The biology of dust mites and the remediation of mite allergens in allergic disease

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In most temperate humid areas of the world, house dust mites are a major source of multiple allergens in house dust. Mite allergens sensitize and induce perennial rhinitis, asthma, or atopic dermatitis in a large portion of patients with allergic disease. There is convincing evidence that avoidance of mite allergen can effectively reduce allergic symptoms. Patients can be moved to a mite allergen–free environment, or mite and mite allergen abatement can be performed to reduce exposure in existing residences. Some knowledge of the biology of house dust mites is essential to understand the basis of the recommendations for reducing mites and mite allergens in homes and to appreciate the difficulty of eliminating house dust mites and mite allergens from homes. This article reviews key aspects of the biology of dust mites, the properties of mite allergens, recommendations for reducing mite and mite allergen concentrations in homes, and practical recommendations for treatment. (J Allergy Clin Immunol 2001;107:S406-13.)

Key words: *House dust mite abatement, allergen remediation, mite allergy, dust mite biology*

One of the most important events in the history of allergic disease was the discovery by Voorhorst et al[1] that dust mites are the major source of allergen in house dust. They went on to explain many features of the biology of mites and provided much of the theoretical argument for current strategies used for the control of dust mites. In humid areas of the world, dust mites are ubiquitous, and up to 30% of the population have positive skin test reactions to at least one dust mite species. Sensitization to allergens derived from dust mites is strongly associated with 3 diseases: asthma, perennial rhinitis, and atopic dermatitis. Evidence for the efficacy of avoidance of dust mites and their allergens in the treatment of these diseases comes from (1) experiments in which patients' symptoms improved when they were removed from their houses[2,3] and (2) successful controlled trials of avoidance in patients' houses.[4] These studies provide both the evidence for recommending avoidance as part of treatment and also evidence about the methods that are most effective in controlling mite allergens.

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Abbreviation used
RH: Relative humidity

BIOLOGY OF HOUSE DUST MITES

Any explanation of the biology of house dust mites cannot be complete without an overview of their classification and relationship to other arthropods, a discussion of commonly found species in both the environment and in household dust, and an examination of their prevalence, life cycle, and the roles humidity and temperature play in their development.

CLASSIFICATION AND RELATIONSHIP TO OTHER ARTHROPODS

The phylum Arthropoda is comprised of 3 subphyla of living organisms: Chelicerata, Uniramia, and Crustacea. House dust mites are arthropods belonging to the subphylum Chelicerata, class Arachnida, order Acari, and suborder Astigmata (Table I). Other suborders of mites include Mesostigmata, Metastigmata (ticks), Prostigmata, and Oribatida.

The chelicerae for the house dust mite are pincer-like and consist of both movable and fixed digits. For comparison, other chelicerates have either stylet-like chelicerae for piercing (eg, spider mites and chiggers) or sickle-like chelicerae for cutting an incision in the host skin (eg, ticks).

In addition to the mites, the subphylum Chelicerata consists of other organisms, such as sea spiders, horseshoe crabs, spiders, scorpions, and harvestman spiders (daddy longlegs), whereas insects, centipedes, and millipedes all belong to the subphylum Uniramia. Therefore mites are not closely related to insects. Mite morphology and many aspects of their physiology are very different from those of insects. For example, mites excrete primarily guanine, whereas terrestrial insects excrete primarily uric acid. Because of the differences in physiology, many insecticides and growth regulators used successfully to control insect populations are ineffective for controlling dust mite populations.

