

Vector-Borne Diseases, Surveillance, Prevention

The Influence of Indoor Environmental Factors on the Prevalence of House Dust Mites as Aeroallergens in Bandar Abbas Student Dormitories, South of Iran, 2019

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Abstract

This study was conducted to determine the influence of environmental factors on the prevalence of house dust mites in student dormitories of Bandar Abbas city. In this study, 64 dust samples were collected from seven randomly selected dormitories located in various areas of the Bandar Abbas. The collected mites were isolated and mounted in Hoyer's medium and identified using a morphological key. The associations between the environmental factors and the density of house dust mites were investigated. In total, 1,093 adult mites were collected and identified. They consisted of four species including *Dermatophagoides pteronyssinus* Trouessart (57.6%), *Dermatophagoides farinae* Hughes (24.3%) and *Dermatophagoides evansi* Fain (14.9%) (Acari: Pyroglyphidae), and *Cheyletus malaccensis* Oudemans (3.2%) (Acari: Cheyletidae). All of the dormitories were contaminated by more than one house dust mites species and the mean density of house dust mites in dormitories was 8.3 ± 0.2 mites/g of dust. There was a significant relationship between average house dust mites density and some of environmental factors such as relative humidity, temperature, floor covering type, and number of occupants ($P < 0.05$). Results of this study revealed that two major allergenic dust mites, *D. pteronyssinus* and *D. farinae*, were the most prevalent and collected from all of dormitories and some of indoor environmental factors found to influence mites' population.

Key words: environmental factor, house dust mite, dormitory, Bandar Abbas, Iran

Respiratory allergies are one of the most common allergies within different populations around the world (Milián and Dlaz 2004). The prevalence of allergic respiratory diseases is increasing worldwide and it may be as high as 40% in children in developed countries (Bauchau and Durham 2004, Asher et al. 2006). Aeroallergens play a great role in the pathogenesis of most allergic diseases such as rhinitis, asthma, and atopic dermatitis (Milián and Dlaz 2004, Pawankar 2006). House dust mites are considered as the most important source of aeroallergens in the human dwellings (Colloff 2009).

The term house dust mites is used to define *Dermatophagoides farinae* (Hughes), *D. pteronyssinus* (Trouessart), and *Euroglyphus*

maynei (Cooreman) mite species belong to the Pyroglyphidae family (Acari: Pyroglyphidae), which inhabits mostly in house dust (Spieksma 1997, Colloff 2009). House dust mites are cosmopolitan and usually live in human habitats. But there are differences in their allergens and density in different locations (Service 2014). In the recent decades, lifestyle changes including use of central heating systems in homes has provided favorable conditions for proliferation of house dust mites. Consequently, these arthropods have been thriving in many countries (Soltani et al. 2011). They inhabit areas and items of the homes such as bedding, carpets, soft furnishings, books, soft toys, and clothing (Colloff 2009, Macan et al. 2012, Service 2014). The main food sources for mites are microorganisms living on skin

and skin scales rich in lipids and proteins (Zeytun et al. 2016). Allergic reactions to house dust mites occur due to the exposure to their feces and excretions as digestive waste products and enzymes such as proteases, peptidases, glycosidases, and transferases (Stewart et al. 1992, Colloff 2009). Mites defecate, averagely, 20 times per day, and these feces are biodegraded and may become airborne and dispersed on the house items such as furniture, carpets, and other objects on which dust may accumulate. These aeroallergens may be inhaled and stimulate the immune system in the respiratory tract and initiate allergic reactions (Colloff 2009, Calderón et al. 2015, Zeytun et al. 2016). The severity of allergic reactions depends on some of factors including the number of mites and their density (Weinmayr et al. 2007). Usually, there are 300 house dust mites/g of house dust and 5,000 mites may be found in 1 g of mattress dust under ideal breeding conditions. A concentration of more than 100 mites/g of dust is considered as a risk factor for sensitization to allergens (Service 2014).

Some environmental parameters such as relative humidity, amount of rainfall, and temperature play important roles in determining the mite population in the human dwellings. The house dust mites obtain water mostly by absorbing it from the humid air (Fereidouni et al. 2013). The favorable environmental conditions for house dust mites to grow up and proliferate are 55–75% RH at 15–35°C. Thus, mites are typically present in the tropical and humid environments (Johnston et al. 2018).

Bandar Abbas is located in a subtropical area with average relative humidity and annual temperature of 64.4% and 21.5°C, respectively. Such conditions are suitable for proliferation of house dust mites (Yu et al. 2015).

Since the species, density, and distribution of house dust mite species is of importance for predicting the allergen burden in an area and implementing preventive measures to reduce exposure to house dust mite allergens (Zeytun et al. 2016), this study was conducted to determine the influence of indoor environmental factors on the prevalence of house dust mites as aeroallergens in student dormitories of Bandar Abbas city.

Methods

Study Areas

This study was carried out in Bandar Abbas, capital of Hormozgan province, located in south of Iran. It is the largest seaport in Iran, situated at an altitude of 10 m in a coastal area. The city has an area of 45 km² and is located between latitudes 26°53'–27°31'N and longitudes 54°53'–56°03'E, with 680,366 population according to 2016 census from which 51% were males and 49% females (Fig. 1). Bandar Abbas city has a tropical climate with a mean annual temperature of 27.1°C ranging from 18.8 to 35.5°C. Maximum temperature can reach up to 46.3°C in summers, while the minimum temperature drops to about 6.7°C in winters. The rainfall happens

