

Comparison of Living and Bedrooms in Terms of House Dust Mites in the Province of Erzincan, Turkey

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Abstract

The most important factors in development of symptoms such as allergic asthma, rhinitis, conjunctivitis, and dermatitis in atopic persons are the allergens of house dust mites. The objective of this study was to compare living rooms and bedrooms, and woolen and spring mattresses in terms of the number and species of mites in houses in the province of Erzincan, Turkey. In total, 74 dust samples were collected from living rooms and bedrooms of 37 randomly selected houses from various districts of the city. All examined houses were positive for house dust mites. In total, 5,210 mites were isolated, 1,058 from the living rooms and 4,152 from the bedrooms, and the differences were statistically significant ($P < 0.05$). Of 4,152 mites detected in bedrooms, 1,330 (32%) were isolated from 31 spring mattresses and 2,822 (68%) from 6 woolen mattresses ($P < 0.001$). The study identified 14 families, 17 genera, and 16 species belonging to Astigmata, Prostigmata, and Oribatida. Of these, *Dermatophagoides pteronyssinus* (Trouessart) was the dominant species: living rooms, 63.3%; bedrooms, 74.4%; woolen mattresses, 84.6%; and spring mattresses, 52.8%. This was followed by *Lepidoglyphus destructor* (Schränk) (9.8%), *Dermatophagoides farinae* Hughes (5.1%), *Tyrophagus putrescentiae* (Schränk) (4.3%), and *Acarus siro* L. (2.5%) in living rooms; *L. destructor* (11.2%), *Euroglyphus maynei* (Cooreman) (4.2%), *D. farinae* (3.8%), and *T. putrescentiae* (1.0%) in bedrooms; *L. destructor* (11.8%), *D. farinae* (2.1%), *E. maynei* (0.3%), and *T. putrescentiae* (0.2%) in woolen mattresses; and *E. maynei* (12.5%), *L. destructor* (9.9%), *D. farinae* (7.5%), and *T. putrescentiae* (2.7%) in spring mattresses.

Key words: house dust mite, allergy, living room, bedroom, Erzincan

House dust mites belong to the class Arachnida and superorder Acariformes (Krantz and Walter 2009, Zhang 2011). The primary nutritional sources for mites are skin scales rich in proteins and lipids and the microorganisms living on skin. The term “house dust mite” usually is used to define *Dermatophagoides pteronyssinus* (Trouessart), *Dermatophagoides farinae* Hughes, and *Euroglyphus maynei* (Cooreman) mite species, which live in house dust and belong to the Pyroglyphidae family (Spieksma 1997, Colloff 2009). These mites transform from egg to adult stage within about 3–4 wk at 75–80% humidity and 25–30°C. Mean life cycle of adults is 4–6 wk, and each female lays 40–80 eggs within this period (Mumcuoğlu 1977; Colloff 1987, 2009).

The target tissue in respiratory symptoms such as allergic asthma and allergic rhinitis is the respiratory tract's mucosa (Bousquet et al. 2008). Aeroallergens that can directly influence the respiratory tract include allergens from plant pollens, fungal spores, house dust mites, and cockroaches, with house dust mites being the most important in the indoor environment (Bousquet et al. 2008, Gaffin and Phipatanakul 2009). Allergic reactions to house dust mite are the

result of exposure to their excretions or feces, which are digestive waste products and enzymes such as peptidases, proteases, transferases, and glycosidases (Stewart et al. 1992, Arlian and Platts-Mills 2001, Colloff 2009). The main biotopes of house dust mite are mattresses, carpets, and upholstered sofas. A mite defecates, on average, 20 times a day, and these fecal pellets are biodegraded and become airborne, dispersing throughout the house, including onto toys, books, and any other object on which dust can accumulate. These allergens are inhaled, stimulating the immune system in the mucosa of the respiratory tract and initiating specific IgE-mediated allergic reactions (Arlian 1991, Roche et al. 1997, Colloff 2009, Gaffin and Phipatanakul 2009, Gregory and Lloyd 2011, Wu et al. 2014, Calderon et al. 2015).

Knowing the species, quantity, and distribution of house dust mite species in the rooms of a house is of great importance to predicting the potential allergen burden in that area and to taking preventive measures to diminish exposure to house dust mite allergens. The aim of this study was to compare living rooms and bedrooms and woolen and spring mattresses in terms of number of house dust

mites per gram of dust and species composition of house dust mites in the Erzincan province in Turkey.

