We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900
Open access books available

185,000
International authors and editors

200M
Downloads

Our authors are among the

154
Countries delivered to

TOP 1%
most cited scientists

12.2%
Contributors from top 500 universities

WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com

Chapter

House Dust Mites: Ecology, Biology, Prevalence, Epidemiology and Elimination

Muhammad Sarwar

Abstract

House dust mites burrow cheerfully into our clothing, pillowcases, carpets, mats and furniture, and feed on human dead skin cells by breaking them into small particles for ingestion. Dust mites are most common in asthma allergens, and some people have a simple dust allergy, but others have an additional condition called atopic dermatitis, often stated to as eczema by reacting to mites with hideous itching and redness. The most common type of dust mites are *Dermatophagoides farinae* Hughes (American house dust mite) and *Dermatophagoides pteronyssinus* Trouessart (European house dust mite) of family Pyroglyphidae (Acari), which have been associated with dermatological and respiratory allergies in humans such as eczema and asthma. A typical house dust mite measures 0.2–0.3 mm and the body of mite has a striated cuticle. A mated female house dust mite can live up to 70 days and lays 60–100 eggs in the last 5 weeks of life, and an average life cycle is 65–100 days. In a 10-week life span, dust mite produces about 2000 fecal particles and an even larger number of partially digested enzyme-covered dust particles. They feed on skin flakes from animals, including humans and on some mold. Notably, mite's gut contains potent digestive enzymes peptidase 1 that persist in their feces and are major inducers of allergic reactions, but its exoskeleton can also contribute this. Allergy testing by a physician can determine respiratory or dermatological symptoms to undergo allergen immunotherapy, by exposing to dust mite extracts for "training" immune system not to overreact. The epidemiologic data on the occurrence of house dust mites convincingly associates with an increased indoor air humidity by increased occurrence of mites. The most effective way to prevent or minimize exposure to dust mites in our homes is thorough cleaning, use of high-efficiency particulate air filters and pest management. There are a number of things that can be done to get rid of dust mites, for instance, using a dehumidifier and washing bedding in hot water. Additionally, it is a noble practice to encase bedding, mattress and pillows in impermeable covers that prevent dust mites from taking up residence in beds. Owing to their everywhere presence, diversity, and wide distribution, mite species can be used as valid and reliable pieces of evidence for resolving of forensic cases.

Keywords: dust mite, allergy, itching, immunotherapy, *Dermatophagoides*

1. Introduction

The dust mites usually refer to those species of the mite family Pyroglyphidae that are known to commonly occur widely, although sometimes regionally, in the

dust of human dwellings. Dust mites sometimes called dirt mites or bed mites are microscopic creatures, measuring only about one-quarter to one-third of a millimeter (250–300 microns) in length; females weigh about 5.8 μg, while males are approximately half of this weight as 3.5 μg. Nearly 72–74% of their total weight is water and they have translucent bodies with a striated cuticle. They are not insects but arthropods like spiders and ticks having eight legs, no eyes and antennae, and bear mouthpart set in front of the body [1]. Dust mites can live in mattresses, bedding, upholstered furniture, carpets, curtains and other places in homes.

Each adult person sheds about one and a half grams of skin every day. This is enough to feed one million dust mites. Dust mites are microscopic creatures that can live in bedding and carpets, and feed on this skin. They feed on flakes of dead skin or skin cells and scales commonly called dander that are shed by people and pets. They like to live indoors, where they can get plenty of food like mold spores and dead skin cells from people and pets. They cannot survive in colder and drier places, however in a warm and humid house, dust mites can survive all the year around. Dust mites thrive in temperatures of 68–77°F (20–25°C) and they also like humidity levels of 70–80% [2].

These tiny individuals (**Figure 1**) are a big source of allergens and can worsen allergies and asthma. An allergen is a substance that causes an allergic reaction. Both the body parts and the waste of dust mites are allergens for many people. Most dust mites die in low humidity level (when the humidity falls below 50%) or extreme temperature, but they leave their dead bodies and waste behind to cause allergic reactions [3].

The house dust mite species of family Pyroglyphidae, commonly occurring in dust of human dwellings, belong to six genera, the so-called *Dermatophagoides*, *Euroglyphus*, *Hirstia*, *Malayoglyphus*, *Pyroglyphus* and *Sturnophagoides*. In total, 13 species have been found in house dust and recorded from different locations throughout the world, including the United States, Hawaii, Canada, Europe, Asia, the Middle East, parts of Australia, South America, and Africa (**Table 1**).

Related species of *Dermatophagoides* have the most worldwide occurrence and are very similar, but bear differences in some physical characteristics, for example, in male ventral posterior idiosoma and the aedeagus, and in female genital opening and bursa copulatrix [4]. Additional mites occurring in house dust are the glistening mites (family Tarsonemidae), storage mites (families Acaridae, Glycyphagidae and Chortoglyphidae) and the predatory mites (family Cheyletidae); however these groups will not be examined in depth in this chapter.

Mites of family Tarsonemidae have modified legs IV (reduced, enlarged with a single tarsal claw on male, setiform on female); body with series of overlapping plates; and gnathosoma cone-like, enclosing minute palps and chelicerae. When mites are not as mentioned above, they may be with striated cuticle (family

Figure 1.
House dust mites.

S. No.	Species	Locations
1	*Dermatophagoides farinae*	Commonly in the United States, not the United Kingdom
2	*D. evansi*	Europe, North America
3	*D. microceras*	Europe
4	*D. halterophilus*	Spain, Singapore, tropical regions
5	*D. pteronyssinus*	Commonly all over Europe
6	*D. siboney*	Cuba
7	*D. neotropicalis*	Tropical areas
8	*Euroglyphus maynei*	Humid geographic areas all over the world
9	*E. longior*	Holarctic, Neotropic
10	*Hirstia domicola*	United States, Canada, Europe, Asia, Middle East, parts of Australia, South Africa
11	*Malayoglyphus carmelitus*	Israel, Spain
12	*M. intermedius*	United States, Canada, Europe, Asia, Middle East, parts of Australia, South Africa
13	*Pyroglyphus africanus*	South America
14	*Sturnophagoides brasiliensis*	Brazil, France, Singapore

Table 1.
Various species of family Pyroglyphidae existing in house dust and their locations recorded (reproduced from Bronswijk [18] and Colloff [5]).

Pyroglyphidae), otherwise with smooth or papular cuticle, long serrated dorsal setae, and legs with long slim tarsi (family Glycyphagidae). Setae sci and sce are about the same length, and tegmen present in genus *Euroglyphus*, but setae sce considerably shorter than sci, and tegmen absent in *Dermatophagoides* of family Pyroglyphidae [5].

An accurate taxonomic documentation of house dust mites is very vital, simply not from a biological standpoint but about the significances of their corresponding allergenic properties as well. Numerous works on immunochemical have exposed variances among the two products hard to differentiate sibling species [6–13]. An introductory practical taxonomic identification for the most common and important house dust mites is presented at this stage. The main species, identified as *Dermatophagoides farinae* Hughes (American house dust mite), *Dermatophagoides microceras* Griffiths and Cunnington, *Dermatophagoides pteronyssinus* (Trouessart) (European house dust mite), *Euroglyphus maynei* (Cooreman) (Mayne's house dust mite), *Dermatophagoides evansi* Fain and *Euroglyphus longior* (Trouessart), are discussed here. However, three *Dermatophagoides* species, *D. pteronyssinus*, *D. farinae* and *E. maynei*, are the most common, comprising up to 90% of the house dust mite fauna of the world. Morphologically, the most conspicuous difference in these *Dermatophagoides* species is that there are no four long train hairs on the abdomen end [14].

Many aspects on the biology of house dust mites are not understood; therefore, a greater understanding of their biology may reveal new strategies for controlling of mites and their allergens in homes.

2. Family Pyroglyphidae Cunliffe 1958 acarofauna

Pyroglyphidae belongs to the order Astigmata of the subclass Acari (also known as Acarina). The order Astigmata is differentiated from other orders of Acari by

the lack of stigmata on idiosoma. This order is furthermore categorized into two suborders, the Acaridia that includes free-living mites and the Psoroptidia which comprises mites parasitic in nature. The former suborder is divided into many families, including the Pyroglyphidae, to which house dust mites belong. Pyroglyphidae are minute mites (full grown adults 170–500 μm in length), cuticle excellently or crudely wrinkle, tarsi termination in a circular pulvillus and a minute claw, anus ventral in position, vestigial genital structures present in both sexual category, vulva of female reverse Y or V fashioned, oil glands existing and exposed among L2 and L3, and vertical setae lacking [15].

Pyroglyphidae is a family of nonparasitic mites, wherein a great variety of species has been observed. It includes the house dust mites that live in human dwellings, many species that live in the burrows of other animals, and some are pests of dried products stored in humid conditions. The family Pyroglyphidae contains mainly species of astigmatid mites that live in the nests of birds and mammals, where they feed on the epidermal detritus (skin, feathers) left by the host, and occurs worldwide [16].

Among the genera of the family Pyroglyphidae, the most outstanding are *Dermatophagoides* and *Euroglyphus*. Three species, *D. farinae*, *D. pteronyssinus*, and *Euroglyphus maynei*, are commonly found in homes of humans and mostly prevalent in high-use areas, where shed skin scales are collected and serve as their food. House dust mites, mostly of the genus *Dermatophagoides*, is important medically and although *D. pteronyssinus* and *D. farinae* are known as the European and American dust mites, both of these are found worldwide. Both mites *D. farinae* and *D. pteronyssinus* move steadily and slowly; however walk quickly without altering way at whatever time they are opened to an extreme light or heat. In contrary, *E. longior* and *B. evansi* express a negative phototropic response when exposed to an electric lamp of bright light [17].

