



Biology of house dust mites and storage mites

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Summary House dust mites and storage mites have a high allergenic potential and lead to sensitization through the formation of specific IgE antibodies. Due to their preferred residence in houses, they belong to the group of house mites, which are referred to as “domestic mites” in English. Their anatomy and biology account for their amazing adaptability to changing environmental situations (including temperature, humidity, food) and make it understandable that measures to reduce their abundance are usually difficult to implement in practice.

Keywords IgE-mediated sensitization · Anatomy · Storage mites · Allergies · Hypersensitivity

Dust mites and “house mites”

All mites (Acari) belong to the arthropods (arthropods)—and here to the arachnids (Arachnida: Chelicerata). They are divided into a variety of orders (Fig. 1)—especially under the aspect of the formation of their respiratory openings: Astigmata (none), Prostigmata (anterior), Cryptostigmata (hidden), Mesostigmata (middle), Metastigmata (posterior).

The mites most commonly responsible for allergic diseases in humans belong to the superfamilies Pyroglyphoidea (house dust mites, HSM, with *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae* and *Euroglyphus maynei*) and Acaroidea (stor-

age mites, VRM). The storage mites belong mainly to the families of Acaridae and Glycyphagidae, which often live in stored foods and grains, hence their name.

All mite species that occur in houses or apartments and can trigger IgE-mediated sensitization are referred to in English as “domestic mites” [2], for which no generally accepted German term has yet been found. We would like to explicitly suggest in this publication to simply call them “domestic mites”. Domestic mites all have well-developed and sophisticated systems of respiration, digestion and water balance, enabling them to live and survive in the various habitats of houses.

A basic knowledge of the biology of house mites is important to understand the background of recommendations to reduce mites and their allergens—and thus their problems in implementing exposure prevention measures [3].

Anatomy of house dust and storage mites

House dust mites are usually 0.1–0.4 mm in size, storage mites can grow to approximately 0.6 mm in size and are thus practically invisible even to the naked eye. A striking feature of the mites is the extensive abolition of the segmentation of their bodies, which is characteristic of arthropods (e.g., insects). Thus, the boundaries between the head (caput), thorax, and hindquarters (abdomen) cannot be defined. Adults and nymphs have four pairs of legs, larvae only three pairs of legs. The legs are composed of six limbs. The basal limb is fused to the body. The soles of the feet have great absorbency, allowing the mites to hold many times their body weight even on smooth surfaces (Fig. 2).

The body, legs and mouth apparatus bear numerous hairs, which are differently pronounced in all mite

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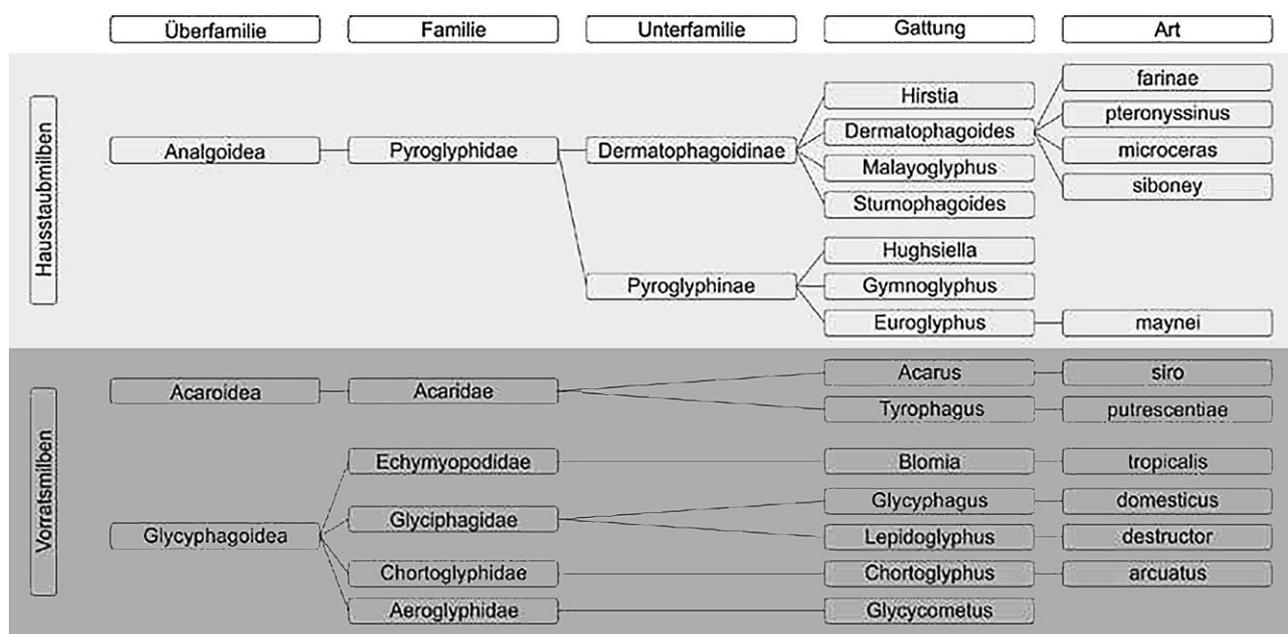