Materials and Methods

This study was conducted in the province of Erzincan, in the Eastern Anatolian region of Turkey, which has a continental climate and elevation of 1,185 m above sea level. The study collected separately 74 dust samples from the living rooms and bedrooms of 37 randomly selected houses in various districts of the city. The Erzincan University Ethical Committee approved the study (Decision no: 2014-02/06), and at least one members of each household read and signed the informed consent form. Dust samples were compositely collected from carpets and fabric-covered furniture in living rooms and from either spring mattresses or woolen mattresses in bedrooms by a 2-min vacuuming of an area of 1 m² (Colloff 2009) using a vacuum cleaner (Bosch, München, Germany). To prevent results from being affected by seasonal factors, the dust samples were collected within one 1-mo period (July 2014). A separate bag was used to collect dust in each room in each house. The bags were labeled, brought to the laboratory within 6 h, and sieved using 1.5- and 1-cm mesh sieves. Sieved dust samples were transferred to plastic cups, labeled, and kept in a refrigerator until microscopic examination. One gram of each dust sample was examined using the lactic acid method to separate mites from dust (Spieksma and Spieksma-Boezeman 1967, Colloff 2009). For this purpose, dust samples were transferred to Petri dishes, and 10 ml of 90% lactic acid was added, mixed thoroughly, and the dish placed on a hot plate (Velp Scientifica, Europe) and heated at 70–80°C for 30 min. The lactic acid containing the dust was transferred in small quantities to new Petri dishes and examined under a stereomicroscope (Leica EZ4, Switzerland; Colloff 2009, Aykut 2013a). Mites were collected with the help of a No. 00 needle, transferred to a microscope slide with 90% lactic acid, and incubated for 24 h to make mites more transparent, which was helpful in identifying them. Thereafter, a permanent slide was prepared in Hoyer's solution (20 ml glycerin, 30 g crystalline gum arabic, 50 ml pure water, and 200 g chloral hydrate), which was labeled and left in an incubator at 50°C (Binder, Germany) for 7–10 d. Permanent slides were deposited in the Acarology Laboratory, Erzincan University, Erzincan, Turkey. Species identification was carried out with differential interference contrast-equipped light microscope (Olympus BX63, Japan) using known identification keys (Griffiths 1964, Hughes 1976, Martin 1978, Colloff and Spieksma 1992, Zhang 2003, Fan and Zhang 2007, Colloff 2009, Krantz and Walter 2009, Solarz 2012). In mite classification, taxa make use of Krantz and Walter (2009) and Zhang (2011).

Mean number of mites per gram dust was expressed as arithmetic mean, which was calculated by dividing the number of all mites collected from the samples by the number of samples. Statistical analysis was carried out using the Statistical Package for Social Sciences for Windows version 20.0 software (Chicago, IL). Compliance of data to normal distribution was examined by Kolmogorov–Smirnov test, and descriptive analyses were expressed as median and min–max values for nonnormally distributed variables. The Mann–Whitney *U*-test was used to evaluate nonnormally distributed variables. $P < 0.05$ values were considered statistically significant.

Results

In this study, all houses and dust samples included were found positive for mites. The study isolated 1,058 mites, with min 2 and max

Table 1. The number of house dust mites in living rooms and bedrooms

Rooms / Bed type	The number of house dust mites per gram of dust [Median (min–max)]	Mean number of house dust mites per gram of dust	<i>P</i> *
Rooms			
Living room (<i>n</i> : 37)	1,058 [14 (2–136)]	28.5	<0.05
Bedroom (<i>n</i> : 37)	4,152 [24 (2–1,160)]	112.2	
Bed type			
Spring mattress (<i>n</i> : 31)	1,330 [12 (2–270)]	42.9	<0.001
Woolen mattress (<i>n</i> : 6)	2,822 [237 (48–1,160)]	470.3	

* Mann–Whitney *U*-test.