The presence of house dust mites can be confirmed microscopically, which requires collecting samples from mattresses, couches, or carpets. Also, in general practice, it takes at least a 10X magnification to be able to correctly identify them. A modified Berlese funnel is commonly used for extraction of mites from stored grain and has also been successfully used for extraction of *E. longior* and *D. evansi*; however, *D. farinae* cannot be extracted from the dust in this way. A simple method to extract most house dust mites, mite fragments and debris is as follows: weigh 0.1 g of dust from the vacuum cleaner bag, filter by 0.5 and 0.125 mm mesh sieves, relocate dust on 0.125 mm sieve to a lookout glass, moist it with alcohol or ether, whirl suspension to spread out dust uniformly, let the solvent to vaporize, calculate the number of mites below a stereomicroscope, and accumulate them with a camel's hair short-bristled brush. Mites removed through these procedures can be well-maintained in 85% alcohol for an indefinite period. Short-term mounts of mites can be done in lactic acid, glycerin, mineral oil, phenol, etc. A comparatively long-lasting mounting medium is Hoyer's modified Berlese solution ringed with Canada balsam, glycerol, or glyptol. Proof of specimen identity can be done underneath a phase or interference contract microscope only [18].

Three species, *E. maynei*, *D. pteronyssinus*, and *D. farinae*, are usually observed in home environment of humans. Within homes, these mite species are at peak prevailing in high-use parts, wherever shed skin scales accumulate and assist as their diet. Hence, their highest masses are set up in carpets, nearby easy chairs and sofas, in mattresses, and in fabric-covered overstuffed furniture. But, they may also be found on clothing, in bedding, on pillows, on train and automobile seats, and from time to time in workplaces and schools. Every species is the basis of several potent allergens, which in predisposed people trigger and sensitize allergic reactions. These allergens are cause of asthma, atopic dermatitis and perennial rhinitis [19].

Dust mites are most closely related to spiders and ticks. These mites are about 25–30 millimeters in size and cannot be seen without magnification. The translucent body of a house dust mite is 300–400 μm in length and only visible under a microscope. They have eight hairy legs, a mouth-like appendage in front of the body, a tough shell and no eyes or antennae. The lifetime stages of the dust mites are eggs, larvae, protonymphs, deutonymphs, tritonymphs, and adult males and females. The duration of life cycle is dependent on temperature while relative humidity (RH) is beyond 60%. At 23°C, life cycle proceeds 36 and 34 days for *D. pteronyssinus* and *D. farinae*, respectively, to be completed. Females at 23°C create 2 or 3 eggs every day during the reproductive history. At 35 and 16°C, mite *D. pteronyssinus* ensues 15 and 23 days for complete development, respectively; however. *D. farinae* does not grow well at 35 and 16°C. A desiccation-resistant inactive protonymphal stage can occur which permits persistence during lengthy times (months) in dry (less relative humidity) environment. As soon as relative humidity circumstances turn out to be optimum, the dormancy is finished and growth carries on [20].

The female lays eggs singly or in small groups. The adult mated female can lay 40–80 eggs in its lifetime. When the egg hatches, a six-legged larva emerges. There are two nymphal stages that feed and molt before an eight-legged adult is developed. Transition from egg to adult takes about 3–4 weeks. The duration of the cycle is usually 1 month but is dependent on the climate, however 25°C and 75% relative humidity are ideal. An adult house dust mite can live for 1–3 months under favorable conditions. Normally, adult dust mites live for about a month and female dust mites live for about 8–10 weeks. It is estimated that the house dust mite can produce 20 fecal pellets/day that range from 20 to 50 μm. House dust mites are ~75% water by weight and therefore need to absorb water from the water vapor in the air, making relative humidity a critical factor for survival.

The population of *Dermatophagoides* species has been observed in hospital halls, non-carpeted patient's rooms, and carpeted patient's rooms through vacuuming of floor in winter and summer periods. As a summer control set, bedrooms in homes of workers have been checked out. Out of 141 total dust samples obtained, *D. pteronyssinus* or *D. farinae* have not been found in 60 hospital dust samples that are acquired during winter period. Even though mites have been originated in certain sites in hospital during summer dust assemblage, mite population in these localities and mean mite population for entirely samples persisted insignificant. For the period of summer dust sampling taken from bedroom carpets of altogether worker houses checked out observed positive for mites, with a number of homes having high or moderate densities (ranged 22–8340 mites/g of dirt). Prevalence of dust mite in a hospital might be retained very little even if in worker homes, mite levels are found moderate to high. The reasons accountable for little mite populations in hospital are the usage of low-pile carpets, keeping low relative humidity, and upright laundering and housekeeping practices [21].

The house dust mites *D. farinae* and *D. pteronyssinus* are cosmopolitan inhabitants of human dwellings. They are most prevalent in high-use areas in homes (e.g., beds, furniture, floors), where shed human skin scales are collected and serve as a source of food. Relative humidity is an important factor regulating the geographic prevalence and density of these mites. In humid geographic areas, most homes contain mite populations, whereas in dry (low-humidity) geographic areas, few homes contain mites. The species prevalence and density of these mites varies both geographically and between homes in the same geographic area. Although factors influencing variations in mite density between homes are not well understood, it appears that mite density is not correlated with housecleaning practices. However, carpeted floors support significantly greater mite populations than do wood or

tile floors. A home may contain only one species or multiple species can coexist. Most homes are coinhabited by more than one species. In coinhabited homes, one species generally constitutes the greatest percentage of the total population, but the dominant species varies between homes within a geographic area. Knowledge of the mite species prevalence and density in a patient's home is important in evaluating the role of mites as allergens, and in selecting and assessing effective immunotherapy for individual cases. Many species of mites besides *D. farinae* and *D. pteronyssinus* may occur in homes, at times in significant numbers. Therefore, one must be careful when conducting mite surveys to differentiate between not only the primary allergy-causing species but other species as well if species, and density determinations are to be accurate and meaningful. House dust mites live in a microenvironment in which no liquid water is present. However, their bodies are 70–80% water by weight, which must be maintained above a critical lower limit in order to survive for them. Active life stages are able to survive at ambient humidity as low as 60% relative humidity because they extract sufficient water directly from unsaturated air by means of a special adaptation to compensate for water losses. A desiccation-resistant protonymph can survive prolonged periods at low relative humidity, and this stage probably serves as a source of mites for breeding during optimal conditions [22, 23].

An understanding of the life cycle of house dust mites, as well as environmental factors influencing mite populations, can be exploited in mite control. Experiments have been carried out to observe the influences of specific relative humidity maintained at 20°C on population dynamics of mixed and single species of *E. maynei*, *D. pteronyssinus*, and *D. farina*, with indefinite diet. The population density of mixed and single species (*D. pteronyssinus* and *D. farinae*) exponentially increased when reared at 65, 70, and 75% RH. The average population growth amounts are 32.5 ± 4.7 and 17.3 ± 4.4 per week for *D. pteronyssinus* and *D. farina*, respectively. Average populations doubling up periods are 4.2 ± 1.3 and 2.2 ± 0.3 weeks for *D. farinae* and *D. pteronyssinus*, respectively. Diversified cultures of species, initiated with identical numbers of *D. pteronyssinus* and *D. farina*, caused greater percentages of *D. pteronyssinus* and *D. farina.* In cultures taking place with 25% of one species and 75% of the other, the more frequent species throughout the experiment continued prevailing and in similar ratios. Population densities of *D. pteronyssinus* and *D. farina* both kept at 85% RH dropped over a period of 12-week culturing owing to growth of mold. At 65, 70, 75 and 85% RH, mite *E. maynei* is not capable to stay alive which indicates that its requirements of climate are dissimilar from those of *D. pteronyssinus* and *D. farina.* When held at 21–22°C and relative humidity of ≤50%, population densities of *D. pteronyssinus* and *D. farina* cultures dropped; on the other hand, noteworthy amounts of populations lasted for 10 weeks at 50% RH. At 45% RH, half-life for dryness of *D. pteronyssinus* and *D. farina* is 11.5 and 1.2 weeks, respectively, however, 4.0 and 86.3 weeks, respectively, at 50% RH. The information indicates that a ≤50% RH would have to be retained for longer times to decrease *D. pteronyssinus* and *D. farina* both through drying processes. The outcomes of this work express that *D. pteronyssinus* and *D. farina* have great population growth and reproductive potential rates, which designate that mite decline processes must be thoroughgoing otherwise densities of mite will reappear to great points rapidly following remediation if suitable diet and appropriate microclimatic situations occur [24, 25].

Mites are complex organisms, which produce thousands of different proteins and other macromolecules. Allergens from dust mites are connected to body secretions (chitinase), fecal material (enzymes) and body anatomy (muscle tropomyosin). Twenty diverse sets of mite allergens have been categorized. The incidence of reactivity to the majority of these allergens between patients sensitive to dust mites is beyond 50%. Sensitivity to allergens differs equally within and between persons.

Generally, the prevalence of sensitivity to house dust mites is about 27.5% in the few populations. Allergens from one species may be species specific, or they may cross-react with allergens from another mite species. Most patients with mite sensitivities are allergic to multiple allergens of a species and to multiple mite species.

Allergies to dust mites are associated with allergic rhinitis and asthma. Systemic anaphylaxis may take place after eating of unheated or heated mite-polluted diets. This problem can be more widespread in subtropical and tropical states than earlier documented. The greatly common signs resulting after the consumption of mite-polluted flour are breathlessness, wheezing, angioedema and rhinorrhea, and these start in the middle of 10 and 240 minutes later after eating of contaminated foods [26].

