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Source: Journal of Medical Entomology, 50(1):31-36. 2013.
Published By: Entomological Society of America
URL: http://www.bioone.org/doi/full/10.1603/ME12036

Species Diversity of House Dust Mites in Beijing, China

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J. Med. Entomol. 50(1): 31–36 (2013); DOI: http://dx.doi.org/10.1603/ME12036

ABSTRACT Even though house dust mites are one of the most important allergens, there have been few studies in China for their identification and diversity. In this study, we reported that *Dermatophagoides siboney* was found for the first time in Beijing, China, in a temperate zone and it was also the first reported in Asia. This survey of mite prevalence was carried out in several districts of Beijing, a city of thirty million people. House dust samples were collected from 38 homes of mite-allergic patients who visited our Allergy Department from December 2008 to January 2010. Out of 345 house dust samples collected, 64% contained mites. *Dermatophagoides farinae* was the predominant species in the mite population found and *Dermatophagoides pteronyssinus* was second, and *Dermatophagoides siboney* was the third. The positive rates of samples were higher in single-story homes and lower buildings. The seasonal density distribution of house dust mites showed the highest mite concentration in September through October, followed by May through July, December to next January; and lowest in March and November.

KEY WORDS *Dermatophagoides siboney*, *Dermatophagoides farinae*, *Dermatophagoides pteronyssinus*, house dust mite, seasonal distribution

With the improvement of household living conditions, the incidence of allergic diseases is rising worldwide. A self-reported prevalence of childhood allergic diseases in Beijing, Chongqing, and Guangzhou, China, the prevalence rates of asthma were 3.15, 7.45, and 2.09%, respectively; the rates of allergic rhinitis were 14.46, 20.42, and 7.83%; and the rates of eczema were 20.64, 10.02, and 7.22% (Zhao et al. 2010). In Taiwan, the overall 8-yr prevalence of atopic dermatitis, allergic rhinitis, and asthma was 6.7, 26.3, and 11.9% from 2000 to 2007, respectively (Hwang et al. 2010). In 2009, current asthma prevalence of the United States was 8.2% (Akinbami et al. 2011). Allergic rhinitis is the fifth most common chronic disease in the United States with a prevalence ranging between 5 and 22% (Bernstein 2010); 10.7% of children were reported to have a diagnosis of eczema in 2010 (Shaw et al. 2011).

Reactions to domestic mites can cause asthma, allergic rhinitis, atopic dermatitis, and urticaria. Therefore, with the increasing numbers of patients allergic to domestic mites, more monitoring of allergen levels is needed to improve the hygiene conditions of homes (Arlian and Platts-Mills 2001). Because China is geographically large, there are big differences in geographic and climate factors (temperature and humidity) from continental and oceanic climates. Predominant domestic mite species may be different in different regions, and allergenic levels of mites vary.

Previous reports about distribution of domestic mites in China mostly were limited in regions south of Yangtze River, whereas they rarely were in the northern region (Cai and Wen 1989, Chang and Hsieh 1989, Zhou et al. 1996, Lai et al. 1988). The data are limited and old, without systemic study of domestic mite species.

Materials and Methods

Subjects, Collection Places, Area, and Time. This survey of mite prevalence was carried out in several districts of Beijing, China, a city of 30 million people. The subjects included the 38 families of patients visiting clinics of our allergy department; tests showed a positive prick test (ALK Denmark skin prick test solution) to mite allergen extracts from *Dermatophagoides farinae* Hughes, 1961; *Dermatophagoides pteronyssinus* Trouessart, 1897; and sIgE (d1 and d2) test ≥2 class (Phadia, Uppsala, Sweden). The Institutional Review Board of Peking Union Medical College Hospital approved the study protocol. Oral informed consent was given by every patient included in this study in agreement with Good Clinical Practice. Collection places were where mites easily survive and breed, including pillows, quilts, sheets, bed pads, mattresses, sofas, and carpets. Collection equipments included a vacuuming device of 1,200-W highest output power, the ALK Dust Trap (ALK, Copenhagen, Denmark), a device to define 1 m^2 of collection area or measuring scale. Collection area was 1 m^2, and collection time

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was 3 min. For places with surface area <1 m^2, such as pillows, sofas, or carpets, samples were collected from the whole surface, and collection time was shortened to 2 min. The indoor temperature and relative humidity were measured by our staff.