136, in 1 g of dust from samples collected in living rooms and 4,152 mites, with min 2 and max 1,160, in 1 g of dust from samples collected in bedrooms. Mean number of mites in a gram of dust was 28.5 in living rooms and 112.2 in bedrooms. A statistically significant difference was found between the room types in terms of the number of mites per gram of dust ($P < 0.05$). In addition, of 4,152 mites detected in bedrooms, 1,330 (32%) were isolated from spring mattresses and 2,822 (68%) from woolen mattresses. Mean number of mites in a gram of dust was 42.9 in spring mattresses and 470.3 in woolen mattresses. The difference between spring and woolen mattress was statistically significant ($P < 0.001$; Table 1). The study detected 14 families, 17 genera, and 16 species belonging to Astigmata, Prostigmata, and Oribatida. Of these, *D. pteronyssinus* was the dominant species, both in living rooms and bedrooms and both in spring and woolen mattresses (living rooms, 63.3%; bedrooms, 74.4%; woolen mattresses, 84.6%; spring mattresses, 52.8%). This species was followed by *Lepidoglyphus destructor* (Schränk) (9.8%), *D. farinae* (5.1%), *Tyrophagus putrescentiae* (Schränk) (4.3%), and *Acarus siro* L. (2.5%) in living rooms; *L. destructor* (11.2%), *E. maynei* (4.2%), *D. farinae* (3.8%), and *T. putrescentiae* (1%) in bedrooms; *L. destructor* (11.8%), *D. farinae* (2.1%), *E. maynei* (0.3%), and *T. putrescentiae* (0.2%) in woolen mattresses; and *E. maynei* (12.5%), *L. destructor* (9.9%), *D. farinae* (7.5%), and *T. putrescentiae* (2.7%) in spring mattresses. Overall, 91.6% of mites collected from living rooms and 96.3% of mites collected from bedrooms belonged to Astigmata, while 69.2% of mites collected in living rooms and 82.6% of those collected in bedrooms belonged to the family Pyroglyphidae (Table 2).

Discussion

Numerous studies have been conducted worldwide investigating the distribution of house dust mite, the species involved, and the correlation of mite numbers with the quantity of allergens and the prevalence of allergic diseases. To the best of our knowledge, this study was the first to compare living rooms and bedrooms and spring and woolen mattresses in terms of the species of house dust mite and the number of house dust mite per gram of dust.

In the present study, all 74 dust samples (100%) collected separately from living rooms and bedrooms of 37 houses were positive for house dust mite. Other studies worldwide have reported differing positivity rates of houses, as shown by the following: 67% of 52 houses of patients with allergic dermatitis in Copenhagen, Denmark (Alani and Haarlow 1972); 91% of 291 houses in Israel (Feldman-Muhsam et al. 1985); 100% of 124 dust samples collected from 74 houses in Glasgow, Scotland (Colloff 1987); 70.4% of dust samples collected from 15 houses and 2 hotels in Shanghai, China (Tinghuan 1989); 88.3% of 60 dust samples collected from 40 houses in

Table 2. Distribution of house dust mites in living rooms and bedrooms

Superorder/Order/Suborder and family and genus and species				Living room (n: 37)				Bedroom (n: 37)							
								Woolen mattress (n: 6)				Spring mattress (n: 31)			
				A	B	C	D	A	B	C	D	A	B	C	D
Astigmata	Pyroglyphidae	<i>Dermatophagoides</i>	<i>D. pteronyssinus</i>	670	63.32	25	67.57	2,388	84.62	6	100	702	52.78	27	87.10
			<i>D. farinae</i>	54	5.10	3	8.11	60	2.14	2	33.33	100	7.52	6	19.35
		<i>Euroglyphus</i>	<i>E. maynei</i>	8	0.76	2	5.41	8	0.28	1	16.67	166	12.49	3	9.67
	Glycyphagidae	<i>Lepidoglyphus</i>	<i>L. destructor</i>	104	9.82	16	43.24	332	11.77	5	83.33	132	9.93	12	38.71
		<i>Glycyphagus</i>	<i>G. domesticus</i>	0	0	0	0	0	0	0	0	4	0.30	1	3.23
	Acaridae	<i>Tyrophagus</i>	<i>T. putrescentiae</i>	46	4.34	10	27	6	0.21	2	33.33	36	2.70	8	25.81
			<i>T. perniciosus</i>	6	0.57	2	5.41	2	0.07	1	16.67	28	2.10	1	3.23
		<i>Acarus</i>	<i>A. siro</i>	26	2.47	4	10.81	4	0.14	0	0	14	1.05	3	9.67
	Acaridae (Hypopus)			40	3.80	9	24.32	0	0	0	0	16	1.20	6	19.35
	Histiostomatidae	<i>Histiostoma</i> spp. (Hypopus)		14	1.33	3	8.11	4	0.14	1	16.67	14	1.05	5	16.13
	Suidasiidae	<i>Suidasia</i>	<i>S. nesbitti</i>	2	0.19	1	2.70	0	0	0	0	6	0.45	1	3.23
	Total			970	91.70	—	—	2,804	99.37	—	—	1,218	91.58	—	—
Prostigmata	Siteroptidae	<i>Siteroptes</i> spp.		22	2.09	8	21.62	6	0.21	1	16.67	20	1.5	9	29.03
	Tarsonemidae	<i>Tarsonemus</i> spp.		14	1.33	5	13.51	2	0.07	1	16.67	20	1.5	5	16.13
	Raphignathidae	<i>Raphignathus</i>	<i>R. collegiatus</i>	6	0.57	3	8.11	0	0	0	0	8	0.60	4	12.90
	Cheyletidae	<i>Cheyletus</i>	<i>C. malaccensis</i>	0	0	1	2.70	2	0.07	1	16.67	10	0.75	2	6.45
			<i>C. eruditus</i>	2	0.19	0	0	0	0	0	0	4	0.30	1	3.23
	Tetranychidae	<i>Bryobia</i> spp.		2	0.19	1	2.70	4	0.14	1	16.67	12	0.90	5	16.13
		<i>Tetranychus</i> spp.		2	0.19	1	2.70	0	0	0	0	2	0.15	1	3.23
	Trombidioidea			12	1.14	3	8.11	0	0	0	0	4	0.30	1	3.23
	Total			60	5.70	—	—	14	0.49	—	—	80	6.00	—	—
Oribatida	Cosmochthoniidae	<i>Cosmochthonius</i>	<i>C. reticulatus</i>	6	0.57	2	5.41	0	0	0	0	6	0.45	2	6.45
			<i>C. lanatus</i>	6	0.57	2	5.41	0	0	0	0	4	0.30	2	6.45
	Oribatulidae	<i>Zygoribatula</i>	<i>Z. excavata</i>	2	0.19	2	5.41	0	0	0	0	4	0.30	1	3.23
	Hemileiidae	<i>Domatorina</i>	<i>D. plantivaga</i>	2	0.19	2	5.41	0	0	0	0	4	0.30	1	3.23
	Total			16	1.52	—	—	0	0	—	—	18	1.35	—	—
Mesostigmata				12	1.14	3	8.11	4	0.14	1	16.67	14	1.06	4	12.90
Total				1,058	100	—	—	2,822	100	—	—	1,330	100	—	—

