

Indoor mites and forensic acarology

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Abstract House dust mites (HDM) have been shown to produce allergens causing atopic allergies in human beings, known in medicine as house-dust-mite allergy or atopy. Over the past 25 years (1981–2006) a survey of dust samples from different places was made in the southern part of Poland, to determine the diversity of indoor acarofauna. In total, 1,532 samples were taken from dwellings, hospitals, libraries, research laboratories, drug-stores, and offices and other workplaces. More than 30 mite species were found of which the most abundant and common were HDM, especially *Dermatophagoides farinae*. Highest mite densities (g^{-1} dust) were noted in dwellings. This survey revealed differences in the occurrence and prevalence of various species of domestic mites between and within (dwellings in) geographical areas. This knowledge may be useful in the field of forensic medicine.

Keywords Indoor mites · Forensic acarology · House dust mites · Domestic mites · House-dust-mite atopy · Allergenic acarofauna

Introduction

It is impossible to draw a line between allochthonic (visiting) and autochthonic (inhabiting) indoor mite species (Van Bronswijk 1981). In total at least 150 species of mites have been found in dwellings, including plant parasites, animal parasites, predatory mites, oribatid mites and storage mites. But most abundant are house dust mites (HDM), i.e., members of the family Pyroglyphidae, in particular *Dermatophagoides pteronyssinus*, *D. farinae* and *Euroglyphus maynei*. These HDM have been shown to produce allergens causing atopic allergies in human beings, known in medicine as house-dust-mite allergy or atopy (Korsgaard 1983b; Arlian 1991, 2001, 2002; Arlian and Platts-Mills 2001; Vargas and Mairena 1991; Arlian et al. 1993a, b, 2002; Colloff et al. 1992; Platts-Mills et al. 1992; Pope et al. 1993; Robinson et al. 1997; Hallas 1998; Hallas and Korsgaard 1997, 1998).

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HDM usually make up 60–90% of the indoor acarofauna in temperate climate regions throughout the world (Feldman-Muhsam et al. 1985; Hallas 1991; Chew et al. 1999). Although these mites have not been explored yet in forensic investigations, they may have potential use as part of the fauna associated with eventual indoor decomposition.

House dust mites have been reported from a wide variety of other habitats associated with man and his environment, both indoor and outdoor. The possible sources of these mites in house dust are nests of synanthropic birds and stored products (Hughes 1976; Wharton 1976; Van Bronswijk 1981; Fain et al. 1990). These mites are the major sources of indoor inhalant allergens facilitating both the sensitization of atopic subjects and asthmatic attacks in patients (Arlian 1991; Colloff et al. 1992; Fain et al. 1990; Platts-Mills et al. 1992). Since also storage mites have been found in house dust, the term ‘domestic mites’ (DM) has been proposed, including HDM (Pyroglyphidae) and other allergenic mites (mainly DM) occurring in dwellings (Platts-Mills et al. 1992).

DM species have been recovered from animal and human carcasses and only recently they are being studied for their potential as forensic indicators (Baker 2009; Braig and Perotti 2009; Frost et al. 2007; OConnor 2009). The usability of DM/HDM in forensic investigations is dependent on a thorough knowledge of their diversity and abundance in a variety of indoor environments. Over the past 25 years (1981–2006) a survey of dust samples was made from different places throughout the south of Poland (especially in the region of Upper Silesia), to determine the diversity of indoor acarofauna. The details of this extensive survey will be published elsewhere; here a summary of the relevant results on the allergenic mite fauna in dust samples is presented.

Materials and methods

A total of 1,063 house dust samples from 161 dwellings from 31 localities in south-west Poland were taken in the period 1981–2006, including samples from beds, non-carpeted floors, carpets, linoleum, upholstered and wooden furniture, pictures and shutters, taken from bedrooms, living-rooms, kitchens and ante-rooms. In addition to the dwellings, also 281 samples were taken from 11 hospitals (floors and patients’ mattresses), 70 from 9 libraries (floors, chairs, blinds, desks, shelves and books), 31 from research laboratories (floors, chairs, furniture), 30 from drug-stores (floors, chairs), 43 from offices (floors, documents, furniture) and 14 from other workplaces (floors, documents, chairs, furniture).

