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Article

Species identification and seasonal prevalence of house dust mites in Assiut City, Egypt: A descriptive study in an urban area

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ABSTRACT
Our study aimed to identify and characterize the common species of house dust mites collected from different areas in Assiut city, study their seasonal variation, and effects of some housing criteria on their prevalence. This could help in the assessment of the magnitude of the current situation in this locality and assist in implementing appropriate investigations and diagnostic tools which in turn offers a better quality of life to allergy sufferers in our study locality as well as for others. Dust samples were collected from eight regions representing the two main districts of Assiut City as systemic random samples. For proper dust collection we used both a vacuum cleaner and a hand sweeper from different rooms of each house (bedrooms, mattresses, floor, bedding and living rooms). Also, two methods were used for mite extraction: Kero-float method and modified Berlese-Tullgren funnel. Light microscopy as well as SEM were used to identify different mite species with the aid of an identification key. The overall prevalence of house dust mites in collected samples was 94 positive samples per 300 houses examined in this study. Seasonal variations significantly affected the prevalence of house dust mites; the highest frequency was noticed during winter (66.7%) and the least frequency was noticed during summer (13.3%). Kero-float method was more sensitive and accurate than modified Berlese-Tullgren funnel in mites' extraction in a given sample (100% and 47.9% respectively). The most frequently isolated species were *Dermatophagoides farinae* (80.9%) and *D. pteronyssinus* (58.5%) followed by stored products mite, *Tyrophagus putrescentiae* (50%) and predatory mite, *Cheyletus malaccensis* (31.9%) while the least frequent species was *Dermanyssus gallinae* (21.3%). Mixed species were detected in 48 (51.1%) of the positive samples. Some housing criteria: age of the house, damp or moldy stains on floor or on other indoor surfaces (walls, ceiling), presence of carpets/rugs and aeration style (sunny/shady) have significantly affected the prevalence of house dust mites in different houses. We concluded that although Assiut is the driest city in Egypt with low relative humidity, which is an essential factor in the survival of mites, there is significant prevalence of house dust mites (31.3%). Housing criteria significantly affected the presence of HDMs.

KEY WORDS: *Cheyletus malaccensis*; *Dermanyssus gallinae*; *Dermatophagoides farinae*; *D. pteronyssinus*; environmental factors; low humidity; *Tyrophagus putrescentiae*.

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INTRODUCTION

House dust mites (HDM) are arachnids that live in dust in nearly every home and are important

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sources of indoor allergens worldwide, found more commonly in humid regions. They are classified within Astigmata (Arlian and Morgan 2003; Colloff 2009). Being associated with dust in houses, workplaces, hospitals and bird nests, these arachnids are nearly distributed worldwide and no place is immune against infection with them (Damle *et al*. 2016).

These mites are very small (240−435μm in length and 3.5−13.0 μg in weight), and are able to survive in household dust and fabric material, like carpet, bedding, stuffed furniture, old clothing and stuffed toys (Arlian and Morgan 2003; Bonnefoy *et al.* 2008). They live in their food source, which consists of shed human skin, pollen, spores of microorganisms, fungal mycelia, and bacteria (Hay *et al*. 1992; Bonnefoy *et al*. 2008). Molva *et al*. (2019) considered some bacterial and fungal species as an important food source for dust mites.

Characteristically, they have no respiratory system and instead they use their cuticle for gas exchange (Arlian 1989); this leaves them susceptible to humidity changes (Warner *et al*. 1999). Pyrogyphidae is the most important family of dust mites; the widely distributed species *Dermatophagoides pteronyssinus* (Trouessart) and *Dermatophagoides farinae* Hughes belong to this family and represent 80−90% of the house dust acarofauna (Arlian *et al*. 2002). They are commonly known as the European and American house dust mites respectively (Arlian *et al*. 2002). Despite the region-specific common names, both of these mites occur worldwide. The allergens that these mites produce are able to accumulate in the home, which can negatively affect sensitized humans (Colloff 2009).

The mites' guts contain potent digestive enzymes (notably Peptidase 1) that persist in their feces and are major inducers of allergic reactions such as wheezing. House dust mites are associated with allergic rhinitis and asthma, as well as allergic conjunctivitis. Estimates are that dust mites may be a factor in 50 to 80% of asthmatics, as well as in countless cases of eczema, hay fever, and other allergic ailments. It is the number one cause of childhood visits to the hospital in the United States (Bonnefoy *et al*. 2008). Mite allergens are found throughout homes. High allergen levels are most often found in areas inhabited by HDM's including mattresses, carpets, corners of rooms, and under beds. The bed has the highest concentration of HDMs due to human skin dander accumulating in the beddings during sleep (Nadchatram 2005).

The number of house dust mites and the amount of mite allergens depends on the relative humidity. A humidity of > 50%, which can typically occur in very well insulated houses, or simply due to the climate, leads to a rapid flourishing of these mites. *Dermatophagoides farinae* has an optimum range of developmental temperatures between 23–30 °C; outside of this temperature range *D. farinae* eggs do not hatch. This species prefers a relative humidity of 75%. The age of the dust also appears to be a factor in the degree of allergen activity (Arlian and Dippold 1996).

Scanning electron microscopy (SEM) has been used to look at mites' ultrastructure (Alberti and Coons 1999; Kennaway *et al*. 2004). SEM images of dust mites are presented to provide an improved visualization of the taxonomic characters of these mites (Ahamad *et al*. 2011).

The aim of this study was to morphologically identify the HDMs collected from dust samples obtained from different areas in Assiut city and study the effects of seasonal variation and some housing criteria on their prevalence.

MATERIALS AND METHODS

Study area

The present study is a descriptive analytical cross-sectional study conducted within a three-year period from October 2016 to December 2019 for detection and identification of house dust mites present in houses of eight different localities in two districts of Assiut city, Western district, 139 samples (El-Sadat, El-Arbeen, Arab el-madabegh and CID region) and Eastern district, 161 samples (Al-Walidya, Al-Nemeis, El-Gomhorya, El-Hoqoquin) (http://Assiut.gov.eg/AssiutGov. aspx), during the four seasons starting from autumn through winter, spring and then summer. The study

was conducted in the research laboratory of the Parasitology Department, Faculty of Medicine and the Electron Microscope Unit of Assiut University.