Fig. 1 Taxonomy of dust mites (modified after [1])

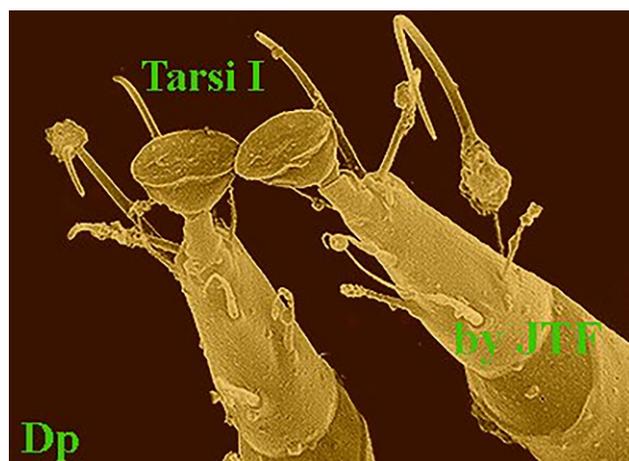


Fig. 2 View of the soles of the first pair of legs of *Dermatophagoides pteronyssinus* (source: J.-T. Franz)

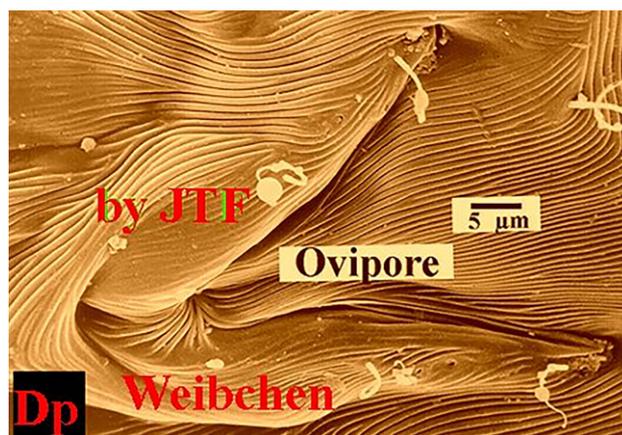


Fig. 3 Ovipore of *Dermatophagoides pteronyssinus* (source: J.-T. Franz)

species. The possible functional significance of the hairs has not been clarified to date.

The vulva of the female (primary sexual opening, ovipore) is located ventrally at the level of the posterior pairs of legs (Fig. 3). In addition, there is a mating pouch dorsally, which serves as a sperm receptacle and is connected to the ovaries.