MITES IN THE ENVIRONMENT

The acari are a very diverse group of organisms that have exploited some unusual microenvironments. For

TABLE I. Abbreviated classification of phylum Arthropoda

Phylum Arthropoda
- 1. Subphylum Uniramia
  - Class Insecta (insects)
  - Class Myriapoda (centipedes, millipedes)
- 2. Subphylum Crustacea
  - Class Malacostraca (crayfish, lobsters, crabs)
  - Class Maxillopoda (copepods)
- 3. Subphylum Chelicerata (Cheliceriformes)
  - Class Merostomata (horseshoe crabs)
  - Class Pycnogonida (sea spiders)
  - Class Arachnida
    - Order Aranea (spiders)
    - Order Opiliones (daddy longlegs)
    - Order Scorpiones
    - Order Pseudoscorpiones
    - Order Solifugae (whipscorpions)
    - Order Acari
      - Suborder Mesostigmata (free-living, predaceous, and parasitic mites)
      - Suborder Prostigmata (chiggers, follicle mites)
      - Suborder Metastigmata (ticks)
      - Suborder Astigmata (house dust, storage, & scabies mites)
      - Suborder Oribatids (soil mites)

example, some species inhabit the nasal passages of birds and mammals, the trachea of insects (mites are a major pestilence of honey bees), the hair follicles of humans and other mammals, the skin of mammals (scabies mites and others), the feathers of birds, the skin scales of reptiles, and the gills of mushrooms. In addition, many species are plant parasites, some of which are major pests for citrus, apple, strawberry, bean, and wheat crops. Many species are blood- or fluid-feeding ectoparasites of birds, mammals, and reptiles (eg, chiggers and ticks) and can transmit diseases, such as scrub typhus (chiggers) and Lyme disease (ticks). Some live in soil litter, where they are predators, fungal feeders, and detritus feeders.

MITES INDUCING ALLERGIC REACTIONS

Many species of mites that humans come in contact with, besides those found in house dust, induce allergic reactions. These include the citrus red mite *(Panonychus citri)* and the 2-spotted spider mite *(Tetranychus urticae)*, which are common pests in apple orchards.[5] The mite *Hemisarcoptes cooremani*, a parasite of scale insects that is commonly found in orchards, yards, and gardens, was recently discovered to induce IgE-mediated reactions.[6] Scabies mites *(Sarcoptes scabiei)* burrow into the skin and induce an IgE-mediated response in many infected individuals.[7] Many species of storage mites induce IgE-mediated reactions in exposed individuals.[8] It should come as no surprise to learn that chiggers, ticks, and other species of ectoparasitic mites of fowl, birds, mice, guinea pigs, and other mammals and predaceous mites either sensitize or induce allergic reactions in humans as well.

MITES FOUND IN HOUSEHOLD DUST (DOMESTIC MITES)

House dust mites belong to the suborder Astigmata and family Pyroglyphidae. However, mites belonging to other families are also present in house dust, and the term domestic mites includes both mites from the Pyroglyphidae family or dust mites and mites from other families. Astigmatid mites are unusual in that they lack organized respiratory systems and associated external openings for ventilation. They are aerobic and apparently exchange O_2 and CO_2 through their general body surface. They feed principally on skin scales and other organic detritus that collects in homes. The family Pyroglyphidae contains about 16 genera and 46 species.[9-11] A phylogenetic perspective, the evolutionary ecology, and the cladistic relationships of families and species of astigmatid mites, can be found in several reports.[10,12-14]

Thirteen species have been found in house dust, 3 of which are very common in homes worldwide and are the major source of mite allergen. The most common of these species are *Dermatophagoides farinae, Dermatophagoides pteronyssinus*, and *Euroglyphus maynei*, which are found in temperate climates. In tropical climates, the storage mite *Blomia tropicalis* (Family Echymyopodidae) can be a prevalent mite in dwellings, along with other Pyroglyphid mites. In addition, other astigmatid mites (storage mites) can be found in homes and are a potent source of allergens. Most notable are species in the families Glycyphagidae (*Glycyphagus domesticus* and *Lepidoglyphus destructor*), Acaridae (*Tyrophagus putrescentiae* and *Acarus siro*), and Chortoglyphidae *(Chortoglyphus ancutatus)*. Predaceous mites (eg, Cheyletus) and parasitic mites of plants (Tetranychidae [spider mites] and Tarsonemidae) can also be present in homes. The significance of these as sources of indoor allergens is yet to be determined.