A, Number of isolated mites; B, Percentage of the total number of mites; C, Number of the dust samples with mites; D, Incidence of mites.

Florida state in the United States (Fernandez-Caldas et al. 1990); 96% of dust samples collected from bedrooms and 90% of the samples collected from floors in the Cartagena region of Colombia (Fernandez-Caldas et al. 1993); 87.8% of 90 houses in Rome, Italy (Bigliocchi and Maroli 1995); 71.99% of 3,303 houses in which patients with allergic diseases live in another study from Denmark (Hallas and Korsgaard 1997); 73.7% of dust samples collected from 57 mattress in Puerto Rico (Montealegre et al. 1997); 92.9% of 65 houses in Korea (Ree et al. 1997); 97% of 65 houses in rural regions in another study from Israel (Mumcuoglu et al. 1999); 100% of 20 houses in the Klang Valley, Malaysia (Mariana et al. 2000); 47.2% of 335 dust samples collected from 109 houses in Poland (Solarz 2001); 99.4% of 332 dust samples collected from houses of persons with allergic diseases in Galicia, Spain (Boquete et al. 2006); 47.8% of 1,532 dust samples collected from houses, libraries, and hospitals in another study from Poland (Solarz 2009); and 88% of 50 houses in Bandar Abbas, Iran (Soltani et al. 2011).

In Turkey, 24.06% of 133 houses examined from five regions of Anatolia (Kalpaklıoğlu et al. 1997); 18.5% of 72 dust samples collected from six houses in Kütahya (Akdemir and Gürdal 2005); 23.1% of 290 houses in a study including Afyon, Uşak, Denizli, Isparta, and Kütahya (Çiftçi et al. 2006); 23.1% of 303 houses in Malatya (Atambay et al. 2006); 22.7% of 88 houses in Aydın (Ertabaklar et al. 2006); 16.67% of 72 houses in Eskişehir (Doğan et al. 2008); 48% of 50 houses in Hasköy County of Muş (Aykut and Yılmaz 2010); 42% of 100 houses in Diyarbakır (Aykut et al. 2013b); and 85.1% of 54 dust samples collected from 18 houses in Erzincan (Zeytun et al. 2015) were positive for house dust mite.

Generally, it can be said that rates of mite positivity are lower in houses in Turkey than elsewhere. However, it is remarkable that the highest positivity rate was found in the houses in Erzincan province. In addition, results of this study indicate that houses in Erzincan have favorable conditions required by house dust mite.

