first time in house dust samples in Poland. DF was predominant in Iwonicz-Zdrój (96.6%), Katowice (91.8%), Sosnowiec (89.4%), Chorzów (94.8%), Bytom (50.9%), Świętochłowice (96.7%) and generally in Upper Silesia (88.2%), whereas DP dominated in Łódź (92.9%), Wodzisław (80.9%), Kraków (45.6%) and Bielsko-Biała (24.8%). Only 14.3% of the mites collected were alive. Total mean number of domestic mites per gram of dust (in all samples examined) was 204.1 ± 1079.8. The greatest number of mites per 1 gram of dust was 14,971.4. Mite densities and levels of mite allergens (expressed as Acarex test steps) in samples from beds, floors and upholstery furnitures at particular localities in Poland, and in dwellings of atopic *versus* non-atopic subjects were compared. Highest mite concentrations were usually found in dust from beds, carpets and shutters. *D. farinae* was distinctly more abundant both per 1 gram of dust and per 1 sample than the species *D. pteronyssinus*. Other pyroglyphid mites, *E. maynei* and *H. chelidonis*, occurred in very small numbers. No significant differences were found between the counts of mites (total and live) in the dwellings of atopic and non-atopic persons. Approximately 49.5% of samples showed positive levels of the mite allergens (Acarex test steps). An influence of some abiotic indoor factors on the mite prevalence in the examined dwellings was analysed separately in relation to samples of bed dust, floor dust and dust from upholstery furnitures. The density of mites was influenced mainly by the type of heating, temperature, type of sleeping accommodation, type of floor or furniture, sampling method, and type of building, whereas levels of the mite allergens were associated with the mite density, relative humidity, month, sampling method, type of building and type of heating.

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Key words: ***Acari*, acarofauna, dwellings, house dust mites, allergenic mites, house-dust-mite allergens, house-dust-mite atopy, *Pyroglyphidae*, *Dermatophagoides* spp., Poland.**

INTRODUCTION

Atopic allergies have increased in industrialised countries. House dust mites from the family *Pyroglyphidae (Acari: Acaridida)* are recognized as the most important risk factors causing allergies in indoor environments [1, 9, 12, 15, 21, 39]. Three species of house dust mites, *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae* and *Euroglyphus maynei*, are reported to be the major sources of allergen in house dust [1, 5, 6, 17, 44, 45, 48]. There is

Received: 3 July 2000
Accepted: 20 December 2000

Table 1. Dominance and frequency of pyroglyphid dust mites in Poland (based on the literature data from previous surveys in our country). Comparison with the results actually obtained.

Locality [Literature data]	Total *Pyroglyphidae*		*Dermatophagoides pteronyssinus*		*Dermatophagoides farinae*		*Euroglyphus maynei*		*Gymnoglyphus longior*	
	D	F	D	F	D	F	D	F	D	F
Warsaw [50]	NP	NP	69.1**	43.7	69.1**	19.4	18.2	18.5	NF	NF
Poznań and vicinity [20]	50.9	NP	28.9	27.7 [44.8*]	18.0	16.0 [27.1*]	NF	NF	NF	NF
Poznań*** [14]	NP	NP [100.0*]	NP	NP [100.0*]	NF	NF	NP	NP [100.0*]	NP	NP [12.0*]
Gdańsk and Gdynia [46]	94.9	37.3 [88.0*]	16.0	NP [16.0*]	78.9	NP [84.0*]	NF	NF	NF	NF
Upper Silesia [34]	94.7	NP	30.4	NP	62.7	NP	1.6	NP	NF	NF
Upper Silesia [35]	93.2	NP	23.0	NP	62.6	NP	7.6	NP	NF	NF
Upper Silesia [52]	89.2	44.1 [86.1*]	45.1	34.0 [66.4*]	40.2	34.9 [68.0*]	2.6	2.9 [5.7*]	0.05	0.4 [0.8*]
Actual results	86.5	44.5 [94.3*]	17.6	17.0 [36.1*]	67.0	37.6 [79.7*]	1.6	2.1 [4.4*]	NF	NF

Key: D – dominance (percent of all mites collected), F – frequency (percent of total samples examined), * frequency in relation to samples positive for mites; ** *Dermatophagoides* spp. together; *** samples only from a single basement flat; NF – not found; NP – not published.

increasing evidence that mite allergens are important in the etiology and perhaps the pathogenesis of atopic asthma, perennial rhinitis, atopic dermatitis, urticaria and oculorhinitis [1, 11, 21, 44, 45, 48, 57]. Research on mite allergenicity has focused recently on the seven house dust mite species: *D. pteronyssinus, D. farinae, Dermatophagoides microceras, Dermatophagoides siboney, Sturnophagoides brasiliensis, E. maynei* and *Gymnoglyphus longior* [1, 5, 6, 10, 12, 17, 23, 33, 42, 45, 48]. Recent studies show that the enzymatically active allergens are found in mite faeces. Those faecal allergens include a cysteine proteinase, several serine proteinases and glutathione-S-transferase [1, 21, 32, 48]. These proteinases remain active in the mite faeces and have a direct potential to penetrate epithelial barriers [48]. They can cause lesions in lungs when inhaled by sensitised human beings; the lungs damaged by these enzymes are vulnerable to a wide range of other triggers such as rhinoviruses, bacteria or outdoor allergens [40, 48]. Therefore, recommendations for both mite and allergen reduction should take an important place in the treatment of sensitized patients. It was also recently demonstrated that the mite moulting fluid (from the partition between old and new cuticle) may be an alternative source of major mite-body allergens [28]. Moreover, a wide range of abiotic indoor environmental factors in dwellings have been investigated to date for their influence on pyroglyphid dust-mite populations, presuming that limiting factors may be exploited in the control [26, 30, 31, 37, 38, 39, 43, 47].

In Poland, the knowledge of the occurrence of house dust mites from the family *Pyroglyphidae* is still poor. For the first time in Poland, the finding of members of this family was published in 1972 by Boczek and Dutkiewicz [8]. The former author found single specimens of *D. farinae* in sweepings from mills and warehouses. Later, the first samples of house dust collected in Poland were examined by Romański *et al.* [49]. This study was followed by the surveys carried out in the Upper Silesia (Southern Poland) [34, 35, 51, 52], in Warsaw (Central Poland) [50, 57], Poznań and vicinity (Western Poland) [14, 20], Lublin (Eastern Poland) [24], and in Gdańsk and Gdynia (Northern Poland) [46] (Tab. 1).

The aim of the present research was to study the occurrence of pyroglyphid mites and their allergens in the dwellings of certain Polish cities. The work was directed at:

1. Occurrence, prevalence and species composition of mite fauna in house dust samples from beds, couches, sofas, upholstery and wooden furnitures, carpets, wooden floors and linoleums, and some other indoor places in the examined houses and flats.
2. Levels of house dust infestation with mite populations in particular sites of dwellings examined.
3. Levels of mite allergens in the examined dwellings.
4. Finding of main habitats of house dust mite occurrence and breeding.
5. Influence of air temperature and humidity, and some other environmental factors, on abundance and frequency of house dust mites, especially pyroglyphid mites.
6. Comparison of the actual data with the results previously obtained in the Upper Silesia and other regions of our country.