Collection Methods. Data recorded included the number of the collection device, filter plate, collection place, and record-related information, including family living condition, recent cleaning history by vacuum, and age of bedding used. Upon the completion of sample collection, dust samples were transported to a lab and mites were isolated immediately or stored at −20°C in a freezer until later isolation.

Isolation and Storage of Mite Samples. Laboratory apparatus and materials were as follows: stereo microscope (Nikon SMZ 1500; Nikon, Tokyo, Japan), optical microscope (Leica DM 2500; Leica Microsystems, Inc., Deerfield, IL), 70% alcohol, saturated brine, quantitative *filter* paper, ink, needle, Hoyer's Medium, forceps, and slide drier.

Isolation of Mite Bodies From Dust Samples. Flotation method was used to isolate the mite bodies from dust samples, picked up body, and stored in 70% alcohol.

Storage of Specimens. Mite specimens were stored in 70% alcohol for a long time. For convenience in isolation and identification, permanent slides were prepared using Hoyer's Medium.

Identification of Specimens. Ready-made slides were observed under a microscope, and mites species were defined according to morphology of mites described in Krantz and Walter classification method (2009), combined with other related information. *Dermatophagoides siboney* Dusbábek, Cuervo *et* Cruz, 1982, were checked again by three professors. They were professor Larry G Arlian from Department of Biological Sciences, Wright State University, United States; Prof. Alexis Labrada from National Center of Bioproducts, Cuba; and Dr. Enrique Fernández-Caldas, CBF LETI, Research Laboratories, Madrid, Spain.

Data Analysis. Summarize the number of samples with detectable mites, calculate positive rate: positive rate = positive sample number/total sample number × 100%.

Summarize number of each type of mites, calculate the percentage of each species of mites in total mites, and determine the predominant species.

Count the total number of mites isolated from dust sample (including live mites, dead mites, and incomplete remains), and calculate mite density: mite density (individuals per gram house dust) = total number of detected (individuals)/weight of isolated dust (gram house dust).

Results

Composition of Domestic Mites. Three hundred forty-five dust samples were collected from 38 families in Beijing area with 64% of detected mites. Among 345 dust samples, 130 were collected from 10 families with two repeats, and 215 from 28 families. Each of the 10 households was sampled twice in different time points.

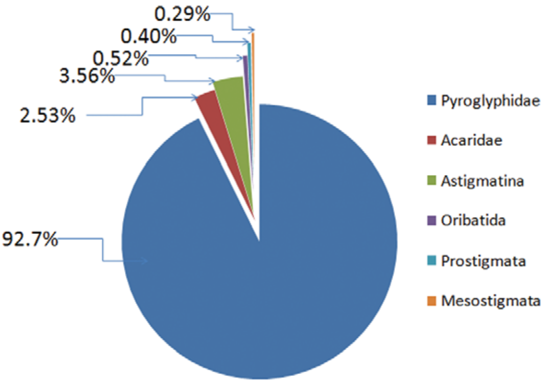

Fig. 1. Proportion of domestic mites. (Online figure in color.)

Altogether, 4,757 individuals in different development stages were detected, and 1,144 slides were prepared; 3,992 individuals were identified (mites remains were not identified),and in total there were 22 species of 15 genera representing 12 families belonging to three orders of Acari, among of which *Dermatophagoides siboney* can also cause allergic diseases, and was found for the first time in China. In addition, 57 individuals were identified in insect class, two species of one genera representing one family belonging to Psocoptera of Insecta.

