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OCCUPATIONAL EXPOSURE TO ALLERGENIC MITES IN A POLISH ZOO

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Abstract: The study was carried out from April 2000–March 2001. During this period 49 samples of dust, litter, debris and residues from cages and run-offs of mammals, birds and reptiles in the Silesian Zoo, were examined for the presence of mites, especially the allergenic taxa. Mites were extracted using the Berlese method and preserved in 70% ethanol. For identification, the mites were mounted in Hoyer's medium on microscope slides. Mites were found in 44 of 49 samples analyzed (89.8%). A total of 5,097 mites were collected, from which 60.3% were found in samples collected in spring, whereas only 13% in summer and 24.1% in autumn. The remaining 2.6% of the total mite population was found in winter. Majority of mites (82.7%) were collected from aviaries of macaws and cockatiels (*Ara ararauna* and *Nymphicus hollandicus*). A total of 10 species of astigmatid mites were identified that belong to 4 families - Acaridae, Glycyphagidae, Anoetidae and Pyroglyphidae. Generally, the allergenic mites of the order Astigmata constituted 49.5% of the total count. Among them *Acarus farris* was predominant (34% of the total count), followed by *Tyrophagus putrescentiae* (4.7%), *Caloglyphus* sp. (4.35%) and *Acarus immobilis* (4.31%). *Dermatophagoides farinae*, the house-dust-mite species, was for the first time found in this environment. *D. farinae* (0.05% of the total population) was associated with parrots, canids and artiodactyls. Summarizing, it should be stressed, that cages and run-offs of different mammals, aviaries of parrots and terrariums of snakes are important sources of some allergenic mites, especially *A. farris* and *T. putrescentiae*, that might cause allergies in workers.

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INTRODUCTION

Atopic allergies have increased in industrialised countries. House dust mites from the family Pyroglyphidae (Acari: Acaridida) are recognized as the most important risk factor causing allergies in indoor environments [1, 2, 3, 4, 5, 11, 15, 16]. 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, 3, 5, 11, 28]. There is 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, 4, 11, 26, 29, 31, 33]. At least 14 groups of allergens have been identified from *D. farinae* and *D. pteronyssinus* [2]. The house dust mites have been reported from human dwellings and a wide variety of other habitats associated with man and his environment, both indoor and outdoor (e.g. in hospitals, libraries, cinemas, schools, nursery schools, hotels,

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students' hotels, offices, military barracks, workplaces and other public places, farming environments, passenger aircrafts and trains, automobile seats, naval ships, ocean-going ships, birds' nests, city pavements, among others) [5, 9, 33, 35, 36, 37, 41].

The term storage mites includes a variety of mites, but especially certain astigmatid species from the families Acaridae, Glycyphagidae and Chortoglyphidae [3, 6, 7, 11, 13, 38]. Mites of the genera *Acarus*, *Tyrophagus* (Acaridae), *Lepidoglyphus* and *Glycyphagus* (Glycyphagidae) are most often found in ecological studies of hay, straw and vegetable products in farming environments throughout the world [6, 8, 12, 17, 18, 20, 21, 24, 27, 35, 39, 40]. The storage mites are commonly found in different stored food products, in granaries, barns and other farming and occupational environments, but also in samples of house dust. The most abundant and most often reported are the species *Acarus siro*, *A. farris* and *Tyrophagus putrescentiae* from Acaridae, *Lepidoglyphus destructor*, *Glycyphagus domesticus* and *Gohieria fusca* from Glycyphagidae and *Chortoglyphus arcuatus* from Chortoglyphidae [6, 7, 8, 11, 13, 14, 17, 18, 24, 35, 37]. These mites are also the sources of clinical important allergens and the causers of occupational allergy (known as allergy to storage mites) among farmers, grain-storage workers, bakers, pastry-cooks, shopkeepers, millers, store-keepers, cheese-makers, horse riders, dockers, transport workers, upholsterers, miners, and some other occupational categories [3, 10, 11, 13, 25, 30, 34, 38].