MATERIALS AND METHODS

The study was carried out from January 1989 to February 2000, on the territory of Katowice, Sosnowiec, Chorzów, Bytom, Gliwice, Zabrze, Mysłowice, Ruda Śląska, Wodzisław, Lubliniec vicinity, Pszczyna, Świętochłowice, Jaworzno, Chrzanów, Dąbrowa Górnicza, Bielsko-Biała, Szczyrk, Rabka, Iwonicz-Zdrój, Opole, Kęty, Skarżysko-Kamienna, Kraków, Węgrzce (near Kraków) and Łódź (Fig. 1). A total of 335 house dust samples from 109 houses and/or flats were analysed for the presence of house dust mites and for guanine, including 133 samples (39.7%) from 42 dwellings of atopic patients. The dust samples were collected from beds, upholstery and wooden furniture, carpets, wooden floors, linoleums and some other places (pictures, shutters). The age of buildings varied from 2–89 years. Information on various parameters which could influence mite numbers, was obtained by questioning the residents and analysed using the Pearson's correlation test. These parameters (explanatory variables *x*) were: type of building, age of house, sampling method, type of heating, type of floor, type of bed, type of upholstery furniture, inhabitants atopic or not, presence or absence of pets, relative humidity, temperature, weight of samples and date of sampling (month). The criterion variables analysed (*y*) were: number of mites per gram of dust (total or live, in relation to the particular species of *Pyroglyphidae*, total house dust pyroglyphid mites and total domestic mites) and number of mite species (in relation to the total mites, pyroglyphid mites and non-pyroglyphid mites including acarids, glycyphagids, chortoglyphids, tarsonemids, cheyletids, oribatids and gamasids). The Acarex test was taken into account as both the explanatory and the criterion variable.

A surface area of $1m^2$ at each sampling site was vacuumed (for 2 minutes) or brushed (in the case of sweepings). Next, samples of dust were weighed in a 150 ml beaker and analysed for mites as it was in details previously described [51, 52]. 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 were measured out with Digital Humidity/Temperature Meter TES 1360 (TES Electrical Electronic Corp.) or with a hair hygrometer, and noted. Mite density was calculated as the number of specimens both per 1 gram of dust and per 1 sample. The weight of samples ranged from 0.075–1.8 gram. Mites that were alive at the time of sampling could easily be distinguished as intact (not damaged) and by their plump and/or white appearance.

An indirect method (semiquantitative guanine determination, Acarex® test) was used to determine the level of mite allergens. According to the manufacturer's instructions the Acarex test results were expressed in six increasing classes as follows: – – – (= -3.0), – – (= - 2.0), – (= -1.0), + (= 1.0), ++ (= 2.0) and +++ (= 3.0), including also intermediate values. Moreover, the evaluation of guanine content, according to Pauli *et al*. [44], may be performed as follows: for values from -1 to -3, the guanine content is <600 µg/gram of dust; for 1.0, the guanine content is between 600 and 2,500 µg/gram of dust; for 2.0, it is between 2,500–10,000 µg/gram of dust; and for 3.0 – at least 10,000 µg/gram of dust.

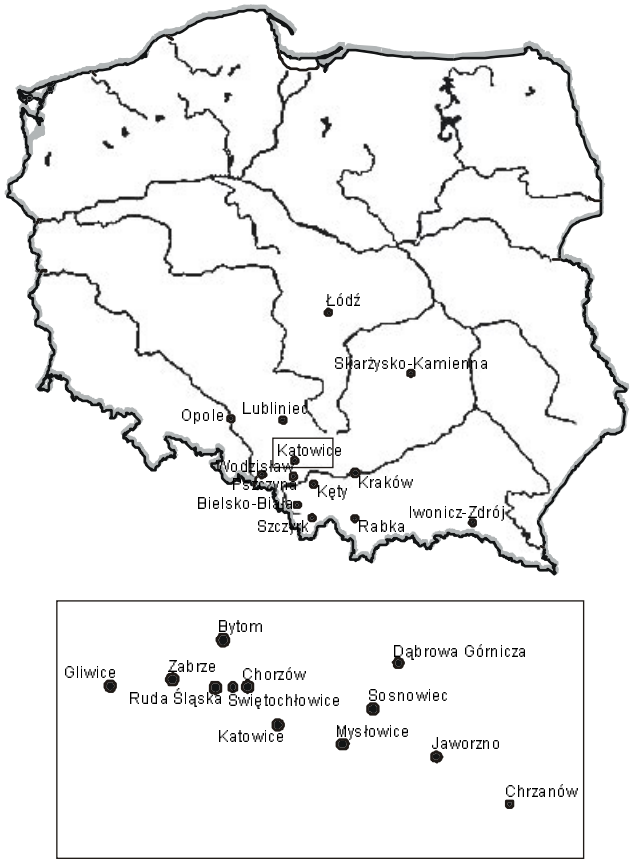

Figure 1. Localities examined in Poland.

Results were analysed using the Kolmogorov-Smirnov test, χ^2 test, Student's *t*-tests, one-way analysis of variance (ANOVA), the Wilcoxon matched pairs test, the Pearson's product-moment correlation test and the Spearman's rank correlation test.

RESULTS

Overall results. The overall results obtained are presented in Tables 1-7 and in Figures 3 and 4. Of a total of 335 dust samples examined, 158 (47.2%) were positive for mites (Tab. 2). A total of 3,714 mite specimens were isolated, including 3,212 members of the family *Pyroglyphidae* (86.5%) (Tab. 2). The dominant species were *D. farinae* (n = 2,488; 67.0% of all mites) and *D. pteronyssinus* (n = 653; 17.6%). In addition, 61 specimens of *E. maynei* (1.6%), seven unidentified specimens of *Dermatophagoides* spp. (0.2%) and three specimens of *Hirstia chelidonis* (0.1%) were collected (Tab. 2). The latter species (Fig. 2) was found for the first time in house

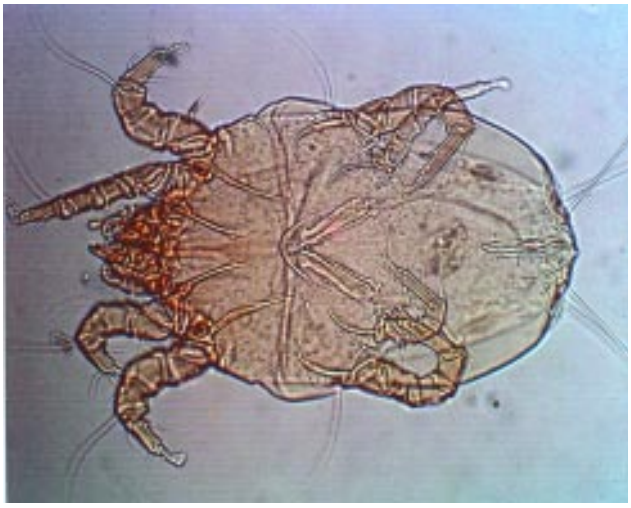

Figure 2. *Hirstia chelidonis* – female (in ventral aspect), × 130.

dust samples in Poland. Pyroglyphid mites were found in 149 samples (44.5% of all samples). Only nine samples (2.7%) contained exclusively non-pyroglyphid mites, mainly members of families *Chortoglyphidae* (*Chortoglyphus arcuatus*), *Glycyphagidae* (*Glycyphagus domesticus*, *G. privatus*, *Gohieria fusca*, *Lepidoglyphus destructor*, *L. fustifer*), *Acaridae* (*Tyrophagus putrescentiae*, *T. neiswanderi*, *Acarus siro* complex and *Tyrolichus casei*), *Cheyletidae* and *Tarsonemidae*.

D. farinae was also the most frequent species and was found in 126 samples (37.6% of the total count and 79.7% of samples positive for mites) (Tab. 2). Also in the Upper Silesia, *Dermatophagoides farinae* was the dominant species with 2,218 specimens (constituting about 88.2% of the total mite population) and mean number per 1 sample (mite positive) 19.6, and was found in 97 samples (36.6% of the total count and 85.8% of mite positive samples). Among pyroglyphids, *D. farinae* was predominant in Iwonicz-Zdrój (96.6%), Katowice (91.8%), Chorzów (94.8%), Sosnowiec (89.4%), Bytom (50.9%), Świętochłowice (96.7%), whereas *D. pteronyssinus* was dominant in Łódź (92.9%), Wodzisław (80.9%), Kraków (45.6%) and Bielsko-Biała (24.8%) (Tab. 3). Generally, *D. farinae* was also the most abundant species both per 1 sample (mite positive) (15.8) (Tab. 2) and per 1 gram of dust in all of indoor places examined (Tab. 4), especially in the majority of the examined localities in Upper Silesia region (Tab. 3; Fig. 1).