Males have a sclerotized penis (aedeagus) located ventrally at the level of the third pair of legs. The anus is flanked by a pair of copulatory suckers (Fig. 4), which facilitate copulation with females because the suckers allow the male to adhere firmly to the female during copulation, which can last several hours. Similarly, suction cups on the fourth pair of legs of the male allow adhesion to the female during copulation (Fig. 5). The female carries the male on her back during this time (Fig. 6).

Mites do not have eyes and noses, but they can “smell”, i.e., they have receptors for odors (pheromone messages), the supracoxal hairs (Fig. 7). These are not true hairs, but chemoreceptors located near the “mite brain” in the axilla of the first front legs. The house mite species have different, species-specific supracoxal hairs.

So both dust mites and storage mites communicate through pheromones. In doing so, they communicate three basic messages to each other: alarm or danger, aggregation, and sexual behavior. The alarm pheromones are produced by the large and paired opisthosomal glands (Fig. 8); they are stored there and released only in cases of suspected danger by relaxing the glandular muscles. Fig. 9 shows an opened opisthosomal gland—a unique photograph!



Fig. 4 Anal suckers of a male *Dermatophagoides farinae* (a), in detail (b) (source: J.-T. Franz)

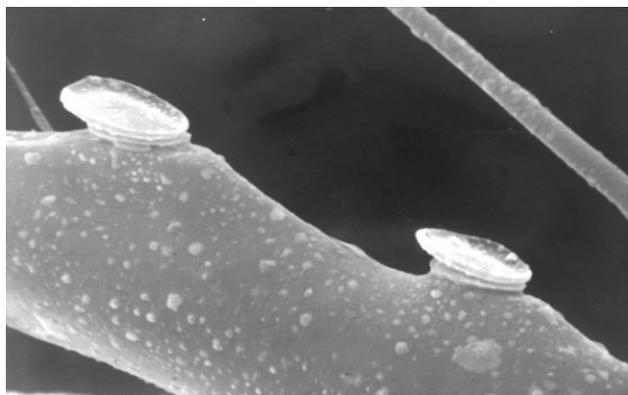


Fig. 5 Suction cups on the fourth pair of legs of a male *Dermatophagoides pteronyssinus* (source: J.-T. Franz)

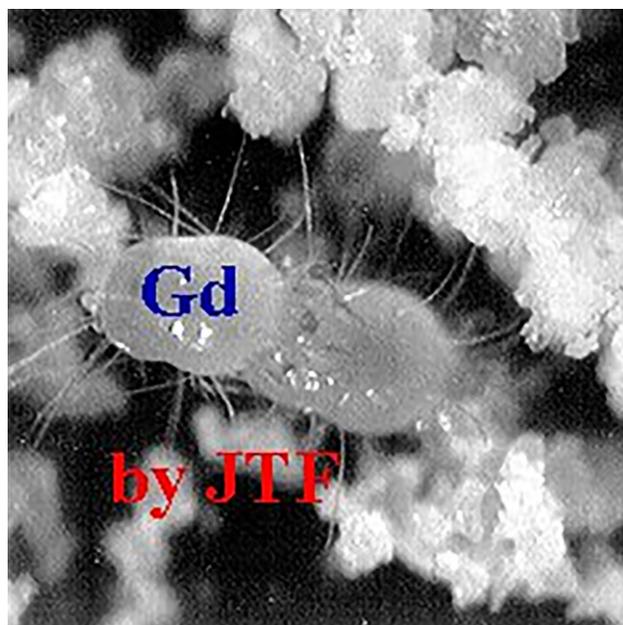


Fig. 6 Mating of *Glycyphagus domesticus* (source: J.-T. Franz)