Many species of mites with which humans come in contact, besides those found in house dust and stored products, induce allergic reactions. These include some species of spider mites (e.g., the 2-spotted spider mite *Tetranychus urticae* and *Panonychus ulmi*), which are common pests in orchards, yards, greenhouses, and gardens. These mites were recently discovered to induce IgE-mediated reactions [3, 4].

Moreover, it should be stressed that a large part of the territory of Poland was not examined for the occurrence of allergenic mites, including the pyroglyphid and non-pyroglyphid mites of medical concern of the order Acaridida. It is noteworthy that, to the best of our knowledge, samples from a zoological garden were actually analysed for the first time for the occurrence of allergenic mites.

The aim of this work was to study the occurrence, prevalence and species composition of allergenic acarofauna in cages, terrariums and runs of animals of the Silesian Zoo, as occupational biohazards, and, therefore, an attempt to assess the exposure of workers on allergenic mites.

MATERIALS AND METHODS

The study was carried out in the Silesian Zoo (Katowice, Upper Silesia), from April 2000–March 2001. During this period, 49 samples of dust, litter, debris and residues from cages, terrariums and run-offs of mammals, birds and reptilians were examined for the presence of mites, especially the allergenic taxa. Table 1 shows all animals whose environments were examined.

Table 1. List of the animals from the Silesian Zoo whose environments were examined, and numbers of mites collected.

Animals examined	Total number of mites collected	Mean number of mites per 1 gram of sample
Nymphicus hollandicus (cockatiel)	3,079	14.5
Ara ararauna (macaw)	1,138	3.06
Canis dingo (dingo)	216	2.36
Cercopithecus petaurista (Lesser white-nosed monkey)	127	9.32
Addax nasomaculatus (addax)	100	1.55
Lynx lynx wrangeli (Eurasian lynx)	135	1.07
Mandrillus sphinx (mandrill)	49	0.96
Giraffa camelopardalis (giraffe)	78	0.92
Amphibolurus barbatus (Bearded Dragon)	24	0.83
Lampropeltis getulus californiae (California king snake)	10	0.60
Gekko gecko (tokay gekko)	58	0.52
Boa constrictor (boa constrictor)	22	0.44
Corallus enydris (common tree boa)	34	0.29
Erythrocebus patas (red guenon)	7	0.20
Felis pardalis (ocelot)	9	0.12
Canis lupus (wolf)	2	0.12
Epicrates cenchris (rainbow boa)	4	0.06
Chrysocyon brachyurus (maned wolf)	1	0.05
Python regius (royal python)	4	0.03
Papio hamadryas (hamadryas baboon)	not found	not found
Total	5,097	3.22

Mites were extracted using the "Berlese method" and preserved in 70% ethanol [6]. For identification, the mites were mounted in Hoyer's medium on microscopic slides. Mite density was calculated as the number of specimens per 1 gram of the material analyzed. Because of difficulties with standardization of mite collection, the calculation of mite numbers of each taxon per gram of sample was recommended as the best method for determining mite exposure [29]. Mite abundance was also calculated as the number of specimens per 1 sample. Four seasons were defined: January, February, and March as

Table 2. Species list, dominance, occurrence and mean number of mites per 1 sample, in total samples from the examined places in the Silesian Zoo.