Mean relative humidities were 54.9%, 56.3%, 57.6% and 81.7% for samples of bed dust, floor dust, dust from upholstery furnitures and other places, respectively (Tab. 4). Mean temperatures were respectively 21.2, 20.7, 21.8 and 21.8°C (Tab. 4).

Mite exposure. Numbers and densities of mites. Most mite specimens were damaged and probably dead at the time of collection. Only 14.3% of the mites collected were alive (Tab. 2). Most of them were found in dust samples from beds and other sleeping accommodations, with mean number per 1 sample (mite positive) 4.6.

Mean numbers of mites per 1 sample in relation to all mite positive samples are presented in Table 2. These numbers were approximately 20.3, 15.8, 4.1, 0.4, 23.5, 2.4, 3.3 and 3.4 for the *Pyroglyphidae* (total), *D. farinae*, *D. pteronyssinus*, *E. maynei*, total mites, live pyroglyphids, live domestic mites and total live mites, respectively.

Densities (numbers of mites per gram of dust) of the total mite population, total domestic mites, total pyroglyphids or particular pyroglyphid mite species

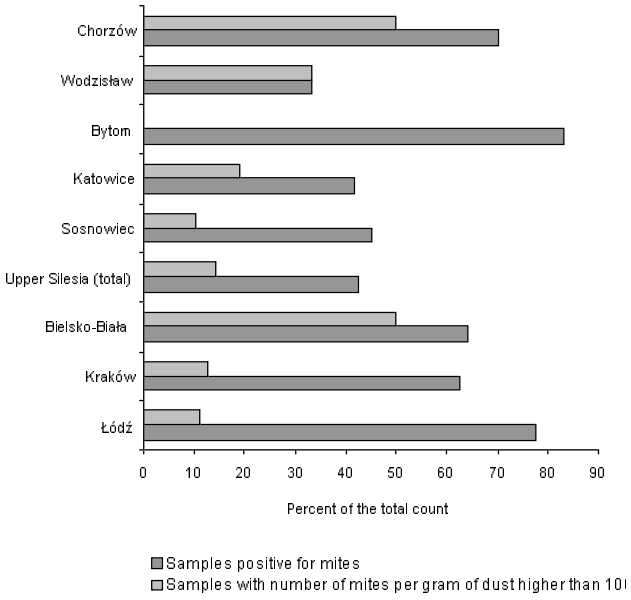

Figure 3. Percentage of mite positive samples and samples with a number of mites (per gram of dust) higher than 100, at different localities examined.

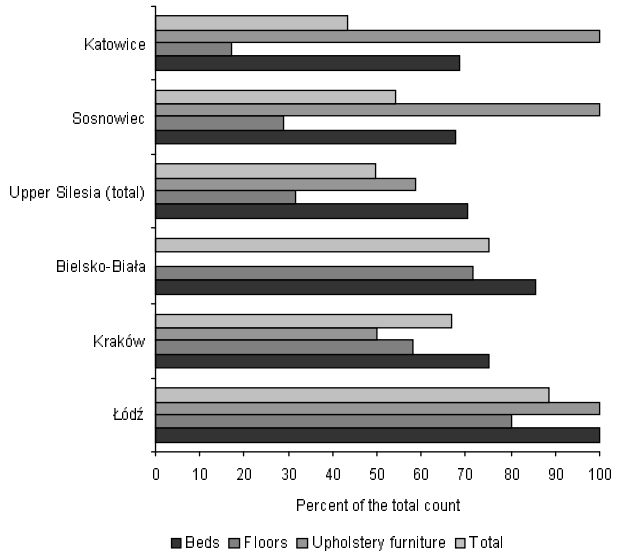

Figure 4. Percentage of samples with the positive levels of the Acarex test at different localities examined.

Table 2. Species list, dominance, occurrence and mean number of mites per 1 mite positive sample, in total dust samples from the examined localities in Poland.

Mite taxa	Dominance		Occurrence			Mean number of mites per 1 sample positive for mites
	Number of mites	Percent of the total count	Number of samples	Percent of the total count	Percent of samples mite positive	
Dermatophagoides farinae	2488	66.99	126	37.61	79.75	15.75
D. pteronyssinus	653	17.58	57	17.01	36.08	4.13
Dermatophagoides sp.	7	0.19	5	1.49	3.16	0.04
Euroglyphus maynei	61	1.64	7	2.09	4.43	0.39
Hirstia chelidonis	3	0.08	3	0.89	1.90	0.02
***Pyroglyphidae* (total)**	**3212**	**86.48**	**149**	**44.48**	**94.30**	**20.33**
Acarus siro	3	0.08	3	0.89	1.90	0.02
Tyrophagus putrescentiae	17	0.46	8	2.39	5.06	0.11
T. neiswanderi	2	0.05	1	0.30	0.63	0.01
Tyrolichus casei	4	0.11	1	0.30	0.63	0.02
Caloglyphus sp.	1	0.03	1	0.30	0.63	0.01
Thyreophagus sp.	1	0.03	1	0.30	0.63	0.01
Acaridae hypopi unident.	2	0.05	2	0.60	1.27	0.01
***Acaridae* (total)**	**30**	**0.81**	**16**	**4.78**	**10.13**	**0.19**
Lepidoglyphus destructor	10	0.27	2	0.60	1.27	0.06
L. fustifer	1	0.03	1	0.30	0.63	0.01
Glycyphagus domesticus	37	0.99	2	0.60	1.27	0.23
G. privatus	4	0.11	2	0.60	1.27	0.02
Gohieria fusca	17	0.46	7	2.09	4.43	0.11
***Glycyphagidae* (total)**	**69**	**1.86**	**11**	**3.28**	**6.96**	**0.44**
Chortoglyphus arcuatus	309	8.32	3	0.89	1.90	1.96
***Chortoglyphidae* (total)**	**309**	**8.32**	**3**	**0.89**	**1.90**	**1.96**
TARSONEMIDA	**16**	**0.43**	**9**	**2.69**	**5.70**	**0.10**
Cheyletidae	**49**	**1.32**	**17**	**5.07**	**10.76**	**0.31**
Tetranychidae	**1**	**0.03**	**1**	**0.30**	**0.63**	**0.01**
Other *ACTINEDIDA*	**2**	**0.05**	**2**	**0.60**	**1.27**	**0.01**
ORIBATIDA	**13**	**0.35**	**5**	**1.49**	**3.16**	**0.08**
GAMASIDA	**13**	**0.35**	**9**	**2.69**	**5.70**	**0.08**
Live *Pyroglyphidae*	**372**	**10.02**	**68**	**20.30**	**43.04**	**2.35**
Live domestic mites	**517**	**13.92**	**77**	**22.98**	**48.73**	**3.27**
Live mites	**531**	**14.30**	**81**	**24.18**	**51.27**	**3.36**
TOTAL MITES	**3714**	**100.0**	**158**	**47.16**	**100.0**	**23.51**

varied from one town to another, from one dwelling to another in the same town, and from one locus to another within the dwellings (Tables 3-6, Fig. 3-4). For example, *D. farinae* was most abundant (per gram of dust) in Upper Silesia (total samples), Kraków and Iwonicz-Zdrój, whereas *D. pteronyssinus* was distinctly more numerous in Łódź, Bielsko-Biała and Wodzisław (Tab. 3). Total mean number of domestic mites per gram of dust (in all samples examined) was 204.1, and was lowest in Jaworzno and Chrzanów (0.5) and highest in Bielsko-Biała (one-family houses) (1159.4). Among the examined localities of the Upper Silesia region, this number was highest in Katowice (287.3) (Tab. 3). Generally, the number of total mites per 1 gram of dust varied in the dwellings actually examined in Poland from 0.0–14,971.4, whereas in the case of live mites from 0.0–2,971.4. Total mean numbers

Table 3. Abundance (per gram of dust) and dominance (percent of the total mite populations) of mites found in the examined localities in Poland.