3. Dust mite habitat

House dust mites primarily feed on organic detritus such as flakes of shed skin. Other nutrients are provided by animal dander, pollen, bacteria and mold. House dust mites reproduce and survive the greatest in soft stuffs (like carpets with lengthy pile, bedclothes and plush toys) that contain a big source of their diet source. The unchanging environmental circumstances are best provided inside homes. Internal domestic humidity is very vital, when moisture is less than 50%; house dust mites are incapable to sustain their water balance and become more vulnerable to desiccation. The house dust mites select diet which has been pre-decomposed by fungi that decrease fat content of skin cells. The fungi in turn usage house dust mite skin cells and feces as nitrogen source, which form a minute ecosystem in their environment [27].

The maximum vital limiting cause for house dust mite population densities is air humidity. House dust mite osmoregulation is through cuticle and for that purpose, they need a great ambient air humidity to avoid extreme water loss. Additionally, supracoxal glands take up ambient water vapor actively and protonymph stage in the life cycle is desiccation resistant. Greater house dust mite population densities are created when indoor absolute air humidity is beyond 7 g/kg (45% relative humidity at 20°C). As a result, aeration by air-conditioning structures is being established as a resource of mite control. In an integrated approach, a number of other features of home atmosphere are likewise being operated to render the habitation less fit for mites. The prospective occurs for evolving models of house dust mite populations, environmental features and influences of several tactics to control [28].

4. House dust mite fauna of prominence

Pyroglyphidae is divided into subfamily Pyroglyphinae wherein anterior extremity of the body is prolonged by a pointed or forked tegmen, which covers the base of the gnathosoma in both male and female, while tegmen absent in the second subfamily Dermatophagoidinae.

4.1 Subfamily Dermatophagoidinae Fain, 1963

Males in *Dermatophagoides* Bogdanov are with hairs sce much longer and thicker than sci and tarsus III without spines. Perianal ring is simple (not denticulate) and with a hysteronotal shield. Females have hairs sce much longer and thicker than sci. Legs III and IV are equal or subequal in length, and hysteronotal shield is absent. However, *Malayoglyphus*, *Hirstia* and *Sturnophagoides* do not have this combination of characters.

4.1.1 Dermatophagoides farinae *Hughes (American house dust mite)*

American house dust mite *D. farinae* (**Figure 2**) is found in flour, poultry and pig feeds, safflower seed meal, and albumin tannate in the drugstore. Differential diagnosis in females are the following: idiosoma is 395–435 μm in length; propodonotal shield about 1.4 times as lengthy as broad; vestibule of bursa sclerotized well and designed similar to a calabash pipe; bursa is not extended further than this vestibule; generally tarsus I with well-built curled progression (ongle); and epigynum crescent fashioned. In males, idiosoma is 285–345 μm long; males either homeomorphic with epimera I free (and normal first legs) or heteromorphic with epimera I fused to form a V or Y (and enlarged I legs).

Females of *D. farinae* tarsi I and II are with prominent, pointed apical spine (s); bursa copulatrix broad and strongly sclerotized in region adjacent to external opening (arrow); and sclerotized section pointed. Females: tarsus I with short, straight, blunted spine (s); and tarsus II lacking spine. Bursa copulatrix is narrow and weakly sclerotized in region adjacent to external opening anteriorly. Female is with central area of dorsum among hairs d2-d2-d3-d3 with crosswise striations in the frontal half and with oblique or convex striations in the latter half. Bursa copulatrix proximal portion is without sclerifications and distal portion widened into a minute, sclerified, and triangular sack. Male hysteronotal shield is short (broader than long) and not reaching the base of hairs d2. Epimera I either free or fused to form a sternum and legs I generally swollen. Male tarsus I is with small apical protuberance (process S) and curved apical spine (f), and tarsus II with process S and no spine.

Duration of the life cycle at 16, 23, 30 and 35°C, and fecundity at 23°C and 75% RH have been determined for *D. farinae*. Durations of the life cycles at 30 and 23°C are 17.5 ± 1.2 and 35.6 ± 4.4 days, respectively. At 16 and 35°C, only a small number of eggs finalized growth to the adult stage. At 75% RH and 23°C, following development of female from tritonymph, the preoviposition period is 3.7 ± 1.1 days. The mean reproductive duration is 34.0 ± 10.7 days with an average of total 65.5 ± 17.4 eggs laid per female. Longevity of female is 63.3 ± 64.6 days after termination of egg production. The females weigh approximately 5.8 ± 0.2 μg (fresh weight), while males are approximately half of this weight 3.5 ± 0.2 μg [29].

Studies of the life cycle of cultured *D. farinae* found that after initial mating, *D. farinae* females lived for 63.3 days after their egg production period ended. The long period after cessation of egg production for *D. farinae* suggested that *D. farinae* females could mate multiple times and produce eggs continuously for a longer period. This study revealed that *D. farinae* females are capable of more than one successful mating that results in an increased egg production than that of a single mating. Females actively attract males during the reproductive period, but not

Figure 2.
Dermatophagoides farinae.

afterward even though it continues to live a long time. These females have 11 days longer reproductive period and produced 30.7% more eggs than in females that only mated one time after they emerged from the tritonymphal stage. However, the post-reproductive period is still long (58.6 days) [30].

Adopting the separate culturing technique, under a continuous temperature at 25°C, the effects of relative humidities of 86, 76, 61 and 36% on the life cycle of *D. farinae* and *D. pteronyssinus* have been detected. At 76% RH, the development of eggs to adults takes place in the shortest period of 39.6 ± 6.6 (29–60) days, for egg 8.1 ± 0.1 days, for larva 8.2 ± 0.3 days, for protonymph 17.0 ± 5.7 days and for tritonymph 6.6 ± 0.4 days. The number of eggs laid is generally 1 or 2 per day by a female, but, certain females in a day sometimes laid 5 or 6 eggs. The biggest total number of eggs (80.6 ± 8.2) laid per female is observed at 86% RH, while nu-mated female at 76% RH showed longest longevity of 188.8 ± 60.9 days ranging from 92 to 378 days. The longevity of the female is usually longer than that of the male [31].

4.1.2 Dermatophagoides pteronyssinus *(Trouessart) (European house dust mite)*

This particular species of mite has been found in all dust samples from many different countries in varying numbers. Hysteronotal shield of *D. pteronyssinus* (**Figure 3**), in males, is lengthy (lengthier than wide), and spreading further frontward than hairs d2, epimera I diverging or parallel and legs I are usual. Females are only with central area of dorsum among hairs d2-d2-d3-d3 having longitudinal patterns. Bursa copulatrix has proximal portion with a sclerite in the form of a daisy and distal portion expanded very slightly. Base of receptaculum seminis are U-shaped in cross section, broader apically than basally, circular with 10–13 lobes when viewed from above and ductus bursae of uniform thickness.

The life cycle of *D. pteronyssinus* has been studied at 25°C and 80% relative humidity. Observations made on freshly laid eggs until they develop into adults and periods between different stages are recorded. The life cycle of *D. pteronyssinus* consists of five stages: egg, larva, protonymph, tritonymph and adult. Adult females lay up to 40–80 eggs singly or in small groups of 3–5. After eggs hatch, a six-legged larva emerges and after two nymphal stages occur, an eight-legged nymph appears. The life cycle from egg to adult is about 1 month with the adult living an additional 1–3 months. The average life cycle for a house dust mite is 65–100 days. A mated female house dust mite can last up to 70 days, laying 60–100 eggs in the last 5 weeks of her life. The eggs required an average of 11.26 days to develop into adults.

Figure 3.
Dermatophagoides pteronyssinus.

The ranges of life longevity of mated males and females are 18–64 and 20–54 days, respectively. At 76% RH, mite *D. pteronyssinus* exhibited the shortest duration of development. It took a total duration of 37.1 ± 2.5 days with a range from 30 to 54 days, for egg 6.2 ± 0.3 days, for larva 10.7 ± 0.3 days, for protonymph 8.6 ± 1.0 days and for tritonymph 11.4 ± 2.2 days. The largest total number of eggs, 76.2+22.2, is laid by a female of *D. pteronyssinus.* In a 10-week life span, a house dust mite will produce approximately 2000 fecal particles and an even larger number of partially digested enzyme-covered dust particles. The conditions used in the rearing experiments may be considered optimal for maintaining culture of *D. pteronyssinus* [32].

4.1.3 Dermatophagoides microceras *Griffiths and Cunnington (House dust mite, dust mite)*

House dust mite *Dermatophagoides microceras* Griffiths and Cunnington (**Figure 4**) is a species first described in 1971 and part of the Pyroglyphidae family of mites. This mite has been identified in house dust in various geographic regions, including Great Britain, Scandinavia, the Netherlands, Spain and United States; however its distribution in the rest of the world has not been explored well. Morphologically, males tarsus I is without small apical protuberance (process S), but with curved spine and tarsus II without process S or spine. Females tarsus I with short, straight, blunted spine, tarsus II lacking spine and bursa copulatrix narrow as well as weakly sclerotized in region adjacent to external opening. In females, propodonotal shield is about 1.4 times as lengthy as wide; idiosoma 395–435 μm in length; vestibule of bursa absent, bursa unfastens at the bottom of a non-sclerotized depression of tegmen; first portion of bursa proper is a little dilated and clearly sclerotized; and apical progression of tarsus I mostly very minor or absent. In males, idiosoma is 285–345 μm in length; males either heteromorphic with epimera I joined to form a V or Y shape (and first legs enlarged) or homeomorphic with epimera I free (and first legs normal) [33].