Mite taxa	Dominance		Frequency			Mean number of mites per 1 sample
	Number of mites	Percent of the total count	Number of samples	Percent of the total count	Percent of samples mite positive	
ACARIDIDA						
Acaridae						
Acarus farris	1,736	34.05	5	10.20	11.36	35.42
Acarus immobilis	220	4.31	13	26.53	29.54	4.48
Acarus siro	7	0.13	2	4.08	4.54	0.14
Tyrophagus putrescentiae	239	4.68	15	30.61	34.09	4.8
Tyrophagus longior	65	1.27	11	22.44	25.0	1.32
Tyrophagus similis	10	0.19	2	4.08	4.54	0.20
Caloglyphus sp.	222	4.35	3	6.12	6.82	4.53
Rhizoglyphus sp.	1	0.01	1	2.04	2.27	0.02
Glycyphagidae						
Lepidoglyphus destructor	19	0.37	8	16.32	18.18	0.38
Pyroglyphidae						
Dermatophagoides farinae	3	0.05	3	6.12	6.82	0.06
Anoetidae (unidentified)	463	9.08	4	8.16	9.09	9.44
ACTINEDIDA						
Cheyletidae	20	0.39	8	16.32	18.18	0.40
Tetranychidae	26	0.51	5	10.20	11.36	0.53
Bdellidae	7	0.13	3	6.12	6.82	0.14
Other Actinedida	3	0.05	3	6.12	6.82	0.06
ORIBATIDA	906	17.77	28	57.14	63.64	18.48
GAMASIDA	1,146	22.48	30	61.22	68.18	23.38
IXODIDA	4	0.07	3	6.12	6.82	0.08
Total mites	5,097	100.0	44	89.8	100.0	103.3

winter; April, May, and June as spring; July, August, and September as summer; October, November, and December as autumn. Results were analysed using χ^2 test and the Pearson's product-moment correlation test.

RESULTS

Overall results. The weight of samples ranged from 8.8–197.17 gram. Mites were found in 44 of the 49 samples examined (approx. 89.8%). Percent of samples positive for mites was highest in terrariums (100%), then in cages (91.3%) and in runs (76.9%). A total of 5,097 mite specimens were isolated, including 2,985 members of the order Acaridida (astigmatic mites) (58.6%). The Gamasida were the second most numerous group of mites (22.48%) (Tab. 2). The remaining part of mites consisted of the following taxa: Tetranychidae (0.51%), Cheyletidae (0.39%), Bdellidae (0.13%), other unidentified Actinedida (0.05%), Oribatida (17.77%) and Ixodida (0.07%). Generally, the actinedid mites constituted only 1.1% of the total mite population. As may be seen in Table 2, the astigmatid mites of families Glycyphagidae, Acaridae and Pyroglyphidae (allergenic taxa) constituted 49.48% of all mites collected. Among them *A. farris* was predominant (approx. 34% of the total count), followed by *T. putrescentiae* (4.7%), *Caloglyphus* sp. (4.35%) and *Acarus immobilis* (4.31%); all species of the family Acaridae. *Tyrophagus longior*, *T. similis*, *A. siro* and *Rhizoglyphus* sp. were less abundant and formed 1.27, 0.19, 0.13 and 0.01% of the total mites, respectively. Members of the family Acaridae (acarid mites) were distinctly more abundant as glycyphagids and constituted approximately 39.5% of all mites collected. Moreover, 463 unidentified mites of the family Anoetidae (hypopi) were isolated (9.1%). The remaining part of the astigmatid mite fauna consisted of the following 2 species - *L. destructor* (Glycyphagidae) (0.37%) and *D. farinae* (Pyroglyphidae) (0.05%) (Tab. 2).

Table 3. Abundance and occurrence of allergenic mites found in the particular types of places examined in the Silesian Zoo.

Places examined/Mites[1]	Terrariums			Cages			Runs		
	D (%) (n = 156)	F (%) (N = 13)	M	D (%) (n = 4578)	F (%) (N = 23)	M	D (%) (n = 363)	F (%) (N = 13)	M
Acarus immobilis	NF	NF	NF	3.05	39.13	6.08	22.03	30.76	6.15
Acarus farris	NF	NF	NF	37.87	17.39	75.39	0.55	7.69	0.15
Acarus siro	NF	NF	NF	0.15	8.69	0.30	NF	NF	NF
Tyrophagus longior	NF	NF	NF	0.21	26.08	0.43	16.80	38.46	4.69
Tyrophagus putrescentiae	8.33	23.07	1.0	4.36	43.47	8.69	5.23	15.38	1.16
Lepidoglyphus destructor	NF	NF	NF	0.21	21.73	0.43	2.75	23.07	0.76
Dermatophagoides farinae	NF	NF	NF	0.04	8.69	0.08	0.27	7.69	0.07

[1]including only the allergenic mite species; D - relative dominance (percent of the total count of mites isolated); F - relative frequency (percent of the total count of samples examined); M - mean number of mites per 1 sample; n - number of mites; N - number of samples; NF - not found.