Localities[1]	Mean ± SD: Total mites [Live mites] (*Percent of dominance*)						Mean ± SD
	Dermatophagoides farinae	*D. pteronyssinus*	*Euroglyphus maynei*	*Hirstia chelidonis*	Total house dust mites (*Pyroglyphidae*)[2]	Total domestic mites	Acarex test levels
Łódź and vicinity (n = 9)	1.95 ± 3.94 [0.41 ± 0.82] (*4.19*)	60.16 ± 175.47 [4.22 ± 11.24] (*92.90*)	NF	NF	62.30 ± 179.16 [4.63 ± 11.10] (*97.42*)	62.91 ± 179.69 [4.45 ± 11.17] (*100.0*)	0.39 ± 0.55
Kraków and vicinity (n = 24)	32.15 ± 74.64 [5.31 ± 15.20] (*43.25*)	18.67 ± 82.17 [0.32 ± 1.57] (*45.63*)	NF	NF	50.98 ± 145.44 [5.68 ± 15.57] (*89.29*)	55.05 ± 156.82 [6.87 ± 16.29] (*98.81*)	0.20 ± 1.52
Bielsko-Biała (n = 28)	178.57 ± 611.09 [11.90 ± 36.52] (*19.80*)	340.09 ± 807.79 [64.71 ± 198.16] (*24.79*)	NF	NF	518.67 ± 1005.05 [76.61 ± 209.61] (*44.59*)	1159.36 ± 2905.98 [207.65 ± 582.65] (*99.67*)	0.86 ± 0.65
Iwonicz-Zdrój (n = 4)	560.0 ± 1016.14 [NF] (*96.55*)	NF	NF	NF	560.0 ± 1016.14 [NF] (*96.55*)	560.0 ± 1016.14 [NF] (*96.55*)	-0.25 ± 1.95
Sosnowiec (n = 115)	42.93 ± 184.40 [10.10 ± 59.64] (*89.36*)	0.41 ± 2.99 [0.08 ± 0.85] (*1.77*)	0.11 ± 1.17 [NF] (*0.35*)	NF	43.47 ± 184.61 [10.27 ± 59.63] (*92.19*)	43.75 ± 184.79 [11.11 ± 59.95] (*99.65*)	-0.31 ± 1.57
Katowice (n = 84)	273.71 ± 1162.57 [21.21 ± 100.49] (*91.83*)	6.52 ± 38.18 [0.19 ± 1.00] (*2.99*)	1.68 ± 10.26 [0.83 ± 5.11] (*3.54*)	1.19 ± 10.91 [NF] (*0.07*)	279.92 ± 1194.50 [22.25 ± 100.52] (*98.43*)	287.26 ± 1204.40 [24.83 ± 102.19] (*99.80*)	-0.65 ± 1.76
Chorzów (n = 10)	87.48 ± 105.40 [18.60 ± 26.84] (*94.80*)	3.36 ± 9.38 [1.00 ± 3.16] (*1.16*)	NF	NF	91.84 ± 113.65 [19.60 ± 26.25] (*96.15*)	97.54 ± 116.10 [21.62 ± 29.35] (*99.22*)	2.25 ± 0.35
Gliwice (n = 3)	6.20 ± 8.11 [NF] (*100.0*)	NF	NF	NF	6.20 ± 8.11 [NF]	6.20 ± 8.11 [NF]	-0.33 ± 2.36
Bytom (n = 6)	2.69 ± 5.67 [0.66 ± 1.02] (*50.85*)	7.63 ± 9.75 [2.00 ± 4.00] (*25.42*)	0.65 ± 1.59 [0.08 ± 0.20] (*13.56*)	NF	11.14 ± 10.18 [2.74 ± 3.92] (*93.22*)	12.97 ± 13.38 [2.82 ± 3.92] (*100.0*)	ND
Wodzisław (n = 9)	17.04 ± 44.11 [NF] (*14.29*)	73.70 ± 134.99 [14.81 ± 44.44] (*80.95*)	NF	NF	90.74 ± 176.99 [14.81 ± 44.44] (*95.24*)	91.85 ± 177.44 [14.81 ± 44.44] (*100.0*)	-1.10 ± 1.24
Dąbrowa Górnicza (n = 2)	NF	NF	NF	0.50 ± 0.70 [0.50 ± 0.70] (*5.56*)	0.50 ± 0.70 [0.50 ± 0.70] (*5.56*)	9.00 ± 12.73 [9.00 ± 12.73] (*100.0*)	ND
Zabrze (n = 2)	NF	NF	NF	0.05 ± 0.05 [0.05 ± 0.05] (*2.33*)	0.05 ± 0.05 [0.05 ± 0.05] (*2.33*)	21.00 ± 29.70 [21.00 ± 29.70] (*100.0*)	ND
Mysłowice (n = 2)	40.00 ± 56.57 [NF] (*36.36*)	42.50 ± 53.03 [10.00 ± 14.14] (*45.46*)	20.00 ± 28.28 [NF] (*18.18*)	NF	102.50 ± 137.89 [10.00 ± 14.14] (*100.0*)	102.50 ± 137.89 [10.00 ± 14.14] (*100.0*)	ND
Świętochłowice (n = 2)	145.0 ± 176.78 [45.0 ± 63.64] (*96.67*)	NF	NF	NF	145.0 ± 176.78 [45.0 ± 63.64] (*96.67*)	150.0 ± 183.85 [45.00 ± 63.64] (*100.0*)	ND
Jaworzno and Chrzanów (n = 26)	NF	0.46 ± 2.16 [0.04 ± 0.20] *(92.31)*	NF	NF	0.46 ± 2.16 [0.04 ± 0.20] (*92.31*)	0.50 ± 2.16 [0.04 ± 0.20] *(100.0)*	0.21 ± 1.99
Szczyrk (n = 2)	0.50 ± 0.71 [NF] (*12.50*)	NF	NF	NF	0.50 ± 0.71 [NF] (*12.50*)	4.00 ± 2.83 [2.50 ± 0.71] (*100.0*)	ND
Total (n = 335)	111.79 ± 633.72 [11.06 ± 62.78]	35.70 ± 251.95 [6.15 ± 59.55]	0.59 ± 5.64 [0.21 ± 2.57]	0.30 ± 5.64 [0.003 ± 0.06]	147.63 ± 697.41 [17.46 ± 88.07]	204.14 ± 1079.78 [29.69 ± 185.32]	-0.15 ± 1.62

Key: [1]excluding single samples of bed dust from Ruda Śląska, Solarnia (Lubliniec vicinity), Pszczyna, Opole, Skarżysko-Kamienna and Kęty, and single sample of floor dust from Rabka; [2]including also unidentified *Dermatophagoides* spp.; n–number of samples; ND - not determined; NF - not found.

Table 4. Abundance (mean number of mites per gram of dust) and dominance (percent of the total population) of house dust mites (*Pyroglyphidae*) and total domestic mites in the samples from various indoor places, compared to mean values of Acarex test levels, relative humidity and temperature in the examined dwellings.

