

Diversity, Distribution, and Abundance of House Dust Mites on Settlement Region in Bogor

Upik Kesumawati Hadi^{1*}, Susi Soviana¹, N Qamariah¹

¹ Entomology Laboratory, Division of Parasitology and Medical Entomology, Faculty of Veterinary Medicine, IPB University, Darmaga, Bogor, West Java 16680, Indonesia

Corresponding author. Email: upikke@ipb.ac.id

ABSTRACT

The house dust mite (HDM) is a major allergen source and a significant cause of allergic rhinitis and allergic asthma. HDM is commonly found in dust originating from human resident and are mainly found in seats (chairs, sofas, benches), carpets, floors and beds (mattresses, pillows, sheets). This study was conducted on six types of settlements in Bogor, *i.e.* densely populated residential, residential complexes, guest houses, boarding schools, boarding houses and student dormitories. Dust from all the settlements collected by vacuum cleaner and HDM were then isolated and identified under microscope at laboratory. The result showed there were 10 types of HDM, *i.e.* *Blomia tropicalis* (45.34%), *Dermatophagoides pteronyssinus* (17.45%), *Cheyletidae* (15.62%), *Blomia* spp. (8.61%), Mesostigmata (7.17%), *Dermatophagoides farinae* (3.67%), Oribatida (0.56%), Acaridae (0.32%), *Tyrophagus* spp. (0.16%), *Lepidoglyphus destructor* (0.08%). The highest density of HDM on housing was found on the carpet, (23.94%) in densely populated residential and (33.71%) in residential complex. HDM mostly found on the furniture at guest houses (100%), boarding schools (37.62%), boarding houses (52.02%) and student dormitories (35.17%). There was significantly correlation between humidity and temperatures against the infestation of HDM in all types of settlements.

Keywords: house dust mite, *Blomia*, *Dermatophagoides*, allergic, Indonesia

1. INTRODUCTION

House dust mites (HDM) are commonly found in dust originating from human habitation and are commonly found in the pillows, sheets, mattresses, sofas, rugs and other home furnishings. HDM found in house dust generally belong to the suborder Astigmata, Prostigmata, Mesostigmata and Cryptostigmata [1, 2]. The major HDM in the climatic area are the Dermatophagoidinae mites, *i.e.*, *Dermatophagoides pteronyssinus*, *D. farinae* and *D. microceras*, and members of the subfamily Pyroglyphinae, of which the most common species is *Euroglyphus maynei*. The Acaridae, *i.e.*, *Acarus siro*, *Tyrophagus putrescentiae*, *T. longior*, and other mites are found in larders or other food stores, where mites of the family Glycyphagidae, *i.e.*, *Lepidoglyphus destructor* and *Glycyphagus domesticus*, also are common [3].

HDM causes asthma that affects millions of people around the world primarily derived from species *D. pteronyssinus*, *D. farinae*, *E. maynei* and *Blomia tropicalis* [4]. The factor that influences the survival of HDM and its prevalence is environmental relative humidities that they are rare or absent in dry conditions. In general, HDM is rarely found in public buildings and modes of transportation than in homes, because HDM could not survive in dry conditions and need sufficient amount of food, they feed on dead skin cells of humans and fungi [5]. HDM species diversity in an urban environment has been reported from several countries [5] and specifically in Asia

by Thomas [6]. The first archives of the HDM in Jakarta reported by Baratawidjaja *et al.* [7] and in Denpasar Bali by Santoso [8], and no informations yet after that.

This study aims to study the diversity, the distribution and density of HDM in the settlement areas in Bogor.

1.1. Materials and Methods

1.1.1. Location and Time Research

The study was conducted in the residential area of society that is divided into two types of regions, *i.e.* housing (densely populated residential and residential complexes) and temporary shelter (guest house, boarding schools, boarding houses and student dormitories). HDM identification process was carried out in the Laboratory of Entomology of Health, Faculty of Veterinary Medicine, IPB University, Bogor, Indonesia. This research was conducted from September 2014 - March 2015.