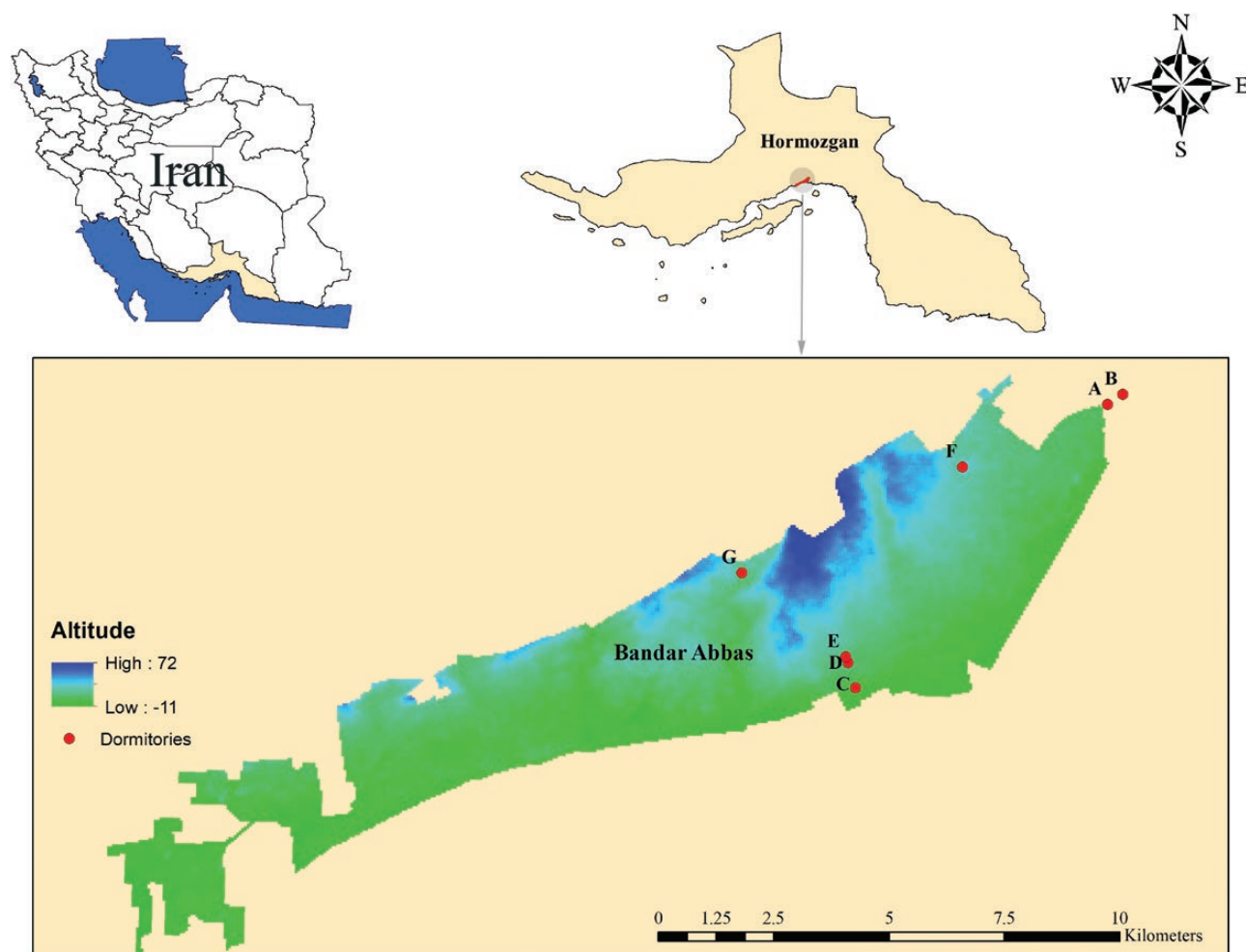


Fig. 1. Map of Iran showing Hormozgan province, Bandar Abbas city, and the location of studied dormitories.

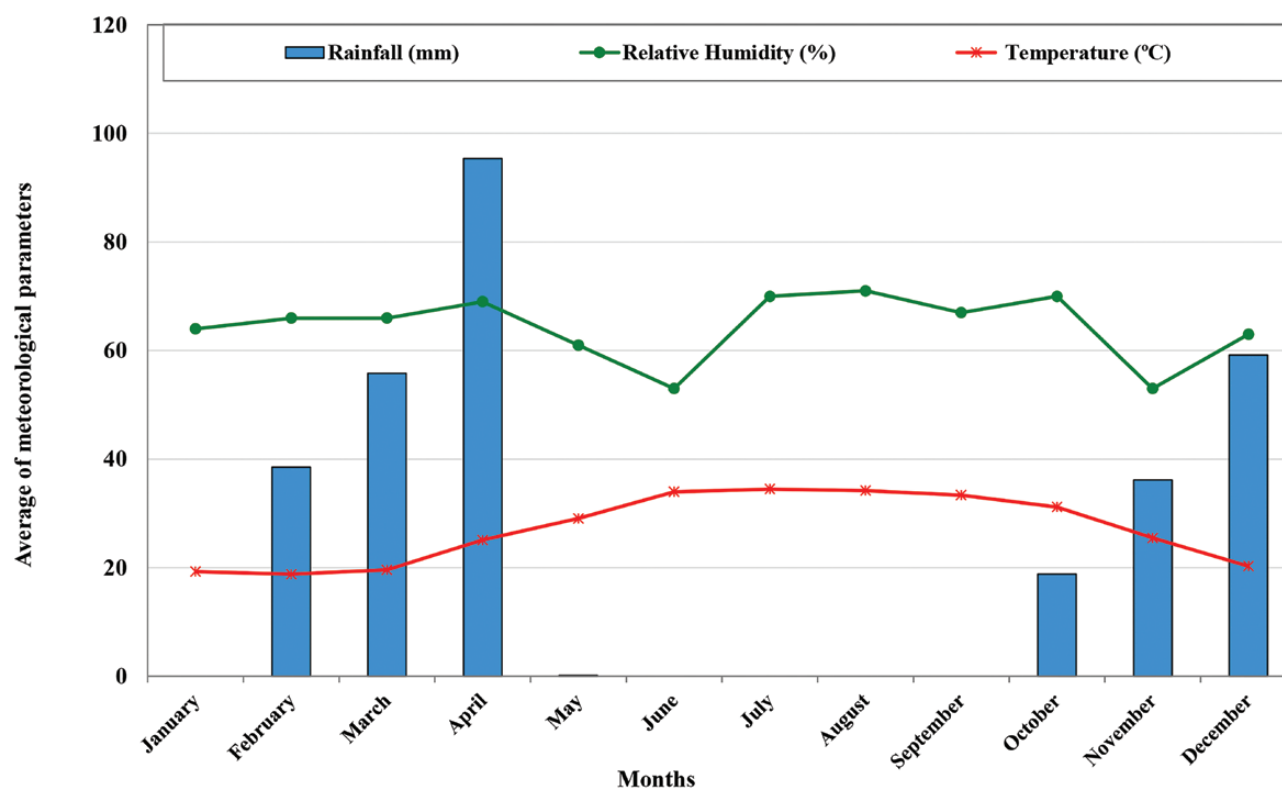


Fig. 2. Average of meteorological parameters influencing prevalence of mites including humidity, temperature, and rainfall during 2018–2019 in Bandar Abbas, southeast of Iran.

through the November–May with a total annual average of 304 mm during 2018–2019. The annual averages of minimum and maximum relative humidity reported to be 53% in November and 71% in August (Fig. 2).