	Bed dust (n = 150) Mean ± SD Total mites [Live mites] (*Percent of dominance*)	Floor dust (n = 145) Mean ± SD Total mites [Live mites] (*Percent of dominance*)	Upholstery furnitures (n = 34) Mean ± SD Total mites [Live mites] (*Percent of dominance*)	Other places[1] (n = 6) Mean ± SD Total mites [Live mites] (*Percent of dominance*)
Dermatophagoides farinae	209.5 ± 920.7 [15.4 ± 76.6] (*71.72*)	11.1 ± 49.4 [2.2 ± 15.8] (*16.84*)	67.8 ± 195.6 [8.8 ± 24.5] (*91.95*)	351.2 ± 762.9 [133.3 ± 242.2] (*100.00*)
Dermatophagoides pteronyssinus	69.9 ± 368.6 [11.8 ± 87.7] (*19.60*)	9.1 ± 65.5 [2.2 ± 19.1] (*7.51*)	4.5 ± 22.8 [NF] (*2.68*)	NF
Dermatophagoides spp. (unidentified)	0.1 ± 0.9 [NF] (*0.19*)	0.01 ± 0.1 [NF] (*0.26*)	0.1 ± 0.3[NF] (*0.67*)	NF
Euroglyphus maynei	1.3 ± 8.4 [0.5 ± 3.8] (*1.93*)	NF	NF	NF
Hirstia chelidonis	0.7 ± 8.2 [0.007 ± 0.08] (*0.10*)	NF	NF	NF
Pyroglyphidae (total)	281.6 ± 1009.4 [27.3 ± 117.8] (*93.54*)	18.3 ± 79.8 [4.5 ± 24.6] (*24.61*)	72.4 ± 33.5 [8.8 ± 4.2] (*95.30*)	351.2 ± 762.9 [133.3 ± 242.2] (*100.00*)
Domestic mites (total)	299.3 ± 1033.6 [31.4 ± 120.3] (*99.46*)	130.3 ± 1245.0 [28.6 ± 249.1] (*97.41*)	73.2 ± 195.2 [9.3 ± 4.2] (*99.33*)	351.2 ± 762.9 [133.3 ± 242.2] (*100.00*)
Relative Humidity (% RH)	54.9 ± 19.5	56.3 ± 19.4	57.6 ± 24.6	81.7 ± 6.7
Temperature (°C)	21.2 ± 2.3	20.7 ± 2.8	21.8 ± 1.3	21.8 ± 0.3
Acarex test levels	0.5 ± 1.5	-0.6 ± 1.6	-0.04 ± 1.4	-0.8 ± 1.8

Key: [1]wooden furniture, pictures and shutters; n - number of samples.

per gram of dust for *D. farinae*, *D. pteronyssinus*, total *Pyroglyphidae* and intact (alive) *Pyroglyphidae* were 111.8, 35.7, 147.6 and 17.5, respectively (Tab. 3).

No mites were found in 177 samples (52.8%). Therefore, in some localities the median values of numbers of mites per gram of dust were 0.0 (e.g. in Sosnowiec, Katowice, Wodzisław, and generally in Upper Silesia). Percent of samples positive for mites was highest in Bytom (83.3%), Łódź (77.7%), Chorzów (70.0%) and in Bielsko-Biała (64.3%), whereas percent of samples with the mite density above 100 specimens per gram of dust was highest in Bielsko-Biała and Chorzów (50.0% in both cases) (Fig. 3).

Main indoor places of mite breeding. About 85% of mites were found in beds, whereas only 10.4% and 4.8% in dust samples from floors and upholstered furniture, respectively. The remaining 0.6% of mites were detected in dust samples from the other indoor places, mainly from shutters. Most frequently, both total mites and pyroglyphid mites were found in samples from upholstery furnitures (70.6% and 73.5% of these samples).

The mean numbers of total mites, domestic mites and pyroglyphid (house dust) mites per 1 sample (mite positive) were also highest in dust from beds and other sleeping accommodations, followed by floors (in the cases of total domestic mites and all mites collected) or by upholstery furnitures and other places (in the case of pyroglyphid mites). The other places (mainly shutters) showed also the highest number of mites per gram of dust (Tab. 4). The small number of samples from other places and their low weight may be the cause of such a high mean number of mites in these samples. Generally, mites (also live mites) were most abundant in samples from beds (and other sleeping accomodations) and carpeted floors (Tables 4-6). Moreover, it should be stressed that in Upper Silesia region mites occurred more numerously in samples from upholstered furniture than in samples from floors, whereas in Kraków they were more numerous in the samples from floors.

Mean densities of mites in beds, upholstered furniture and floor dust samples from dwellings of atopic and non-atopic persons are compared in Table 6. The number of total domestic mites per 1 gram of dust in dwellings of atopics was generally slightly higher and varied from 0.0 to 8,342.9. The live domestic mites were more abundant in the dwellings of non-atopic persons. The mean number of domestic mites per 1 gram of dust was highest in dust from beds and upholstered furniture in dwellings of atopic patients, whereas in dust from floors in the dwellings of non-atopic subjects (Tab. 6). Mean number of pyroglyphid mites per gram of dust in both groups of dwellings was highest in beds and upholstery furnitures. It is noteworthy that in the latter places the pyroglyphids were more abundant in the dwellings of atopics (Tab. 6).

Table 5. Mean numbers of mites per 1 gram of dust and mean steps of Acarex test in particular sites of examined Polish dwellings ($\bar{x} \pm SD$).

Sampling sites/Mites	Sleeping accomodations		Floors			Upholstery furnitures		
	Beds and mattresses	Couches or sofas	Carpets	Linoleums	Wooden floors	Arm-chairs	Couches or sofas in living rooms	Complete sets of furniture
DF	105.0 ± 449.5 (0.0–3233.3)	263.9 ± 1088.7 (0.0–7942.9)	6.8 ± 29.9 (0.0–233.3)	31.1 ± 83.1 (0.0–266.7)	17.5 ± 83.4 (0.0–400.0)	34.8 ± 50.4 (0.0–200.0)	240.2 ± 443.5 (0.0–1133.3)	21.1 ± 43.5 (0.0–122.7)
DP	171.3 ± 604.1 (0.0–3066.7)	14.4 ± 66.5 (0.0–403.8)	4.2 ± 24.5 (0.0–200.0)	NF	5.7 ± 23.8 (0.0–114.3)	7.4 ± 29.7 (0.0–133.3)	0.1 ± 0.2 (0.0–0.6)	0.6 ± 1.6 (0.0–4.5)
TDM	278.2 ± 767.3 (0.0–3233.3)	280.5 ± 1118.1 (0.0–8285.7)	75.7 ± 34.2 (0.0–233.3)	31.1 ± 83.1 (0.0–266.7)	23.2 ± 85.5 (0.0–400.0)	42.3 ± 53.8 (0.0–200.0)	240.3 ± 443.5 (0.0–1133.3)	21.7 ± 45.0 (0.0 –127.3)
TM	320.3 ± 826.4 (0.0–3233.3)	284.9 ± 1129.4 (0.0–8342.9)	152.9 ± 1460.5 (0.0–14971.4)	90.4 ± 182.9 (0.0–600.0)	31.1 ± 94.1 (0.0–400.0)	43.1 ± 53.6 (0.0–200.0)	242.1 ± 442.3 (1.7–1133.3)	21.7 ± 45.0 (0.0–127.3)
LHDM	35.9 ± 152.7 (0.0–1066.6)	22.4 ± 93.6 (0.0–742.9)	2.5 ± 19.8 (0.0–200.0)	8.9 ± 34.4 (0.0–133.3)	10.8 ± 35.8 (0.0–133.3)	6.2 ± 12.8 (0.0–50.0)	28.3 ± 52.3 (0.0–130.0)	0.6 ± 1.6 (0.0–4.5)
LDM	44.3 ± 155.3 (0.0–1066.6)	23.8 ± 94.9 (0.0–742.9)	31.2 ± 290.4 (0.0–2971.4)	33.8 ± 82.6 (0.0–266.7)	15.7 ± 54.1 (0.0–228.6)	6.6 ± 13.4 (0.0–50.0)	30.1 ± 51.3 (0.0–130.0)	0.6 ± 1.6 (0.0–4.5)
AS	0.5 ± 1.3 (-2.5–3.0)	0.5 ± 1.6 (-3.0–3.0)	-0.5 ± 1.6 (-3.0–2.0)	-0.8 ± 1.5 (-3.0–1.0)	-0.7 ± 1.5 (-2.5–1.0)	0.1 ± 1.2 (-2.5–1.0)	1.2 ± 0.6 (0.5–2.0)	-1.3 ± 1.3 (-2–1.0)

Key: DF–*Dermatophagoides farinae*; DP–*D. pteronyssinus*; TDM–total domestic mites (pyroglyphid and/or non-pyroglyphid); TM - total mites; LHDM–live house dust (pyroglyphid) mites; LDM–live domestic mites; AS–Acarex test steps.