Sources of mites in the Silesian Zoo. Associations with animals. About 89.82% of mites were found in cages, whereas only 7.12% in runs and 3.06% in terrariums. The astigmatid mites were found in 61.2% of the total samples examined. These mites most abundantly occurred in cages (2,761 specimens; 60.31% of the total population) and distinctly more numerously in runs (211 ones; 58.13%) and terrariums (only 14 mites; 8.97%) (Tab. 3). About 83% of mites were collected from aviaries of macaws and cockatiels (*Ara ararauna* and *Nymphicus hollandicus*). Only terrariums of lizards contained exclusively non-astigmatid mites (Tab. 4), mainly members of the order Oribatida, which mites constituted 85.4% of the total count of specimens associated with these reptiles.

A. farris was the dominant mainly in cages of birds species with 1,734 specimens (constituting about 41.10% of the total mite population) and mean number per 1 sample 216.75, and was found in 4 samples (50%) (Tab. 4). Considering all samples examined, *A. farris* was also the most abundant species both per 1 sample (35.42) and per 1 gram of sample, especially in bird cages (2.94). *A. immobilis* was the dominant species in runs of canids (35.15%), whereas *T. longior* of felids (24.3%). *T. putrescentiae* was the most frequent species and was found in 15 samples (30.61% of the total count and 34.1% of samples positive for mites) (Tab. 2). Among astigmatid mites this allergenic species was predominant in terrariums of snakes (17.56%), in cages of primates (16.93%) and runs of artiodactyls (9.55%). Of a total of 239 specimens of *T. putrescentiae* collected, 200 mites were found in cages (83.7%), especially in cages of birds (63.6%). *D. farinae*, the house-dust-mite species, was for the first time found in this environment. This allergenic mite was associated with parrots, canids and artiodactyls, whereas *L. destructor* (most important storage mite species) with artiodactyls, felids, canids and primates (Tab. 4).

Summarizing, it should be stressed, that the main sources of allergenic mites in the Silesian Zoo were indoor spaces (cages), especially aviaries of birds (Tab. 3, 4). The most important allergenic species of astigmatid mites (*Acarus* sp., *T. putrescentiae, T. longior, L. destructor, D. farinae*), together with the allergenic spider mites (Tetranychidae), constituted 45.61% of all mites found in the Silesian Zoo (Tab. 2).

Mite fauna from cages. As many as 4,578 mites were isolated from these samples. Cages show also the highest diversity of mite taxa. *A. farris* was the dominant species (37.9%), and most abundant both per 1 sample (75.4) and per 1 gram of dust (2.95), whereas *T. putrescentiae* and *A. immobilis* were most frequent in these samples (43.5 and 38.13% of all samples from cages, respectively). The remaining part of the astigmatid mite fauna consisted of the following taxa - *Caloglyphus* sp. (4.84% of the total count), *L. destructor* (0.21%), *A. siro* (0.15%), *T. longior* (0.21%), *T. similis* (0.21%), *D. farinae* (0.04%), and unidentified hypopi of Anoetidae (9.3%). Moreover, Tetranychidae constituted 0.52% of mites collected, Cheyletidae 0.34%, Bdellidae 0.02%, other Actinedida 0.06%, Gamasida 21.58% and Oribatida 17.16%.