Assiut City, the capital city of Assiut Governorate, is located at latitude of 27° 10' 51.46" N and longitude of 31° 11' 1.25" E and has an elevation of 56 meters above sea level and an average atmospheric pressure at sea level of 1015 hpa. Assiut City is divided by the railway line into two districts, Eastern and Western "http://Assiut.gov.eg/AssiutGov.aspx".

Köppen-Geiger climate classification system classifies Assiut's climate as hot desert. It is the driest city of Egypt, characterized by virtually no rainfall during the year. This gives the city and nearby towns and villages the similar properties of a continental climate, meaning that the city has harsh and chilly cold winter weather, and very hot but non-humid summers. January is the most humid while May is the least humid month with average annual percentage of humidity of 38.0%

Collection of house dust samples

A total of 300 house dust samples were collected from randomly selected houses in eight different regions in Assiut city during the study period. Before sampling, the participants were asked to avoid sweeping or vacuuming the area of dust collection for two days. Samples were obtained from bedrooms, mattresses, floor, bedding and living rooms by any of the two main methods: The first method was vacuuming from 1 m^2 of the surface of each sampling place with a vacuum cleaner (washing its bag before collecting the sample), the second method was the ordinary sweeping with clean brush. Samples were put in plastic bags and carefully tied, each sample was given a numerical label, transferred to Medical Parasitology Department, Faculty of Medicine, Assiut University. Samples were stored at 4 °C to avoid proliferation, and examined in the laboratory within 24 h of collection (Morsy *et al*. 1994).

Ethical approval

The study was approved by the Committee of Research, Publications and Ethics of the College of Medicine, Assiut University, Egypt. The owners of these houses signed an informed consent on approval to share in the study. The aim and method of the study were explained to them.

Examination of dust samples

One sample was taken from each house. For each dust sample, large particles and fibrous materials were separated by sieving through a 300-mesh brass sieve of 6 mm diameter. Mites were extracted from dust samples using two different main methods.

The first method was the modified Berlese-Tullgren funnels in a specially-constructed device adopted from Barberena-Arias *et al*. (2012) to place the samples in different stainless steel containers and allow mites to pass down the sieves into plastic wide-mouth bottles containing either distilled water (to detect live mites) or 70% alcohol; a wooden skeleton was built with basal holes and was covered with a mesh. Over each hole, a corer was placed and covered with a metallic funnel (11 cm × 5 cm). The metallic funnels were then covered with a wooden ceiling. All funnels had the ceiling with an opening. Samples were placed in hand made funnels, a 20V-bulb was hanging through the funnel's opening, and was kept at maximum intensity during all the extraction period to control for the effect of changing light intensity during extractions. All samples were located simultaneously in the same room where temperature and humidity were controlled. Samples were left on the stainless steel containers for 48 h. After the extraction period, the contents of the glass jar were transferred to a Petri dish to be examined under the stereomicroscope, and each identified species was isolated in a separate beaker.

The second extraction method was the kero-float method (Proctor 2001). Samples, each of 5 gm were poured into 600 ml Ethyl alcohol (80%) in 1000 ml Beaker, then 150–200 ml of household kerosene was carefully poured into the Beaker. The contents of the beaker were then gently stirred several times by a glass rod to coat the substrate with kerosene. The mixture was allowed to rest

until the kerosene and ethanol layers had clearly separated and particles were no longer rising through the ethanol (5–10 min). The particle-laden interface between the kerosene and ethanol was siphoned off and washed through a 100 mm mesh sieve. Materials accumulated in the mesh were washed clean of kerosene using 100% ethanol, and then back washed into a Petri dish for examination under a dissecting microscope at 16–40×. Two sequential kero-floats were performed on each sample to maximize recovery of organisms according to Barmuta (1984).

Identification of house dust mites

A – Light microscopic identification: To detect mites according to the general criteria stated by Colloff (2009) [modified after Mumcuoglu (1976); Colloff and Spieksma (1992); and Fain (1990)]. Briefly, this was done by clearing and fixation of the mites by adding a small drop of Hoyer's medium (50 µm) on the mite specimens in the center of a clean glass slide. After drying of Hoyer's medium the slides were microscopically examined creating a permanent preparation method according to Solarz *et al*. (2004). **B –** Electron microscopic identification: 50 mites were prepared for scanning electron microscopic examination by three different methods which were then compared: First method was preserving them in gluteraldehyde after washing the mites several times in phosphate buffered saline (PBS). The second was putting them in 70% ethyl alcohol. The third method was preserving the mite in MA fluids (a mixture of 99.5 methanol and 99.3% acetic acid) (Saito and Osakabe 1992).

Statistical methods

Data were collected and analyzed using SPSS (Statistical Package for the Social Science, version 20, IBM, and Armonk, New York). Continuous data were expressed in form of mean ± SD or median (range) while nominal data were expressed in form of frequency (percentage).

Chi²-test was used to compare the nominal data of samples with positive HDM and those with negative HDM while continuous data of both groups were compared with Student t-test. Diagnostic accuracy of Berlese-Tullgren funnel and Kero-float methods in extraction of HDM in the collected samples was assessed by receiver operating characteristics curve. Level of confidence was kept at 95% and hence, P value was considered significant if < 0.05.

RESULTS

Of 300 collected dust samples from houses of eight different regions in the two districts of Assiut city during the period from October 2016 to December 2019 (Table 1): 94 (31.3 %) samples were positive for HDMs. In Western district, it was noticed that frequency of positive samples was significantly higher in El-Arbeen (42.5%) and Arab el- madabegh (29.4%) in comparison to other Western district areas including El-Sadat (9.1%) and CID region (15.6%).

In Eastern district, frequency of positive samples was significantly higher in Al-Walidya (90%) in comparison to other areas including El-Gomhoryaa (8.1%), Al-Nemeis (8.3%) and El-Hoqoquin (21.1%). The highest positive samples allover Assiut city were detected in Al-Walidya (90%), followed by El-Arbeen (42.5%), and Arab el-madabegh (29.4%); the lowest frequency was detected in El-Gomhoryaa (8.1%) followed by Al-Nemeis (8.3%).