In previous faunistic studies conducted on house dust mite, carpets and beds have been compared in terms of only mites found in bedrooms or living rooms, respectively. The literature contains no studies that compare number and species of house dust mite in both living rooms and bedrooms and also in spring mattresses and woolen mattresses. Numbers of mites per gram of dust have been reported as follows: mean 970, with min 2 and max 1,210, in 124 dust samples in Glasgow, Scotland (Colloff 1987); mean 139 in beds and 69 in carpets in 3,303 dust samples in Denmark (Hallas and Korsgaard 1997); mean 393 in Houston, TX, and 139 in Dayton, OH, in a study of bedrooms in the United States (Arlan et al. 1999); mean 204.1 in 335 dust samples in Poland (Solarz 2001); mean 65 in 24 dust samples in Bandar Abbas, Iran (Soleimani and Rafinejad 2008); max 6,500 in 291 dust samples in Israel (Feldman-Muhsam et al. 1985); 110–6,200 in beds and 120–5,500 in carpets in Florida state in the United States (Fernandez-Caldas et al. 1990); 1–100 in 90 dust samples in Rome, Italy (Bigliocchi and Maroli 1995); and 10–100 in 65 dust samples in Korea (Ree et al. 1997). In addition, a review published by Colloff (1998) reported a min 3, max 15,600, and mean 297 per gram of dust collected from beds and a min 3, max 1,604, and mean 118 per gram of dust from carpets.

In Turkey, min 25 and max 2,470 mites per gram of dust were isolated from 72 dust samples in Bitlis and Muş provinces (Aykut et al. 2013a), and min 2, max 250, and mean 18.3 mites per gram of

dust were found in 54 dust samples in Erzincan (Zeytun et al. 2015). The collection method of the dust samples used in our study was same with the other studies.

In the present study, 1,058 mites (min 2, max 136, and mean 28.6) were found in the living rooms and 4,152 mites (min 2, max 1,160, and mean 112.2) in the bedrooms of 37 houses. In addition, 2,822 (min 48, max 1,160, and mean 470.3) mites were isolated from woolen mattresses and 1,130 (min 2, max 270, and mean 42.9) mites from spring mattresses. These data demonstrate that bedrooms hosted four times as many mites as living rooms, suggesting that this is the result of using woolen mattresses. Similarly, woolen mattresses hosted 11 times as many mites as spring mattresses. This might be because woolen is an organic fiber with nutritional value in the protein and keratin in its structure, creating a favorable environment for mites in terms of humidity and temperature.

In the present study, 14 species of mites were found in living rooms and 16 species in bedrooms. Of these, *D. pteronyssinus* was the most dominant species in both types of rooms and in both types of mattresses. Likewise, *D. pteronyssinus* has been reported as the most common species in dust samples in Denmark, Hawaii, India, Iran, Israel, Lithuania, Malaysia, Nigeria, Puerto Rico, Scotland, Spain, Switzerland, and Taiwan (Sharp and Haramoto 1970; Alani and Haarlow 1972; Mumcuoglu 1976, 1977; Somorin et al. 1978; Feldman-Muhsam et al. 1985; Colloff 1987; Tinghuan 1989; Montealegre et al. 1997; Mumcuoglu et al. 1999; Agratorres et al. 1999; Sanchez-Covisa et al. 1999; Mariana et al. 2000; Sun and Lue 2000; Deutartiene 2001; Boquete et al. 2006; Soleimani and Rafinejad 2008; Podder et al. 2009; Soltani et al. 2011).

In addition, *D. pteronyssinus* has been reported as the common species in dust samples in other locales in Turkey (Mediterranean, Black Sea, Central, Western, and Eastern Anatolia regions, Sivas, Afyon, Uşak, İzmir, Denizli, Isparta, Kütahya, İstanbul, Ankara, Konya, Bursa, Malatya, Eskişehir, Samsun, Diyarbakır, Bitlis, and Muş; Aygan and Özçelik 2002; Kalpaklıoğlu et al. 2004; Çiftçi et al. 2004, 2006; Aldemir and Baykan 2004; Güleğen et al. 2005; Atambay et al. 2006; Doğan et al. 2008; Çelik and Sullivan 2009; Aykut and Yılmaz 2010; Aykut et al. 2013a,b). However, Zeytun et al. (2015) reported that *A. siro* (55.5%) was the most common species in the houses, followed by *D. pteronyssinus* (50%). This result suggested that *A. siro*, which is a storage mite, is transferred to the houses through stored foods and that the houses have suitable conditions for the proliferation of this mite species. We hope that data obtained from this study have contributed to the knowledge of acarofauna of our nation and the world.