Among domestic mites, Pyroglyphidae (genera of dust mites) has the highest percentage (92.70%), followed by Acaridae (2.53%), whereas other species rarely were detected in several families (Fig. 1). There are nine allergenic mites, including *Dermatophagoides farinae; Dermatophagoides pteronyssinus; Dermatophagoides siboney; Dermatophagoides microceras* Griffiths *et* Cunnington, 1971; *Tyrophagus putrescentiae* (Schrank, 1781); *Aleuroglyphus ovatus* (Troupeau, 1878); *Suidasia nesbitti* Hughes, 1948; *Chortoglyphidae arcuatus* (Troupeau, 1879); and *Lepidoglyphus destructor* (Schrank, 1781). A list of mite and insect species found in house dust can be seen in Table 1.

Among the predominant dust mites, *Dermatophagoides farinae* (69%) was the predominant species in the Pyroglyphidae, and *Dermatophagoides pteronyssinus* (24%) was the next. The third was *Dermatophagoides siboney* (6%) (Fig. 2). *Dermatophagoides siboney* can also cause allergic diseases, which only were reported in Caribbean region of Middle America (such as Cuba and Puerto Rico) and now are reported for the first time in China. We will report the morphological diagnosis and seasonal prevalence of *Dermatophagoides siboney* in another article.

Most of the mite samples collected this time were dead mites, only 326 live mites were found among 65 samples, accounting for 19%, and most of the live mites were nymph mites or larva mites. In addition, most of the detected mite samples are incomplete; only 1,034 individuals are complete, accounting for 22%. Among dust mites, detected nymph mites were more than adults, with the percentage of 48% (Table 2).

Table 1. List of mite and insect species found in house dust

Arachnida
Acari
Sarcoptiformes
Pyroglyphidae
D. farinae
D. pteronyssinus
D. siboney
D. microceras
Acaridae
T. putrescentiae
Tyrophagus sp.
A. ovatus
Rhizoglyphus sp.
Thyreophagus sp.
Suidasiidae
S. nesbitti
Chortoglyphidae
C. arcuatus
Glycyphagidae
L. destructor
Histiostomatidae
Histiostoma sp1.
Histiostoma sp2.
Haplochthoniidae
Haplochthonius sp.
Trombidiformes
Cheyletidae
Cheyletus sp.
Tetranychidae
Eotetranychus sp.
Tetranychidae gen. sp.
Tarsonemidae
Tarsonemus granarius Lindquist, 1972
Mesostigmata
Blattisociidae
Blattisocius dentriticus (Berlese, 1887)
Blattisocius sp.
Laelapidae
Haemolaelaps casalis (Berlese, 1887)
Insecta
Psocoptera
Liposcelididae
Liposcelis bostrychophila (Badomnel, 1931)
Liposcelis entomophila (Enderlein, 1907)
Liposcelis sp.

Among the investigated families, 30 families had >2 species of mites, in only eight families there was only one species, accounting for 21%. Predominant mite species are different between families; there are 27 families with prevalence of *Dermatophagoides farinae*

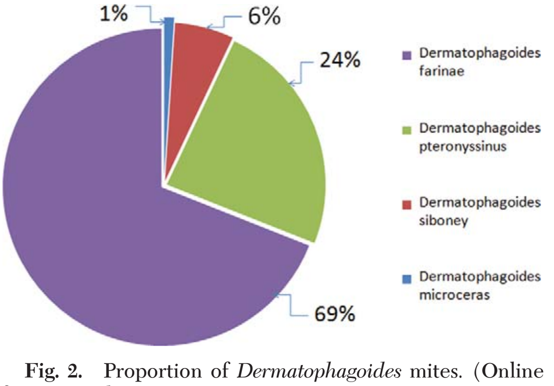

Fig. 2. Proportion of *Dermatophagoides* mites. (Online figure in color.)

Table 2. Specimens composition of different life stages of Dermatophagoides

Dermatophagoides	No.	%
Adult	1,613	41
Nymph	1,854	48
Larva	390	10
Total	3,857	100

(71%), and five families with prevalence of *Dermatophagoides pteronyssinus* (13%). The percent of predominant mites in most of families is higher than 70%. We also found that the number of mites and percentage of predominant mites changed with seasons switching, and even in some families, predominant mite species changed.