1.1.2. House Dust Mites Sampling

1.1.2.1. At housing

HDM sampling at this place were carried out in (1) densely populated residential (irregular dense cluster housing area *i.e.* Cibanteng, Babakan Leak and Babakan Raya villages) and (2) residential complexes (the area where a cluster of housing lined up regularly *i.e.* IPB Housing Complex). 20 houses on each type of housing were examined for the prevalence of HDM. HDM samples were collected by using vacuum cleaner on five points, namely bed (mattress dust, sheets dust, pillow dust), seat (sofas, chairs and benches) carpet, flooring and home furnishings (desks, cabinets, furniture, fans *etc.*). The collected dust samples from every point were taken and put in plastic bags and labelled.

1.1.2.2. At transitional shelter

Sampling of dust in a temporary shelter was done in four types of areas *i.e.* guest house (two guest houses), Islamic boarding schools (male and female dormitory), boarding houses (male and female boarding house), student dormitories (male and female dormitory) closest to the campus area of IPB University Bogor. Dust sampling was conducted at 30% of the number of available rooms at each study site, and the dust was collected at three points within each room, namely on the floor, the bed (sheets dust, pillow dust, mattress dust, beds dust) and furnishings.

1.1.3. Isolation and Identification of HDM

Isolation of HDM was done by putting 1 g dust into the Berlese funnel [9] in 30 minutes. The collected HDM was examined under a microscope and counted by using a needle. Furthermore, the HDM preparations were made on the microscope slide using Hoyer medium or Canada balsam [9]. Identification was done by using identification keys of Colloff and Spieksma, Krantz and Walter, and Roden [1, 2, 10].

1.1.4. Data analysis

HDM species diversity including data on relative abundance, the frequency of species, dominance of species was analysed and the Shannon-Wiener diversity index (H) followed the formula according to Odum [11].

$$(H) = -\sum P_i \ln (P_i); \text{ with } P_i = N_i/N$$

Where:

P_i : Comparison of the number of individuals of a species with an overall species

N_i : the number of individuals to- i

N : The total number of individuals

Criteria is the diversity index followed Krebs [12]: High ($H > 3$); Moderate ($1 \leq H \leq 3$); Low ($H < 1$) [12].

Humidity and temperature data obtained from BMKG Bogor, The Meteorology, Climatology and Geophysics Agency [13] inputted into the database using SPSS 16. The non-parametric statistics (Spearman Correlation Test) to determine the relationship of the humidity and temperature of the HDM infestation. The level power relations are no association/weak ($R = 0.00 - 0.25$), ($R = 0.26 - 0.50$), strong ($R = 0.51 - 0.75$), and very strong/perfect ($R = 0.76 - 1.00$).

1.2. Our Contribution

This paper presents some informations on diversity, distribution and abundance of house dust mite infestations in six types of settlements in Bogor Indonesia, *i.e.* densely populated residential, residential complexes, guest houses, boarding schools, boarding houses and student dormitories. The correlation between humidity and temperatures against the infestation of HDM in all types of settlements were also described in this paper.

1.3. Paper Structure

The rest of the paper is organized as follows: Section 2 described the diversity of types of HDM, the relative abundance and species dominance of HDM, the density and distribution of HDM at housing areas, and the density and distribution of HDM at the transitional shelter areas. Finally, Section 3 concludes the paper and presents directions for future studies.