Study Design and Sample Size

This descriptive analytical study was conducted from January to November in Bandar Abbas student dormitories in 2019. To calculate the sample size, the maximum variability was assumed to be 92.5% (Soleimani-Ahmadi et al. 2017). With 95% confidence level and $\pm 7\%$ precision, the minimum number of dust samples was determined using the formula ($n = z^2pq/d^2$) to be 60. A multistage stratified random sampling method was used to select the student suites in dormitories where dust samples were collected. In this regard, seven dormitories were selected according to the geographical distribution and type of dormitories (governmental and self-governing) and the number of students. In the next stage, in each dormitory, in average, nine suites were randomly selected and one dust sample was collected from each suite.

The ethics committee of the Hormozgan University of medical sciences approved this study (Code No: IR.HUMS.REC.1397.086).

Dust Sampling and Identification of Mites

From each suite, one dust sample was collected from the different localities like mattresses, bedroom, living room, sofas, and carpets using a 1,800-W vacuum cleaner.

Dust was collected from 1 m² of the surface during 2 min (Colloff 2009). A paper filter was located in the vacuum cleaner and after vacuuming, filters were placed in plastic bags. In addition, contaminated pieces of the vacuum cleaner were cleaned in every suite to prevent any probable contamination. Each dust sample was labeled

indicating the time, date, and site of collection and transferred to the laboratory for analysis.

A checklist was used to collect information including students' gender, number of students in each suite, and type of floor covering (carpet, moquette). Moreover, indoor temperature and relative humidity of each sampling point were recorded. After collection, samples were transferred to the laboratory and stored in a refrigerator at a temperature of 5°C to kill live mites to prevent increased quantities of mites resulting from oviposition or breeding, and to avoid desiccation of the mites before counting and identification (Spieksma 1997, Colloff 2009).

In the laboratory, the collected dust samples were weighed and separated into 50–100 mg aliquots. To isolate the mites, 10 ml of 90% lactic acid was added to 100 mg of the dust sample. This mixture was heated until boiling and diluted using 90 ml of distilled water. After heating, small samples of the liquid were transferred to a Petri dish and examined under a stereomicroscope for the presence of mites (Colloff 2009, Aykut et al. 2013). Mites were transferred to Hoyer's medium using a fine needle in order to prepare permanent slides. Then, the prepared slides were dried in an oven at 40°C for 10–12 d. Finally, mites were counted and identified according to Colloff and Spieksma (1992). The results were expressed as the number of mites per gram of dust.

Statistical Analysis

Data of mite collection were presented as absolute and also relative frequencies for dormitories and suites. The mean and standard deviation of the mites collected from each dormitory were calculated. The associations between the indoor mean temperature, humidity, type of dormitory, number and gender of students, and type of floor

coverings and the mean density of house dust mites were tested by chi-squared test. Statistical significance was set for values of $P < 0.05$. Statistical analysis was performed using SPSS version 22.0 software.

Results

In this study, 64 dust samples were collected from 64 suites of seven student dormitories in different areas of Bandar Abbas. Mites were detected in 62/64 (96.9%) of dust samples. In total, 1,705 mites, including 612 (35.9%) nymphs and 1,093 (64.1%) adults, were collected and identified. Collected mites were classified in four species and two genera including *D. pteronyssinus*, *D. farinae*, *Dermatophagoides evansi*, and *Cheyletus malaccensis*.

Dermatophagoides pteronyssinus which is a species from the Pyroglyphidae family was the dominant house dust mite and present in all dormitory mite-positive samples. *Dermatophagoides farinae* and *D. evansi*, another species of the Pyroglyphidae mites, were, respectively, the second and the third most frequent species (Fig. 3). The predator mite, *C. malaccensis* of the Cheyletidae family, was the next frequent species (Table 1). The most abundant species of Pyroglyphidae family were *D. pteronyssinus* (57.6%), *D. farinae* (24.3%), and *D. evansi* (14.9%), which together accounted for 96.8% of the total collected mites.

In the present study, all of the dormitories and 96.9% of the suites were contaminated by more than one house dust mites species. The mean number of house dust mites collected from dormitories

was 8.3 ± 0.2 , ranging from 4.9 ± 0.1 to 13.5 ± 0.3 mites/g of dust sample (Table 1).

The average density of house dust mites in the governmental and self-governing dormitories was 9.6 ± 0.2 and 7.1 ± 0.1 mites/g of dust, respectively (Table 2). Although the average density of house dust mites from self-governing dormitories was lower than that of governmental dormitories, no significant differences was found ($P = 0.068$).

Investigation of the relationship between indoor relative humidity changes and house dust mites density in different dormitories showed that, the lowest (4.9 ± 0.1) and the highest (13.5 ± 0.3) mean density of house dust mites were observed in 51 and 59% relative humidity, respectively. There was a significant relationship between indoor relative humidity and house dust mites density ($P = 0.002$) (Fig. 4). Moreover, mean density of house dust mites was significantly associated with indoor temperature changes ($P = 0.001$) and house dust mites abundance increased by the temperature changes from 21 to 24°C. So that the minimum and maximum of house dust mite mean density were observed at 21 and 24°C, respectively (Fig. 4).

In the studied dormitories, most of the suite floors were covered with carpets (82.8%) and higher densities of house dust mites were observed in suites with carpet compared to moquette coverings (Table 2). Statistical analysis showed that there is a significant relationship between the floor covering type and the average abundance of mites ($P = 0.018$).

On average, the abundance of mites in girls' and boys' dormitories were 8.6 ± 0.3 and 8.3 ± 0.2 mites/g of dust, respectively