Mite fauna from runs. A total of 363 mites were isolated from these samples. *A. immobilis* was the dominant species (22.03%), and most abundant per 1 sample (6.15), whereas *T. longior* was most frequent in these samples (38.5%). The remaining part of the astigmatid mite fauna consisted of the following taxa - *T. putrescentiae* (5.23% of the total count), *L. destructor* (2.75%), *A. farris* (0.55%), *D. farinae* (0.27%) (Tab. 5), and unidentified hypopi of Anoetidae (10.5%). Moreover, Tetranychidae constituted 0.55% of mites collected, Cheyletidae also 0.55%, Bdellidae 0.02%, Gamasida 37.19%, Oribatida 2.47% and Ixodida 1.1%.

Mite fauna from terrariums. Only 156 mites were isolated from these samples, including only 14 specimens of the order Acaridida (astigmatid mites). Among them, 2 species, *T. putrescentiae* and *Rhizoglyphus* sp. were found (Tab. 5). These samples were dominated by members of the order Oribatida (71.15% of the total count). The remaining part of the acarofauna consisted of the following taxa - Bdellidae (3.84% of the total count), Cheyletidae (1.28%) and Gamasida (14.74%).

Table 4. Abundance and occurrence of allergenic astigmatid mites associated with particular groups of animals examined.

Groups of animals/Mites[1]	Canids (N=5)	Felids (N=7)	Artiodactyls (N=7)	Primates (N=7)	Snakes (N=8)	Lizards (N=5)	Birds (N=10)
	mean number of mites per 1 sample/mean number of mites per 1 gram (percent of dominance[2]/percent of frequency[3])						
Acarus immobilis	12.83/0.62 (35.15/33.33)	0.42/0.01 (2.08/28.57)	1.62/0.08 (7.30/37.50)	3.0/0.17 (11.47/42.85)	NF	NF	13.25/0.17 (2.51/37.50)
Acarus farris	NF	0.28/0.01 (1.38/0.28)	NF	NF	NF	NF	216.75/2.94 (41.10/50.0)
Acarus siro	NF	NF	NF	NF	NF	NF	0.87/0.01 (0.16/25.0)
Tyrophagus longior	4.33/0.2 (11.87/33.33)	5.0/0.17 (24.3/42.85)	0.37/0.02 (1.68/25.0)	0.14/0.008 (0.54/14.28)		NF	0.75/0.01 (0.14/37.50)
Tyrophagus putrescentiae	3.16/0.15 (8.67/33.33)	NF	2.12/0.11 (9.55/25.0)	4.42/0.26 (16.93/28.57)	1.62/0.03 (17.56 /37.50)	NF	19.0/0.25 (3.60/75.0)
Lepidoglyphus destructor	1.0/0.94 (2.73/33.33)	0.57/0.02 (2.77/14.28)	1.0/0.05 (4.49/50.0)	0.28/0.01 (1.09/14.28)	NF	NF	NF
Dermatophagoides farinae	0.16/0.008 (0.45/16.66)	NF	0.12/0.006 (0.56/12.50)	NF	NF	NF	0.12/0.001 (0.02/12.50)

N - number of samples; [1]including only the allergenic astigmatid mite species; [2]relative dominance (percent of the total count of mites isolated); [3]relative frequency (percent of the total count of samples examined); NF - not found.

Mite exposure. Numbers and densities of mites. Densities (numbers of mites per gram of sample or per 1 sample) of the total mite populations and particular astigmatid mite species were varied between places and/or groups of animals examined, and between seasons (Tab. 1, 3, 4, 5). The mean number of mites per gram of sample was highest in samples from cages and other indoor spaces (4.03), followed by runs (1.24) and terrariums (0.68). Generally, the number of total mites per 1 gram of sample varied from 0.0–31.5 and was highest in cages (aviaries) of cockatiels *Nymphicus hollandicus* (Tab. 1). The mean numbers of total mites per 1 sample was also highest for cages (199.4), followed by runs (27.9) and terrariums (12.0).