There was significant difference in the frequency of house dust mites in Assiut City based on seasonal variations (Table 2), where the highest frequency was noticed during winter (66.7%) and the least frequency was noticed during summer (13.3%).

Table 3 shows that housing criteria were significantly different between those areas with HDM samples and those with negative HDM samples ($P < 0.001$); these include age of the house, damp or moldy stains on floor, damp or moldy stains on other indoor surfaces (walls, ceiling), presence of carpets/rugs and aeration style (sunny/shady), and the number of occupants with exception of vaccum cleaning ($P > 0.05$).

Table 1. Prevalence of house dust mites in different regions in Assiut city.

Region	No. of examined samples	No. of positive samples (%)	No. of negative samples (%)	Chi²-test	P-value
Western District				36.21	< 0.001
El-Sadat	33	3 (9.1%)	30 (90.9%)		
El-Arbeen	40	17 (42.5%)	23 (57.5%)		
Arab el-madabegh	34	10 (29.4%)	24 (70.6%)		
CID-region	32	5(15.6%)	27 (84.4%)		
Eastern Disrtict				21.30	< 0.001
Al-Walidya	50	45 (90%)	5 (10%)		
Al-Nemeis	36	3 (8.3%)	33 (91.7%)		
El-Gomhoryaa	37	3 (8.1%)	34 (91.9%)		
El-Hoqoquin	38	8 (21.1%)	30 (78.9%)		

Data expressed as frequency (percentage). *P* value was significant if < 0.05.

Table 2. Prevalence of house dust mites based on seasonal variation in Assiut city.

Season	No. of examined samples	No. of positive samples (%)	No. of negative samples (%)	Chi²-test	P-value
Season				80.02	< 0.001
Winter	75	50 (66.7%)	25 (33.3%)		
Spring	75	14 (18.7%)	61 (81.3%)		
Summer	75	10 (13.3%)	65 (86.7%)		
Autumn	75	20 (26.7%)	55 (73.3%)		

Data expressed as frequency (percentage). *P* value was significant if < 0.05

It was noticed that both modified Berlese-Tullgren funnels and Kero-float methods were accurately able to exclude negative samples but modified Berlese-Tullgren funnel was able to detect only 45/94 of positive cases with 47.9% sensitivity and overall accuracy was 83.7% while Kero-float method was able to detect all positive case with 100% sensitivity and 100% overall accuracy (Table 4).

Table 5 shows distribution of house dust mite species in the examined samples. It was noticed that the most frequently isolated species were *Dermatophagoides farinae* (80.9%) and *Dermatophagoides pteronyssinus* (58.5%) followed by stored products mites, *Tyrophagus putrescentiae* (Schrank) (50%) and predatory mites, *Cheyletus malaccensis* (Oudemans) (31.9%) while the least frequent species was *Dermanyssus gallinae* (De Geer) mites (21.3%). Mixed species were detected in 48 (51.1%) of the positive samples.

Table 6 shows the prevalence of the recovered species of HDMs in the different examined regions in Assiut city. The predominance of *Dermatophagoides farinae* was also observed.

Morphological identification and classification of the detected HDMs

After isolation, preservation, and mounting of different found mites, species identification was carried out according to Colloff (2009). Isolated *Dermatophagoides farinae* female showed a finely striated cuticle; transverse striations faintly apparent above epigynium (which is slightly curved); two solenidia at distal end of tarsi; tarsus I ends with spine, while tarsus II has two spiny tubercles; bursa copulatrix is broad and strongly sclerotized in region next to external opening, sclerotized section pointed anteriorly; ratio of distance between posterior end of genital apodeme and base of seta *4a* to distance between bases of setae *4a* is 1:2 (Fig. 1).