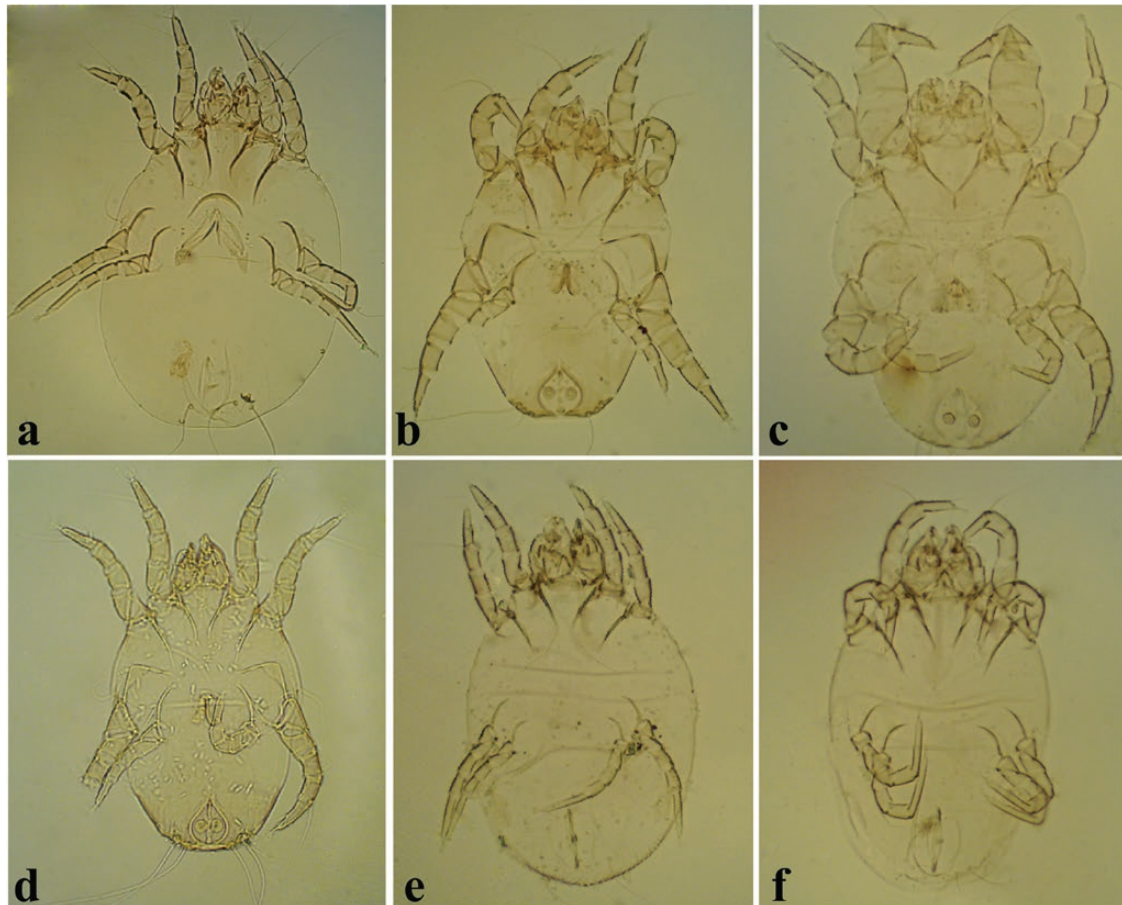


Fig. 3. Some of house dust mites collected in Bandar Abbas dormitories, south of Iran, 2019: *Dermatophagoides pteronyssinus*, female (a); *D. pteronyssinus*, male (b); *D. farinae*, male (c); *D. evansi*, male (d); *Dermatophagoides* spp. Protonymph (e); *Dermatophagoides* spp. tritonymph (f).

Table 1. Species identification and prevalence of house dust mites in Bandar Abbas student dormitories, south of Iran, 2019

Dormitories surveyed	Mites								Total	Mean density $\pm$ SD (mites/g of dust)	
	Pyroglyphidae				Cheyletidae						
	<i>Dermatophagoides pteronyssinus</i>		<i>Dermatophagoides farinae</i>		<i>Dermatophagoides evansi</i>		<i>Cheyletus malaccensis</i>				
	No.	%	No.	%	No.	%	No.	%			
A	166	26.3	81	30.5	0	0.0	4	11.8	251	23.0	13.5 $\pm$ 0.3
B	144	22.9	21	7.9	69	42.3	2	5.9	138	12.6	10.6 $\pm$ 0.2
C	87	13.8	16	6.0	44	27.0	11	23.4	155	14.2	9.7 $\pm$ 0.2
D	88	14.0	45	16.9	0	0.0	5	14.7	236	21.6	8.7 $\pm$ 0.2
E	37	5.9	42	15.8	25	15.3	0	0.0	104	9.5	6.6 $\pm$ 0.1
F	91	14.4	10	3.8	25	15.3	7	20.6	133	12.2	5.6 $\pm$ 0.1
G	17	2.7	51	19.2	0	0.0	5	14.7	76	7.0	4.9 $\pm$ 0.1
Total	630	57.6	266	24.3	163	14.9	34	3.2	1093	100	8.3 $\pm$ 0.2

(Table 2). The frequencies of mites in dust samples were not significantly associated with the gender of student ($P = 0.219$).

The results showed that house dust mite contamination rate in dormitories was positively associated with number of students in each suite ($P = 0.0001$) and the highest mean density of house dust mites (11.2 ± 0.3) was observed in suites with more than eight occupants (Table 2).

Discussion

House dust mites are one of the most important sources of indoor allergens associated with many allergic diseases such as asthma, rhinitis, sinusitis, conjunctivitis, and atopic dermatitis (Miller 2019).

In the recent decades, the prevalence of allergic diseases due to house dust mites have significantly increased, because in the modern life style, people spend most of their time in their houses which are filled with furniture, warmer, and less ventilated (Yong and Jeong 2009).

The present study confirms that house dust mites are prevalent in Bandar Abbas student dormitories.

According to the results, *D. pteronyssinus* was the most dominant species accounting 59.5% of the pyroglyphid mites and 57.6% of the total mites' population. In recent studies in residential places, Kindergartens, and hotels of the Bandar Abbas city, *D. pteronyssinus* was the most abundant species and 86, 63, and 31% of the collected house dust mites belonged to this species, respectively (Soleimani and Rafinejad 2008, Soltani et al. 2011, Soleimani-Ahmadi et al. 2017). Similarly, in a study in the residential places in Iran, this mite was reported as the most prevalent species with a relative frequency of 90% (Amoli and Cunningham 1977).

Parallel to these findings, a study in Brazil reported *D. pteronyssinus* as the most frequent species in houses followed by *D. farinae* and *E. maynei* (Terra et al. 2004). In another study conducted in Williamsburg, Virginia, United States, high prevalence of *D. pteronyssinus* species in residential places was observed (Lassiter and Fashing 1990). Likewise, *D. pteronyssinus* has been considered as the most common species in dust samples in Turkey, Saudi Arabia, Taiwan, Hong Kong, China, Malaysia, India, and Spain (Agratorres et al. 1999, Mumcuoglu et al. 1999, Mariana et al. 2000, Sun and Lue 2000, Sun et al. 2004, Feng et al. 2009, Podder et al. 2009, Edrees 2012, Zeytun et al. 2016).

According to the results of many studies from all around the world, high humidity is an important factor for proliferation of *D. pteronyssinus* and it occurs in every household with a relative humidity of more than 45% (Arlian et al. 2002, Zeytun et al. 2016, Pei et al. 2020). The high prevalence of *D. pteronyssinus* in our study area may be explained by high relative humidity because the study area is located close to the Persian Gulf and has a warm and humid climate.