Dust sampling

All samples (sample area 1 m²) were collected with portable vacuum cleaners, on a specially constructed dust trap filter attached to the end of the hose. A new filter was used for each sample, and samples were kept separately. After vacuuming, dust samples were weighed in a 150 ml beaker and analysed for mites as described by Arlian et al. (1983), with some modifications. Samples were soaked in 75% ethanol for 4 h, suspended in a saturated NaCl solution and a few drops of soap, stirred with a magnetic stirrer, and held in flotation for 24 h. Then supernatants were poured over a filter paper. Sediments were again suspended in NaCl solution—the procedure was repeated at least three times. Filters with the material retained were placed in Petri dishes onto which a saturated NaCl solution was poured. Surface of the liquid and of the filter paper was carefully examined for mites under a binocular stereomicroscope, starting 1–2 h after pouring. Mites were mounted on microscope slides in Hoyer’s medium. Damaged mites were assumed dead at the time of

sampling, whereas intact mites were assumed alive at this time (Colloff 1992). Mite density of each taxon was calculated as number of specimens g^{-1} dust (Platts-Mills et al. 1992) or as number of specimens per sample.

Sampling effort was not homogeneously distributed for all indoor sites over the whole 25 year period. For this paper summarizing averages are presented, based on pooled data for the various sampling periods. A more subtle treatise of the data, including an analysis of variability in the datasets, will be published elsewhere.

Results

Mites were found in 733 of 1,532 samples examined (47.8%). A total of 13,194 mite specimens were collected, of which 95.5% was found in dwellings, whereas only 2.3% occurred in hospitals, 0.95% in libraries, 0.7% in the bakery, 0.4% in coal-mine offices and social rooms, 0.14% in research laboratories and 0.02% in drug-stores. Mean numbers of mites per sample ranged from 0.1 to 18.4, in drug stores and the bakery, respectively.

Mite fauna in dwellings

Of a total of 1,063 samples examined, 596 (56%) were positive for mites. A total of 12,600 mites were isolated, including 9,962 of the family Pyroglyphidae (79%). The species composition of domestic acarofauna in dust samples from dwellings is listed in Table 1 and shows that 19 species of astigmatic mites were identified, including five pyroglyphid species (house dust mites). Most of the pyroglyphid mites found in dwellings belong to the genus *Dermatophagoides* (9,809 specimens; 78% of all mites, 98.5% of all pyroglyphids). Among them, *D. farinae* was predominant (approx. 44% of the total count), followed by *D. pteronyssinus* (34%) and *Euroglyphus maynei* (1%). The other pyroglyphid mites *Hirstia chelidonis* and *Gymnoglyphus longior* occurred in very small numbers (approx. 0.04 and 0.02% of the total count, respectively). *Dermatophagoides farinae* was also the most frequent species and was found in 384 samples (36% of the total count, 64% of samples positive for mites), whereas 291 samples (27%) contained specimens of *D. pteronyssinus* (Table 1).

Among the non-pyroglyphids there were mainly members of the families Chortoglyphidae (*Chortoglyphus arcuatus*), Glycyphagidae (*Gohieria fusca*, *Lepidoglyphus destructor* and *Glycyphagus domesticus*), Acaridae (*Tyrophagus putrescentiae* and *Acarus siro* complex), Cheyletidae, Tarsonemida and Gamasida (Table 1).

Mite fauna in other indoor sites

(Almost) all of the hospitals proved positive for mites. Total number of mites isolated from hospital dust and the number of the samples positive for mites were distinctly lower than in dwellings. As in the dwellings and consistent over the whole survey period and geographical sample area, the most abundant mites were members of the family Pyroglyphidae. Overall, the dominant species was *D. farinae*, followed by *D. pteronyssinus* (Table 2).