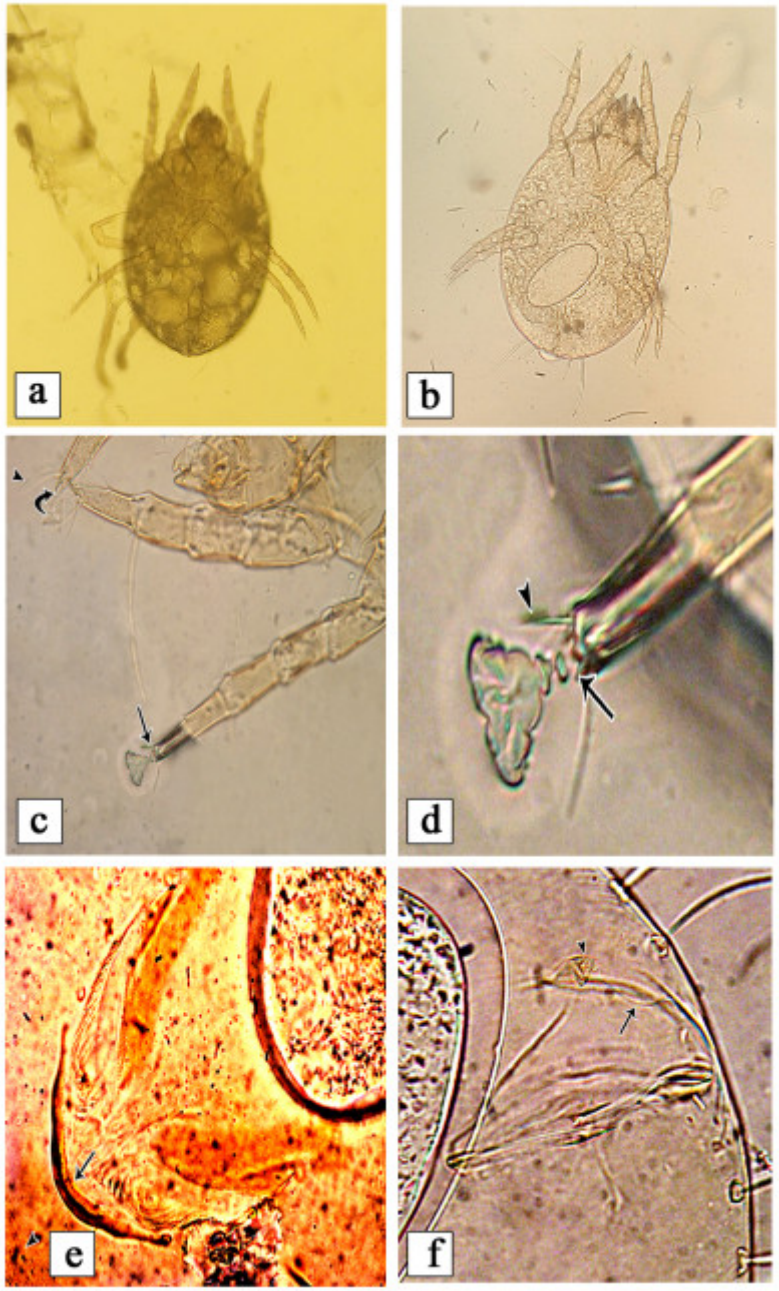

Figure 1. *Dermatophagoides farinae* (adult female) – **a.** Habitus (before being cleared) (10×); **b.** Habitus (after being cleared in Hoyer's medium) (x100); **c.** Distal solenidion on tarsus I (arrow head), terminal spinous process (curved arrow) and tarsus II with the two distal solenidia (arrow) (200×); **d.** Magnified tarsus II with distal solenidia (arrow head) and two small spinous tubercles (long arrow) (400×); **e.** The low-arched epigynium (arrow) and the faint transverse striations above it (arrow head); **f.** Bursa copulatrix (arrow), its external opening and sclerotized part (arrow head).

On the other hand, on examination of the female *Dermatophagoides pteronyssinus*, the clear difference between it and *Dermatophagoides farinae* was in bursa copulatrix: Receptaculum seminis is cup-shaped with wide opening; ductus bursae is of uniform thickness; the external opening of ductus bursae is inverted cup-shape and is situated at a lower level than in *Dermatophagoides farinae* which is near anal opening.

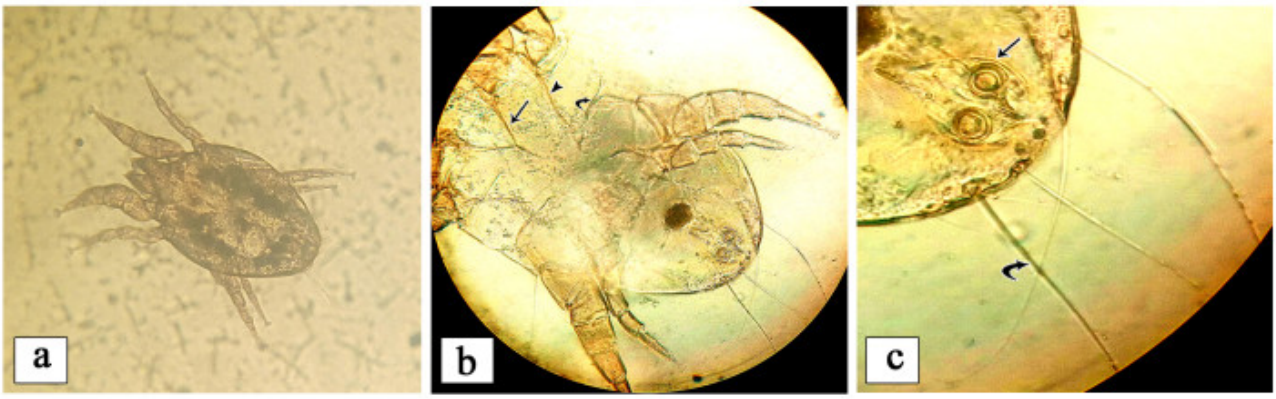

Figure 2. *Dermatophagoides farinae* (adult male) – **a.** Habitus (100×) before being cleared in Hoyer's medium and the enlarged 1st and 3rd pairs of legs are noted; **b.** Fused apodemes I (arrow) while apodemes II (arrow head) and apodemes III (curved arrow) are not fused (200×); **c.** Anal plate (arrow), post anal seta 2 (*ps2*) (curved arrow) (400×).

Table 3. Prevalence of HDM in studied houses in relation to some housing criteria.

Housing characteristic	No. of positive HDM samples (n = 94)	No. of negative HDM samples (n = 206)	Total (n = 300)	Chi^2-test	P-value
Age of house					
- More than 30 years	66 (70.2%)	56 (27.2%)	122 (40.7%)	86.92	< 0.001
- Less than 30 years	28 (29.8%)	150 (72.8)	178 (59.3%)		
Damp stains on floor observed by investigator					
- present	60 (63.8%)	5 (2.4%)	65 (21.7%)	72.72	< 0.001
- absent	34 (36.2%)	201 (97.6%)	235 (78.3%)		
Mouldy stains on floor observed by investigator					
- present	54 (57.4%)	4 (1.9%)	58 (19.3%)	89.09	< 0.001
- absent	40 (42.6%)	202 (98.1%)	242 (80.7%)		
Damp or mouldy stains on other indoor surfaces (walls, ceiling) observed by investigator					
- present	62 (65.9%)	4 (1.9%)	66 (22%)	49.68	< 0.001
- absent	32 (34.1%)	202 (98.1%)	234 (78%)		
Age of carpets/rugs					
- present	88 (93.6%)	100 (48.5%)	188 (62.7%)	49.13	< 0.001
- absent	6 (6.4%)	106 (51.5%)	112 (37.3%)		
Aeration style					
- Sunny	15 (15.9%)	200 (97.1%)	215 (71.7%)	52.12	< 0.001
- Shady	79 (84.1%)	6 (2.9%)	85 (28.3%)		
-Vaccum cleaning					
- Yes	50 (53.2%)	106 ((51.5%)	156 (52%)	0.87	0.07
- No	44 (46.8%)	100 (48.5%)	144 (48%)		
Number of occupants					
- More than 3 members	60 (63.8%)	100 (48.5%)	160 (53.3%)	6.05	0.03
- Less than 3 members	34 (36.2.%)	106 (51.5%)	140 (46.7%)		

Data expressed as frequency (percentage). P value was significant if < 0.05.

Table 4. Accuracy of two methods in extraction HDM in collected samples.