Comparison of Mite Composition and Mite Density Between Different Living Conditions. The positive rate in single-story houses was 91%, higher than that of buildings (60%) (Table 3).

Positive rate in samples collected from carpets was highest (78%), the rate in bed pad was next (69%), and the lowest was on the floor around the bed (44%). There was no significant difference between positive rates in pillow, bed pad, and mattress. In aspect of species diversity, there were highest numbers of species (16) in bed pad, followed by mattress (11). The composition of mites in both quilt and floor around bed revealed four species.

In different habitats, mite density in pillows was highest (282 individuals per gram), followed by mattress (120 individuals per gram), and sofa (115 individuals per gram). Mite densities in all of those three places were higher than 100 individuals per gram. The highest mite density existed in pillows, reaching to 8,000 individuals per gram, whereas peak mite densities in mattress, sofa, quilt, bed pad, sheets, and sponge mattress were higher than 500 individuals per gram, which possibly stimulates the acute attack of asthma. In addition, floor mite density was higher in floor carpet. Domestic mites propagated more in bed and sofa (Table 4).

Among of the investigated samples, mite density was higher than 100 individuals per gram dust in 71 samples (21%), and in seven samples mite density was higher than 500 individuals per gram dust (8%).

Seasonal Prevalence of Domestic Mites. There are three peaks for average mite density, existing in May–July, September–October, and December-next January, respectively, among which the density in September–October is highest, followed by January and May, and the bottom value of density appeared in March and November (Fig. 3).

Table 3. Positive rate of mite samples in different type of housing

	Single-story house	High-rise block
No.	6	32
No. samples	56	289
Positive no.	51	172
%	91.07	59.52

Table 4. Density statistics of mites living in different habitats

Dust source	Peak value (individuals per gram dust)	Average mite density (individuals per gram dust)		The no. of sample
Pillow				
Buckwheat	900	129		22
Cotton and synthetic fiber	8,000	318	282	26
Mixed	3,770	680		8
Quilt	1,294	71		45
Sheet	560	32		31
Bed pad				
Top	765	42	81	56
Bottom	1,250	175		29
Sponge mattress	522	64		12
Mattress	3,330	120		53
Sofa	1,471	115		35
Carpet	116	40		9
Floor around bed	100	13		10
Other				
Blanket	220	47		4
The hammock head	10	7		5
Total				345

During the whole year, live mite density reached to peak from September to October, with the highest value in October, and mite density stayed low level during left months. The lowest value existed in March, when no live mite was detected (Fig. 4).

The number of mite species were highest in the spring and autumn, with the peak in October, when 12 species were detected; next were May and September with 10 species; and the lowest was in November with three species.

Discussion

Composition of Domestic Mites. In this survey, we found a newly reported *Dermatophagoides siboney*, which was reported previously in Caribbean areas such as Cuba (Dusbábek et al. 1982), and Puerto Rico (Montealegre et al. 1997), which is a tropical zone, with tropical rainforest climate. This is the first time that this mites has been reported in a temperate zone or in Asia. One possibility is that this mite is reported later than other mites, by when the systemic domestic mite's survey has been finished in many countries, so this mite was not reported yet. The next possibility is that *Dermatophagoides siboney* is hard to be identified from other mites; it was demonstrated that morphology and molecular biology of *Dermatophagoides siboney* are similar to *Dermatophagoides farinae* and *Dermatophagoides microceras* (Ferrándiz et al. 1998). Moreover, current transportation is rapid and convenient. Beijing, as the capital of China, has frequent traffic with foreign people, so it is necessary to investigate if the appearance of *Dermatophagoides siboney* in Beijing is related to frequent travel.