Also almost all samples from libraries contained mites, and again most abundant were pyroglyphids. Dominance was variable between sampling periods, between libraries, and between sites within a library (e.g., book shelves, upholstered chairs), but overall *D. pteronyssinus* was the dominant species (Table 2). After dwellings the highest mite

Table 1 Domestic mite species list found in dust samples from dwellings in southern Poland, over the period 1981–2006

Mite taxa	Dominance		Frequency	
	<i>N</i>	% ^a	<i>n</i>	% ^a
<i>Dermatophagoides farinae</i>	5,562	44.1	384	36.1
<i>D. pteronyssinus</i>	4,247	33.7	291	27.4
<i>Dermatophagoides</i> sp.	30		16	1.5
<i>Euroglyphus maynei</i>	116		16	1.5
<i>Gymnoglyphus longior</i>	2		2	
<i>Hirstia chelidonis</i>	5		5	
<i>Acarus siro</i> complex	18		16	1.5
<i>Tyrophagus putrescentiae</i>	58		33	1.4
<i>T. neiswanderi</i>	2		1	
<i>Tyrolichus casei</i>	4		1	
<i>Caloglyphus</i> sp.	2		2	
<i>Rhizoglyphus robini</i>	1		1	
<i>Thyreophagus</i> sp.	1		1	
Acaridae—unidentified	6		4	
<i>Lepidoglyphus destructor</i>	90		15	1.4
<i>L. fustifer</i>	1		1	
<i>Glycyphagus domesticus</i>	40		5	
<i>G. privatus</i>	4		2	
<i>Gohieria fusca</i>	272	2.2	50	4.7
Glycyphagidae—unidentified	5		3	
<i>Chortoglyphus arcuatus</i>	1,790	14.2	43	4.1
Saprogllyphidae	4		3	
Anoetidae	3		3	
Tarsonemida	65		23	2.2
Cheyletidae	172	1.4	76	7.2
Bdellidae	2		2	
Other Actinedida	4		4	
Oribatida	34		20	1.9
Gamasida	60		39	3.7
Total mites/samples	12,600	100	596	100

Partly based on previous publications (Solarz 1998, 2004, 2006)

N number of specimens; *n* number of samples positive for mites (in total, in 596 samples 1 or more mites were found)

^a All percentages can be calculated by the reader—only those >1 are shown

densities were noted in libraries. Therefore, there is a potential risk of an occupational exposure to dust mite allergens among librarians.

Of 43 samples examined in offices, only 5 (12%) were positive for mites. A total of 55 mites were isolated: 54 specimens of *D. farinae* and 1 of *A. siro* (Acaridae). All mites were found in offices, in samples from upholstered chairs (3 samples) and from carpets (2 samples). Generally, mite densities were comparable with those in hospitals (Table 2).

Table 2 Mean abundance of domestic mites (number of mites g⁻¹ dust) in dust samples from hospitals, libraries and offices in southern Poland (mostly Upper Silesia), based on surveys within the period 1981–2006

	<i>Dermatophagoides pteronyssinus</i>	<i>Dermatophagoides farinae</i>	All mites ^a
Hospitals	8	12	18
Libraries	103	24	125
Offices	–	23	24

^a Includes all pyroglyphid and non-pyroglyphid mites

In samples of dust from research institutes only non-pyroglyphid mites were found; 16% of these samples were mite positive. Of 30 drug-store samples, only 2 (7%) were positive for mites and only three mite specimens were found, all from the family Pyroglyphidae: *D. farinae*, *D. pteronyssinus* and *H. chelidonis*. Four species of astigmatic mites were identified in dust samples from a bakery, including only one pyroglyphid (12 specimens of *D. pteronyssinus*); *G. fusca* (Glycyphagidae) was predominant (approx. 40% of the total count), followed by *A. siro* (34%).