Characters	Berlese-Tullgren funnel	Kero-float method
Detected positive cases	45	94
Sensitivity	47.9%	100%
Specificity	100%	100%
Positive predictive value	100%	100%
Negative predictive value	80.7%	100%
Accuracy	83.7%	100%

Table 5. Distribution of house dust mite's species in the examined samples.

Dust mite's species	Number of positive samples (n = 94)
Dermatophagoides farinae	76 (80.9%)
Dermatophagoides pteronyssinus	55 (58.5%)
Tyrophagus putrescentiae	47 (50%)
Cheyletus malaccensis	30 (31.9%)
Dermanyssus gallinae	20 (21.3%)
Mixed species	48 (51.1%)

Data expressed as frequency (percentage).

Table 6. Prevalence of species of HDMs in different regions in Assiut city.

Region	No. of total positive samples	No. of samples positive for *D. farinae*	No. of samples positive for *D. pteronyssinus*	No. of samples positive for *T. putrescentiae*	No. of samples positive for *C. malaccensis*	No. of samples positive for *D. gallinae*
Western District						
El-Sadat	3 (9.1%)	3	1	0	2	0
El-Arbeen	17 (42.5%)	14	10	15	5	4
Arab el-madabegh	10 (29.4%)	10	12	5	3	6
CID-region	5 (15.6%)	4	10	0	6	2
Eastern Disrtict						
Al-Walidya	45 (90%)	36	20	20	10	8
Al-Nemeis	3 (8.3%)	3	0	0	1	0
El-Gomhoryaa	3 (8.1%)	2	0	0	0	0
El-Hoqoquin	8 (21.1%)	4	2	7	3	0

Dermatophgoides farinae male is characterized by fused apodemes I to form Y-shaped median structure and apodemes II, III not fused (Fig. 2). Prodorsal setae 2 (*ps*2) shorter than anal plate, positioned lateral to anal plate, more or less at level of anal suckers (Fig. 2). Male *Dermatophagoides pteronyssinus* could not be recovered.

The third recovered species was *Tyrophagus*. It is characterized by being a hairy mite with long setae; thin, reticulate cuticle and large gnathosoma. Prodorsal shield and dorsal transverse groove are present. Tarsus ends with one curved hook and has two solenidia: one distal and the other proximal. Tibia and genu are nearly of equal length. One pair of dorsolateral transverse setae on each side.

The fourth recovered species was the predatory mite (*Cheylatus malaccensis*). It is a large mite, length is about 500 µm. The most characteristic structures are the large palps, with curved spinal distal end and the chelicera enclosed in conical gnathosoma. It has an M-shaped peritreme on anterior prodorsum. Tarsi have two claws.

The last found species was *Dermanyssus gallinae* which is characterized by being Large (ca. 1 mm) and brownish, with a prominent pair of palps protruding anteriorly.

SEM was done on *Dermatophgoides farinae* as it was the predominant species (Figs. 7, 8). *Dermatophgoides farinae* female SEM (Fig. 3) demonstrated external scapular seta much longer than internal scapular seta, a detailed view of the external genital system of the female, the finely striated body and the prodorsal shield. While that of the male showed the enlarged first pair of legs, the aedeagus and the anal plate containing the anal suckers (Fig. 4).