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References Cited

- Agratorres, J. M., A. Pereira-Lorenzo, and I. Fernandez. 1999. Population dynamics of house dust mites (Acari: Pyroglyphidae) in Santiago de Compostela (Galicia, Spain). *Acarologia* 40: 59–63.
- Akdemir, C., and H. Gürdal. 2005. House dust mites in Kütahya of Turkey. *Acta Parasitol. Turc.* 29: 110–115.
- Alani, M. D., and N. Haarlow. 1972. The house dust mite: A possible source of allergen in the environment of patients with atopic dermatitis. *J. Nat. Med. Assoc.* 64: 302–304.
- Aldemir, O. S., and M. Baykan. 2004. The investigation of house dust mites (*Dermatophagoides pteronyssinus*) in dust samples collected with a water reservoir and dust bag vacuum cleaners. *Kafkas Univ. Vet. Fac.* 10: 171–173.
- Arlian, L. G. 1991. House-dust-mite allergens: A review. *Exp. Appl. Acarol.* 10: 167–186.
- Arlian, L. G., M. S. Morgan, and J. F. Goetz. 1999. Quantitation of dust mites and allergen in small dust samples. *J. Allergy Clin. Immunol.* 104: 707–709.
- Arlian, L. G., and T. A. E. Platts-Mills. 2001. The biology of dust mites and the remediation of mite allergens in allergic disease. *J. Allergy Clin. Immunol.* 107: 406–413.
- Atambay, M., Ö. M. Aycan, and N. Daldal. 2006. House dust mites fauna in Malatya of Turkey. *Acta Parasitol. Turc.* 30: 205–208.
- Aygan, Ç., and S. Özçelik. 2002. The prevalence of mites in specimens of house dust and their possible role in atopic allergy, in Sivas. *Acta Parasitol. Turc.* 26: 186–191.
- Aykut, M., and H. Yılmaz. 2010. Distribution of house dust mites in Haskoy town, Muş of Turkey. *Acta Parasitol. Turc.* 34: 160–163.
- Aykut, M., Ö. K. Erman, and S. Doğan. 2013a. Seasonal changes of house dust mite population in Bitlis and Muş provinces of Turkey. *Acta Parasitol. Turc.* 37: 113–117.
- Aykut, M., Ö. K. Erman, and S. Doğan. 2013b. The incidence of house dust mites in home, hotels and dormitories in Diyarbakir of Turkey. *Dicle Univ. J. Inst. Sci. Technol.* 2: 41–47.
- Bigliocchi, F., and M. Maroli. 1995. Distribution and abundance of house dust mites (Acarina: Pyroglyphidae) in Rome, Italy. *Int. J. Aerobiol.* 11: 35–40.
- Boquete, M., V. Iraola, E. Fernandez-Caldas, L. A. Villaroel, F. J. Carballada, C. González de la Cuesta, M. R. López-Rico, R. Núñez Orjales, G. A. Parra, M. T. Soto-Mera, et al. 2006. House dust mite species and allergen levels in Galicia, Spain: A cross-sectional, multicenter, comparative study. *J. Invest. Allergy Clin. Immunol.* 16: 169–176.
- Bousquet, J., N. Khaltaev, A. A. Cruz, J. Denburg, W. J. Fokkens, A. Togias, T. Zuberbier, C. E. Baena-Cagnani, G. W. Canonica, C. van Weel, et al. 2008. Allergic rhinitis and its impact on asthma (ARIA). (in collaboration with the World Health Organization, GA²LEN and AllerGen). *Allergy* 86: 8–160.
- Calderon, M. A., A. Linneberg, J. Kleine-Tebbe, F. De Blay, D. H. R., de Rojas, J. C., Virchow, and P. Demoly. 2015. Respiratory allergy caused by house dust mites: What do we really know? *J. Allergy Clin. Immunol.* 136: 38–48.
- Çelik, N., and S. K. Ö. Sullivan. 2009. House dust mites in house with patients allergic Asthma in Samsun of Turkey, p. 64. *In Proceedings, Turkey III. Plant Protection Congress*, 15–18 Temmuz, Van.
- Çiftçi, İ. H., Z. Çetinkaya, O. C. Aktepe, N. Kiyıld, Ö. M. Aycan, M. Atambay, and M. Altındış. 2004. The relation in between house dust allergens and slgE. *Med. J. Kocatepe.* 5: 29–32.
- Çiftçi, İ. H., Z. Çetinkaya, M. Atambay, N. Kiyıld, Ö. M. Aycan, and N. Daldal. 2006. House dust mite fauna in western Anatolia, Turkey. *Korean J. Parasitol.* 44: 259–264.
- Colloff, M. J., 1987. Differences in development time, mortality and water loss between eggs from laboratory and wild populations of *Dermatophagoides pteronyssinus* (Trouessart, 1897) (Acari: Pyroglyphidae). *Exp. Appl. Acarol.* 3: 191–200.
- Colloff, M. J., 1998. Distribution and abundance within homes. *Allergy* 53: 24–27.
- Colloff, M. J., 2009. House dust mites. Csiro Publishing, New Zealand and Australia.
- Colloff, M. J., and F. T. H. Spijksma. 1992. Pictorial keys for the identification of domestic mites. *Clin. Exp. Allergy* 22: 823–830.
- Deutartiene, A., 2001. Seasonal changes in house dust mites. *Ecology* 2: 1–5.
- Doğan, N., Ö. M. Aycan, Ö. Miman, M. Atambay, and N. Daldal. 2008. The incidence of house dust mites in Eskişehir of Turkey. *Acta Parasitol. Turc.* 32: 139–141.