Dermatophagoides farinae was not detected in the Cuba survey where *Dermatophagoides siboney* was discovered (Ferrándiz et al. 1996), whereas in most of the dust samples collected in Beijing *Dermatophagoides farinae* were found together with *Dermatophagoides siboney* (Data will be published in another paper). *Dermatophagoides farinae* and *Dermatophagoides siboney* have similar morphological characteristics; therefore, identification of these two mites could be mixed up because of different slides preparation positions. Further studies should investigate habitat and mutualism of different mites in genera of *Dermatophagoides*.

Composition of Mites in Different Living Conditions. It was shown from this survey that mite densities are distinct in different living conditions that could be associated with houses structures, ventilation devices, humidity, and hygiene conditions. In the house, the highest mite density is on the bed, and most mites are living in pillows, mattresses, and sofas, where people contact beds and pillows most frequently for sleeping, causing high humidity and many skin scales, and these are good environments for mite growth. Moreover, it is hard to clean and dry sofas and mattresses, so they are the main places of mite propagation. In addition, the ventilation condition in the bed room is usually bad, and people stay in the bed room for a comparably long time, increasing humidity, creating a good condition for growth and propagation of dust mites.

In developed countries, carpet is the main habitat for dust mites; therefore, removal of carpet is recom-

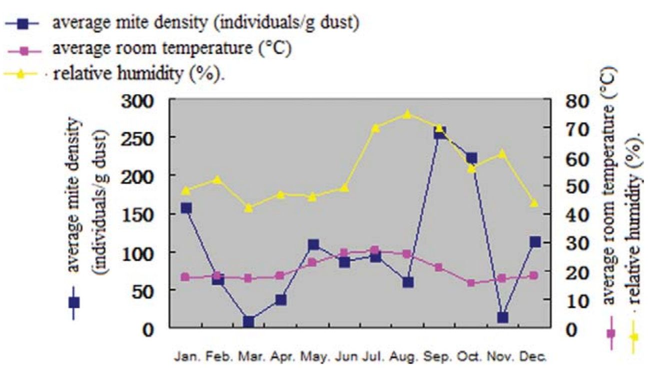

Fig. 3. Seasonal prevalence of domestic mites in relation with temperature, relative humidity, and precipitation. (Online figure in color.)

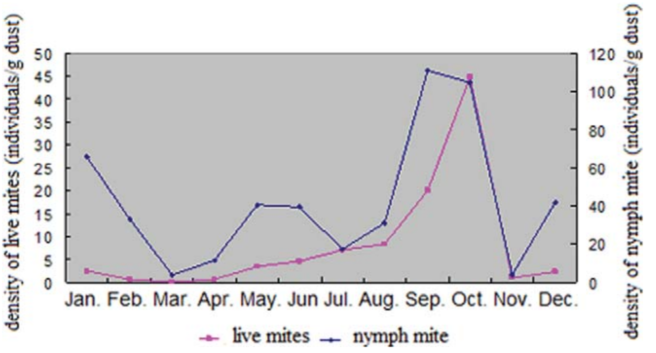

Fig. 4. Seasonal prevalence of live mites and nymph mite. (Online figure in color.)

mended in families with patients allergic to mites (No authors listed 1989). In our survey, although mite density on carpeted floor was higher than that in uncarpeted floor, it was still much lower than that in the bed and sofa. Among the surveyed 38 families, only five were using carpets (small pieces of carpet), which indicates that under different living habits in different areas, main mite living places are different. However, because carpet is hard to clean, mite density in carpeted floor is still higher than that on uncarpeted floor, and positive rate is the highest; we recommend avoiding using carpet in families with patients allergic to mites. It also was found in this survey that hygiene habit and cleaning frequencies affect mite density to a large degree; mite density is relatively low in families who frequently clean and dry their bedding.