D. microceras is more closely related to *D. farinae*, and the biological and immunochemical identification of these two species are argued. Using an enzyme-linked immunosorbent assay (ELISA) technique, the response of mite material from different stock cultures demonstrated that *D. farinae* and *D. microceras* are discrete entities, and also at the major allergen level, with no apparent subspecies or strain variation. Females of *D. farinae* and *D. microceras* receptaculum seminis not U-shaped in cross section, while males with hysteronotal shield as long as broad and extending anteriorly to point between setae d1 and e or slightly anterior of d1 [34].

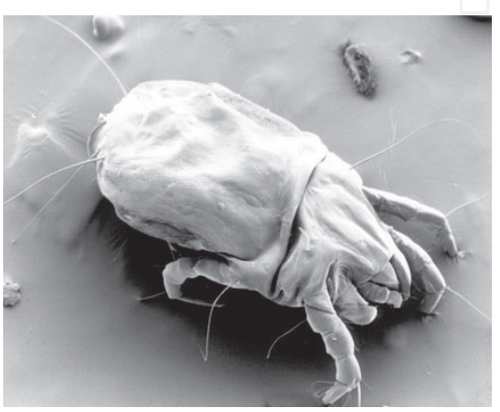

Figure 4.
Dermatophagoides microceras.

4.1.4 Dermatophagoides evansi *Fain, Hughes and Johnston*

Specifically, *Dermatophagoides evansi* Fain (**Figure 5**) Hughes and Johnston mites are found in the poultry dust samples and also in bird's nests. Hen poultry farmers and their families, but also other professionals working in the poultry industry, such as veterinarians, may be exposed to house dust mites. In females, bursa copulatrix is strongly enlarged in its distal third and very narrow in proximal two thirds (internal); and spermatheca sclerotized and tulip-like. In males, hysteronotal shield markedly spread frontward away from bases of setae d1; adanal suckers 12 μm in span; coxae II shut; legs III 1.8 times denser (at level of femur) and 1.6 times lengthier (length of 4 distal segments) than legs IV; tarsus I with 2 uneven apical progressions (ongles); tarsus II with a slight apical progression; setae cp 110 μm in length; setae d2 located at 55–65 μm from opening of fat gland; setae h2 and h3 with bases intensely sclerotized; epimera I free; and males are homeomorphic. The males differ from males of *D. pteronyssinus* primarily through dorsal hysterosomal shield that is longer and narrower; ratio width (at level of setae d1):length = 1:2.5 [whereas in *D. pteronyssinus* this ratio is 1.8–1.9]; while legs III and IV are much more unequal than in *D. pteronyssinus* [35].

The life cycle of *D. evansi* has been studied and reared at a relative humidity of 75–80% and temperature 25–27°C in a medium consisted of human skin or chicken skin scales plus baker's yeast powder. The average period of mite life cycle for each stage in days is the following: egg 8.3; larva and protonymph 5.4; tritonymph 6.6; female 52.9; and male 28.9. The mean time necessary for accomplishment of one generation is 28.7 days. The female is oviparous, parthenogenesis not detected, and lays 35.5 mean eggs during its life span. The adults copulate repeatedly and the female-male ratio is 1:1.2 [36].

4.2 Subfamily Pyroglyphinae Cunliffe, 1958

Female with the distal part of the bursa copulatrix in the form of a small, oval and strongly sclerotized pocket, while male is with anal suckers (*Euroglyphus* Fain), but male and female are without this combination of characters in *Pyroglyphus*. In *Euroglyphus maynei* (Cooreman), male trochanters I–III without hairs and is with a large oval anal plate spreading near to posterior edge of body, while female hairs ga, ae and those of trochanters I–III missing, and have a small posterior vulval lip that does not shelter to anterior of vulva. In case of *Euroglyphus longior* (Trouessart), male trochanters I–III with one hair and is with a minute hexagonal anal plate distant from posterior edge of the body. Female hairs ga, ae and those on trochanters I–III present, and posterior vulval lip is long nearly completely casing to vulva.

Figure 5.
Dermatophagoides evansi.

4.2.1 Euroglyphus maynei *(Mayne's house dust mite) (Cooreman)*

The house dust mite *Euroglyphus maynei* (Cooreman) (**Figure 6**) infests stored products and is considered pests in cottonseed meal, bean curd, Chinese medicines, crabmeat and shrimps. This occurs in homes worldwide and is an important source of many allergens. Differential diagnosis in both sexes; setae sci and sce about the same length and tegmen (t) present. Length of idiosoma 195–225 μm; posterior edge of idiosoma with 2 minute lobes without hairs; tegmen well developed, triangular with rounded apex (not bifid in the male); cuticle somewhat sclerotized with rather fine formed markings or creases; hysteronotum within a median shield with margins poorly distinct; anterior legs missing chitinous membranes; chaetotaxy condensed; tibials IV, trochanterals I–III, anal external setae and genital anterior setae are absent; tarsi IV with 3 setae; tarsi III with 5 setae; dorsal setae very short and thin; setae h3 very short (maximum length 50 μm) and thin; setae h2 very thin and short (not more than 30 μm); and genu I with one solenidion. In males, tegmen with unforked, rounded apex; dorsal setae variable; opisthosoma slightly but narrowed backwards regularly; anus more posterior (anal suckers situated at 25 μm from posterior body margin); posterior body margin wide and straight with 2 small paramedian lobes; adanal suckers well developed; and tarsi IV lacking suckers. In females, setae sce short (maximum 50 μm) and thin; at bases of legs II no chitinous pouches; tegmen either prominent and triangular but with apex rounded and not forked or poorly developed and rounded with a small median notch; posterior lip of vulva short and punctate, not covering vulvar slit; or anterior angle of posterior vulvar lip not incised; vulva uncovered; tegmen triangular with rounded, not incised apex; hysteronotum striated with a median shield; copulatory vestibule ovoid, strongly sclerotized and opaque; and tarsi I–IV without apical processes nor spines [37].

The reproductive biology of house dust mite *E. maynei* is not studied well. This mite is generally less common than *D. pteronyssinus* and *D. farinae* in homes. While it is present, it commonly coinhabits with species of *Dermatophagoides* and in geographic distribution, is more restricted. The period of life cycle (egg to adult) for *E. maynei* at 75% relative humidity as well as 23 and 30°C and fecundity at 75% RH and 23°C have been concluded, and data compared similar to data for *D. pteronyssinus* and *D. farinae*. Adults hatched from eggs at 23°C after 28 days and at 30°C in 20 days. At 23°C, females during a reproductive period of 24 days produced 1.4 eggs/day. At 23°C, mite *E. maynei* has a smaller life cycle than *D. pteronyssinus* and *D. farinae*; however, at 30°C, this have a lengthier life cycle and produced fewer eggs than both mites [38].

Figure 6.
Euroglyphus maynei.

4.2.2 Euroglyphus longior *(Trouessart)*

This species infests stored products, and is considered pests in granary debris, wheat, bean, oat, barley, rice, dried clover and hide dust [39]. Data used for identification of this mite are the following: length of idiosoma is 245–265 μm and posterior edge of idiosoma with 2 distinct lobes each having 3 hairs. Male (darker, smaller) internal and external scapular setae and II pair of legs in line, a small hexagonal anal plate distant from posterior edge of body, anal suckers present, while trochanters I–III with one hair. Female (paler, larger) internal base of seminal receptacle simple, while posterior vulval lip or membrane long and almost entirely covering the vulva (on genital plate external genital opening). Hairs go, ae and those on trochanters I–III present.

The determination of the life cycle of the mite species has provided vital information on its biology showing that pre-reproductive period from mating to birth of first eggs is 12.78 ± 1.06 days and reproductive period between production of first and last eggs 39.78 ± 4.99 days. Fecundity, the total number of eggs laid per female is 48.00 ± 3.89 and rate of reproduction calculated as the number of eggs laid per of female's reproductive period 1.33 ± 0.18. Finally, the development of immatures is completed in 30.14 ± 3.4 days [40].

The house dust mites *D. farinae*, *D. pteronyssinus* and *E. maynei* are cosmopolitan inhabitants of human dwellings. They are most prevalent in high-use areas in homes (e.g., beds, furniture, floors), where shed human skin scales are collected and serve as a source of food. Relative humidity is an important factor regulating the geographic prevalence and density of these mites. In humid geographic areas, most homes contain mite populations, whereas in dry (low-humidity) geographic areas, few homes contain mites. The species prevalence and density of these mites varies both geographically and between homes in the same geographic area. Although factors influencing variation in mite density between homes are not well understood, it appears that mite density is not correlated with housecleaning practices. However, carpeted floors support significantly greater mite populations than do wood or tile floors. A home may contain only one species or multiple species may coexist. Most homes are coinhabited by more than one species. In coinhabited homes, one species generally constitutes the greatest percentage of the total population, but the dominant species varies between homes within a geographic area [41].

Knowledge of the mite species prevalence and density in a patient's home is important in evaluating the role of mites as allergens, and in selecting and assessing effective immunotherapy for individual cases. Many species of mites besides *D. farinae*, *D. pteronyssinus* and *E. maynei* may occur in homes, at times in significant numbers. Therefore, one must be careful when conducting mite surveys to differentiate between not only the primary allergy-causing species but other species as well if species and density determinations are to be accurate and meaningful. House dust mites live in a microenvironment in which no liquid water is present. However, their bodies are 70–80% water by weight, which must be maintained above a critical lower limit in order to survive. Active life stages are able to survive at ambient humidities as low as 60% relative humidity because they extract sufficient water directly from unsaturated air by means of a special adaptation to compensate for water losses. A desiccation-resistant protonymph can survive prolonged periods at low relative humidity and this stage probably serves as a source of mites for breeding during optimal conditions [42].