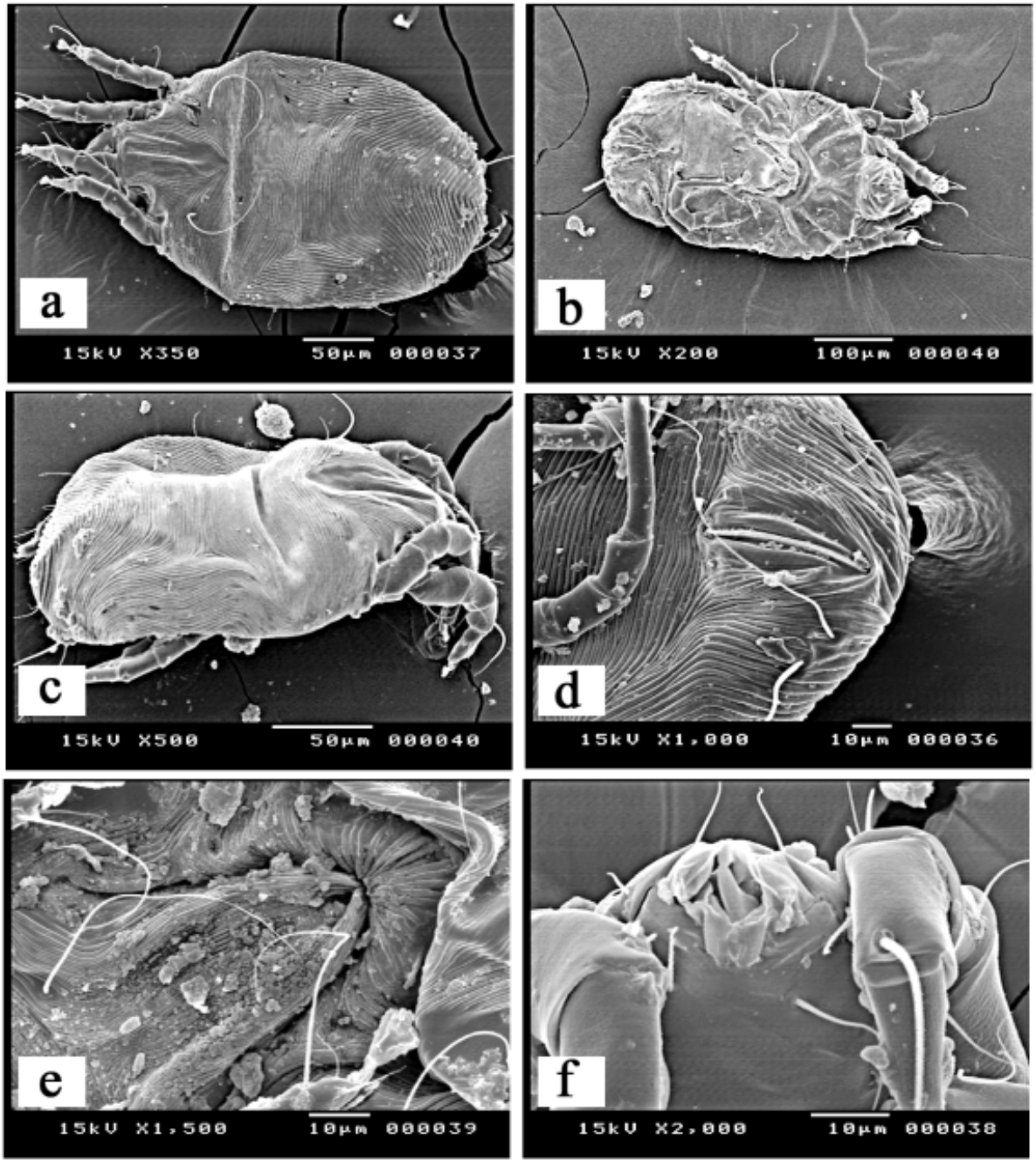

Figure 3. *Dermatophagoides farinae* adult female (SEM photo) – **a.** Dorsal view shows sce (external scapular seta) is much longer than sci (internal scapular seta); **b.** Ventral view shows the genital system of the female; **c.** Lateral views shows the finely striated body and prodorsal shield; **d.** Hysterostoma region and anal opening; **e.** Epigynium and genital opening; **f.** Ventral view of the gnathostoma.

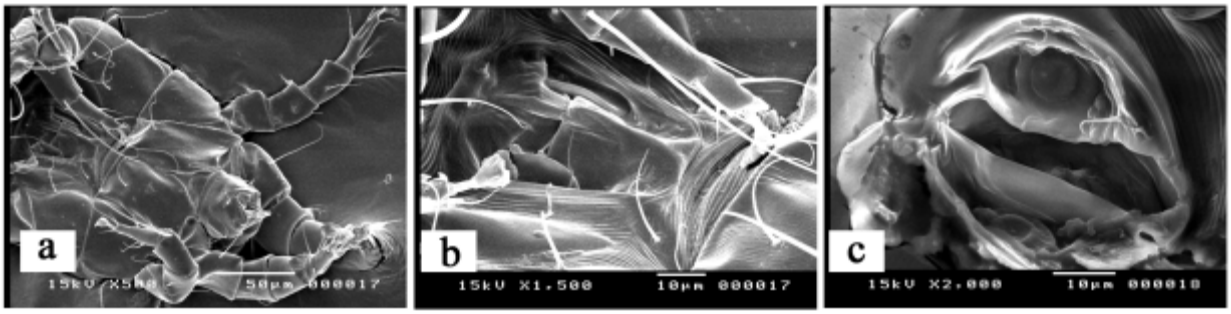

Figure 4. *Dermatophagoides farinae* adult male (SEM photo) – **a.** Ventral view showing the enlarged first pair of legs. **B.** The aedeagus; **c.** The anal plate containing the anal suckers.

DISCUSSION

Over last two decades, the medical importance of dust mites as a predisposing factor for allergy in humans has gained the attention of researchers.

It has been 50 years since the dust mite was first appreciated to be a major source of allergens in house dust, and by extension a key trigger of allergic respiratory disease (Miller 2019). They are responsible for causing asthma, rhinitis and contact dermatitis, respiratory allergies are caused by the inhalation of dead or live mites, their fecal matter or other byproducts (Nadchatram 2005).

Accordingly, due to the growing number of HDM-associated allergies, studies concerning prevalence of HDM have dramatically increased aiming to decrease the potential source.

In Egypt, a few studies over the last 10 years have been devoted to study the prevalence of dust mites' allergens in the blood and houses of sensitized individuals. Different mite species have been recorded and associated with many types of human allergies in different ages and localities in Egypt (Yassin *et al*. 2009; Antonios *et al*. 2012; Hossny *et al*. 2014; Al-Dhduh *et al*. 2015; Taha *et al*. 2018; El Kersh *et al*. 2019).

The present study was designed to perform morphological identification of house dust mites (HDMs) from dust samples from different areas in Assiut city and studying the effects of seasonal variation and some housing criteria on their prevalence. It was carried out through a period of three years and two months, in which dust samples were collected during the four seasons of the year and revealed a prevalence rate of 31.3%. Our study revealed that the highest density of HDM in Eastern district (36.6%), was mainly in Al-Walidya region (90%), compared to Western District (25.2%), mainly in El-Arbeen (42.5%) which are regions with low economic standard; the lowest infestation in Eastern Disrtict, was El-Gomhoryaa region (8.1%) then Al-Nemeis (8.3%), which are of high economic standard, with high significant difference.

These results are consistent with the results of other studies in Egypt. In Menoufia Governorate, El Kersh *et al*. (2019), El-Meligy (2002) and Faheem *et al*. (2000) found high density and prevalence of mites in areas in which the economic standard was very low with high relative humidity. Similar results were obtained in Sharkia governorate by Yahia and Metwally (2019). This is on the contrary with El-Shazly *et al*. (2006), in Dakahlia Governorate who revealed dust mites in urban areas (with higher economic standard) more than in rural areas. This might be explained by the higher relative humidity in Dakahlia all over the year, compared to other governorates.

In our study, the most prevalent species in all examined areas was *Dermatophgoides farinae* (80.9%) followed by *Dermatophagoides pteronyssinus* (58.5%) and *Tyrophagus putrescentiae* (50%). These results correspond with the results of Heikal (2015) who found the highest dominant species was *Dermatophgoides farinae* (66.1%), followed by *Dermatophgoides pteronyssinus* (23.3%) of the total collected mites from rural houses of Shebin El-Kom locality in Menoufia Governorate. Whereas El Kersh *et al*. (2019) examined dust from rural and urban houses from

Menoufia governorate and detected the prevalence of *Dermatophgoides pteronyssinus* (72.6%) over *Dermatophgoides farinae* (51.2%).

Our study also detected the prevalence of other species in a moderate prevalence: *Cheyletus malaccensis* and *Dermanyssus gallinae* in a prevalence of 31.9% and 21.3 % respectively. However, Heikel (2015) detected the percentages of the rest of their species such as *Chortoglyphus arcuatus* (Troupeau), *Lepidoglyphus destructor* (Schrank), *Glycyphagus domesticus* (de Geer), *Gohieria fusca* (Oudemans), *T. putrescentiae*, *Caloglyphus* sp., *Cheyletus malaccensis*, *Blomia* spp. and *A. siro* L. in a range between 0.16 and 2.0%.