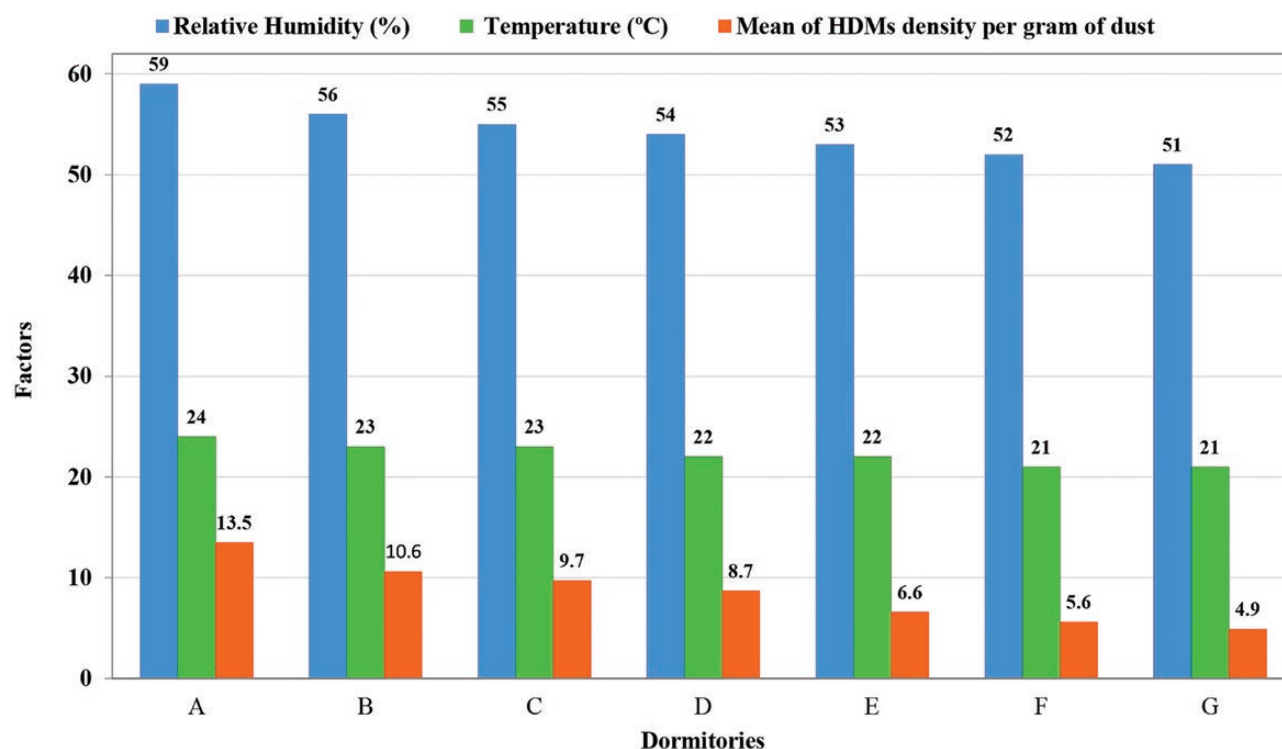
In this study, *D. farinae*, another species of pyroglyphid mites, was the second most prevalent species with a frequency of 24.3% and collected from all of the dormitories. In previous faunistic studies conducted on house dust mites in this area, the frequency of this species in the hotels, kindergartens, and residential places was 11.6, 17.7, and 32.8%, respectively (Soleimani and Rafinejad 2008, Soltani et al. 2011, Soleimani-Ahmadi et al. 2017).

This finding is in agreement with results from Thailand and Turkey which showed low prevalence of this species with a frequency of 24.4 and 12% of pyroglyphid mites, respectively (Malainual et al. 1995, Kalpaklioglu et al. 2004).

Dermatophagoides farinae has a better ability to adapt to dry environments and is the most prevalent in dry continental

Table 2. Factors influencing abundance of house dust mites in Bandar Abbas student dormitories, south of Iran, 2019

Variable	Categories	Suites		Mean density $\pm$ SD (mites/g of dust)	P-value
		No.	%		
Dormitory type	Government	40	62.5	9.6 $\pm$ 0.2	0.068
	Self-governing	24	37.5	7.1 $\pm$ 0.1	
Students' gender	Female	42	65.6	8.6 $\pm$ 0.3	0.219
	Male	22	34.4	8.3 $\pm$ 0.2	
Floor type	Carpet	35	82.8	12.2 $\pm$ 0.4	0.018
	Moquette	11	17.2	4.9 $\pm$ 0.2	
Number of students in each suite	1–3	11	17.2	4.9 $\pm$ 0.1	0.0001
	4–7	25	39.1	6.8 $\pm$ 0.3	
	≥ 8	28	43.7	12.2 $\pm$ 0.3	

**Fig. 4.** House dust mites' density per gram of dust, indoor temperature, and relative humidity in Bandar Abbas student dormitories, South of Iran, 2019.

climates, sporadic in coastal climates, such as the Black Sea and Mediterranean regions of Turkey, and the British Isles, and absent in Central Africa and Cuba (Malainual et al. 1995, Arlian et al. 1998, Hill and DeBoer 2001). Accordingly, low frequency of *D. farinae* in this study can be attributed to unfavorable environmental conditions such as high level of humidity.

The results showed that, *D. evansi*, another species of pyroglyphid mites, was the third frequent species with a frequency of 14.9%. Results of different studies in Iran have shown low prevalence of this species in residential places. For example, small numbers of *D. evansi* has been reported by Amoli and Cunningham (1997) in different parts of Iran. Moreover, in recent studies conducted in residential places and kindergartens of Bandar Abbas, 4.1 and 23.9% of the collected mites were *D. evansi* (Soltani et al. 2011, Soleimani-Ahmadi et al. 2017). This mite has also been reported from other countries such as Poland, the Baltic States, Russia, and Bulgaria (Edrees 2012). In most cases, *D. evansi* has been reported to be associated with poultry (Mumcuoglu and Lutsky 1990). The presence

of this species in the studied dormitories may be due to the fact that neighbors keep poultry in their homes.

Moreover, we observed, low numbers of *Cheyletus malaccensis* (Oudemans), which is a predatory mite from the Cheyletidae family (Acari: Cheyletidae). This species has been reported from different parts of the world and is associated with parasitism, and in a case study from Brazil, it was responsible for dermatological manifestations (Ezequiel et al. 2001, Dutra et al. 2018).

This study reveals that, all dormitories were contaminated with at least one house dust mite species and mean density of house dust mites in dormitories was 8.3 ± 0.2 mites/g of dust. This finding is similar to previous studies in residential places and kindergartens of the Bandar Abbas city, which reported the rate of house dust mites contamination to be 88 and 100%, respectively (Soleimani and Rafinejad 2008, Soltani et al. 2011, Soleimani-Ahmadi et al. 2017). The high house dust mite contamination in the dormitories of Bandar Abbas city can be explained by high relative humidity and temperature, because the city is

situated in a coastal tropical area at an altitude of 10 m higher than the sea level.