Seasonal Prevalence of Domestic Mites in the Beijing Area. Seasonal prevalence of mite density is different between areas (Platts-Mills et al. 1987, Lai et al. 1988, Cai and Wen 1989, Chang and Hsieh 1989, No authors listed 1989, Zhou et al. 1996). Highest density happens in spring in London, United Kingdom; Tokyo, Japan; and Brisbane, Australia; summer in Virginia, United States; and Shanghai, China; autumn in Basel, Switzerland; and winter in Honolulu, HI. The highest density happens in summer (May–July) in Shanghai, spring (April–June) in Nanchang, and autumn (October–November) in Taiwan; the lowest density season is winter (January–February) in Shanghai and Nanchang, and summer (July) in Taiwan. Even in different areas of same country, mite density can reach to a peak in different seasons. By a 2-yr investigation, Arlian et al. (1982) reported that even in the same area, seasonal prevalence could be changed between different years. Therefore, difference in peak time of mite density cannot only be explained by temperature, relative humidity, and amount of precipitation, and it can also be attributed to microenvironment in the house.

It was shown in this survey, in the Beijing area, that from December 2008 through January 2010, mite density reached to peak in autumn September–October, followed by winter (December-next January), and summer (May–July), and the lowest density appeared in spring (March) and winter (November). This pattern does not coincide with outdoor temperature spectrum; instead, it could be related to living habit in the Beijing population. Biological studies showed for dust mites development, the ideal temperature is 20≈25°C, relative humidity is 70≈75%, whereas the lowest tolerable daily temperature is 12°C and the highest tolerable temperature is higher than 27°C (Arlian and Morgan 2003). Although winter outdoor temperature is low in Beijing, heating is delivered from 15 November to 15 March next year. From March to November, indoor temperature is relatively low without heating provided, so mite density falls to the lowest level. Despite the fact that outdoor temperature and relative humidity are much lower in winter, indoor temperature usually is maintained higher than 16°C, and indoor humidity is also kept in a higher level because of low ventilation and frequent usage of humidifier, all of which provide a suitable environment for mites' growth. This could be the reason for the appearance of a peak mite density in winter from December to next January. Moreover, during dry winter, people have many skin scales that provide abundant food for mites. In summer, high humidity provide advantageous for mold growth, inducing competition between mites and mold, and that is why mites growth peak occurs in autumn instead of summer (June–August), and the number of mite species is also highest in autumn.

One survey on patients allergic to dust mites from our allergy department demonstrated that there are four properties in the episode of patients allergic to dust mites: 1) symptoms aggravated in summer, 2) symptoms deteriorate in winter, 3) symptoms deteriorate in both summer and winter, and 4) symptoms continue without any seasonal tendency (Ye 1998). This current study showed that in families from the Beijing area, mite density shows two peaks in summer and winter, and mites can be detected during the whole year, indicating a seasonal prevalence coincident with data documented in our allergy department. Patients visiting the peak did not occur in autumn when mite density is highest because air conditioner and heating devices are frequently used in summer and winter, causing high concentration of allergens indoor, whereas in autumn frequent ventilation can reduce allergens level and decrease incidence of allergy.

In summary, *Dermatophagoides siboney* was found for the first time in Beijing, China in the temperate zone, and it was also the first reported in Asia. *Dermatophagoides farinae* was the predominant species in the mite population found in house dust in Beijing, followed by *Dermatophagoides pteronyssinus* and *Dermatophagoides siboney.*

Acknowledgments

We thank Prof. Larry G Arlian from Department of Biological Sciences, Wright State University, United States; and Prof. Alexis Labrada from BIOCEN, Cuba, for identifying *Dermatophagoides siboney.* We thank Prof. Bobby Quentin Lanier, MD, University of North Texas HSC, Fort Worth, TX, United States; and Prof. Holger Fausbøll Mosbech, Allergic Unit, National University Hospital, Copenhagen, Denmark for our manuscript. We thank Asia Pacific Regional Office and Beijing Rep. Office of ALK-Abelló A/S Company, Denmark for supplying dust collector devices and our manuscript. We thank Prof. Zhang Hong-Yu in our allergy department for our manuscript. J. Y. received grant from the Ministry of Science and Technology, China; and the National Epidemiology Study of Asthma and Allergies in China project (grant no. 200802001). J.-L.S. received grant support from the National Science Foundation of China (grant no. 30671943).

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Received 21 February 2012; accepted 31 October 2012.