PREVALENCE OF HOUSE DUST MITES

Worldwide and in the United States, the most prevalent pyroglyphid mites found in homes are *D farinae* and *D pteronyssinus*. *E maynei* may also be prevalent in some temperate geographic areas, and at times, their density may even exceed that of *D farinae* and *D pteronyssinus. Blomia tropicalis* is an important source of allergen in homes in the subtropics and tropics.

In a US study of homes located in 8 different geographic areas,[15] most houses were coinhabited by *D farinae* and *D pteronyssinus*. However, one species usually predominated in each home and constituted greater than 70% of the total mite population. Only a few homes in each geographic area of this study had populations containing one species only. An important discovery was that within the same geographic area, the predominant species present varied between homes. These findings illustrate the need to test for both species when a patient undergoes skin testing and when using immunotherapy.

LIFE CYCLE OF HOUSE DUST MITES

House dust mites reproduce sexually. In the female the sperm is stored in a seminal vesicle and released into the oviduct to fertilize the egg during ovulation.[16] The structure of the bursa copulatrix and seminal vesicle is species specific and can be used for identification of *Dermatophagoides* species.[16,17]

The life cycle of *D farinae*, *D pteronyssinus*, and *E maynei* consists of 5 stages: egg, larva, protonymph, tritonymph, and adult. The duration of development from egg to adult and population growth is influenced by both ambient relative humidity (RH) and temperature.[11,18-28]

For *D pteronyssinus*, laboratory studies report that the greatest population growth occurs at 25°C, with slower growth rates occurring at lower temperatures of 10°C, 15°C, and 20°C and at higher temperatures of 30°C and 35°C.[29-31] Arlian et al[18] reported the mean ± SD length of the life cycle to be 122.8 ± 14.5 days at 16°C (61°F), 34.0 ± 5.9 days at 23°C (73°F), 19.3 ± 2.5 days at 30°C (86°F), and 15.0 ± 2.0 days at 35°C (95°F) at 75% RH. In comparison, for *D farinae*, few mites complete the life cycle at extreme temperatures of 16°C and 35°C, but at 23°C and 30°C, lengths of the life cycle were 35.6 ± 4.4 days and 17.5 ± 1.2 days, respectively.[25]

Because temperatures are not uniform in the various areas where these mites are found in homes, the rate of reproduction, development, and mite population growth vary. For example, mite populations in carpets over slab floors that remain cool develop slower than populations inhabiting mattresses or sofas. Likewise, population growth of the 2 species in specific locations may differ because of the differences in the reproductive biology of the 2 species.

Both species produce 2 to 3 eggs per day during an approximate 26- and 34-day reproductive period for *D pteronyssinus* and *D farinae*, respectively, at 23°C and 75% RH. Mean population growth for *D farinae* and *D pteronyssinus* is 17.3% and 32.5% per week, respectively, for the humidity range of 65% to 75%.[32] In laboratory cultures population densities of the 2 species decline when humidity is continuously maintained at 85% RH. However, populations exposed to daily regimens of 85% RH for 2 to 8 hours alternated with regimens of 35% RH increased in inverse proportion to time in the moist air.[23] Thus although the underlying mechanism is not fully understood, this investigation suggested that too much moist air can inhibit mite growth.

IMPORTANCE OF AMBIENT RH

House dust mites are 70% to 75% water by weight, and they obtain and maintain their water balance primarily by absorbing water from the water vapor in air.[33-36] The lowest critical humidity at which fasting *D farinae* females can gain sufficient water from the atmosphere to maintain water balance and survive is about 55% RH at 20°C to 25°C. The critical humidity is temperature dependent, and for *D farinae*, it ranges from 55% to 75% RH over the temperature range from 15°C to 35°C.[37,38]

Dust mites obtain water from the air by secreting a hyperosmotic solution from the supracoxal glands that open just above the first pair of legs.[39] The secretion flows through an open trough to the preoral cavity located beneath the chelicerae, where it is ingested. The hygroscopic solution absorbs water as it flows from the gland opening to the preoral cavity.