Discussion

To date, only 15 species of pyroglyphid dust mites have been found in indoor environments: *D. pteronyssinus*, *D. farinae*, *D. evansi*, *D. microceras*, *D. siboney*, *D. neotropicalis*, *Hirstia domicola*, *H. chelidonis*, *Malayoglyphus intermedius*, *M. carmelitus*, *Sturnophagoides brasiliensis*, *Hughesiella africana*, *Hu. valerioi*, *E. maynei* and *G. longior* (Fain et al. 1990; Vargas and Smiley 1994; Ree et al. 1997; Mehl 1998; Colloff 1998a; Solarz 2001a, b, 2006). Most often these species are found in habitats intimately associated with man, such as beds, couches, sofas, other upholstered furniture, clothing and carpets (Van Bronswijk 1981; Suggars 1987; Fain et al. 1990; Van der Hoeven et al. 1992; Tovey 1992; Horak et al. 1996; Colloff 1998b).

It comes as no surprise that *D. pteronyssinus* and *D. farinae* were found to be the most frequent and most abundant mite species in dust samples. In the literature 32–100% of dust samples from homes and dwellings were positive for both species (Arlian et al. 1978; Van Bronswijk 1981; Halmai 1984; Fain et al. 1990; Hallas 1991; Solarz 2006). Density ratios of *D. pteronyssinus* and *D. farinae* are different in separate regions of the world (Fain et al. 1990; Hart and Whitehead 1990; Mumcuoglu et al. 1999). Decisive factors influencing their occurrence and abundance are mainly relative humidity and temperature, of both outdoor and indoor air (Dusbábek 1995; Korsgaard 1983a; Arlian 1989; Arlian et al. 1978, 1982, 1998a, b; De Boer 1998; Solarz and Seńczuk 2003). Of the two species, *D. farinae* generally survives better in drier habitats, whereas lower temperature (15–20°C) and higher humidity (75–80%RH) favors *D. pteronyssinus* in mixed laboratory cultures (Arlian et al. 1998a). Ambient indoor air humidity varies with degree of ventilation, depending on building construction (Van Bronswijk and Schober 1991), and, therefore, energy-saving dwelling insulation tends to increase indoor humidity and may lead to higher house dust mite densities (especially *D. pteronyssinus*) (Korsgaard 1988, 1998; Harving et al. 1993; Sundell et al. 1995).

In hospitals house dust mites were less frequent and abundant than in dwellings. The low densities correspond with data obtained in British and American hospitals

(Blythe et al. 1975; Rao et al. 1975; Babe et al. 1995), where densities of mites were insignificant. In this study, mite density (g^{-1} dust) was overall higher in dust from beds than in dust from floors. In the area of Stockholm (Sweden), several mite species were found only in floor-dust samples from a hospital for long-term therapy, whereas all examined hospital beds were free from mites (Turos 1979). No *D. farinae* or *D. pteronyssinus* were found in 60 hospital dust samples from carpeted patients' rooms and hallways of a tertiary care hospital in winter in a temperate region in the USA, and average mite density was low in summer (Babe et al. 1995). Actual and previous results are also consistent with the data obtained by Colloff et al. (1991) in Western Australia, where mite concentrations were significantly lower in a sanatorium than in patients' homes (13 and 170 mites g^{-1} dust, respectively). In a Czech study, HDM were only twice as abundant in homes of eczematous children than in hospitals (Vobrázková et al. 1986).

The most important factor for occurrence and breeding of pyroglyphid dust mites is the presence of human beings, dead skin scales being the main source of food for these mites (Hallas 1991; Fain et al. 1990; Van der Hoeven et al. 1992). Beds are commonly known as the main indoor location of HDM; still, they were found in higher density in libraries than in hospitals. Repeated routine cleaning practices, as well as maintenance of low relative humidity, could in part explain the low abundance of mites in public buildings (Green et al. 1992; Babe et al. 1995; Racewicz 2001). High densities on library book shelves may be due to significant quantities of skin scales or dander from readers or library workers associated with (older) books, which serve as suitable food for HDM—but this needs experimental testing.