Mite fauna in beds. Among 150 samples examined from beds, 92 (61.3%) were positive for mites. A total of 3,158 mites were isolated from these samples (85.0%). Beds and other sleeping accommodations show also a highest diversity of mite species (Tab. 4). *D. farinae* was the dominant species, most frequent and abundant both per 1 sample and per 1 gram of dust (Tables 4-6) in these samples. *E. maynei* and *H. chelidonis*, and also many other non-pyroglyphid species, were found only in the samples from sleeping accommodations (Tab. 4). It should be stressed that among sleeping accommodations, *D. farinae* was more abundant per gram of dust in samples from couches and sofas whereas in bed mattresses it was *D. pteronyssinus* (Tab. 5).

Mite fauna on carpeted and non-carpeted floors. From 145 samples examined from floors, 38 samples (only 26.2%; the lowest frequency, also for particular mite species) were positive for mites. A total of 386 mites were isolated from these samples (10.4% of the total count). Most frequent and abundant (per 1 sample and per 1 gram of dust) was *D. farinae*. Among floor dust samples, mites were most abundant in samples from carpets, then on linoleums, and the lowest mite density was found on wooden floors (Tab. 5).

Mite fauna from upholstery furnitures. Among 34 samples examined from upholstered furniture, 25 samples (73.5%) were positive for mites; thus, these places show the highest frequency of mites in the examined samples. However, only 149 mite specimens were isolated from these samples (4.0% of the total). Among pyroglyphids, only two species, *D. farinae* and *D. pteronyssinus*, were found (Tab. 4.). The former species was the dominant and the most frequent and abundant species – both per gram of dust (Tables 4-6) and per 1 sample. Generally, numbers of house dust mites per gram of dust from upholstered furniture were lower than in bed dust samples and distinctly higher than in floor dust samples (Tables 4-6). Among upholstered furniture actually examined, the highest numbers of mites per gram of dust were found in samples from couches and sofas located in living rooms (or family rooms) (Tab. 5).

Other indoor sites. Some other indoor places (shutters, pictures and wooden furniture) contained high concentrations of mites per gram of dust (Tab. 4) or per 1 sample. However, small number of samples from these places and their low weight may be the cause of such a high mean number of mites in these samples [26].

Exposure to mite allergens. Percent of samples with the positive Acarex test was highest in Łódź (88.9%), Bielsko-Biała (75.0%) and in Kraków (66.7%), whereas in Upper Silesia it was below 50% (49.5%) (Fig. 4). Generally, samples from upholstered furniture were most frequently positive for Acarex test (Fig. 4). On the whole, 49.5% of samples examined were positive in the Acarex test. Mean values of the Acarex test levels in samples from different localities, in samples from beds, floors and

Table 6. Mean numbers of mites per 1 gram of dust and mean steps of Acarex test in samples from particular sites in the examined dwellings, depending on the atopic status of inhabitants (x ± SD).

Sampling sites/Mites	Dwellings of atopic patients (n = 42)			Dwellings of non-atopic persons (n = 67)		
	Bed dust	Floor dust	Dust from upholstery furnitures	Bed dust	Floor dust	Dust from upholstery furnitures
DF	282.4 ± 1179.4 (0.0–7942.9)	14.3 ± 47.3 (0.0–233.3)	215.64 ± 454.1 (0.0–1133.3)	119.2 ± 412.7 (0.0–3233.3)	9.9 ± 50.3 (0.0–400.0)	36.1 ± 51.8 (0.0–200.0)
DP	14.4 ± 69.3 (0.0–528.0)	0.3 ± 2.0 (0.0–12.5)	0.1 ± 0.2 (0.0–0.6)	138.6 ± 540.5 (0.0–3066.7)	12.2 ± 76.1 (0.0–742.9)	5.4 ± 25.1 (0.0–133.3)
THDM	300.5 ± 1210.2 (0.0–8285.7)	7.7 ± 37.9 (0.0–233.3)	215.7 ± 454.0 (0.0–1133.3)	258.1 ± 692.3 (0.0–3233.3)	22.1 ± 90.0 (0.0–742.9)	41.7 ± 54.4 (0.0–200.0)
TDM	306.3 ± 1221.3 (0.0–8342.9)	15.6 ± 49.8 (0.0–233.3)	215.8 ± 454.0 (0.0–1133.3)	290.6 ± 747.5 (0.0–3233.3)	171.0 ± 1448.6 (0.0–600.0)	42.6 ± 54.0 (0.0–200.0)
LHDM	19.2 ± 85.1 (0.0–34.0)	1.2 ± 5.5 (0.0–33.3)	21.7 ± 53.1 (0.0–130.0)	37.4 ± 148.8 (0.0–1066.6)	5.6 ± 28.4 (0.0–200.0)	6.0 ± 12.9 (0.0–50.0)
LDM	22.7 ± 84.5 (0.0–742.9)	2.0 ± 7.6 (0.0–33.3)	21.7 ± 53.1 (0.0–130.0)	41.7 ± 152.9 (0.0–1066.6)	38.0 ± 289.7 (0.0–2971.4)	6.7 ± 13.3 (0.0–50.0)
AS	0.5 ± 1.5 (-3.0–3.0)	-0.3 ± 1.6 (-3.0–2.0)	0.4 ± 1.3 (-2.0–2.0)	0.5 ± 1.5 (-2.0–3.0)	-0.7 ± 1.6 (-3.0–2.0)	-1.0 ± 1.4 (-2.5–1.5)

Key: n–number of dwellings; DF–*Dermatophagoides farinae*; DP–*D. pteronyssinus*; THDM–total house dust mites (pyroglyphids); TDM–total domestic mites (pyroglyphid and/or non-pyroglyphid); LHDM–live house dust (pyroglyphid) mites; LDM–live domestic mites; AS–Acarex test steps.

upholstered furniture, and in samples from dwellings of atopic or non-atopic subjects, are presented in Tables 3-6. Guanine contents, after recalculation of mean and/or median values of Acarex steps (as described above in "Materials and Methods"), were approximately between 600–950 µg per gram of dust from upholstery furnitures, between 950–2500 µg per gram of dust in bed dust samples, and below 600 µg/gram of dust in floor dust samples.

Sources of mite allergens in dwellings. Main sources of mite allergens in the examined dwellings were beds, couches or sofas in bedrooms and couches or sofas in living rooms (family rooms) (Tab. 5).

Statistical analysis

The majority of the obtained actually data were distributed normally (as tested by the Kolmogorov-Smirnov test; $p < 0.01$ or $p < 0.05$). The remaining data were analysed as non-parametric (Wilcoxon test, Spearman's test).

Mite densities. Differences between particular indoor sites, dwellings or localities examined. Significant differences in the pyroglyphid mite concentrations were found between samples from floors and both samples of bed dust (*t*-test, $p < 0.001$) and samples from upholstered furniture (*t*-test, $p < 0.05$), whereas the difference between samples from beds and upholstered furniture was not significant (*t*-test, $p = 0.38$). Accordingly, a significant correlation was also found for numbers of pyroglyphid mites per gram of dust between the samples of bed dust and samples from upholstered furniture (Pearson's product-moment correlation test, $r = 0.98$; $p < 0.01$), and moreover between samples from floors and the samples from other places examined (Pearson's test, $r = 0.99$; $p < 0.01$).