Seasonal fluctuations of mite densities. Majority of mites, about 60.3%, was collected during spring, 24.1% during autumn, whereas only 13% in summer and 2.6% in winter. During the winter, mites were found mainly in associations with birds and arctiodactyls. Moreover, mites were found during this season in runs or cages of felids and canids, but only the non-astigmatid taxa, mainly of Gamasida and Oribatida. Among allergenic mites, *Tyrophagus putrescentiae* was most abundant during summer, and more abundant in autumn than in spring. In the case of *D. farinae*, single specimens of the species were found in summer, autumn and winter. *A. siro* occurred most numerously during winter, whereas mites of the family Tetranychidae in autumn. Both dominant species, *A. farris* and *A. immobilis*, as well as *Lepidoglyphus destructor*, were most abundant during the spring months (Tab. 5).

Statistical analysis. The significant correlation in numbers of mites per gram of sample (Pearson's correlation test) was found only between lizards and snakes ($r = 0.73^*$), primates and artiodactyls ($r = 0.62^*$), felids and lizards ($r = 0.51$), and between primates and felids ($r = 0.50$) (Pearson's correlation test; $p < 0.05$, $p < 0.005^*$).

In the case of an occurrence of allergenic mites, *T. putrescentiae* and *A. immobilis* were significantly more frequent in cages than the dominant species *A. farris* ($\chi^2 = 16.1$, $p = 0.0001$ and $\chi^2 = 12.0$, $p = 0.0005$, respectively). Analogically, the latter species occurred in runs significantly less frequently than *T. longior*, *A. immobilis* and *L. destructor* ($\chi^2 = 25.41$, 16.85 and 8.59, respectively; $p < 0.005$), whereas the difference between *A. farris* and *T. putrescentiae* statistically was nonsignificant ($p = 0.12$). Considering individual species of allergenic mites, *T. putrescentiae* was found more frequently in indoor spaces (cages) than in runs and terrariums ($\chi^2 = 19.05$, $p < 0.0001$; $\chi^2 = 9.05$, $p < 0.05$, respectively). Other frequent species, *T. longior*, *A. farris*, *A. immobilis* and *L. destructor*, showed no clear associations with types of examined places ($p > 0.05$). The highest differences, but statistically not significant, were found in the frequency of *A. farris* and *T. longior* between the cages and runs; the former species was more frequent in cages ($\chi^2 = 3.7$, $p = 0.054$), whereas the latter in runs ($\chi^2 = 3.31$, $p = 0.069$).

DISCUSSION

Among the astigmatid mites isolated from the examined samples were found some potentially pathogenic species and genera evoking allergic reactions. The species *L. destructor*, *Acarus siro* complex, *T. putrescentiae*, *T. longior* and *D. farinae* possess strong allergenic properties and represent the main cause of the storage mite allergy, according to many authors [3, 7, 11, 13, 18, 24, 30, 38, 41]. The latter mite plays main role in

Table 5. Abundance and occurrence of allergenic mites isolated in particular seasons of the year during the study (April 2000–March 2001).

Seasons/Mites[1]	Spring			Summer			Autumn			Winter		
	D (%) n = 3075	F (%) N = 13	M	D (%) n = 661	F (%) N = 12	M	D (%) n = 1228	F (%) N = 12	M	D (%) n = 133	F (%) N = 12	M
Acarus farris	54.93	15.38	129.92	1.97	8.33	1.08	NF	NF	NF	5.26	16.67	0.58
Acarus immobilis	6.05	46.15	14.31	0.60	16.67	0.33	1.55	25.0	1.58	827	16.67	0.92
Acarus siro	0.03	7.69	0.08	NF	NF	NF	NF	NF	NF	4.51	8.33	0.50
Tyrophagus longior	1.27	38.46	3.00	3.03	25.0	1.67	0.41	16.67	0.42	0.75	8.33	0.08
Tyrophagus putrescentiae	0.42	30.77	1.00	26.63	41.67	14.67	3.50	33.33	3.58	5.26	16.67	0.58
Lepidoglyphus destructor	0.45	38.46	1.08	0.15	8.33	0.08	0.33	16.67	0.33	NF	NF	NF
Dermatophagoides farinae	NF	NF	NF	0.15	8.33	0.08	0.08	8.33	0.08	0.75	8.33	0.08
Tetranychidae	0.32	15.38	0.77	0.15	8.33	0.08	1.22	16.66	1.25	NF	NF	NF