2. RESULTS AND DISCUSSION

2.1. The Diversity of HDM Types

The type and the percentage of HDM found in the settlements showed varying results as shown in Table 1. The HDM found in densely populated housing, mostly was *Blomia tropicalis* (48.18%), followed by *Dermatophagoides pteronyssinus* (11.66%), Cheyletidae (10.13%), *Blomia* sp. (13.58%), Mesostigmata (9.75%), *D. farinae* (5.35%), Pseudoscorpion (1.15%) and Oribatellidae (0.19%). Meanwhile, there were 8 types of HDM found in a residential complex *i.e.* *B. tropicalis* (44.42%), followed by Cheyletidae (23.95%), *D.*

pteronysinus (21.63%), *Blomia* sp. (4.65%), Mesostigmata (2.33%), *D. farinae* (0.93%) Pseudoscorpion (0.93%), Oribatidae (0.70%) and Tyrophagus spp. (0.47%). Also, there were 8 types of HDM found in the temporary residence of student i.e. *B. tropicalis* (41.53%), *D. pteronyssinus* (21.59%), Cheyletidae (12.96%), *Blomia* sp. (5.65%), Mesostigmata (9.63%), *D. farinae* (4.65%), Acaridae (1.33%), Oribatidae (1.00%), Pseudoscorpion (1.00%) and *Lepidoglyphus destructor* (0.66%). However, there were only two types of HDM found in the guest house i.e. *B. tropicalis* (50%) and Cheyletidae (50%).

In this study, a total of 11,298 HDM from 534 g dust samples were collected from six locations in Bogor. Of 10 HDM species found were classified into one Class Arachnida, 4 different suborders (i.e. Astigmata, Prostigmata, Mesostigmata and Oribatida) and 5 families i.e., Glycyphagidae (*B. tropicalis*, *Blomia* sp., *L. destructor*), Pyroglyphidae (*D. pteronyssinus* and *D. farinae*), Acaridae (*Tyrophagus* spp.), Cheyletidae, and Oribatidae. These results were different to that found by Baratawidjaja *et al.* [7] 7 types of HDM namely, *D. pteronyssinus*, *D. farinae*, *B. tropicalis*, *Sturnophagoides* sp, *Tyrophagus putrescentiae*, *Austroglycyphagus* sp and *Cheyletus* sp were found in Jakarta. In this study, there were no finding of *Sturnophagoides* sp and *Austroglycyphagus* sp instead another type of HDM (*L. destructor*) was found.

Blomia tropicalis was detected in all types of settlements, found in carpets, beds, seats, floor and household furniture. This species was commonly known as a causing agent of asthma and rhinitis. 62% of asthma patients have positive allergen against *B. tropicalis* and 38% of patients positive against *D. farinae* and *D. pteronyssinus* [14].

Dermatophagoides pteronyssinus was found in densely populated areas, residential complexes and temporary residence of students. This mite found in carpets, bedding,

seating, flooring and home furnishings. This species is commonly found in homes and distributes worldwide [15]. This mite can complete its life cycle in temperature 16-35 °C, from egg to adult takes approximately 20 days [16]. The adult male mites live for about 77 days while females 45 days, and the females can produce 40-80 eggs during her lifetime [17].

Dermatophagoides farinae was found in a densely populated residential, residential complexes and temporary student residences. According to Larry *et al.* [18] the temperature range for optimum development of *D. farinae* is between 23-30 °C. These mites can complete its life cycle for 28 days at a temperature of 23 °C, and 20 days at 30 °C. This mite reproduction period at a temperature of 23 °C was 24 days and can lay 1 to 4 eggs a day, and can produce 40-80 eggs during their lifespan. The eggs are unable to hatch when the temperature above 30 °C. *D. farinae* has a cosmopolite distribution that likes 75% of humidity [19]. Females may live longer (about 100 days) than other HDM types [20].

Family Cheyletidae found in all types of settlements. This study found Cheyletidae mite mixed with other dust mites and many were found in the living room on a couch, floor and carpet. According to Danny *et al.* [21] Cheyletiella caused cheyletiellosis or "walking dandruff" in dogs and cats with variably pruritic and non-seasonal. These mites do not burrow but live in keratin of skin-surface. They move rapidly but periodically attach firmly to the epidermis, pierce the skin with their chelicerae, and become engorged with tissue fluids. The eggs are smaller than louse nits and are attached to hairs by fine fibrillar strands.