As regards localities, the significant correlation in numbers of pyroglyphids per gram of dust was found only between Bielsko-Biała and Kraków, and between Bielsko-Biała and Upper Silesia (total), (Pearson's correlation test, $p < 0.05$). Significant differences were found in the numbers of house dust mites (pyroglyphids) per gram of dust between the following localities: Bielsko-Biała and - Łódź, Sosnowiec, Jaworzno/Chrzanów, Chorzów, Bytom, Wodzisław (*t*-test, $p < 0.05$); Sosnowiec and Chorzów (*t*-test, $p < 0.05$); Bytom and Jaworzno/ Chrzanów (Wilcoxon matched pairs test, $p < 0.05$); Wodzisław and Chorzów (Wilcoxon matched pairs test, $p < 0.05$); Chorzów and Jaworzno/ Chrzanów (Wilcoxon matched pairs test, $p < 0.05$); Chorzów and Sosnowiec (Wilcoxon matched pairs test, $p < 0.05$).

Dwellings of atopic or non-atopic subjects. The difference between the numbers of pyroglyphid mites per gram of dust in dwellings of atopic and non-atopic subjects was not significant (*t*-test, $p = 0.35$), whereas a significant difference could be shown in allergen levels (Acarex test steps) which were higher in dwellings of

Table 7. Positive correlations observed between housing conditions and the prevalence of house dust mites (pyroglyphid and non-pyroglyphid) and mite allergens in dust samples from the dwellings examined (results of the Pearson's correlation test analysis; $p < 0.05$).

Positive explanatory variables (*y*)	**Dwelling conditions examined (positive criterion variables *x*)/Correlation coefficient**				
Floor dust samples	Type of building[1]	Type of heating[2]	Relative humidity (% RH)	Month	Acarex steps[3]
Number of mites/g:					
Dermatophagoides pteronyssinus		0.36			0.27
Pyroglyphidae (total)	0.24	0.27	0.25		0.32
Domestic mites (total)		0.35			
Number of live mites/g:					
Pyroglyphidae (total)	0.21		0.23		0.22
Domestic mites (total)		0.32			
Number of species:					
Total mites	0.27			0.27	0.37
Pyroglyphid mites					0.25
Non-pyroglyphids	0.23	0.21		0.28	0.34
Acarid mites	0.22		0.21		0.22
Glycyphagid mites		0.22			
Cheyletid mites					0.22
Presence of:					
Chortoglyphus arcuatus		0.47			
Acarex steps[3]	0.52	0.22	0.30	0.54	[1.00]
Samples from upholstery furnitures	Type of building[1]	Sampling method[4]	Weight of samples (in grams)	Month	Acarex steps[3]
Number of species:					
Total mites					0.41
Non-pyroglyphids	0.46		0.39	0.48	
Glycyphagid mites	0.43		0.64	0.26	
Gamasid mites	0.43				
Acarex steps[3]		0.41			[1.00]

Key (data matrix): [1] recreation house [1], block house [2], tenement-house [3], one-family house [4], old house [5]; [2] central [1], electric [2] or coal-stove [3]; [3] as both criterion (*x*) and explanatory (*y*) variable; [4] sweepings [1], car vacuum cleaner [2], domestic vacuum cleaner [3], „Rainbow" cleaner [4], Burkard Cyclone Surface Sampler [5].

atopic patients (*t*-test, $p < 0.05$). No significant differences were found between the counts of viable (alive) mites in samples from beds, floors and upholstered furniture of atopic and non-atopic persons (*t*-test, $p = 0.47$, 0.25 and 0.54, respectively). Also, relationships in numbers of mite positive and mite negative samples between dwellings of atopic and non-atopic persons were not significant (χ^2, $p = 0.95$). Only in the case of samples from upholstered furniture, a significant relationship was found in the frequency of samples with numbers of mites per gram of dust higher than 100, in relation to all samples positive for mites from each place examined, that was significantly higher for dwellings of atopic subjects ($\chi^2 = 32.12$, $p < 0.0001$). In relation to bed dust samples and samples from upholstered furniture, a significant relationship was found in the numbers of pyroglyphid mites per gram of dust, which were greater in dwellings of atopic persons (Yate's corrected $\chi^2 \geq 99$, $\alpha < 0.0001$ and $\chi^2 = 22.3$, $\alpha = 0.0005$, respectively). However, in relation to floor dust samples those numbers were greater in dwellings of non-atopic persons ($\chi^2 = 47.73$, $\alpha < 0.0001$).

These findings show that generally in the examined dwellings or localities there was no distinct difference in mite exposure between allergic patients and persons without a predisposition to allergy (atopy).

Housing conditions influencing an abundance and prevalence of mites and their allergens in houses and dwellings. Influence of relative humidity and temperature. The results of the Pearson's test for

correlation between some abiotic and biotic indoor environmental factors (housing conditions) and mite prevalence and density in the examined dwellings suggest associations between the mite density (per gram of dust) and the following abiotic or biotic indoor environmental factors - type of heating, type of building, relative humidity, and levels of Acarex test, especially in the case of samples of floor dust (Tab. 7). Significant positive correlations were also found between Acarex steps and type of building, type of heating, relative humidity, month (floor dust samples), and sampling method (samples from upholstered furniture) (Tab. 7). Other correlations were negative or not significant ($p > 0.05$). In relation to bed dust samples, both the total number of mite species and the number of species of the non-pyroglyphid mites were negatively correlated with the sampling methods. In relation to floor dust samples and samples from upholstered furniture much more positive significant correlations ($p < 0.05$) were found. These are presented in Table 7.

The values of temperature were also significantly correlated (Spearman's rank correlation test, $p < 0.01$) with concentrations (per gram of bed dust) of *E. maynei* (total) (positive correlation; $R = 0.40$) and intact *D. pteronyssinus* (negative correlation; $R = -0.38$). In relation to samples of floor dust, a significant correlation was found only between the values of temperature and numbers of total domestic mites (per gram of dust) (Spearman's test, negative correlation; $R = -0.27$, $p < 0.05$). Statistical analysis by the Spearman's rank correlation test of the results from upholstered furniture revealed no correlation between the temperature levels and concentrations of mites (both live and total).

Generally, it should be stressed that significant relationships were found between the numbers of mites per gram of dust and the levels of temperature and RH values, separately for bed/mattress dust, floor dust and dust from upholstered furniture; in all these cases χ^2 was ≥ 99.99 ($p < 0.0001$).

DISCUSSION

The results of the present work correspond well with literature data. It is evident from a review of the literature, that 32-100% of homes and dwellings or dust samples analysed are positive for both pyroglyphid or other house dust mites (known as domestic mites). Three mite species *D. pteronyssinus, D. farinae* and *E. maynei* are most often and most abundantly found in house dust throughout the world [1, 10, 18, 21, 25, 45]. *H. chelidonis* was also recently found in the indoor environment in Norway [41]. Pyroglyphid mites usually make up 60-90% of the house dust acarofauna in temperate climate regions throughout the world [21, 25, 27, 45], including Poland (Tab. 1). Most often they are found in habitats intimately associated with man, such as beds, couches, sofas, other upholstered furniture, clothing, floors and carpets [10, 21, 51, 55].

The mean concentration of mites in examined samples and mite frequency was at the lower end of the published range for more humid regions [10, 21, 27, 31, 47]. It was comparable with some American [3], Asiatic [43] or European results [10, 21], and comparable also (or slightly higher) with other results from Poland (Upper Silesia [35, 51, 52], Poznań [14], Gdańsk and Gdynia [46]). In Denmark, Hallas and Korsgaard [27] found average concentrations of mites approximately tenfold higher than those actually observed in Poland, with the exception of Bielsko-Biała, where those values are comparable.