There are 47 different species of house dust mites, and dust mites *D. farinae*, *D. pteronyssinus* and *E. maynei* are sources of multiple potent allergens in the indoor environment. An ambient RH is a key factor in determining where these mites are found. Bedding, carpeting, and furniture cushions all trap and hold moisture,

allowing these tiny creatures to flourish. Dust mites settle down in carpet, draperies, stuffed animals and upholstered furniture. Mattresses, pillows and soft bedding are favorite hangouts [43]. These same symptoms can be caused by a variety of other allergens as well, so consultancy to an allergist is needed for their testing. To diagnose a dust mite allergy, a physician may suggest a skin test [skin prick test (SPT)] or blood test (specific IgE blood test).

5. Epidemiology of house dust mites

For a lot of years, it has been advocated that allergens resulting from house dust mite show a foremost part in pathogenesis of eczema, asthma and certain circumstances of allergic rhinitis. In recent times, allergens by house dust mite have been refined and precise immunoassays established with which acquaintance to allergens and house dust mites can be more simply determined. By means of these tools, epidemiological homework have delivered positive confirmation that not merely house dust mite acquaintance has been linked with the majority of asthma cases in young adults and children but then again that it is causally connected to asthma development. Two main allergenic dust mite species, *D. pteronyssinus* and *D. farina*e, are important components in the development of asthma [44].

Epidemiologic data available on incidence of house dust mites in residences demonstrate a perfect relationship among increased interior air humidity and increased existence of dust mites in house dust. Moreover, in temperate climates, there is threshold level of indoor air humidity 7 g/kg (45% relative humidity at normal indoor air temperature). Interior air humidity under this level for prolonged times will eliminate house dust mites from residences. A decrease in residents involvement to house dust mites is executed by lessening of indoor air humidity through organized mechanical air circulation. Individually, ventilation levels are assessed from actual house size, inhabitant numbers and mean outdoor air humidity in winter. In divergence, more moist zones of the world with mean outdoor humidity beyond 6–7 g/kg in winter will keep up great densities of house dust mites uniformly and a decrease in indoor air humidity will have a relatively slight effect on existence of house dust mites. Modern construction of energy-efficient houses by better fastening of building envelope, paralleled by an alike makeover of older houses, has increased indoor air humidity and is perhaps the cause of nearly fourfold rise in incidence of house dust mites in residences [45].

There are up to 2 million dust mites living in a standard mattress. Dust mites produce mite feces, which add up to 200 times of their own body weight within their lives of 2 months [46]. Although exposure to house dust mite allergen is a major risk factor for allergic sensitization and asthma, the percentages of homes with dust mite allergen concentrations at or greater than detection, 2.0 μg bed dust and 10.0 μg bed dust, have been estimated to be 46.2, and 24.2%, respectively. Independent predictors of higher levels have been lower household income, older homes, no resident children, single-family homes, musty or mildew odor, heating sources other than forced air and higher humidity in bedroom. Most of homes in a bed have measurable levels of dust mite allergen. Levels earlier allied to allergic asthma and sensitization in bedrooms are common. Predictors can be utilized to detect situations under which homes are more possibly to have greater levels of dust mite allergen [47].

Epidemiologic works [48] studying the relationship among house dust mite distribution and outdoor humidity level have revealed that: (1) Outdoor humidity level that is reliant on climate of region and altitude is linked to house dust mite distribution, and peak number of mites is originated in the most moist regions. (2)

Indoor humidity level that is reliant upon seasonal difference in outdoor humidity is connected to number of mites and the greatest number of mites is originated during the months wherever indoor humidity level is at peak. (3) Pronounced variances in the number of mites in diverse residences at the same time of year and in same area can be attributed owing to changes in indoor air humidity among residences.

Additional studies [49] recommend that there is a lesser edge of absolute humidity of 7.0 g water vapor/kg dry air, equivalent to 45% relative humidity at 20–23°C, under that house dust mites will not multiply. In residences with less than 7.0 g/kg, vapour house dust mites will arise as background contamination only and in numbers commonly below 100 mites/g dust.

For geographic regions with a temperate environment, it can be identified rather exactly that in order to stop buildup of hazardous levels of house dust mites in residences, indoor air humidity might be kept under a level of 7.0 g/kg or 45% relative humidity at usual indoor air temperature for a small number of winter months for every year. This extreme absolute humidity level in air indoor once more can be altered into a tiniest ventilation level stated in ACH (air changes per hour that strips with geographical locality (average outdoor air humidity in three dry winter months)) and inhabitants mass in the residence. As a whole, if (1) average outdoor air humidity in three winter months is recognized, (2) it is expected that each occupant of family creates a mean of 3000 g water vapor/24 hour in the residence, (3) water vapor is rapidly disseminated similarly to all air in construction, (4) rooms have a 2.0 m ceiling height, (5) a security margin of 30% is added to the minimum ventilation level, and steady-state situation can be calculated (production of water vapor divided by elimination equals 1):

$$1 = N \times 3000 \times 1.3/\mathrm{m}^2 \times 2 \times (\text{indoor AH} - \text{outdoor AH}) \times \text{ach} \times 24 \qquad (1)$$

where N = absolute number of inhabitants in household, m^2 = area of dwelling in square meters, indoor AH = maximum wanted indoor air absolute humidity (usually set to 7.0 g/kg), outdoor AH = average 3-month outdoor absolute humidity (three most dry winter months), and ACH = air changes per hour (ACH of 1.0 means that all air is exchanged once every hour).

From these calculations, figures can be made that the lowest ventilation desired may without difficulty be assessed with variable family size and space of the residence. Climate analysis with controlled and improved building ventilation is presently used to eradicate house dust mites from residences occupied by patients with asthma caused by allergy due to house dust mites [45].

6. Prevalence of house dust mites

The precise nature of dust mite density or the seasonal populations of house mites in homes are of paramount importance to reduce their development and in clarifying the role they play in dust allergy. A surrounding relative humidity is an important feature that controls prevalence and geographic spreading of these mites. This is for the reason that in humid air water vapors are key source of liquid for their existence. They thrive and survive fine at relative humidity exceeding 50%, however dry and decease at relative humidity less than this. As a result, dust mites and allergens they produce are an important problem merely for persons who live in moist temperate and tropical geographic regions. Mites *D. pteronyssinus* and/or *D. farinae* are prevalent in homes in Asia, Europe, the United States, and South America. However, most home environment are coinhabited by several species, but then again the greatest species prevalence differs both between homes in a

geographic region and between geographic regions. For instance, in the United States, both *D. pteronyssinus* and *D. farinae* are prevalent in homes; however *D. farinae* is more prevalent in homes than *D. pteronyssinus* within northern moist environments. However, in South America, *D. pteronyssinus* is prevalent in homes, whereas *D. farinae* is not. In temperate type of weather, densities of *D. pteronyssinus* and *D. farinae* display distinct periodic variations that are equivalent to seasonal instabilities in indoor relative humidity. Their great densities arise for the duration of moist summer months and little densities in winter, while relative humidity in homes is low [50].

Significantly, higher abundance levels of the house dust mites *D. farinae* and *D. pteronyssinus* arise on the most greatly used carpeted floor areas and fabric-upholstered furniture by the family living in bedrooms and room. Mattresses do not originate to be the key foci for occurrence of mites. There is no major positive correlation known among frequency or thoroughness of cleaning and mite abundance, as well as age of furnishings or dwelling and amount of dust. Considerably, greater mite levels arise on carpeted floorings than on non-carpeted grounds. A continuous vacuuming does not considerably decrease abundance of mites. Density of mites demonstrated a seasonal variability, with the lowermost mass during dryer along with late heating season and the uppermost mass arising in humid summer months. Alive mites are more plentiful than deceased mites for the period when overall abundance is great. In homes occupied by both mite species, *D. farinae* is more prevailing, excluding in one home that has considerably a greater relative humidity [51].

Of the systematically isolated mites from house dust samples, 90% are pyroglyphids, with 75% of these *D. pteronyssinus*, 10.5% *D. farinae* and 3.6% *E. maynei*, while Cheyletidae constituted 5.7% of the house dust mites. The maximum number of house dust mites recorded is 6500/g of house dust and the highest numbers are isolated in samples from humid areas (Feldman-Muhsam et al. 1985). Mites are present in 97% of the house dust samples and the maximum number of mites (7440/g dust) is found in the carpet. Most of the mites are isolated from the carpets and sofas (37.0 and 33.7%, respectively) and less from the beds (29.3%) [52].

It is well known that mite prevalence is greater in more humid geographic areas than in dry ones. Outdoor climatic conditions and indoor ambient RH are essentially the same for all homes in similar vicinity. Therefore, differences in mite abundance must be associated with other features of the homes (RH in mite microhabitat) and persons residing in these. A very important factor that correlates with the level of mite prevalence is the presence or absence of carpeting. Carpeted floors contain significantly more mites than tile or wood floors and none or very few mites are found on wood or vinyl-covered floors. Apparently, long-pile carpets reduce the efficiency of vacuuming and provide an excellent microhabitat for accumulation of food material and moisture for mites survival and breeding. From homes of house dust-sensitive patients, removing of fitted carpet would decrease the level of mites contact making from floors. Anywhere this cannot be undertaken or is not desirable; usage of short-pile carpets rather than large rough pile types would deal with important decline in levels of mites [53].