In other studies, conducted in the north of Iran in Guilan Province and Sari city, respectively, 98 and 37.5% of the houses were contaminated with house dust mites (Haghi et al. 2003, Soltani et al. 2011).

The results of the present study have confirmed the relationship between the density of house dust mites and indoor air humidity and temperature. Similarly, numerous studies have demonstrated the crucial influence of indoor relative humidity and temperature on the abundance of house dust mites around the world (Lassiter and Fashing 1990, Terra et al. 2004, Colloff 2009, Soltani et al. 2011). House dust mites obtain water mostly by absorbing it from humid air (Arlian 1992). The favorable environmental conditions for house dust mites to grow up and proliferate are 55–75% relative humidity at 15–35°C (Arlian 1992, Arlian and Platts-Mills 2001). In this regard, previous studies have shown that climate affect mite numbers, and usually higher densities of house dust mites are found in humid and warm climates in contrast with dry ones (Crisafulli et al. 2007). Therefore, high density of house dust mites in the studied dormitories may be explained by the relative humidity in the area which ranges from 51% (November) to 72% (August), and the temperature which ranges from 5 to 49°C, providing an ideal year-round environment for house dust mites proliferation.

This study also showed a positive relationship between floor covering type and the average abundance of mites. In this regard, carpeted floors contained significantly more mites than moquette floors. This finding is supported by other studies in different parts of Iran (Amoli and Cunningham 1977, Soltani et al. 2011, Ziyaei et al. 2017). Similarly, in studies conducted in Denmark, United States, Netherlands, New Zealand, Singapore, Korea, and Australia, an association between house dust mites infestation and carpeted floors in homes was reported (Fernández-Caldas et al. 1990, Van Strien et al. 1994, Hallas and Korsgaard 1997, Wickens et al. 1997, Chew et al. 1999, Dharmage et al. 1999, Nam et al. 2008).

Dust mites and mite allergens are more abundant on carpeted than on smooth floors and several studies have shown that carpets are important sources of dust mite allergen (Miller 2019). Carpets have gaps between fibers, which provide a dark and humid space for mites to thrive. Dust can settle in carpets and they are not regularly cleaned, and even with modern vacuum cleaners, it is hardly possible to get all the debris including human skin scales (as a food source for mites) and dust mite allergens out of a carpet (Sercombe et al. 2007). Moreover, it is impossible to remove the live mites from a carpet by a vacuum cleaner, because they have elegant foot pads that help them to hold on to any surface (Wilson et al. 2018).

In this study, the mean density of house dust mites in the students' suites was also positively associated with the number of occupants. In accordance with this finding, Hoeven et al. (1992) concluded that there is a tendency for heavier infestations to occur in rooms with more occupants. Similarly, results of the studies in Netherlands and New Zealand showed that the density of house dust mites in houses is significantly associated with the number of occupants (van der Hoeven et al. 1992, Van Strien et al. 1994, Wickens et al. 1997, Chew et al. 1999, Dharmage et al. 1999, Sercombe et al. 2007, Nam et al. 2008, Wilson et al. 2018). Higher abundance of house dust mites in crowded suites may be explained by the influence of increasing the relative humidity due to the increased occupants' density. Another reason may be that in the crowded suites more meals are served which results in more debris as a food source for mites' reproduction and population development.

Dermatophagoides farinae and *D. pteronyssinus* are the most important mite species in terms of clinical relevance and allergenicity

(Arlian 1991). They are two pyroglyphid mites and have Der f1 and Der p1 allergens, which elicit IgE antibody responses in the most of the patients (Arlian 1991, Fereidouni et al. 2013).

Different studies in the Middle East region have reported house dust mites as respiratory allergens. In this regard, results of a study conducted in United Arab Emirates, Saudi Arabia, and Sudan showed that *D. pteronyssinus* and *D. farinae* extracts are the main causes of allergenicity in the studied patients (Hasnain et al. 2012). Other studies in Jordan, Iraq, Qatar, Kuwait, and Palestine have also reported *D. farinae* and *D. pteronyssinus* as the main house dust mite allergens (Goronfolah 2016).

Similarly, a recent study on 255 allergic patients in Tehran showed 25.8 and 21.5% positive skin prick test in the case of exposure to extracts of *D. farinae* and *D. pteronyssinus*, respectively (Pazoki et al. 2018). The results of another study in Tehran showed that 18 and 19% of asthmatic patients who referred to an allergy clinic had a positive response to *D. farinae* and *D. pteronyssinus*, respectively (Farhoudi et al. 2005). Moreover, the results of a similar study in Mashhad, north east of Iran, showed that the prevalence of positive skin prick test to *D. pteronyssinus* and *D. farinae* was 20.1 and 17.5%, respectively (Fereidouni et al. 2009). In addition, results of atopy studies using skin prick test to find most common aeroallergens in allergic patients in different cities of Iran including Yazd, Shiraz, Sari, and Ahwaz revealed *D. farinae* and *D. pteronyssinus* as the main house dust mite allergens (Farhoudi et al. 2005, Fereidouni et al. 2009, Assarehzadegan et al. 2013, Goronfolah 2016, Pazoki et al. 2018).

Since common dust mite species including *D. pteronyssinus* and *D. farinae* feed mainly from skin scales shed by humans and other organic detritus that accumulate in homes, the prevalence of these mites can be controlled by good housekeeping. In addition, in this area because of the sultry weather, students prefer to stay more indoors and it increases their exposure to house dust mite allergens. Therefore, a comprehensive program for improvement of housing conditions needs to be implemented to reduce house dust mite prevalence and exposure. Moreover, as house dust mites satisfy their requirement of water by taking up vapor from the surroundings, maintaining a low humidity in dormitories can be considered as an effective measure to reduce the prevalence of house dust mites (Milián and Dlaz 2004). It is also important to provide appropriate educational programs to students to increase their awareness about house dust mites and related health risks.

According to the results, the highest mean density of mites collected from Bandar Abbas dormitories was 13.5 ± 0.3 mites/g of dust, which is lower than the allergenicity index, meaning that the studied dormitories are not considered 'allergic high risk' regions. Therefore, the possibility of severe mite-related respiratory allergies, such as severe bronchitis and asthma attacks, in students residing in Bandar Abbas dormitories is low. But due to the presence of *D. pteronyssinus*, *D. farinae*, and *D. evansi* mites and their role in respiratory allergic diseases, and considering the influence of some of indoor environmental factors such as relative humidity, temperature, and floor covering type on the mites' density, a comprehensive program for improvement of housing and environmental conditions is necessary for reduction of mite population and prevention of respiratory diseases in dormitories.