SOURCES OF MITE ALLERGENS

Much has been learned about dust mite allergens in the last 20 years. It is clear that mite bodies and mite feces are the sources of many allergens.[40,41] The allergens associated with mite fecal matter are enzymes that originate from the mite's digestive tract. Possible sources of other allergens include enzymes associated with the molting process that occurs as mites change from one life stage to the next. Some allergens may be components of mite saliva that is left in the environment on food substrates where mites feed. Secretions from the supracoxal glands that are involved in the active uptake of water likely contain proteins, as well as sodium and potassium chloride.[39] After death, soluble protein in body fluids may be released as the body disintegrates. Some proteins from all of these sources could be allergenic.

CHARACTERISTICS OF MITE ALLERGENS

Mite allergens are divided into specific groups (1-13) on the basis of their biochemical composition, sequence homology, and molecular weight. The designation for a characterized allergen is the first 3 letters of the genus, the first letter of the species name, and a number designating the order in which the allergen was isolated or the number for other already characterized allergens it matches in homology and molecular weight. The characteristics of group 1 and 2 allergens are shown in Table II.

Group 1 allergens are glycoproteins with cysteine protease activity similar to that of some plant and mammalian enzymes.[4,42] They originate from cells lining the intestinal tract of the mite.[43,44] Der p 1 can cleave the CD23 IgE receptor on the membrane of human B cells and the CD25 subunit of the T-cell IL-2 receptor, which enhances its allergenicity.[45,46] Der f 1 and Der p 1 have sequence homology of 80% and have cross-reactive epitopes. However, they also have species-specific epitopes.[47] There is some evidence that the group 1 allergens may be released as preproproteins[47] that are activated by gluthathione found in respiratory secretions when deposited on mucus membranes.[42]

Group 2 allergens are 14-kd nonglycosylated proteins that have high sequence homology.[48-50] Der f 2 and Der p 2 show 88% sequence homology. Group 2 allergens seem to be associated with secretion from the male mite reproductive tract,[51] although Lep 2 is also associated with the gut and other areas of the mite's anatomy.[52] The mAb 1D8 that recognizes Der p 2 but not Der f 2 also binds to Eur m 2.[53] This indicates that Der p 2 and Eur m 2 share an epitope not present on the Der f 2 allergen.

TABLE II. Characteristics of group 1 and 2 allergens and percentage of patient reactivity to them

Allergen group	Specific allergens characterized	Molecular weight (kd)	Frequency of reactivity (%)	Homology
Group 1	Der f 1, Der p 1, Eur m 1, Der m 1	25	>90	Cysteine protease, homology similar to enzymes papain, actinidin, cathepsin H and B, bromelain, frein
Group 2	Der f 2, Der p 2, Eur m 2, Tyr p 2, Lep d 2	14	>90	Homology with primate Epididymus protein

RECOMMENDATIONS FOR REDUCING MITE AND ALLERGEN LEVELS IN HOMES

Interventions in the home should have 3 interrelated goals: (1) reduce live mite populations; (2) reduce mite allergen levels; and (3) reduce human exposure to both. The methods used in a particular home to accomplish these 3 goals depend on many factors, most notably the cost of the intervention, the ease with which it can be implemented, the importance of a particular source of exposure, the safety of any chemicals used, and the potential effectiveness (benefit) of the intervention used. The methods selected may vary depending on one or more of these factors. A comprehensive plan, especially in a household where mite populations are extremely heavy or where persons are experiencing severe allergic reactions, may use multiple methods.

Reducing indoor RH

Maintaining RH below 50% is one of the most common recommendations for reducing dust mites and their allergen levels in homes because ambient RH is the key factor that influences dust mite prevalence. Mites must obtain sufficient water from the air to survive. Laboratory studies have shown that adult mites die of dehydration in 5 to 11 days, depending on temperature (25°C-34°C), when continuously exposed to RHs of 40% or 50%.[35,54] Field studies report that homes located in dry climates, such as those of the mountain states or upper Midwest, have few mites and little mite allergen present. Many studies[26-28,55-58] report seasonal fluctuations in mite and allergen levels that parallel seasonal fluctuations in indoor relative humidity. In dry climates use of evaporative coolers can raise RH enough to support mite populations.[59,60]