[1]including only the allergenic mite taxa; D - relative dominance (percent of the total count of mites isolated); F - relative frequency (percent of the total count of samples examined); M - mean number of mites per 1 sample; n - number of mites; N - number of samples; NF - not found.

the house dust mite allergy [1, 2, 3, 4, 5, 11, 15]. It is commonly known that the most important species of allergenic mites which are found in both residential and occupational environments throughout the world include genera *Dermatophagoides*, *Lepidoglyphus*, *Tyrophagus*, *Acarus* and *Glycyphagus*. The spider mites (Tetranychidae) were also recently discovered to induce IgE-mediated reactions [3, 4]. All these allergenic species collected, commonly occur in farming environments in Poland [6, 7, 35]. Majority of them have been found in Poland in bird nests, coal-mines, house dust samples or samples of dust from ocean-going ships [6, 9, 32, 33, 34, 35, 36, 37, 41]. The stated prevalence of acarids and gamasids is in accordance with earlier data from farming environments of Finland, Faroe Islands and Iceland by Hallas [14], Hallas and Solberg [20] and Terho *et al*. [39]. In Poland, the abundance of acarids was smaller and dominance of oribatids and glycyphagids was stated in samples of dust and organic debris from farming environments in Southern Poland [35]. The number of astigmatid mite species was actually higher than that in farming environments in Finland [39], Sweden [8], Norway [27] and Iceland [14, 17], or in coal mines in Poland [34], but lower than in farming environments in Poland [35] or Germany [12], and much lower in comparison with house dust samples [19, 22, 23, 32, 33] or samples of dust from ocean-going ships [41]. Moreover, the pyroglyphid mites were not found in farming environments in Finland, Sweden and Iceland [8, 14, 17, 39]. Mite density per gram of sample was similar as in stored grain, hay and straw or in coal-mine dust [14, 17, 21, 34].

Exposure to storage mite allergens can be through ingestion or by inhalation. The importance of storage mites as ingested or aeroallergens in the urban population has not been studied extensively [3]. The greatest exposure to storage mites usually occurs in an occupational setting where allergies to these mites are of major importance [3]. Allergens of the pyroglyphid mites (e.g. *D. farinae*), show limited cross-reactivity with the storage mites (acarids or glycyphagids) [2]. For the urban population, sensitivity to particular species of storage mites and their cross-reactivity with pyroglyphid dust mites found in house dust are not important because exposure to storage mite species is usually minimal [32, 33]. On the other hand, sensitization to storage mites in urban dwellers has been reported from Spain, Croatia, Denmark, Germany and the USA [2, 3, 4, 5]. For farmers and other agricultural workers, however, both storage and house dust mites may act as inhalant allergens. Therefore, for people living in agricultural or subagricultural settlements, sensitivity to various species of domestic mites and storage mites and cross-reactivity between species may be of clinical significance [2, 3, 4, 5, 35, 37].

Summarizing, the present results reveal the occurrence of allergenic mites in the examined places of the Silesian Zoo. Thus, they should all be regarded as a potential source of mite allergens in this environment. So far, the mites have not been reported as occupational biohazards for workers of Zoo gardens. Our study suggests that the zoological allergenic mites belonging to Acaridae, Glycyphagidae, Pyroglyphidae and Tetranychidae should be considered as occupational risk factors contributing to the occurrence of respiratory and dermal diseases among these workers. As the occurrence and concentration of mites in samples from different places may vary to a considerable extent, further studies are highly desirable.

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