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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.
- Amoli, K., and A. M. Cunningham. 1977. House dust mites in Iran. *Clin. Allergy* 7: 93–101.
- Arlian, L. G. 1991. House-dust-mite allergens: a review. *Exp. Appl. Acarol.* 10: 167–186.
- Arlian, L. G. 1992. Water balance and humidity requirements of house dust mites. *Exp. Appl. Acarol.* 16: 15–35.
- 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.
- Arlian, L. G., P. D. Confer, C. M. Rapp, D. L. Vyszynski-Moher, and J. C. Chang. 1998. 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, L. G., M. S. Morgan, and J. S. Neal. 2002. Dust mite allergens: ecology and distribution. *Curr. Allergy Asthma Rep.* 2: 401–411.
- Asher, M. I., S. Montefort, B. Björkstén, C. K. Lai, D. P. Strachan, S. K. Weiland, and H. Williams; ISAAC Phase Three Study Group. 2006. Worldwide time trends in the prevalence of symptoms of asthma, allergic rhinoconjunctivitis, and eczema in childhood: ISAAC Phases One and Three repeat multicountry cross-sectional surveys. *Lancet* 368: 733–743.
- Assarehzadegan, M. A., A. Shakurnia, and A. Amini. 2013. The most common aeroallergens in a tropical region in Southwestern Iran. *World Allergy Organ J.* 6: 1–7.
- Aykut, M., Ö. K. Erman, and S. Dogan. 2013. Seasonal changes of house dust mite population in Bitlis and Muş provinces of Turkey. *Acta Parasitol. Turc.* 37: 113–117.
- Bauchau, V., and S. R. Durham. 2004. Prevalence and rate of diagnosis of allergic rhinitis in Europe. *Eur. Respir. J.* 24: 758–764.
- Calderón, M. A., A. Linneberg, J. Kleine-Tebbe, F. De Blay, D. Hernandez Fernandez 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.
- Chew, F. T., L. Zhang, T. M. Ho, and B. W. Lee. 1999. House dust mite fauna of tropical Singapore. *Clin. Exp. Allergy* 29: 201–206.
- Colloff, M. J. 2009. Dust mites. Csiro Publishing, Collingwood, Australia.
- Colloff, M. J., and F. T. Spiessma. 1992. Pictorial keys for the identification of domestic mites. *Clin. Exp. Allergy* 22: 823–830.
- Crisafulli, D., C. Almqvist, G. Marks, and E. Tovey. 2007. Seasonal trends in house dust mite allergen in children's beds over a 7-year period. *Allergy* 62: 1394–1400.
- Dharmage, S., M. Bailey, J. Raven, A. Cheng, J. Rolland, F. Thien, A. Forbes, M. Abramson, and E. H. Walters. 1999. Residential characteristics influence Der p 1 levels in homes in Melbourne, Australia. *Clin. Exp. Allergy* 29: 461–469.
- Dutra, M. S., C. Roncada, G. L. da Silva, N. J. Ferla, and P. M. Pitrez. 2018. Mite fauna assessment in houses of two distinct socioeconomic groups from Southern Brazil. *J. Med. Entomol.* 55: 620–625.
- Edrees, N. O. 2012. Prevalence of house dust mites in two levels of dorms (hotel and motel) of Jaddah District Western Saudi Arabia. *Life Sci. J.* 9: 3673–3683.
- Ezequiel, O. d. S., G. S. Gazêta, M. Amorim, and N. M. Serra-Freire. 2001. Evaluation of the acarofauna of the domiciliary ecosystem in Juiz de Fora, State of Minas Gerais, Brazil. *Mem. Inst. Oswaldo Cruz* 96: 911–16.
- Farhoudi, A., A. Razavi, Z. Chavoshzadeh, M. Heidarzadeh, M. H. Bemanian, and M. Nabavi. 2005. Descriptive study of 226 patients with allergic rhinitis and asthma in Karaj city. *Iran J. Allergy Asthma Immunol.* 4: 99–101.
- Feng, M., W. Sun, and X. Cheng. 2009. Seasonal dynamics and distribution of house dust mites in China. *Biosci. Trends* 3: 210–215.
- Fereidouni, M., R. F. Hossini, F. J. Azad, M. A. Assarehzadegan, M. Ali Assarehzadegan, and A. Varasteh. 2009. Skin prick test reactivity to common aeroallergens among allergic rhinitis patients in Iran. *Allergol. Immunopathol. (Madr)*. 37: 73–79.
- Fereidouni, M., F. Fereidouni, M. Hadian, S. h. Nourani Hasankiadeh, M. Mazandarani, and M. Ziaee. 2013. Evaluation of the level of house dust mite allergens, Der p 1 and Der f 1 in Iranian homes, a nationwide study. *Allergol. Immunopathol. (Madr)*. 41: 381–386.
- Fernández-Caldas, E., R. W. Fox, G. A. Bucholtz, W. L. Trudeau, D. K. Ledford, and R. F. Lockey. 1990. House dust mite allergy in Florida. Mite survey in households of mite-sensitive individuals in Tampa, Florida. *Allergy Proc.* 11: 263–267.
- Goronfolah, L. 2016. Aeroallergens, atopy and allergic rhinitis in the Middle East. *Eur. Ann. Allergy Clin. Immunol.* 48: 5–21.
- Haghi, F., M. Sharif, R. Esmaeli, J. Rafinejad, and B. Parsi. 2003. Identification of different species of mites in dust, collected from residents of sari township in 1999–2000. *J. Maz. Univ. Med. Sci.* 13: 54–58.
- Hallas, T., 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. Allergol. Immunol. Clin.* 12: 173–177.
- Hasnain, S. M., A. R. Al-Frayh, J. L. Subiza, E. Fernández-Caldas, M. Casanovas, T. Geith, M. O. Gad-El-Rab, E. Koshak, H. Al-Mehdar, S. Al-Sowaidi, et al. 2012. Sensitization to indigenous pollen and molds and other outdoor and indoor allergens in allergic patients from Saudi Arabia, United Arab Emirates, and Sudan. *World Allergy Organ J.* 5: 59–65.
- Hill, P. B., and D. J. DeBoer. 2001. The ACVD task force on canine atopic dermatitis (IV): environmental allergens. *Vet. Immunol. Immunopathol.* 81: 169–186.
- Johnston, J. D., T. P. Barney, J. H. Crandall, M. A. Brown, T. R. Westover, S. M. Paulson, M. S. Smith, and K. S. Weber. 2018. Prevalence of house dust mite allergens in low-income homes with evaporative coolers in a semiarid climate. *Arch. Environ. Occup. Health* 73: 38–41.
- Kalpakklioglu, A. F., M. Emekçi, A. Ferizli, and Z. Misirligil; House-Dust Mite Working Group. 2004. A survey of acarofauna in Turkey: comparison of seven different geographic regions. *Allergy Asthma Proc.* 25: 185–190.
- Lassiter, M. T., and N. J. Fashing. 1990. House dust mites in Williamsburg, Virginia. *VA. Med.* 117: 152–157.
- Macan, J., B. Kanceljak-Macan, and S. Milković-Kraus. 2012. Pyroglyphid mites as a source of work-related allergens. *Arh. Hig. Rada Toksikol.* 63(suppl. 1): 57–66.
- Malainual, N., P. Vichyanond, and P. Phan-Urai. 1995. House dust mite fauna in Thailand. *Clin. Exp. Allergy* 25: 554–560.
- 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.
- Milián, E., and A. M. Díaz. 2004. Allergy to house dust mites and asthma. *P R Health Sci. J.* 23: 47–57.
- Miller, J. D. 2019. The role of dust mites in allergy. *Clin. Rev. Allergy Immunol.* 57: 312–329.
- Mumcuoglu, K., and I. Lutsky. 1990. The life-cycle of *Dermatophagoides evansi* Fain, 1967 (Acari: Pyroglyphidae), a mite associated with poultry. *Acarologia* 31: 191–194.
- 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.
- Nam, H. S., R. Siebers, S. H. Lee, J. S. Park, Y. B. Kim, Y. J. Choi, S. H. Lee, and J. Crane. 2008. House dust mite allergens in domestic homes in Cheonan, Korea. *Korean J. Parasitol.* 46: 187–189.
- Pawankar, R. 2006. Allergic rhinitis and asthma: are they manifestations of one syndrome? *Clin. Exp. Allergy* 36: 1–4.
- Pazoki, N., A. Ahmadi, F. Onori, M. Mosavi Khorshidi, M. Mansori, and J. Salimian. 2018. Prevalence of aeroallergens and food allergens in allergic patients in Tehran, Iran. *Int. J. Med. Lab. Sci.* 5: 246–254.
- Pei, J., J. Gong, and J. Liu. 2020. Influences of indoor environment and occupant behavior on mite allergen concentration in different regions of China. *Build. Environ.* 178: 106922.