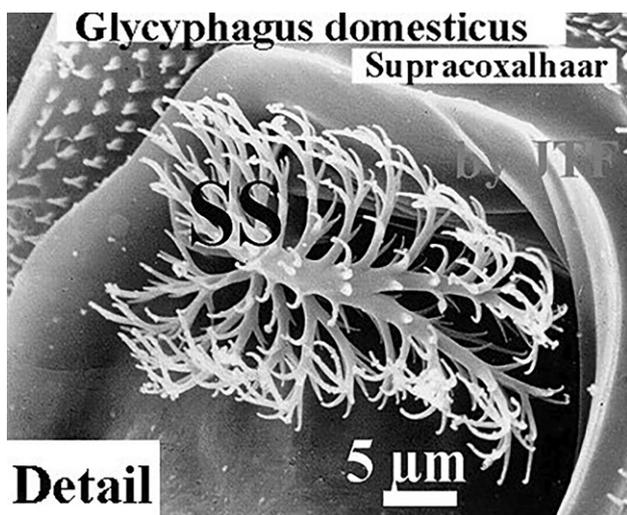


Fig. 7 Supracoxal hair of *Glycyphagus domesticus* (source: J.-T. Franz)

Aggregation and sex pheromones are produced and released by smaller skin glands. They lead to attraction and mutual sexual recognition within the species.

Male and female *D. farinae* and *D. pteronyssinus* have been shown to be attracted by the aggregation

pheromone Neral in the so-called Y-tube test at doses of 10–100 ng [4], which is self-released as a volatile pheromone by both mite species (Fig. 10). It has the basic potential to be used for mite removal by attraction to acaricidal substances and thus could be an attractant and killing system for house dust and storage mites [5]. Unfortunately, no commercial application of this possibility has yet occurred.

Also dorsal to the coxae of the first pair of legs are two supracoxal glands with external skin openings (Fig. 11). Their secretions contain sodium and potassium chloride salts, i.e., they are hygroscopic, and flow to the oral vestibule. Atmospheric water is absorbed by this saturated solution and creates a high water vapor saturated atmosphere in front of the mouth, which is absorbed by the mite in the digestive tract (midgut). Thus, the mites create a higher relative hu-

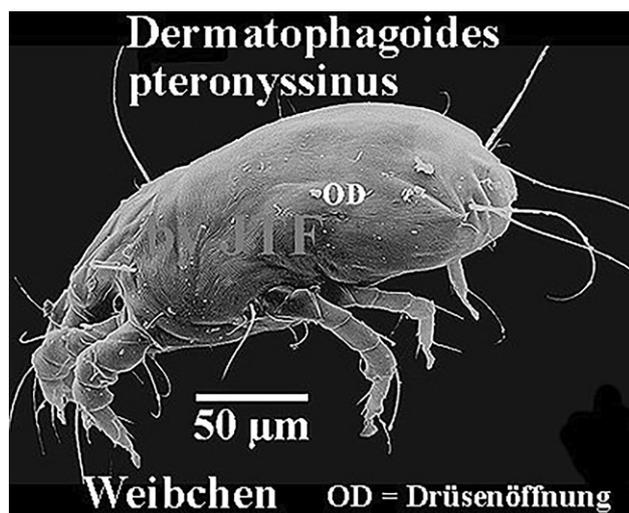


Fig. 8 Opisthosomal glands for the production and storage of alarm pheromone are located laterally on both sides; here a female *Dermatophagoides pteronyssinus* (source: J.-T. Franz)

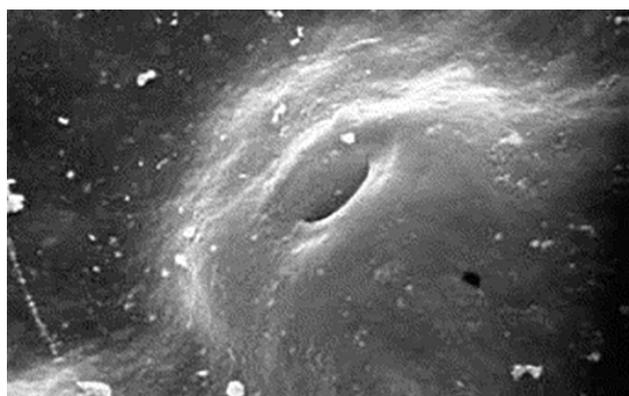


Fig. 9 Loosened ring muscle around an opisthosomal gland after release of alarm pheromone (source: J.-T. Franz)

midity in front of their mouth than is present in their environment [6]—another clever adaptation to their environment.