Table 1 The number and percentage of house dust mites on settlements in Bogor from October 2014-February 2015

No	Type of mite	Location-type settlements				Total
		A Σ (%)	B Σ (%)	C Σ (%)	D Σ (%)	
1	<i>Blomia tropicalis</i>	252 (48.1)	191 (44.4)	125 (41.5)	1 (50)	569
2	<i>Dermatophagoides pteronyssinus</i>	61 (11.6)	93 (21.6)	65 (21.5)	0 (0)	219
3	Cheyletidae	53 (10.1)	103 (23.9)	39 (12.9)	1 (50)	196
4	<i>Blomia</i> Spp	71 (13.5)	20 (4.65)	17 (5.65)	0 (0)	108
5	Mesostigmata	51 (9.75)	10 (2.33)	29 (9.63)	0 (0)	90
6	<i>Dermatophagoides farinae</i>	28 (5.35)	4 (0.93)	14 (4.65)	0 (0)	46
7	Oribatidae	1 (0.19)	3 (0.70)	3 (1.00)	0 (0)	7
8	Acaridae	0 (0.00)	0 (0.00)	4 (1.33)	0 (0)	4
9	<i>Tyrophagus</i> spp	0 (0.00)	2 (0.47)	0 (0.00)	0 (0)	2
10	<i>Lepidoglyphus destructor</i>	0 (0.00)	0 (0.00)	2 (0.66)	0 (0)	2
11	Pseudoscorpion*	6 (1.15)	4 (0.93)	3 (1.00)	0 (0)	13
Total		523 (100)	430 (100)	301 (100)	2 (100)	1256

Note: (A) Densely populated residential area, (B) Residential complex, (C) Temporary student residence, (D) Guest house, (*) Not a group of mites

2.2. The Relative Abundance and Species Dominance of HDM

The relative abundance and dominance value of HDM in Bogor were showed in Table 2. *Blomia tropicalis* and Cheyletidae were always obtained (the frequency value 1.00) which means these HDM were discovered at all types of settlements. Based on species dominance, HDM in Bogor residential area was dominated by *B. tropicalis* (45.30%), followed by *D. pteronyssinus* (13.08%), Cheyletidae (15.61%), *Blomia* spp. (6.45), Mesostigmata (5.37%), *D. farinae* (2.75%), Oribatellidae (0.42%), Acaridae (0.08%), *Tyrophagus* spp (0.04%) and *L. destructor* (0.04%). The species diversity index of HDM in residential areas of Bogor was medium category (1589).

2.3. The Density and Distribution of HDM at Housing Areas

The density and distribution of HDM in the housing areas are presented in Table 3. The highest density of HDM at household furniture in Bogor was found distributed in carpets, both in densely populated residential (23.94% with average 73 ± 61.69 mites per g dust) and in residential complex (33.71% with average 51.88 ± 43.52 mites per g dust). As many 11 carpets and 9 carpets in both areas were examined and all positive infested with HDM (100%). The temperature at the time of sampling was 26.9 °C and 86% – 88% of relative humidity. Furthermore, the percentage of HDM in beds was also detected both in densely populated residential (80%)

Table 2 Relative abundance and dominance Figures House Dust Mites in Bogor settlements from October 2014 - February 2015

Type	Relative abundance (%)	Frequency	Species dominance (%)
<i>B. tropicalis</i>	45.30	1.00	45.30
<i>D. pteronyssinus</i>	17.44	0.75	13.08
Cheyletidae	15.61	1.00	15.61
<i>Blomia</i> Spp	8.60	0.75	6.45
Mesostigmata	7.17	0.75	5.37
<i>D. farinae</i>	3.66	0.75	2.75
Oribatidae	0.56	0.75	0.42
Acaridae	0.32	0.25	0.08
<i>Tyrophagus</i> spp	0.16	0.25	0.04
<i>L. destructor</i>	0.16	0.25	0.04
Pseudoscorpion	1.04	0.75	0.78