- 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.
- Sercombe, J. K., D. Liu-Brennan, S. M. Causer, and E. R. Tovey. 2007. The vertical distribution of house dust mite allergen in carpet and the effect of dry vacuum cleaning. *Int. J. Hyg. Environ. Health* 210: 43–50.
- Service, M. 2014. *Medical entomology for students*. 4th ed. Edinburgh: Cambridge University Press.
- Soleimani, M., and J. Rafinejad. 2008. House dust mite contamination in hotels and inns in Bandar Abbas, south of Iran. *J. Environ. Health Sci. Eng.* 3: 207–210.
- Soleimani-Ahmadi, M., M. Zare, S. M. Abtahi, and A. Khazeni. 2017. Species identification and prevalence of house dust mites as respiratory allergen in Kindergartens of the Bandar Abbas City. *Iran J. Allergy Asthma Immunol.* 16: 133–139.
- 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, Southern Iran. *Exp. Appl. Acarol.* 54: 269–276.
- Spieksma, F. T. M. 1997. Domestic mites from an acarologic perspective. *Allergy* 52: 360–368.
- 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.
- Sun, B. Q., A. Wu, A. Chan, S. Chik, D. Wong, and N. S. Zhong. 2004. House dust mite allergen (Derp1 and Blot5) levels in asthmatics' home in Hong Kong. *Chin. Med. Sci. J.* 19: 185–188.
- Terra, S. A., D. A. Silva, M. C. Sopelete, J. Mendes, S. J. Sung, and E. A. Taketomi. 2004. Mite allergen levels and acarologic analysis in house dust samples in Uberaba, Brazil. *J. Investig. Allergol. Clin. Immunol.* 14: 232–237.
- van der Hoeven, W. A., R. de Boer, and J. Bruin. 1992. The colonisation of new houses by house dust mites (Acari: Pyroglyphidae). *Exp. Appl. Acarol.* 16: 75–84.
- Van Strien, R. T., A. P. Verhoeff, B. Brunekreef, and J. H. Van Wijnen. 1994. Mite antigen in house dust: relationship with different housing characteristics in the Netherlands. *Clin. Exp. Allergy* 24: 843–853.
- Weinmayr, G., S. K. Weiland, B. Björkstén, B. Brunekreef, G. Büchele, W. O. Cookson, L. Garcia-Marcos, M. Gotua, C. Gratzou, M. van Hage, et al.; ISAAC Phase Two Study Group. 2007. Atopic sensitization and the international variation of asthma symptom prevalence in children. *Am. J. Respir. Crit. Care Med.* 176: 565–574.
- Wickens, K., R. Siebers, I. Ellis, S. Lewis, G. Sawyer, S. Tohill, L. Stone, R. Kent, J. Kennedy, T. Slater, et al. 1997. Determinants of house dust mite allergen in homes in Wellington, New Zealand. *Clin. Exp. Allergy* 27: 1077–1085.
- Wilson, J. M., and T. A. E. Platts-Mills. 2018. Home environmental interventions for house dust mite. *J. Allergy Clin. Immunol. Pract.* 6: 1–7.
- Yong, T. S., and K. Y. Jeong. 2009. Household arthropod allergens in Korea. *Korean J. Parasitol.* 47 (suppl.): S143–S153.
- Yu, J. M., Q. H. Luo, J. L. Sun, C. L. Shi, J. Yin, Y. L. Zhou, R. Tang, H. Zhang, Z. Yu, and M. Chen. 2015. Diversity of house dust mite species in Xishuangbanna Dai, a tropical rainforest region in Southwest China. *Biomed. Res. Int.* 2015: 421716.
- Zeytun, E., S. Doğan, F. Özçiçek, E. Ünver, and S. Dilkaraoğlu. 2016. Comparison of living and bedrooms in terms of house dust mites in the Province of Erzincan, Turkey. *J. Med. Entomol.* 53: 26–30.
- Ziyaei, T., F. Berenji, F. Jabbari-Azad, A. Fata, L. Jarahi, and M. Fereidouni. 2017. House dust mite prevalence in the house of patients with atopic dermatitis in Mashhad, Iran. *J. Arthropod. Borne Dis.* 11: 309–314.