House dust mites feed mainly on human skin scales, while storage mites like protein-rich substances of animal or plant origin (grain, feed, hay), but also molds. Since these occur more often in the moister environment, VRM are also more likely to be found there.

The mites' fecal pads have a size of circa 10–20 μm (Fig. 12). The peritrophic membrane (envelope) of the excrement ball, consisting of dried intestinal secretion, remains closed as long as the relative humidity is sufficiently high. When dry, it ruptures and releases approximately 2 ng of guanine and the allergens of groups 1, 6, 18, and 23 in the HSM, while the HSM body releases the allergens of groups 2, 8, 10, 11, 14, and 20, among others, when it disintegrates.

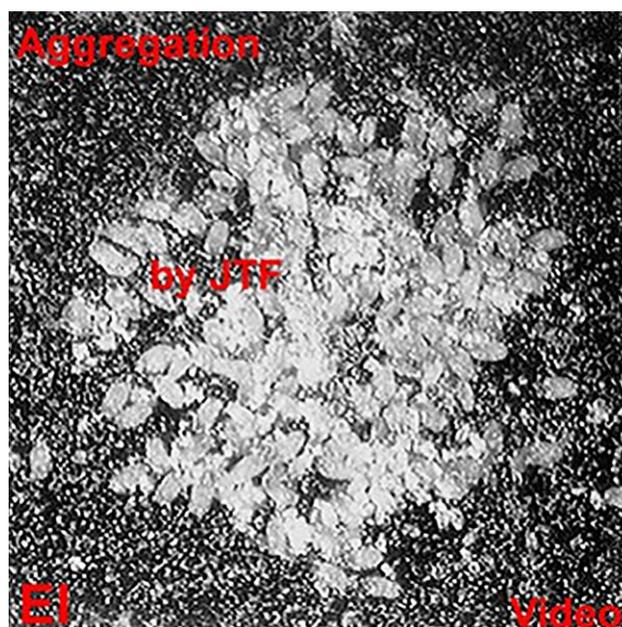


Fig. 10 Neral-induced aggregation of *Euroglyphus* (source: J.-T. Franz)