Table 3 The density and distribution of HDM at the housing area of Bogor from October 2014 - February 2015

No	Habitat characteristic of HDM	Number of point examined	Percentage positive point	The average of mites density / g of dust	Distribution of HDM (%)
1	Densely populated Residential				
	Carpet	11	100.00	73 ± 61.69	23.94
	Seat	19	94.74	66.85 ± 140.06	21.92
	Floor	19	94.74	65.68 ± 84.01	21.54
	Furniture	20	85.00	61.45 ± 164.55	20.15
	Bed	15	80.00	38 ± 43.51	12.46
	Total	84	90.47		100
2	Residential complexes				
	Carpet	9	100.00	51.88 ± 43.52	33.71
	Floor	20	55.00	40.2 ± 59.95	26.11
	Furniture	20	85.00	32.3 ± 42.81	20.98
	Seat	20	95.00	22.8 ± 27.32	14.81
	Bed	20	75.00	6.75 ± 8.11	4.38
	Total	89	79.78		100

positive, with average 38 ± 43.51 mites/g dust) and in residential complex (75% positive with average 6.75 ± 8.11 mites/gr dust).

Habitat distribution of HDM in densely populated residential area was found from high to low, respectively in carpet (23.94%), seat (21.92%), floor (21.54%), furniture (20.15%) and bed (12.46%), meanwhile in residential complex was found in carpets (33.71%), floors (26.11%), furniture (20.98%), seat (14.81%) and bed (4.3%). In addition, HDM were also found on other household furniture, such as jars, paintings, vases, windows etc. This is because household furniture was not daily cleaned therefore so much dust remains as well as many organic ingredients available that provide abundant food for HDM. Santoso [8] reported in Denpasar Bali, all of 14 houses of examined asthma patients were all found positive of HDM. A total of 12 house samples were found *Dermatophagoides* sp. mixed with other HDM, with densities ranging between 20-104 mites/g of dust. In Mexico (Latin America) HDM density (*B. Tropicalis*) can reach to 8.934 mites/g of dust [14].

2.4. The Density and Distribution of HDM at The Transitional Shelter Areas

The density and distribution of HDM in transitional shelter areas are presented in Table 4. In the guest house, HDM were found in furniture (0.15 ± 0.36 mites/g of dust), obtained from 2 rooms (16.67%) a positive of the 12 rooms checked. Meanwhile no HDM found on the bed and

the floor. In this place, although the temperature and the humidity are very supportive for the breeding of HDM, but the presence and density of HDM in this area was low. This was because the homestead floor is always being mopped and cleaned regularly every day, as well as cleaning the mattress, pillow, bed sheets and pillowcases.

In the boarding school, the highest density of HDM was found in the furniture (8 ± 13.64 mites/g of dust), followed by the bed (6.73 ± 7.00 mites/g of dust), and the floor (6.53 ± 7.05 mites/g of dust). Furthermore, the highest density of HDM in boarding house was found in the room's furniture (48.54 ± 29.26 mites/g of dust) followed by the floor (30.62 ± 22.45 mites/gr of dust), and the bed (14.15 ± 10.89 mites/g of dust). Meanwhile, in student dormitories the highest HDM was found in rooms furniture (13.47 ± 17.47 mites/g of dust) followed by the bed (13.13 ± 20.32 mites/g of dust), and the floor (11.72 ± 22.07 mites/g of dust).

The high density of HDM at boarding school, guest house and boarding house compared to the guest house were because of most goods contained in the rooms are not always being cleaned. HDM breed properly in the settlements where many used and unused materials piled inside the houses for a long time, providing abundant organic materials as food intake for HDM. The HDM also can flourish on the bed because there are a lot of available scale or skuama produced by human (0.5-1 g/day) as mite food sources. Additionally, bedroom furniture consisting of a mattress, blankets, curtains and bed linen contains many fibers that are easier to accommodate dust than other home furnishings.