Domestic mites have not yet been explored in forensic investigations, but there is every reason for doing this. Indoor mites are globally present, yet species composition may vary between seasons, between places and even between sites within a single indoor environment (e.g., dust from a bed vs. the floor around it, or dust from a book shelf vs. a librarian's desk). Subtle differences in HDM composition between sites may yield valuable information, for instance as indicator of time and circumstances of death.

References

- Arlian LG (1989) Biology and ecology of house dust mites, *Dermatophagoides* spp. and *Euroglyphus* spp. (Airborne allergens). *Immunol Allergy Clin North Am* 9:339–356
- Arlian LG (1991) House-dust-mite allergens: a review. *Exp Appl Acarol* 10:167–186
- Arlian LG (2001) Dust mites: update on their allergens and control. *Curr Allergy Asthma Rep* 1:581–586
- Arlian LG (2002) Arthropod allergens and human health. *Annu Rev Entomol* 47:395–433
- Arlian LG, Platts-Mills TAE (2001) The biology of dust mites and the remediation of mite allergens in allergic disease. *J Allergy Clin Immunol* 107:406–413
- Arlian LG, Brandt RL, Bernstein R (1978) Occurrence of house dust mites, *Dermatophagoides* spp. (Acari: Pyroglyphidae) during the heating season. *J Med Entomol* 15:35–42
- Arlian LG, Bernstein IL, Gallagher JS (1982) The prevalence of house dust mites, *Dermatophagoides* spp., and associated environmental conditions in homes in Ohio. *J Allergy Clin Immunol* 69:527–532
- Arlian LG, Woodford PJ, Bernstein IL et al (1983) Seasonal population structure of house dust mites, *Dermatophagoides* spp. (Acari: Pyroglyphidae). *J Med Entomol* 20:99–102
- Arlian LG, Rapp CM, Fernandez-Caldas E (1993a) Allergenicity of *Euroglyphus maynei* and its cross-reactivity with *Dermatophagoides* species. *J Allergy Clin Immunol* 91:1051–1058
- Arlian LG, Vyszynski-Moher DAL, Fernandez-Caldas E (1993b) Allergenicity of the mite, *Blomia tropicalis*. *J Allergy Clin Immunol* 91:1043–1050
- Arlian LG, Confer PD, Rapp CM et al (1998a) Population dynamics of the house dust mites *Dermatophagoides farinae*, *D. pteronyssinus*, and *Euroglyphus maynei* (Acari: Pyroglyphidae) at specific relative humidities. *J Med Entomol* 35:46–53