Although *Dermanyssus gallinae* is considered not a true house dust mite as it belongs to family Dermanyssidae (Mesostigmata) which is a parasite with piercing chelicerate mouthparts, Bernecker (1970) found that a fifth of the asthmatics who were skin-prick test positive to *Dermatophagoides pteronyssinus* were also positive to *Dermanyssus gallinae*. This is also reported by Rufli (1970). Frenken (1962) and Sexton and Haynes (1975) reported allergic symptoms due to bites of *Dermanyssus gallinae*. Household exposure due to the bird nest colonization is frequent in Assiut city air-conditioners (Collof 2009).

The diversity of the recovered mites is due to the behavior of the inhabitants (Table 6). In some areas of low socioeconomic level like CID and Arab el-madabegh the people usually have dusty houses and they grow some domestic birds. In addition, there are areas with old houses with small gardens which favor the presence of bird mites in some places.

The predominance of *Dermatophagoides* spp. was also reported by other authors, such as Gamal-Eddin *et al.* (1982) who recorded them in Tanta City in addition to other HDMs, such as *T. putrescentiae*, *Cheyletus malaccensis*, *Blomia kulagini* (Zakhvatkin), and *Acheles gracilis* Rack. Similar results were obtained by Kenawy *et al.* (2012) and Hossny *et al*. (2014) who found that *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* were the most prevalent species.

Over the last few years, many published papers investigated the occurrence of house dust mites in Egyptian households indicating their importance as the predominant aeroallergens. Suitable climatic conditions, population density and other factors (e.g. sanitary behavior of people, economic level of the family, etc.) were found as important risk factors that increased the chances to detect mite allergens in homes and blood of the Egyptian people (Taha *et al*. 2018).

In this work, the influence of seasonal variation concerning humidity and temperature, in addition to some housing criteria on mite populations was investigated. Seasonal climatic changes contributed to the variation in dust mite concentrations in collected samples. The number of mites fluctuated with seasons, with the highest number of mites being detected in winter (66.7%) and autumn (26.7%) while the lowest number of mites were recorded in summer (13.3%) with highly significant differences among them. This result is in accordance with results of other studies conducted in Egypt (Yassin *et al*. 2009; Antonios *et al*. 2012; El Kersh *et al*. 2019; Yahia and Metwally 2019) and another study conducted in India (Van der Heide *et al*. 1997); they recorded high densities of mite population in winter than in summer. This result could be explained on the basis that climatic conditions in summer in the form of high temperature and low humidity are not favorable for mite growth and thriving in dust. In contrast, the study done in Malaysia and Singapore, Nadchatram (2005) reported that the winter months had an adverse effect on the development and reproduction of mites. This was approved also by Sharma *et al*. (2011), South Assam, India, who recorded higher mite populations during the summer and early autumn months. This Indian area is considered of high humidity due to equatorial rainfall during summer.

Assiut is the driest city in Egypt (Köppen-Geiger climate classification system), so this may explain the lowest percentage of positivity of HDM in our study (31.3 %) in comparison with other studies done in Egypt such as the study done by El Kersh *et al*. (2019) in Menoufia Governorate with positivity 71.6% and that done in Sharkia by Yahia and Metwally (2019) (78.8%). In many studies, a significant association between abundance of mites and the percentage of the relative humidity has been documented (Murray and Zuk 1979; Cadman *et al*. 1998; Chew *et al*. 1999;

Yassin *et al*. 2009).

The American house dust mite, *Dermatophagoides farinae*, is known as a cosmopolitan species with a world-wide distribution and commonly inhabits house dust and stored products. In Egypt, this mite has been found in homes in various areas where it may cause allergic symptoms especially for asthmatic patients (Rezk 2004). The mite population decreases in winter and hence, it has been suggested that *Dermatophagoides farinae* favors relatively high temperatures (Rezk *et al*. 1996). However, no quantitative data are available in upper Egypt on its distribution and life history parameters at various temperatures.

Ideal indoor humidity was maintained by household populations who tend to stay at home for long periods, more individuals shared bedding areas and personal items were left in living rooms and this had maintained the reproduction rate of mites in household environment.

The lack of sound data about indoor temperature and humidity in different geographical areas in Egypt represents a complex task facing the researchers when they study mite distribution in household environment (Yahia and Metwally 2019).

However, it is well known that the indoor temperature and humidity of houses in Egypt differ seasonally. Usually we have the shutters and doors closed in the winter, using electric heaters and rooms become more crowded. During summer, the shutters and doors are usually opened to have some fresh air. This allows more heat, dryness and sunshine to affect the prevalence of the mites indoors.

Several factors positively influenced the prevalence of HDM in our study such as age of the house, humidity or dampness of houses (represented by presence of damp and moldy stains on floor or indoor surfaces), presence of carpets or rugs, aeration style, vacuum cleaning and number of occupants. Old, damp, shady and crowded homes provided with carpets and rugs were important factors which significantly increased the prevalence of HDMs in this study. These results come in accordance with those obtained by Antonios *et al.* (2012) Taha *et al*. (2018) and Yahia and Metwally (2019) who found a positive relation between old homes and furniture, home dampness and crowded homes, with high detection levels of mite infestations. This was explained by El-Dib (2007) that old houses may contain dust, molds, and fungi and may encourage mites. On the contrary the modern buildings with smooth walls and floors are not favorable for mites (Mariana *et al*. 2007). Damp houses guarantee the optimum water concentration in the surrounding air which is taken up in vapor by the mites (Arlian and Platts-Mills 2001).

Carpet is a perfect breeding ground for dust mites (Vojta *et al*. 2001; Boquete *et al*. 2006). Carpets should be kept to a minimum, and taken up to be cleaned and dried in the sun (Wilson and Platts-Mills 2018). Although we detected dust mites more frequently in samples collected from houses that use vacuuming as a routine practice in housekeeping, this result was found statistically insignificant. This was in accordance with Sercombe *et al*. (2007) and Wilson and Platts-Mills (2018) who postulated that even with modern vacuums it is impossible to get all the debris and dust mite allergens out of a carpet (de Boer 1990).