Table 4 The density and distribution of TDR in transitional shelter areas of Bogor from October 2014 - February 2015

No	Habitat characteristic of HDM	Σ point examined	Percentage positive point	The average of density mites/gr of dust	Distribution of HDM (%)
1	Guest house:				
	furniture	12	16.67	0.15 ± 0.36	100
	bed	12	0.00	0 ± 0	0
	floors	12	0.00	0 ± 0	0
	Total	36	5.55		100
2	Boarding schools:				
	furniture	15	66.67	8 ± 13.64	37.62
	bed	15	60.00	6.73 ± 7.00	31.66
	floors	15	80.00	6.53 ± 7.05	30.72
	Total	45	68.88		100
3	Boarding houses:				
	furniture	13	92.31	48.54 ± 29.26	52.02
	floors	13	84.62	30.62 ± 22.45	33.81
	bed	13	76.92	14.15 ± 10.89	15.17
	Total	39	84.62		100
4	Student dormitories:				
	furniture	56	69.65	13.47 ± 17.47	35.17
	bed	56	73.22	13.13 ± 20.32	34.26
	floors	56	64.29	11.72 ± 22.07	31.58
	Total	168	69.05		100

Research conducted by Mcrae *et al.* [22] at the student hostel in Dunedin (New Zealand), showed that the density of HDM more commonly found on the floor compared to the bed. This was because the sheets used in dormitory were regularly washed by hot water and washing machine. Besides that, the HDM on bed were only found on the mattress which used for more than one year, and no HDM finding at less than one year mattress.

There was significantly correlation between humidity and temperatures to the infestation of HDM in all types of settlements. High humidity cause the high of HDM density, seen from P value ($P=0.026 \leq \alpha=0.05$) very high level of correlation, and characterized by value of $R=0.769$, belonged to the strong category. On the contrarily, high temperature cause the low of HDM density, seen from P value ($P=0.003 \leq \alpha=0.01$) very high level of correlation, and characterized by value of $R=0.895$ included in the strong category.

3. CONCLUSION

Total of 1,256 HDM were identified on settlement areas in Bogor. The result showed there were 10 types of HDM, *i.e* *Blomia tropicalis* (45.34%), *Dermatophagoides pteronyssinus* (17.45%), Cheyletidae (15.62%), *Blomia* spp. (8.61%), Mesostigmata (7.17%), *Dermatophagoides farinae* (3.67%), Oribatida (0.56%), Acaridae (0.32%), *Tyrophagus* spp. (0.16%), *Lepidoglipus destructor* (0.08%). The highest density of HDM on housing was found on the carpet, both in densely populated residential (23.94%) and residential complex (33.71%). At temporary shelter, HDM mostly found on the household goods, at guest houses (100%), boarding schools (37.62%), boarding houses (52.02%) and student dormitories (35.17%). There was significant correlation between humidity and temperatures against the infestation of HDM in all types of settlements.