- Arlian LG, Neal JS, Bacon SW (1998b) Survival, fecundity, and development of *Dermatophagoides farinae* (Acari: Pyroglyphidae) at fluctuating relative humidity. *J Med Entomol* 35:962–966
- Arlian LG, Morgan MS, Neal JS (2002) Dust mite allergens: ecology and distribution. *Curr Allergy Asthma Rep* 2:401–411
- Babe KS, Arlian LG, Confer PD et al (1995) House dust mite (*Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*) prevalence in the rooms and hallways of a tertiary care hospital. Clinical aspects of allergic disease. *J Allergy Clin Immunol* 95:801–805
- Baker AS (2009) Acari in archaeology. *Exp Appl Acarol* 49. doi:[10.1007/s10493-009-9271-1](https://doi.org/10.1007/s10493-009-9271-1)
- Blythe ME, Al Ubaydi F, Williams JD et al (1975) Study of dust mites in three Birmingham hospitals. *Br Med J* 11:62–64
- Braig HR, Perotti MA (2009) Carcasses and mites. *Exp Appl Acarol* 49. doi:[10.1007/s10493-009-9287-6](https://doi.org/10.1007/s10493-009-9287-6)
- Chew FT, Lim SH, Goh DY et al (1999) Sensitization to local dust-mite fauna in Singapore. *Allergy* 54:1150–1159
- Colloff MJ (1992) Age structure and dynamics of house dust mite populations. *Exp Appl Acarol* 16:49–74
- Colloff MJ (1998a) Taxonomy and identification of dust mites. *Allergy* 53(Suppl 48):7–12
- Colloff MJ (1998b) Distribution and abundance of dust mites within homes. *Allergy* 53(Suppl 48):24–27
- Colloff MJ, Stewart GA, Thompson PJ (1991) House dust acarofauna and Der p I equivalent in Australia: the relative importance of *Dermatophagoides pteronyssinus* and *Euroglyphus maynei*. *Clin Exp Allergy* 21:225–230
- Colloff MJ, Ayres J, Carswell F et al (1992) The control of allergens and domestic pets: a position paper. *Clin Exp Allergy* 22(Suppl 2):1–28
- De Boer R (1998) Reflections on the control of mites and mite allergens. *Allergy* 53(Suppl 48):41–46
- Dusbábek F (1995) Present state of research on house dust mites (Pyroglyphidae) in the Czech Republic. *Wiad Parazytol* 41:337–342
- Fain A, Guerin B, Hart BJ (1990) Mites and allergic disease. *Allerbio*, Varennes en Argonne
- Feldman-Muhsam B, Mumcuoglu Y, Osterovich T (1985) A survey of house dust mites (Acari: Pyroglyphidae and Cheyletidae) in Israel. *J Med Entomol* 22:663–669
- Frost CL, Braig HR, Perotti MA (2007) Indoor arthropods of forensic importance. In: Gomes L (ed) *Forensic entomology: new trends and technologies*. Springer, Amsterdam
- Green WF, Marks GB, Tovey ER et al (1992) House dust mites and mite allergens in public places. *J Allergy Clin Immunol* 89:1196–1197
- Hallas TE (1991) The biology of mites. *Allergy* 46(Suppl 11):6–9
- Hallas TE (1998) Pitfalls in evaluating mite exposure from house-dust samples. *Respir Med* 92:1099–1101
- Hallas TE, Korsgaard J (1997) 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* 12:173–177
- Hallas TE, Korsgaard J (1998) Peak expiration flow variations may reflect house-dust-mite exposure and patient reactivity. *Allergy* 53(Suppl 48):101–103
- Halmi Z (1984) Changes in the composition of house-dust mite fauna in Hungary. *Parasit Hung* 17:59–70
- Hart BJ, Whitehead L (1990) Ecology of house dust mites in Oxfordshire. *Clin Exp Allergy* 20:203–209
- Harving H, Korsgaard J, Dahl R (1993) House-dust mites and associated environmental conditions in Danish homes. *Allergy* 48:106–109
- Horak B, Dutkiewicz J, Solarz K (1996) Microflora and acarofauna of bed dust from homes in Upper Silesia, Poland. *Ann Allergy Asthma Immunol* 76:41–50
- Hughes AM (1976) *The mites of stored food and houses*. HMSO, London
- Korsgaard J (1983a) House-dust mites and absolute indoor humidity. *Allergy* 38:85–92
- Korsgaard J (1983b) Mite asthma and residency: a case-control study on the impact of exposure to house dust mites in dwellings. *Am Rev Respir Dis* 128:231–253
- Korsgaard J (1988) Mite asthma and building construction in Denmark. *Allergologie* 11:286–289
- Korsgaard J (1998) Epidemiology of house-dust mites. *Allergy* 53(Suppl 48):36–40
- Mehl R (1998) Occurrence of mites in Norway and the rest of Scandinavia. *Allergy* 53(Suppl 48):28–35
- Mumcuoglu KY, Gat Z, Horowitz T et al (1999) Abundance of house dust mites in relation to climate in contrasting agricultural settlements in Israel. *Med Vet Entomol* 13:252–258
- O'Connor BM (2009) Astigmatid mites (Acari: Sarcoptiformes) of forensic interest. *Exp Appl Acarol* 49. doi:[10.1007/s10493-009-9270-2](https://doi.org/10.1007/s10493-009-9270-2)
- Platts-Mills TAE, Thomas WR, Alberse RC et al (1992) Dust mite allergens and asthma: report of a second international workshop. *J Allergy Clin Immunol* 89:1046–1060
- Pope AM, Patterson R, Burge H (1993) *Indoor allergens. Assessing and controlling adverse health effects*. National Academy Press, Washington