7. Phylogenetic relationships of family Pyroglyphidae

The pyroglyphids presently consist of 47 species and 20 genera, whose species are parasites associated with birds and mammals that contribute to house dust allergy problem. There has been no detailed phylogenetic analysis of the family

Pyroglyphidae. However, in essence, pyroglyphids are initially bird's-nest inhabitants; however they experienced an alteration in habitation to human nest and bed around the time of the first human settlement and are linked with agrarian production, specifically 10,000 years before. The glycyphagoid and acaroid mites of human residences made habitat transference from nests of small mammals and also come across habitat correspondences within homes, with diets in the form of cereals, seeds and other plant resources. By giving the similarity of trophic niches of human residences to those existing naturally, it is not astonishing that a number of mite species have become allied to human dwellings. Most importantly, many species of pyroglyphoid, glycyphagoid and acaroid appeared to have retained the ancestral ability to feed on fungi [54]. The "host" relationships with birds point out that both subfamilies of pyroglyphids that comprise species found in house dust, Dermatophagoidinae and Pyroglyphinae, are geographically the most widespread and species-rich, and connected with a greater variety of avian taxa than those subfamilies which do not comprise species that are found in house dust. This has a tendency to advocate that Dermatophagoidinae and Pyroglyphinae might denote ancestral taxa within family.

8. Dust mites management

The most effective way to treat dust mite allergies is to eliminate as many dust mites as possible from homes. Dust mites cannot be completely eliminated from home; however, they can be reduced. Reducing dust mites in houses can eliminate or lessen dust mite allergies. Having great physician care and sublingual treatment of dust mite allergies along with cleanup and prevention can be the keys in controlling of dust mite allergies.

8.1 Dust mite allergy treatment

Generally, people who have dust allergies are familiar with sneezing (act of expelling a sudden and uncontrollable burst of air through the nose and mouth), but sneezing is not the only uncomfortable symptom. Typically, sneezing occurs after external elements, or an adequate outside stimulating substance moves across nasal hairs to touch the nasal mucosa. This activates the discharge of histamines that irritate the nerve cells in the nose, causing signals being sent to the brain to start sneezing through the trigeminal nerve complex. The function of sneezing is to expel mucus containing irritants from the nasal cavity [55, 56].

Dust allergies also give to many people a stuffy or runny nose or cause their eyes to itch or become red and watery. A house is thought to be a cheering shelter; however for people having dust allergies, a home can generate painful indications. Strangely sufficient, allergy signs frequently get worse for the period of vacuuming or immediately after it, sweeping and dusting at a place. The practice of dusting can bring dirt particles up by creating these easier to breathe inside. If a person thinks he or she may have an allergy to any of the components of house dust, then see an allergist to pinpoint the cause of symptoms. Often an allergist will need to conduct a skin test and may order a blood test to determine exactly what is triggering an allergic reaction. After a dust allergy is identified, an allergist may recommend one or more of the treatments such as medications, allergy shots (subcutaneous immunotherapy), tablets (oral immunotherapy) and changes to personal household routine. A person may be prescribed by antihistamines to relieve sneezing, runny and stuffed nose, and itching in the nose and eyes; nasal corticosteroids to reduce

swelling in nose and block allergic reactions; commonly sodium nose spray to block the release of chemicals that cause allergy symptoms, including histamine and leukotrienes; leukotriene antagonists, pills which can improve both allergy and asthma symptoms; decongestant pills, liquids and allergy shots; and dust mite sublingual immunotherapy in which tablets of dust mite purified protein are placed under the tongue that may prevent and decrease symptoms of dust mite allergies [57].

8.2 Dust mite prevention strategies

No matter how much clean a home is, dust mites cannot be completely eliminated. However, as a first line of defense, dust mite mass can be condensed by exploiting the subsequent practices. Practice a dehumidifier or an air conditioner to keep humidity intensities at or lower than 50%. Enclose pillows and mattress in dustproof protections or allergen-resistant shelters. Wash down all blankets and bedding in hot water at 130–140°F to kill dust mites, once a week, and non-washable bedclothes can be kept cold overnight. Change feathered or wool bedding articles with synthetic materials and traditional animal stuffed products by washable ones. Within bedrooms, change wall-to-wall fitted carpet by naked floors, and get rid of fabric curtains and covered furniture, at whatever time imaginable. Practice a moist cleaner or duster to get rid of dust and at no time use a dry cloth, as it rises allergens up. Utilize a double-layered microfilter sack or a high-efficiency particulate air filter in a vacuum cleaner. Wear a mask while vacuuming, and stay out of the vacuumed area for 20 minutes after vacuuming, to allow dust and allergens to settle. The dust mite prevalence could be kept very low, and the factors responsible for the low mite density are maintenance of low relative humidity, use of low-pile carpets, and good housekeeping and laundering practices [58].

8.3 Control of house dust mites

An abstract of the study identifies that air conditioning can lessen relative humidity and population of dust mite in home environment in comparison to homes without dehumidification or air conditioning. However, humidity lessening does not stop populations of mites from developing further than the threshold of inducing allergies. An air-conditioning usage in combination with an efficient dehumidifier is effective in dropping of relative humidity in these homes lower than the threshold needed for mite population development, reproduction and growth. Subsequent to fourth week of study, 75% of dehumidifiers fitted homes have zero amount of live mites. House dust mites in clothing and bedding are the source of major allergens, and an average threshold before developing allergies is 100 mites/g of dust [59, 60].

Based upon studies of only *D. pteronyssinus*, weekly washing of clothing and bedding in hot water is suggested to remove allergens and destroy dust mites. But, most often washing is done in cold or warm water and other species of mites are also involved. A study has investigated the fatal influence of different temperatures of hot water alone and hot, warm, and cold water comprising chlorine bleach and detergents on *D. farinae*, *E. maynei*, and *D. pteronyssinus*. Mites have been dipped in test solutions for various lengths of time and at various temperatures, permitted time to recover, and then examined for existence. Mite *D. farinae* has been noted to be the most sensitive to temperature and chlorine bleach among the other two species. In 50°C water alone, 100% death of *D. farinae* has been found within 10 minutes, while most *E. maynei* and *D. pteronyssinus* stayed alive. But, soaking for 5 and 12 minutes at 53°C has been required to destroy all *E. maynei* and *D. pteronyssinus*, respectively. Washing with cleansing agents at suggested and

doubled concentrations and chlorine bleach mostly increased mortalities of three mite species compared to water alone. Soaking in warm water comprising different detergents alone for 4 hours made mortalities of 2–35%, 14–46% and 19–50% for *D. pteronyssinus*, *E. maynei* and *D. farinae*, respectively. Weekly washing of bed linens in warm water comprising bleach and most detergents presoaked for 4 hours can kill maximum number of *D. farinae*, and depending on detergent brand destroy adequate numbers of *D. pteronyssinus*. With warm water comprising the suggested concentrations of different detergents, soaking alone for 4-hour also killed enough numbers of *E. maynei*, *D. farinae* and *D. pteronyssinus*. So, accumulative influence of weekly washing with long presoaks of bed linens must considerably decrease mite levels over time, mainly when pillows and mattresses are sealed to stop reinfestation [61].

People can use mite killers (a number of powders and sprays are available) on mite-infested materials and reapply these occasionally as per manufacturer's directions. Furthermore, antibiotics have been tested, aiming at the control of *D. pteronyssinus* house dust mite. In culture medium, sulfaquinoxaline 30% within 3 weeks killed all the mites, whereas 30 mg/100 mg of culture medium of declomycin, oxytetracycline, tetracycline HCl, and aureomycin in 3 weeks killed 52, .058.9 and 94.6%, respectively, of mites. Cessations of nourishing and reduced coordination have been detected in mite cultures after 24 hours following the use of sulfaquinoxaline, and a week later, no eggs have been found [62–65].

Copper oxide (CuO) has broad-spectrum antimicrobial and antifungal properties and a study taken on common *D. farinae* house dust mite has tested the acaricidal efficiency of CuO-impregnated fabrics. The general mobility or vitality of mites has been reduced when they are exposed to CuO-impregnated fabrics and when possible, dust mites transferred to fabrics where no CuO existed. The mortality of mites exposed for 10 days to fabrics containing 0.2% (w/w) CuO remained significantly higher than the mortality of mites on control fabrics (72 ± 4 and 18.9 ± 0.3%, respectively). The death rate reached to 95.4 and 100% after 47 and 5 days with fabrics comprising 0.4 and 2% CuO, respectively. The acaricidal influence of copper oxide appears because of direct toxicity, and usage of fabrics comprising copper oxide might therefore be a significant opportunity for decreasing populations of house dust mites and the burden of dust mite allergens [66].

9. Domestic mites and forensic science

In fact, mites can be found in all habitats, even in the pores of our skin and almost every single person carries mites. Thus, they may even proof useful, for instance, in forensics. More than 100 species of mites from over 60 families are collected from animal carcasses and approximately 75 mite species from over 20 families gathered from human corpses [67], also including the astigmatid mite taxa. Domestic mites and other dust mites are present globally; however composition of species can be different between seasons, dwellings and even within places of a same indoor atmosphere (floors vs. stuffing furniture, floors vs. beds, or dust from a library desk vs. bookshelves). Distinguished variances in acarofauna of house dust mites among locations can provide valuable facts, for example, as an indicator of time and statuses of a death [68].

Surveys of dust samples have been taken from dwellings, hospitals, libraries, research laboratories, drugstores, offices and other workplaces. More than 30 mite species are found of which the most abundant and common include dust mites especially *D. farinae*. The highest mite densities (g ($^{-1}$) dust) are noted in dwellings [69]. Thus, this knowledge may be useful in the field of forensic medicine.