- Ertabaklar, H., S. Yaman, and S. Ertuğ. 2006. The investigation of mites in dust samples be sent Faculty of Medicine Adnan Menderes University. *Acta Parasitol. Turc.* 30: 29–31.
- Fan, Q.-H., and Z.-Q. Zhang. 2007. *Tyrophagus* (Acari: Astigmata: Acaridae). *Fauna N. Z.* 56: 1–291.
- Feldman-Muhsam, B., K. Y. Mumcuoglu, and T. Osterovich. 1985. A survey of house dust mites (Acari: Pyroglyphidae and Cheyletidae) in Israel. *J. Med. Entomol.* 22: 663–669.
- Fernandez-Caldas, E., R. W. Fox, G. A. Bucholtz, W. L. Trudeav, D. K. Ledford, and R. F. Lockey. 1990. House dust mite allergy in Florida. Mite survey in house hold of mite-sensitive individuals in Tapma, Florida. *Allergy* 11: 263–267.
- Fernandez-Caldas, E., L. Puerta, D. Mercado, R. F. Lockey, and L. R. Caraballo. 1993. Mite fauna, Der p I, Der f I and *Blomia tropicalis* allergen levels in a tropical environment. *Clin. Exp. Allergy* 23: 292–297.
- Gaffin, J. M. and W. Phipatanakul. 2009. The role of indoor allergens in the development of Asthma. *Curr. Opin. Allergy Clin. Immunol.* 9: 128–135.
- Gregory, L. G., and C. M. Lloyd. 2011. Orchestrating house dust mite associated allergy in the lung. *Trends Immunol.* 32: 402–411.
- Griffiths, D. A. 1964. A revision of the genus *Acarus* L., 1758 (Acaridae, Acarina). *Bull. Br. Mus. Nat. Hist. J.* 11: 415–464.
- Güleğen, E., O. Girişgin, F. Kütükoğlu, A. O. Girişgin, and Ş. Z. Çoşkun. 2005. House dust mites in Bursa of Turkey. *Acta Parasitol. Turc.* 29: 185–187.
- Hallas, T. E., and J. Korsgaard. 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. Alergol. Immunol. Clin.* 12: 173–177.
- Hughes, A. M., 1976. The mites of stored food and houses. Her Majesty's Stationery Office, London.
- Kalpakoğlu, A. F., M. Emekci, A. G. Ferizli, and Z. Mısırlıgil. 1997. House dust mite fauna in Turkey. *J. Invest. Allergol. Clin. Immunol.* 7: 578–582.
- Kalpakoğlu, A. F., M. Emekci, A. G. Ferizli, and Z. Mısırlıgil. 2004. A survey of acarofauna in Turkey: Comparison of seven different geographic regions. *Allergy Asthma Proc.* 25: 185–190.
- Krantz, G. W., and D. A. Walter. 2009. A manual of acarology. Texas Tech Univerity Press, Lubbock, TX.
- Mariana, A., T. M. Ho, M. Sofian-Azirun, and A. L. Wong. 2000. House dust mite fauna in the Klang Valley, Malaysia. *Southeast Asian J. Trop. Med. Public Health.* 31: 712–721.
- Martin, N. A. 1978. *Siteroptes* (Siteroptoides) species with *Pediculaster*-like phoretomorphs (Acari: Tarsonemida: Pygmephoridae) from New Zealand and Polynesia. *N. Z. J. Zool.* 5: 121–155.
- Montealegre, F., A. Sepulveda, M. Bayona, C. Quinones, and E. Fernández-Caldas. 1997. Identification of the domestic mite fauna of Puerto Rico. *P. R. Health Sci. J.* 16: 109–116.
- Mumcuoglu, K. Y. 1976. House dust mite in Switzerland: 1. Distribution and taxonomy. *J. Med. Entomol.* 13: 361–373.
- Mumcuoglu, K. Y. 1977. House dust mite in Switzerland: 2. Culture and control. *Int. J. Acarol.* 3: 19–25.
- Mumcuoglu, K. Y., Z. Gat, T. Horowitz, J. Miller, R. Bar-Tana, A. Ben-Zvi, and Y. Naparstek. 1999. Abundance of house dust mites in relation to climate in contrasting agricultural settlements in Israel. *Med. Vet. Entomol.* 13: 252–258.