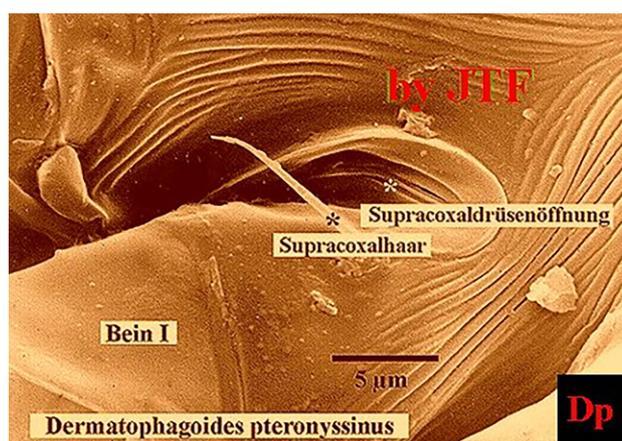


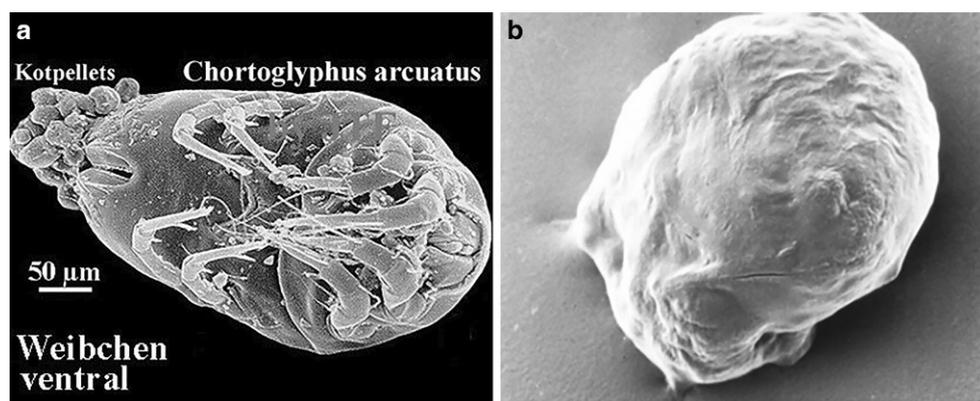
Fig. 11 Supracoxal gland in *Dermatophagoides pteronyssinus* (source: J.-T. Franz)

Oxygen and water balance of house mites

The microclimate of a house has a decisive influence on the reproduction and development of the house mites living in it. Due to their small size, mites do not need and do not possess separate breathing openings (hence the name: astigmata) for sufficient oxygen intake. Oxygen is absorbed directly through the cuticle (skin; passive respiration); this is accordingly very thin and also permeable to water.

Mites require high relative humidity to compensate for their own water loss (transpiration loss) through the cuticle. The mite body consists of more than 70% water. A room humidity of 7 g/kg air (=75% relative humidity at 15 °C) is optimal for their development. Normally, such a high humidity is achieved only in high outdoor humidity or in microclimatic niches of

Fig. 12 *Chortoglyphus arcuatus* releasing dung balls (pellets) (a), dung ball of *Dermatophagoides pteronyssinus* (b) (source: J.-T. Franz)



the house, especially in mattresses. During the sleeping period, the temperature in the mattresses rises to 25–30°C due to the human body heat and the relative humidity increases by 5–8% due to the body transpiration of the sleeper, so that during this period, i.e., during the nights, the development conditions conducive for the mites are present.

In beds, the active, feeding mites prefer to stay in the upper parts of the mattresses at temperatures with 32–36°C; thus, they are close to the human body. They stay there even during the day in the absence of humans. Non-feeding mites stay deeper in the mattress [7].

A mite population fluctuating with the seasons is found in carpets and rugs; increasingly in the summer months, when room humidity is highest with central or underfloor heating switched off. At the beginning of summer, following the heating period, the mite population is small, in late summer a maximum is reached, and in late autumn and winter the mite population drops again to a minimum [8]. These changes in the humidity of the air in the house also make the seasonal changes in nasal and conjunctival symptoms of mite allergy sufferers understandable [9]. Since relative humidity rather than atmospheric pressure is crucial for mites, they also occur at altitudes >2800 m [10]. The absence of mites in higher altitude resorts is the hope of resort administrators, but mites do not adhere to it [11].

Reproduction and development

Males successfully mate only with adult females. After mating, females lay eggs (approximately $80 \times 170 \mu\text{m}$) individually on the ground. HSM produce up to four relatively large eggs daily (Fig. 13 and 14); thus a total of between 80 and 300 eggs can be laid during the lifespan of the females [13].

VRM usually produce more and smaller eggs. Development takes about 4 weeks, depending on temperature, and involves a total of six developmental stages, each separated by a molt: Egg, Prelarva, Larva, Proto- and Tritonymph (juvenile stages) and Adulti (adult male/female).