- Racewicz M (2001) House dust mites (Acari: Pyroglyphidae) in the cities of Gdańsk and Gdynia (Northern Poland). *Ann Agric Environ Med* 8:33–38
- Rao VRM, Dean BV, Seaton A et al (1975) A comparison of mite populations in mattress dust from hospital and from private houses in Cardiff, Wales. *Clin Allergy* 5:209–215
- Ree HI, Jeon SH, Hong CS et al (1997) Fauna and geographical distribution of house dust mites in Korea. *Korean J Parasitol* 35:9–17
- Robinson C, Kalsheker NA, Srinivasan N et al (1997) On the potential significance of the enzymatic activity of mite allergens to immunogenicity. Clues to structure and function revealed by molecular characterization. Review. *Clin Exp Allergy* 27:10–21
- Solarz K (1998) The allergenic acarofauna of house dust from dwellings, hospitals, libraries and institutes in Upper Silesia (Poland). *Ann Agric Environ Med* 5:73–85
- Solarz K (2001a) Risk of exposure to house dust pyroglyphid mites in Poland. *Ann Agric Environ Med* 8:11–24
- Solarz K (2001b) Pyroglyphidae (Acari: Astigmata) in Poland. Distribution, biology, population ecology and epidemiology. *Acta Zool Cracov* 44:435–528
- Solarz K (2004) Distribution and ecology of allergenic mites in Poland. *Phytophaga* 14:675–694
- Solarz K (2006) Allergenic mites in habitats associated with man. *Biol Lett* 43:299–306
- Solarz K, Seńczuk L (2003) Allergenic acarofauna of synanthropic outdoor environments in a densely populated urban area in Katowice, Upper Silesia, Poland. *Int J Acarology* 29:403–420
- Suggars AL (1987) House dust mites: a review. *J Entomol Sci (Suppl 1)*:3–15
- Sundell J, Wickman M, Pershagen G et al (1995) Ventilation in homes infested by house-dust mites. *Allergy* 50:106–112
- Tovey ER (1992) Allergen exposure and control. *Exp Appl Acarol* 16:181–202
- Turos M (1979) Mites in house dust in the Stockholm area. *Allergy* 34:11–18
- Van Bronswijk JEMH (1981) House dust biology (for allergists, acarologists and mycologists). NIB Publishers, Zoelmond
- Van Bronswijk JEMH, Schober G (1991) Management of mite development in the home. In: Schuster R, Murphy PW (eds) *The Acari. Reproduction, development and life-history strategies*. Chapman & Hall, London
- Van der Hoeven WAD, de Boer R, Bruin J (1992) The colonisation of new houses by house dust mites (Acari: Pyroglyphidae). *Exp Appl Acarol* 16:75–84
- Vargas MV, Mairena HA (1991) House dust mites from the metropolitan area of San José, Costa Rica. *Internat J Acarol* 17:141–144
- Vargas MV, Smiley RL (1994) A new species of *Hughesiella* (Acari: Astigmata, Pyroglyphidae) from Costa Rica. *Internat J Acarol* 20:123–131
- Vobrázková E, Kasiakova A, Samšínák K (1986) Analysis of dust samples from the clinical environment of children with eczemas. *Angew Parasitol* 27:53–55
- Wharton GW (1976) House dust mites. *J Med Ent* 12:577–621