Since dust mites feed on the flakes of shed human skin, so human genetic material is expected to be present in these creatures. A study has been conducted to find out if house dust mites can carry the DNA of the house occupants. If this is true, human DNA isolated from the mites, obtained from a crime scene, could be used as evidence in court. The DNA profiles of people (10.25%) from homes (96.3%) showed an exact match with those found in the mite samples from the same house [70]. So, identified human DNA in house dust mites suggests that one can investigate a crime by analyzing DNA samples from house dust mites found in a crime scene and by comparing them with the DNA profiles obtained from victims and suspects.

The blowflies or flesh flies might carry out their life cycle around and in dead body, whereas mites may well forage on young stages of flies. The mites might breed more quickly than their fly carriers, posing themselves as appreciated timeline markers [71]. There are atmospheres at someplace where insects are either rare or absent, or the ecological situations hinder in their contact to carcass. At this point, mites that are previously present and mites which reach through air currents, by walking, or with material transfer come to be vital. There are eight different waves of arthropods colonizing carcasses of human. The first wave comprises flies and mites, whereas sixth wave is exclusively made up of mites. The scope of forensic acarology goes further in forensic investigations as mites compete with insects for food (dead body), slowing their development, or may even feed on insects. Observing mites can improve estimations of postmortem intervals that rely on timeline of when various species usually reach on a carcass and in whatever way long they proceed to grow, thus letting for more precise estimates in murder case. Mites are specific to microhabitat and might deliver evidential data on relocation or movement of bodies or finding a doubt at a crime scene [72]. Therefore, dust mites can be used as evidence in fields of forensic sciences.

10. Conclusion

House dust mites got their names from habitat of household dust and feed on any protein that comes in their way and find easy pickings in the dead skin scales that humans shed every day. House dust mites are not insects but arachnids and relate to spiders and ticks by having lengthy legs. Thirteen important house dust mite species have been identified; but two species that are the greatly common and key cause of allergen include *D. pteronyssinus* and *D. farinae* within Pyroglyphidae family. Unlike scabies mites or skin follicle mites, house dust mites do not burrow under skin and are not parasitic. Severe dust mites infestation in the home has been linked to atopic dermatitis, and epidermal barrier damage documented. Allergenic products of the common species of house dust mites are incompletely cross-reacting, carrying both common and species-specific determinants. It is because of this a correct identification of the mite species is important. It is important to remember that as droppings of dead dust mites continue to provoke allergic reactions, it must be needed not only to reduce their populations but also take steps to remove their dead bodies and feces from homes. Allergy testing of a person can determine whether house dust mites trigger respiratory or dermatological symptoms. If tests show allergic to house dust mites, then reduce immune system response by undergoing allergen immunotherapy. A healthcare provider may recommend medicine to lessen the symptoms of dust mite allergies.

Strategies to reduce dust mites in homes include to cover mattresses, pillows, and quilts with dust mite-resistant covers; wash sheets and pillowcases weekly in water hotter than 55°C; hot tumble dry (for half an hour after dry) or dry clean

household items; wash blankets every 2 months; use synthetic rather than feather pillows; remove sheepskin or woolen underlays; remove all soft toys from bedroom and replace with wooden or plastic toys; damp dust or use electrostatic cloths to clean hard surfaces weekly; reduce humidity to have a dry and well-ventilated house; avoid upholstered furniture; avoid heavy curtains; wash clothing before use if stored for a long time; as well as remove carpets and vacuum home weekly. The truth is that the utility of mites especially in cases where conditions such as the environment of the corpse it is found and the manner of death are not suitable for the presence or arrival of insects, mite populations on corpses can become an important evidence for elucidating of forensic cases.

IntechOpen

IntechOpen

Author details

Muhammad Sarwar
National Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad, Pakistan

*Address all correspondence to: drmsarwar64@gmail.com

IntechOpen

© 2020 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/3.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. CC BY

References

[1] Sarwar M. Biology and ecology of some predaceous and herbivorous mites important from the agricultural perception. In: Haouas D, Hufnagel L, editors. Pests Control and Acarology. London, UK: IntechOpen; 2019. p. 29

[2] Sarwar M. Mites (Arachnida: Acarina) affecting humans and steps taking for the solution of problematics. International Journal for Research in Mechanical Engineering. 2016;**1**(7):1-14

[3] Sarwar M. Diseases transmitted by blood sucking mites and integrated mite management for their prevention. American Journal of Food Science and Health. 2016;**2**(6):169-175

[4] Sarwar M. Feasibility for development of comparative life histories and predation of predatory mites in Phytoseiidae complex and their experimental manipulations for pests control. International Journal of Animal Biology. 2015;**1**(5):150-157

[5] Colloff MJ. Taxonomy and identification of dust mites. Allergy. 1998;**53**(48S):7-12

[6] Sarwar M, Kongming W, Xuenong X. Evaluation of biological aspects of the predacious mite, *Neoseiulus cucumeris* (Oudemans) (Acari: Phytoseiidae) due to prey changes using some selected arthropods. International Journal of Acarology. 2009;**35**(6):503-509

[7] Sarwar M, Xuenong X, Wang E, Kongming W. The potential of four mite species (Acari: Phytoseiidae) as predators of sucking pests on protected cucumber (*Cucumis sativus* L.) crop. African Journal of Agricultural Research. 2011;**6**(1):73-78

[8] Sarwar M, Kongming W, Xuenong X, Wang E. Evaluations of four mite predators (Acari: Phytoseiidae) released for suppression of spider mite infesting protected crop of sweet pepper (*Capsicum annuum* L.). African Journal of Agricultural Research. 2011;**6**(15):3509-3514

[9] Sarwar M, Xuenong X, Kongming W. Suitability of webworm *Loxostege sticticalis* L. (Lepidoptera: Crambidae) eggs for consumption by immature and adults of the predatory mite *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) (Acarina: Phytoseiidae). Spanish Journal of Agricultural Research. 2012;**10**(3):786-793

[10] Sarwar M. Comparing abundance of predacious and phytophagous mites (Acarina) in conjunction with resistance identification between Bt and non-Bt cotton cultivars. African Entomology: Journal of the Entomological Society of Southern Africa. 2013;**21**(1):108-118

[11] Sarwar M. Management of spider mite *Tetranychus cinnabarinus* (Boisduval) (Tetranychidae) infestation in cotton by releasing the predatory mite *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) (Phytoseiidae). Biological Control. 2013;**65**(1):37-42

[12] Sarwar M. Influence of host plant species on the development, fecundity and population density of pest *Tetranychus urticae* Koch (Acari: Tetranychidae) and predator *Neoseiulus pseudolongispinosus* (Xin, Liang and Ke) (Acari: Phytoseiidae). New Zealand Journal of Crop and Horticultural Science. 2014;**42**(1):10-20

[13] Sarwar M. Comparative life history characteristics of the mite predator *Neoseiulus cucumeris* (Oudemans) (Acari: Phytoseiidae) on mite and pollen diets. International Journal of Pest Management. 2016;**62**:140-148

[14] Arlian LG. Chiggers and other disease-causing mites. In: Encyclopedia

of Insects. 2nd ed. London, UK: Academic Press; 2009. p. 1168

[15] Samsinak K, Vobrazkova E, Dubinina V. Contribution to the taxonomic status of *Del'matophagoides schel'emetell'skyi* Bogdanoff, 1864. Folia Parasitologica. 1982;**29**:375-376

[16] Suggars AL. House dust mites: A review. Journal of Entomological Science. 1987;**1**(S):3-15

[17] Motavalli-Haghi F, Sharif M, Esmaeli R, Rafinejad G, Parsi B. Identification of different species of mites in dust, collected from residents of Sari Township in 1999-2000. Journal of Mazandaran University of Medical Sciences. 2003;**13**(38):54-58

[18] Bronswijk JEMH. House Dust Biology for Allergists, Acarologists and Mycologists. The Netherlands: NIB Publishers; 1981. p. 316

[19] Service MW. Medical Entomology for Students. 3rd ed. Cambridge: Cambridge University Press; 2004

[20] Spieksma FTM. Identification of house-dust mites. Aerobiologia. 1998;**6**(2):187-192

[21] Hart BJ. Biology and ecology of house dust mites, *Dermatophagoides* spp. and *Euroglyphus* spp. Immunology and Allergy Clinics of North America. 1989;**9**(2):339-356

[22] Arlian L, Confer P, Rapp C, VyszenskiMoher D, Chang JCS. Population dynamics of the house dust mites *Dermatophagoides farinae, D. pteronyssinus*, and *Euroglyphus maynei* (Acari: Pyroglyphidae) at specific relative humidities. Journal of Medical Entomology. 1998;**35**(1):46-53

[23] Calvo M, Fernandez-Caldas E, Arollano P, Marin F, Carnes J, Hormaechea A. Mite allergen exposure, sensitisation and clinical symptoms in Valdivia, Chile. Journal of Investigational Allergology and Clinical Immunology. 2005;**15**:189-196

[24] Hart BJ, Fain A. Morphological and biological studies of medically important house-dust mites. Acarologia. 1988;**29**:285-295

[25] Hart BJ. Life cycle and reproduction of house-dust mites: Environmental factors influencing mite populations. Allergy. 1998;**53**(48 S):13-17

[26] Sanchez-Borges M, Capriles-Hulett A, Fernandez-Caldas E, Suarez-Chacon R, Caballero F, Castillo S, et al. Mite contaminated foods as a cause of anaphylaxis. Journal of Allergy and Clinical Immunology. 1997;**99**(6 Pt 1):738-743