- Podder, S., S. K. Gupta, and G. K. Saha. 2009. Seasonal prevalence of allergenic mites in house dust of Kolkata Metropolis, India. *Aerobiologia* 25: 39–47.
- Ree, H. I. II, S. H. Jeon, I. Y. Lee, C. S. Hong, and D. K. Lee. 1997. Fauna and geographical distribution of house dust mites in Korea. *Korean J. Parasitol.* 35: 9–17.
- Roche, N., T. C. Chinet, and G. J. Huchon. 1997. Allergic and nonallergic interactions between house dust mite allergens and airway mucosa. *Eur. Respir. J.* 10: 719–726.
- Sanchez-Covisa, A., J. A. Rodriguez, F. De la Torre, and J. C. Garcia-Robaina. 1999. Mite fauna of house dust of the island of Tenerife. *Acarologia* 40: 55–58.
- Sharp, J. M., and F. H. Haramoto. 1970. *Dermatophagoides pteronyssinus* (Trouessart) and other acarina in house dust in Hawaii. *Proc. Hawaii. Entomol. Soc.* 20: 583–589.
- Solarz, K. 2001. Risk of exposure to house dust pyroglyphid mites in Poland. *Ann. Agric. Environ. Med.* 8: 11–24.
- Solarz, K. 2009. Indoor mites and forensic acarology. *Exp. Appl. Acarol.* 49: 135–142.
- Solarz, K. 2012. House dust mites, other domestic mites and forensic medicine. Medical University of Silesia in Katowice, Poland.
- Soleimani, M., and J. Rafinejad. 2008. House dust mite contamination in hotels and inns in Bandar Abbas, south of Iran. *Iran. J. Environ. Health Sci. Eng.* 5: 207–210.
- Soltani, A., K. Azizi, V. Saleh, and T. Dabaghmanesh. 2011. The fauna and distribution of house dust mites in residential homes of Bandar Abbas District, South. Iran. *Exp. Appl. Acarol.* 54: 269–276.
- Somarin, A. O., O. O. Hunponu-Wusu, K. Y. Mumcuoglu, and D. C. Heiner. 1978. Mite allergy in Nigerians: Studies on house dust mites in houses of allergic patients in Lagos. *Irish J. Med. Sci.* 147: 26–30.
- Spieksma, F. T. 1997. Domestic mites from an acarologic perspective. *Allergy* 52: 360–368.
- Spieksma, F. T., and M. I. Spieksma-Boezeman. 1967. The mite fauna of house dust with particular reference to the house dust mite *Dermatophagoides pteronyssinus* (Trouessart, 1897) (Psoroptidae: Sarcoptiformes). *Acarologia* 9: 226–241.
- Stewart, G. A., C. H. Bird, K. D. Krska, M. J. Colloff, and P. J. Thompson. 1992. A comparative study of allergenic and potentially allergenic enzymes from *Dermatophagoides pteronyssinus*, *D. farinae* and *Euroglyphus maynei*. *Exp. Appl. Acarol.* 16: 165–180.
- Sun, H. L., and K. H. Lue. 2000. Household distribution of house dust mite in central Taiwan. *J. Microbiol. Immunol. Infect.* 33: 233–236.
- Tinghuan, C. L. W. 1989. Faunal survey and seasonal prevalence of house dust mites in the urban area of Shanghai. *Acta Ecol. Sin.* 9: 225–229.
- Wu, F.F.S., M. W. Wu, M. H. Ting, J. Crane, and R. Siebers. 2014. Cat, dog and house dust mite allergen levels on children's soft toys. *J. Asthma* 51: 75–78.
- Zeytun, E., S. Doğan, M. Aykut, F. Özçiçek, E. Ünver, and A. Özçiçek. 2015. House dust mites in Erzincan province. *Acta Parasitol. Turc.* 39: 124–130.
- Zhang, Z.-Q. 2003. Mites of greenhouses identification, biology and control. CABI Publishing, UK.
- Zhang, Z.-Q. 2011. Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. *Zootaxa* 3148: 1–237.