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REFERENCES

- [1] M.J. Colloff, F.T. Spieksma, Pictorial keys for the identification of domestic mites Clin. Exp. Allergy, 22 (1992) 823-830
- [2] G.W. Krantz and D.E. Walter, A Manual of Acarology, America: United States of America, 2009.
- [3] A. Warner, S. Bostrom, C. Moller, N.I.M. Kjelman, Mite fauna in the home and sensitivity to house-dust and storage mites, Allergy, 54 (1999) 681-690
- [4] E.M.S. Milian, A.M. Diaz, Allergy to house dust mites and asthma, PRHSJ, 23(1) (2004) 47-57
- [5] G. Larry, L.G. Arlian, S. Marjorie, J.S.Morgan and B.S. Neal, Dust mite allergens: ecology and distribution, Curr. Allergy Asthma Rep. 2(5) (2002)401-411
- [6] W.R. Thomas, Geography of house dust mite allergen, J. Allergy Immunol. 28 (2010) 211-24
- [7] I.R. Baratawidjaja, P.P. Baratawidjaja, and A. Darwis, Mites in Jakarta homes, Allergy, 53(12) (1998) 1226-1227
- [8] H. Santoso, The value of a single skin prick testing for specific IgE Dermatophagoides pteronyssinus to distinguish atopy from non-atopic asthmatic children in the tropics, Asian Pac. J. Allergy Immunol. 16 (1998) 69-74
- [9] U.K. Hadi and S. Soviana, Ektoparasit; Pengenalan, Diagnosa dan Pengendaliannya, Bogor: IPB Press, 2010
- [10] A.L. Roden, Extraction Efficiency and Identification Guide to Common House Dust and Storage Mites, Georgia: Graduate Faculty of the University of Georgia in Partial Fulfillment of the Requirements for the Degree, 2012
- [11] E.P. Odum, Dasar-Dasar Ekologi Terjemahan oleh Tjahjono Samingan Fundamentals of Ecology, Yogyakarta: UGM Press, 1993
- [12] C.J. Krebs, Ecology The Experimental Analysis of Distribution and Abundance Third Edition, New York: Harper and Row Publishers, 1987
- [13] [BMKG] Badan Meteorologi dan Geofisika (The Meteorology, Climatology and Geophysics Agency, abbreviated BMKG) Kabupaten Bogor, Data Klimatologi, Bogor: BMGKK, 2015
- [14] B.E. Stanaland, E. Fernandez-Caldas, C.M. Jacinto, W.L. Trudeau and R.F. Lockey, Sensitization to *Blomia tropicalis*: skin test and cross-reactivity studies, J. Allergy Clin. Immunol. 94(3) (1994) 52-457
- [15] L.G. Arlian and T.A.E. Platts-Mills, The biology of dust mites and the remediation of mite allergens in allergic disease, J. Allergy Clin. immunol. 107(3) (2002) 406-413
- [16] E.C. Liao, C.M. Ho, M.Y. Lin and J.J. Tsai, Dermatophagoides pteronyssinus and Tyrophagus putrescentiae allergy in allergic rhinitis caused by

- cross-reactivity not dual-sensitization, J. Clin. Immunol. 30 (2010) 830-839
- [17] M.J. Colloff, Effects of temperature and relative humidity on development times and mortality of eggs from laboratory and wild populations of the European house-dust mite *Dermatophagoides pteronyssinus* (Acari: Pyroglyphidae), Exp. Appl. Acarol. 3 (1987) 279-289
- [18] G.Larry, M.S. Arlian and Morgan, Reproductive biology of *Euroglyphus maynei* with comparisons to *Dermatophagoides farinae* and *D. pteronyssinus* Exp. Appl. Acarol. 66(1) (2015) 1-9
- [19] T. Chan, K. Ji, A.K.Yim, X. Liu, J.Zhou, R.Li, K.Y Yang, M. Li, P.T. Law, L.A.Yun, B.S.Wu, C. Ze-Lang, Q.Y. Hao, M.S.C, R.K.Bao, Ng Leung, P. Kwong-Shing, X.J. Zou-Zhong, P.M.D Ran, N.Zhong, Z.M.D. Liu and S.KP Tsui, The draft genome, transcriptome, and microbiome of *Dermatophagoides farinae* reveal a broad spectrum of dust mite allergens, J. Clin. Immunol. 135(2) (2015)539-548
- [20] L.G. Arlian and J.S Dippold, Development and fecundity of *Dermatophagoides farinae* (Acari: Pyroglyphidae) J. Med. Entomol. 33(2) (1996) 257-260
- [21] W. Danny, D.V.M Scott, T. Robert and J.R. Horn Zoonotic Dermatoses of Dogs and Cats Veterinary Clinics North America, 17(1) (2015) 117-144
- [22] W.M. Mcrae, E.M. Flannery, J.O. Cowan, C.R.Mclachlan, S.R.W. Herbison, J Crane and C.S. Wong, House dust mite allergen levels in University student accommodation in Dunedin, NZMJ, 115(1157) 20021-6