[27] Denning DW, O'Driscoll BR, Hogaboam CM, Bowyer P, Niven RM. The link between fungi and severe asthma: A summary of the evidence. European Respiratory Journal. 2006;**27**:615-626

[28] Sarwar M. Stored grain and stored product mites from Pakistan and Azad Kashmir. Pakistan and Gulf Economists. 2004;**23**(10):30-31

[29] Arlian LG, Dippold JS. Development and fecundity of *Dermatophagoides farinae* (Acari: Pyroglyphidae). Journal of Medical Entomology. 1996, 1986;**33**(2):257-260

[30] Alexander A, Fall N, Arlian L. Mating and fecundity of *Dermatophagoides farinae*. Experimental and Applied Acarology. 2002;**26**(1-2):79-86

[31] Matsumoto K, Okamoto M, Wada Y. Effect of relative humidity on life cycle of the house dust mites, *Dermatophagoides farinae* and *D. pteronyssinus*. Japanese Journal of Sanitary zoology. 1986;**37**(1):79-90

[32] Podder S, Biswas H, Gupta SK, Saha GK. Life-cycle of house dust mite *Dermatophagoides pteronyssinus* (Acari: Pyrogylphidae) under laboratory conditions in Kolkata metropolis. Acarina. 2009;**17**(2):239-242

[33] Griffiths DA, Cunnington AM. *Dermatophagoides microceras* sp. n.: A description and comparison with its sibling species, *D. farinae* Hughes, 1961. Journal of Stored Products Research. 1971;**7**(1):1-14

[34] Cunnington AM, Lind P, Spieksma FTM. Taxonomic and immunochemical identification of two house dust mites *Dermatophagoides farina* and *Dermatophagoides microceras*. Journal of Allergy and Clinical Immunology. 1987;**79**(2):410-411

[35] Solarz K. House Dust Mites, Other Domestic Mites and Forensic Medicine. Rijeka: IntechOpen; 2011. pp. 327-358

[36] Mumcuoglu KY, Lutzky I. The life-cycle of *Dermatophagoides evansi* Fain, 1967 (Acari: Pyroglyphidae), a mite associated with poultry. Acarologia. 1990;**31**(2):191-194

[37] Morgan MS, Vyszenski-Moher DL, Arlian LG. Population growth and allergen content of cultured *Euroglyphus maynei* house dust mites. International Archives of Allergy and Immunology. 2015;**166**:267-272

[38] Arlian LG, Morgan MS. Reproductive biology of *Euroglyphus maynei* with comparisons to *Dermatophagoides farinae* and *D. pteronyssinus*. Experimental and Applied Acarology. 2015;**66**(1):1-9

[39] Siddiqui QH, Sarwar M. Pre and post-harvest losses in wheat. Pakistan and Gulf Economist. 2002;**21**(6):30-32

[40] Arlian LG. Biology and ecology of house dust mites, *Dermatophagoides* spp. and *Euroglyphus* spp. Immunology and Allergy Clinics of North America. 1989;**9**(2):339-356

[41] Arlian LG, Morgan MS. Biology, ecology, and prevalence of dust mites. Immunology and Allergy Clinics of North America. 2003;**23**(3):443-468

[42] Mahakittikun V, Boitano JJ, Ninsanit P, Wangapai T, Ralukruedej K. Effects of high and low temperatures on development time and mortality of house dust mite eggs. Experimental and Applied Acarology. 2011;**55**(4):339-347

[43] Colloff MJ. Dust mites. Experimental and Applied Acarology. 2010;**52**(4):449-450

[44] Platts-Mills TA, Ward GW Jr, Sporik R, Gelber LE, Chapman MD, Heymann PW. Epidemiology of the relationship between exposure to indoor allergens and asthma. International Archives of Allergy and Immunology. 1991;**94**:339-345

[45] Korsgaard J. Epidemiology of house-dust mites. Allergy. 1998;**53**(48 S):36-40

[46] El-Dib NA. House dust mites—What might a mite do? Encyclopedia of life support systems, UNISCO. Medical Sciences. 2007;**1**:182-193

[47] Arbes SJJ, Cohn RD, Yin M, Muilenberg ML, Burge HA, Friedman W, et al. House dust mite allergen in US beds: Results from the first National Survey of Lead and Allergens in Housing. Journal of Allergy and Clinical Immunology. 2003;**111**(2):408-414

[48] Platts-Mills TAE, Heyden ML, Chapman MD, Wilkins SR. Seasonal variation in dust mite and grass pollen allergens in dust from the houses of patients with asthma. Journal of Allergy and Clinical Immunology. 1987;**79**:781-791

[49] Munir AK, Bjorksten B, Emarson R, Ekstrand-Tobin A, Warner A, Nim K. Mite allergens in relation to home conditions and sensitization of asthmatic children from three climatic regions. Allergy. 1995;**50**:55-64

[50] Feldman-Muhsam B, Mumcuoglu KY, Osterovich T. A survey of house dust mites (Acari: Pyroglyphidae and Cheyletidae) in Israel. Journal of Medical Entomology. 1985;**22**:663-669

[51] Arlian LG, Bernstein IL, Gallagher JS. The prevalence of house dust mites, *Dermatophagoides* spp. and associated environmental conditions in homes in Ohio. Journal of Allergy and Clinical Immunology. 1982;**69**(6):527-532

[52] Mumcuoglu KY, Gat Z, Horowitz T, Miller J, Bar-Tana R, Ben-Zvi A, et al. Abundance of house dust mites in relation to climate in contrasting agricultural settlements in Israel. Medical and Veterinary Entomology. 1999;**13**:252-258

[53] Lang JD, Mulla MS. Seasonal dynamics of house dust mites. *Dermafophagoides* spp. in homes in Southern California. Environmental Entomology. 1978;**7**:281-286

[54] Oconnor BM. Evolutionary ecology of astigmatic mites. Annual Review of Entomology. 1982;**27**:385-409

[55] Nonaka S, Unno T, Ohta Y, Mori S. Sneeze-evoking region within the brainstem. Brain Research. 1990;**11**(2):265-270

[56] Breitenbach RA, Swisher PK, Kim MK, Patel BS. The photic sneeze reflex as a risk factor to combat pilots. Military Medicine. 1993;**158**(12):806-809

[57] Cole EC, Cook CE. Characterization of infectious aerosols in health care facilities: An aid to effective engineering controls and preventive strategies. American Journal of Infection Control. 1998;**26**(4):453-464

[58] Babe KS Jr, Arlian LG, Confer PD, Kim R. House dust mite (*Dermatophagoides farinae* and *Dermatophagoides pteronyssinus*) prevalence in the rooms and hallways of a tertiary care hospital. Journal of Allergy and Clinical Immunology. 1995;**95**(4):801-805

[59] Sarwar M. Mites—The tiny killers to push honeybee colonies into collapse and integrated pest management. International Journal for Research in Applied Physics. 2016;**1**(7):12-21

[60] Sarwar M. Mite culprits for causing mortality and reduction in population of honey bee colonies and measures for pests control. International Journal for Research in Applied Chemistry. 2016;**1**(7):10-22

[61] Vyszenski-Moher DL, Arlian LG, Neal JS. Effects of laundry detergents on *Dermatophagoides farinae*, *Dermatophagoides pteronyssinus*, and *Euroglyphus maynei*. Annals of Allergy, Asthma & Immunology. 2002;**88**(6):578-583

[62] Sarwar M. Frequency of insect and mite Fauna in chilies *Capsicum annum* L., onion *Allium cepa* L. and garlic *Allium sativum* L. cultivated areas, and their integrated management. International Journal of Agronomy and Plant Production. 2012;**3**(5):173-178

[63] Sarwar M. Mite pests (Acari) in mango (*Mangifera indica* L.) plantations and implementation of control strategy. Bioscience and Bioengineering. 2015;**1**(3):41-47

[64] Sarwar M. Biological control to maintain natural densities of insects and mites by field releases of lady beetles (Coleoptera: Coccinellidae).

International Journal of Entomology and Nematology. 2016;**2**(1):21-26

[65] Mumcuoglu KY, Schlein Y. Sulfaquinoxaline, a possible means for the control of the house dust mite *Dermatophagoides pteronyssinus*. Revue Suisse de Zoologie. 1978;**85**:635-640

[66] Mumcuoglu KY, Gabbay J, Borkow G. Copper oxide impregnated fabrics for the control of house dust mites. International Journal of Pest Management. 2008;**54**:235-240

[67] Braig HR, Perotti MA. Carcasses and mites. Experimental and Applied Acarology. 2009;**49**(1-2):45-84

[68] Perotti MA. Megnin re-analysed: The case of the newborn baby girl, Paris, 1878. Experimental and Applied Acarology. 2009;**49**(1-2):37-44

[69] Solarz K. Indoor mites and forensic acarology. Experimental and Applied Acarology. 2009;**49**(1-2):135-142

[70] Çakan H, Güven K, Çevik F, Demirci M, Kocazeybek B. Investigation of human DNA profiles in house dust mites: Implications in forensic acarology. Romanian Journal of Legal Medicine. 2015;**23**(3):187-192

[71] Sarwar M. Typical flies: Natural history, lifestyle and diversity of Diptera. In: Sarwar M, editor. Life Cycle and Development of Diptera. London, UK: IntechOpen; 2020. p. 50

[72] Perotti MA, Goff M, Baker AS, Turner BD, Braig HR. Forensic acarology: An introduction. Experimental and Applied Acarology. 2009;**49**(1-2):3-13