Usually, no mites occur in dwellings with an air relative humidity below 45% and the size of the population increases with increased humidity [4, 21, 25, 27, 30, 39]. Proportions between numbers of the particular pyroglyphid dust mite species, especially between *D. pteronyssinus* and *D. farinae*, different in various regions of the world. Decisive factors influencing their occurrence and abundance are mainly relative humidity and temperature of both outdoor and indoor air [10, 19, 21, 25, 31, 37, 51]. It is commonly known that the optimal temperature is higher (25-30°C) and optimal humidity lower (50-75% RH) for *D. farinae* compared to *D. pteronyssinus*. The former species appear to survive better in dryer habitats than the latter. In turn, lower temperature (15-20°C) and higher humidity (75-80% RH) favours *D. pteronyssinus* in mixed laboratory cultures [4, 19, 21]. Mean values of relative humidity in the examined dwellings (Tab. 4) are generally below a critical equilibrium humidity (CEH) for pyroglyphid house dust mites, especially for *D. pteronyssinus* and *E. maynei* [4, 16, 21], but they are distinctly higher than 45% RH which is the lowest threshold of indoor humidity for mite survival in dwellings [30, 39]. These data explain the high densities of *D. farinae* in the examined samples, consistent with results of other Silesian surveys [34, 35, 51]. As indicated by the results of other previous surveys in Poland, *D. pteronyssinus* was found to be the dominant species in Bydgoszcz [49], Warsaw [50, 57], Poznań and vicinity [14, 20], whereas *D. farinae* was predominant in Gdańsk and Gdynia [46] (Tab. 1). However, in Warsaw *D. farinae* was less numerous than *E. maynei* [57]. Summarizing, it should be stressed that the domination of *D. farinae* in dwellings appears to be the characteristic tendency at many localities in Poland (Tables 1 and 3) [34, 35, 46, 51]. This tendency may also indicate that dwellings at these localities in our country become drier. On the other hand, the indoor air ambient humidity, which varies with the degree of ventilation of the dwellings, depends upon the building construction [11], and, therefore, energy-saving house insulation tends to increase indoor humidity and may lead to higher house dust mite densities (especially of *D. pteronyssinus*) [39].

It was also determined that the CEH for house dust mites is temperature-dependent [4]. Therefore, a lower temperature probably has significant effects on the survival of the hygrophilous species *D. pteronyssinus* and

E. maynei, if the mites are exposed to a relative humidity below their CEH's. But the significant negative correlation between the number of both total and intact *D. pteronyssinus* per gram of dust and levels of temperature was found only in relation to floor dust samples (Pearson's test, r = -0.28 and -0.25, respectively; $p<0.05$). *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, may predominate and occurs more frequently [16, 17, 18, 22, 51, 57]. This mite appears to be less able than *D. pteronyssinus* to withstand low humidity [16, 17]. The observed predilection of *E. maynei* to beddings is consistent with data reported by Walshaw and Evans [56] from Liverpool. These authors [56], and Hart and Whitehead [31] in Oxfordshire found weak or no correlation between the numbers of *E. maynei* and relative humidity of a bedroom.

H. chelidonis (Fig. 2) is known in Poland as the dominant mite species in nests of *Delichon urbica*, *Hirundo rustica* and *Passer domesticus* [13, 54]. Moreover, *H. chelidonis* was found in our country in nests of *Passer montanus*, *Sturnus vulgaris*, *Turdus philomelos*, *Turdus* sp. and *Sylvia* sp. [13, 54], and in byre debris in Lesko [53]. It was also found in two samples of dust from feather-beds from different dwellings and localities (Dąbrowa Górnicza and Katowice), and from one sample of mattress dust from a dwelling in Zabrze. This species is distinguished from *H. domicola* (the typical house dust mite species, not found in Poland to date) by the following characters [21]:

- in both sexes the idiosoma is larger (395-426 μm long in female and 321-345 μm long in male, instead of 298-310 and 240-248 μm in *H. domicola*, repectively);
- in both sexes the legs are longer (legs I-IV: 135-150-175-118 μm long in female and 123-132-163-88 μm long in male, compared to 108-116-127-85 μm and 92-105-102-64 μm long in *H. domicola*, respectively) and the tarsi are more slender (length and width of tarsi I-IV: 40 × 12 – 43 × 14 – 66 × 9 – 48 × 6 μm in female and 33 × 13 – 39 × 14 – 51 × 15 – 24 × 9 μm in male, intead of 27 × 14 – 32 × 15 – 43 × 10 – 32 × 9 μm in female and 22 × 12 – 27 × 12 – 32 × 13 – 18 × 9 μm in male of *H. domicola*);
- in the female the cuticle of the posterior region of the body is distinctly less sclerotized, especially on the dorsum.

Mites of families *Glycyphagidae* and *Acaridae* are considered as much more sensitive to dessication than pyroglyphids [10, 21]. It was also suggested that some domestic mite species thrive in very damp conditions; this group include domestic acarids, glycyphagids (mainly *L. destructor*, *G. domesticus*) and cheyletids (*Cheyletus* spp). Therefore, the presence and abundance of these mite species can be usually assumed as an indicator of humid environments [21, 51]. In general, these mites are not as abundant and frequent in Europe as in tropical countries [10, 12, 21, 25, 27, 47, 55].

In Europe, the most abundant mite populations were usually collected from bed mattresses [1, 10, 21, 27, 35, 51, 55]. However, more abundance of mites in padded furniture than in bed mattresses was also frequently observed [21], for example in Israel [22] and in USA (Ohio) [2, 3]. It was also suggested recently that in the case of small amounts of dust, the mite density per gram of dust is usually reported as being high in comparison with the larger samples [26]. This suggestion explains the high mite density in some other places examined in the present study (shutters) (Tab. 4). On the other hand, the significant negative correlation between numbers of pyroglyphids per gram of dust and weight of samples was found only in the case of samples from floors (pearson's test, r = -0.22; $p < 0.05$).

The influence of different housing conditions (both biotic and abiotic) on dust mite populations was widely reviewed by Hart [30]. Some of them, such as type of heating, type of mattress, age of furniture, type of bedding, carpets, soft furnishing, soft toys, age of house, number of occupants, presence of pets, floor heating, may influence dust mite populations [30]. Certain recent studies, however, showed weak or no correlation between these environmental factors and the mite density [e.g. 47].

The Acarex test is a simple technique for detecting guanine from house dust mite excretions. Usually the level of guanine correlates well with the level of mite allergens [7, 36], and this was found also in some cases during the actual study. On the other hand, it has been suggested that considerable amounts of guanine originate from other, non-house dust mite sources, and therefore house dust samples sometimes contained more guanine than was expected [29].

Final remarks. Differences in the geographic distribution of particular species of both pyroglyphid house dust mites and domestic non-pyroglyphid mites, as well as the mite population densities both within and between dwellings or localities, are attributed to variations in the biotic and abiotic factors of the indoor environment or ecological requirements of the different mite species. In the present study it was found that mite populations on floors were more dependent on environmental factors (such as the type of building, type of heating, relative humidity or temperature) than those from the other places examined. Moreover, some sampling methods (sweepings, car vacuum cleaners) are more effective for collecting non-pyroglyphid domestic mites than for pyroglyphids. Generally, older buildings and stoves are more favourable for the occurrence of both *D. pteronyssinus* and the domestic non-pyroglyphids, whereas new buildings, with central heating systems, for the higher abundance of *D. farinae*. It should be also stressed that *D. farinae* was particularly abundant in dust from couches and sofas whereas *D. pteronyssinus* in dust from bed mattresses.

Acknowledgements

Special thanks are expressed to Professor Andrzej Szeptycki, Professor Krzysztof Siuda and Dr Mieczysław Dymon from Kraków, to Dr Piotr Zygmunt Brewczyński and Dr Krzysztof

Krajewski-Siuda from Katowice, and to Professor Antoni Deryło and colleagues from the Department of Biology and Parasitology of Silesian Medical Academy in Katowice, for their assistance in gathering house dust samples. I am also grateful do Professor Antoni Deryło for his critical review of the manuscript and to Professor Andrzej Szeptycki for helpful discussion.

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