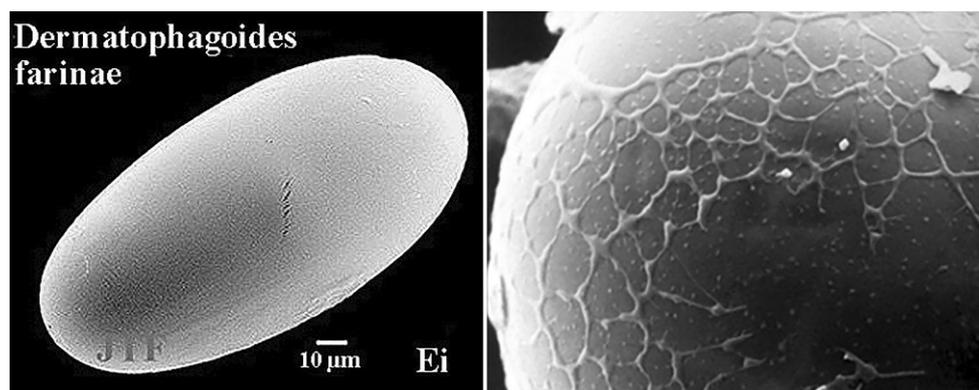
Fig. 13 Pregnant female of *Dermatophagoides farinae* with several eggs (source: J.-T. Franz)

The egg contains the prelarval stage. The hatched larvae and the nymphs (young stages) have active and resting developmental phases. The transformation into the subsequent developmental stage is characterized by resting phases of 2–3 days each, after which molting into the subsequent developmental stage occurs. A deutonymph stage (hypopus: migratory or permanent nymph)—as in some VRM species—does not occur in house dust mites.

Males of *D. pteronyssinus* live between 60 and 100 days, females up to 150 days, and those of *D. farinae* only about 60 days [12].

Temperature has a significant influence on the lifespan of mites. The climatic conditions that are comfortable for mites largely correspond to those of humans. Temperatures between 20 and 28°C and a relative humidity of 75–80% are preferred. Temperatures as low as –25°C are tolerated for a few hours, +50°C for over 4 h and +60°C for 1 h. Below the temperature optimum at 15°C, the development time is considerably prolonged. The cold death point for *D. farinae* is at –18°C for 48 h. For *D. pteronyssinus*, *D. farinae*, and *E. maynei*, exposures above 6 h at –28°C are lethal. The heat death point for *D. pteronyssinus* is 45.5°C over 24 h [14].

Fig. 14 Egg of *Dermatophagoides farinae* (a). In the magnification (b) adhesive structures on the egg surface are visible, which give the egg a strong adhesion (source: J.-T. Franz)



Climate change and house mites

Climate change has an impact on allergens and allergies [16], mainly through changes in outdoor air, but indirectly also on indoor air. The colder the temperatures are in winter, the more the indoor air is heated and is thus drier; this reduces the chances for mite populations to grow. In Germany, it has been shown that unusually cold winters lead to a reduction in mite numbers [15], as is also known from higher regions of some health resorts. Larger temperature variations from summer to winter are also reported to be associated with lower asthma incidences [17]. If the coming winters are less cold and associated with higher humidities, this could lead to increased numbers of house mites and consequences for rhinitis and asthma frequencies.

The storage mites

About 150 storage mite species are known worldwide [18], but by far not all of them are of allergological significance. To date, only about 20 species are of known allergological significance [19].

A recent position paper in this journal provided an overview of the species, their occurrence, cross-reactivity to house dust mites, and their allergological significance [20]. Importantly, allergologically significant VRMs occur in both rural working areas and urban dwellings in Germany—and thus belong to house dust mites as well as dust mites [21].

Outlook

It is reasonable and appropriate to refer to house dust mites and allergologically significant storage mites together as house mites in order to more firmly establish the importance of the latter in allergological awareness and thus to include all house mites in the practice of allergological diagnostics. The complex adaptive biology of house mites is far from fully understood and further research is urgently needed to more effectively design curative measures.

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Conflict of interest K.-C. Bergmann declares that he has no competing interests.

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