In our results, the prevalence of HDM was significantly higher in houses with more than three occupants (P-value = 0.03). Chen *et al*. (2007) and Yahia and Metwally (2019) reported that as the number of household inhabitants increases, the amount of food available for mites also increases with more chances for dust mites to establish more colonies in indoor environments. Also, higher number of individuals in rooms of the same home increases humidity via perspiration and enhances accumulation of more dust over different furniture items. Many other studies documented a positive association between occurrence of house dust mites and presence of large number of persons in the households such as Sakaki and Suto (1994), Hallas and Korsgaard (1997) and Taha *et al*. (2018).

In the current study mites were extracted from dust samples using two main different methods: modified Berlese-Tullgren funnels and kero-float method. Although both extraction methods had good rates of HDM recovery, kero-float method had 100% sensitivity, specificity and accuracy compared to 47.9%, 100% and 83.7 of modified Berlese-Tullgren funnels respectively. This

discrepancy between the extraction rates can be explained by the fact that only live mites can be detected by the Berlese-Tullgren funnel method on contrary to the kero-float method which can detect both live and dead mites. Kero-float method is a time saver which is a very important feature in our study (less than two hours in contrary to 12 to 72 hours with Berlese-Tullgren funnel. Kero-float method had been used by Proctor (2001) for extracting aquatic mites from stream substrates who reported that kerosene floatation extracted a greater number and diversity of mites, with a greater range of body sizes, than did the traditional methods such as the petroleum-based methods which appear to selectively float arthropods. Thind and Dunn (2002) used the kero-float method but in a more complicated way, they detected recovery rates of mites even with different types of materials, ranged from 76 to 100%.

CONCLUSION

Although Assiut governorate is the driest one in Egypt, there is a considerable prevalence of dust mites (31.3%) which entails a good chance for human allergic diseases. *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus* are the most prevalent species specifically during winter. Climatic change as well as human behavior have a great impact on mites' prevalence in spite of their presence indoors.

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شناسایی گونه‌ها و شیوع فصلی کنه‌های گرد و غبار خانگی در شهر اسیوط مصر: مطالعه توصیفی در یک منطقه شهری

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چکیده

این مطالعه با هدف شناسایی و تعیین گونه‌های رایج کنه‌های گرد و غبار خانگی جمع‌آوری‌شده از مناطق مختلف شهر اسیوط، بررسی تغییرات فصلی آن‌ها و تأثیر برخی معیارهای منازل بر شیوع آن‌ها انجام شد. این بررسی می‌تواند به شناسایی بزرگی مشکل این منطقه کمک کند و می‌تواند اجرای پژوهش‌ها و ابزارهای تشخیصی مناسب را بهبود بخشد که به نوبه خود کیفیت زندگی بهتری را برای مبتلایان به آلرژی در منطقه مورد مطالعه و همچنین برای دیگران فراهم کند. نمونه‌های گرد و غبار از هشت منطقه به نمایندگی از دو منطقه اصلی شهر اسیوط به عنوان نمونه‌های تصادفی سیستمیک جمع‌آوری شد. برای جمع‌آوری مناسب گرد و غبار هم از جاروبرقی و هم جارو دستی از اتاق‌های مختلف هر خانه (اتاق خواب، تشک، کف، رختخواب و اتاق نشیمن) استفاده شد. همچنین برای استخراج کنه از دو روش Kero-float و قیف برلز–تولگرن تغییر داده شده استفاده شد. میکروسکوپ نوری و همچنین میکروسکوپ اسکن الکترونی برای شناسایی گونه‌های مختلف کنه با کمک کلید استفاده شد. شیوع کلی کنه‌های گرد و غبار خانگی در نمونه های جمع آوری شده ۹٤ نمونه مثبت در هر ۳۰۰ خانه بررسی شده در این مطالعه بود. تغییرات فصلی به‌طور معنی‌داری بر شیوع کنه‌های گرد و غبار خانگی تأثیر گذاشت، بیشترین فراوانی در فصل زمستان (٦٦/۷ درصد) و کمترین فراوانی در تابستان (۱۳/۳ درصد) مشاهده شد. روش Kero-float نسبت به قیف برلز–تولگرن تغییر داده شده در جداسازی کنه‌ها در یک نمونه معین حساس‌تر و دقیق‌تر بود (به ترتیب ۱۰۰٪ و ٤۷/۹٪). بیشترین گونه‌های جدا شده *Dermatophagoides farinae* (۸۰/۹٪) و *D. pteronyssinus* (۵۸/۵۱٪) و پس از آن کنهٔ محصولات انباری، *Tyrophagus putrescentiae* (۵۰٪) و کنهٔ شکارگر، *Cheyletus malaccensis* (۳۱/۹٪) و کمترین گونه *Dermanyssus gallinae* (۲۱/۳٪). بودند. گونه‌های مخلوط در ٤۸ نمونه (۵۱/۱٪) از نمونه‌های مثبت شناسایی شدند. برخی از معیارهای منزل: سن خانه، لکه‌های مرطوب یا کپک زده بر روی زمین یا سایر سطوح داخلی (دیوارها، سقف)، وجود فرش/موکت و شیوه هوادهی (آفتابی/سایه) به مقدار زیادی بر شیوع کنه‌های گرد و غبار خانگی در خانه‌های مختلف تأثیر گذاشته است. در نتیجه اگرچه اسیوط خشک‌ترین شهر مصر با رطوبت نسبی کم است که عاملی ضروری در زنده‌مانی کنه‌ها است، اما شیوع کنه‌های گرد و غبار خانگی (۳۱/۳٪) را نمی‌توان نادیده گرفت. فراوان‌ترین گونه جدا شده *Dermatophagoides farinae* (۸۰/۹٪) بود. معیارهای منزل به مقدار زیادی بر حضور کنه‌های گرد و غبار خانگی تأثیر گذاشت.

واژگان کلیدی: *Cheyletus malaccensis*؛ *Dermanyssus gallinae*؛ *Dermatophagoides farinae*؛ *D. pteronyssinus*؛ عوامل محیطی؛ رطوبت کم؛ *Tyrophagus putrescentiae*.

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