The use of high-efficiency dehumidifiers and air conditioners in homes has recently been shown to be both practical and effective in reducing RH and thus mite populations. It was found that in a humid temperate climate, it is possible to maintain RH below 50%, which reduces mite and allergen levels over time.[61] In addition, maintaining a mean daily RH below 50%, even when RH rises above 50% for 2 to 8 hours, effectively restricts population growth of *D farinae* and thus the production of allergen.[23] To completely prevent population growth of *D farinae*, RH must be maintained at 35% or less for at least 22 hours per day when daily RH is 75% to 85% for the remainder of the day.[23]

In temperate climates it is possible to maintain RH at less than 50% by using high-efficiency dehumidifiers and air conditioning. In this environment this intervention may be the only control measure needed. New carpets, mattresses, pillows, and sofas should not develop mite populations in this lower humidity environment. In homes with existing mite populations, mites should die in the dry environment, and regular vacuuming and cleaning should reduce the allergen pool in these substrates over time.[61] In some climates there may be major differences in mites and mite allergens between apartments and houses, simply because of the lower humidity in the apartments. Whether dehumidification is practical and effective in warm humid climates, such as that found in Florida, remains to be determined.

Using encasements

Encasing mattresses and pillows in specially manufactured protective coverings is effective in reducing exposure to house dust mites and their allergens.[62-66] Mattress and pillow encasements are recommended for allergic patients. Encasements may be made from plastic, vapor-permeable materials, finely woven fabrics, or nonwoven synthetics.

Pore size of the fabric is important to consider when purchasing mattress or pillow encasements. Ideally, to be comfortable, these encasements should be manufactured from breathable fabrics, be vapor permeable, and be able to block both dust mites and their allergens. Dust mite allergens (Der f 1 and Der p 1) are blocked below detectable limits by fabrics with a pore size of less than 10 μm,[67] whereas the mites themselves would be blocked by pores of less than 20 μm (width of larval stage). Dust mite larvae are generally greater than 50 μm across, and therefore access of all mites will be prevented by fabrics rated as having pore sizes of 20 μm or less.

Rains et al[68] found that new synthetic pillows accumulated Der p 1 more rapidly than new feather pillows over a 1-year period of study. Surveys of allergen levels on pillows found that nonfeather pillows contained almost 5 times more allergen[69] and an 8-fold increase of Der p 1 allergen[70] in contrast to feather pillows. It may be that tightly woven fabric covers on feather pillows prohibit mite entry and colonization of the pillows. If this theory proves to be true, manufacturers should be urged to cover all pillows with tighter fabrics.

Washing, drying, and dry cleaning of bedding materials

Washing sheets, pillow cases, blankets, and mattress pads at least weekly in hot water (55°C [130°F] or higher) kills mites and removes most allergen.[41,71,72] When

TABLE III. House dust mite allergen avoidance: Patient education

___ Assessment of home environment
___ Description of mites (including their foods)
___ Conditions for optimal growth (humidity: >55% RH; temperature: 65°F-75°F)
___ Local areas of dust mite growth (pillows, mattresses, box springs, carpet, upholstered furniture, draperies, stuffed animals/toys)

Priorities for mites/allergens avoidance

Bedroom

___ Encase pillows (<10 μm pore fine woven or vapor-permeable cover)
___ Encase mattress in vapor-permeable or plastic cover
___ Encase box springs in vinyl or plastic
___ Wash bedding weekly in hot (130°F) water

House

___ Vacuum clean weekly (wear mask; leave room for 20 minutes after cleaning)
___ Ensure that vacuum cleaner has good quality bags (usually double thickness) or high-efficiency particulate air filter on air outlet

Long-term changes to decrease mites

___ Reduce indoor relative humidity (with air conditioning, dehumidifier, or opening windows depending on climate and season)
___ Replace carpets with polished flooring (wood, vinyl, tile)
___ Replace upholstered furniture with leather, vinyl, or wood
___ Replace draperies with wipeable shades/blinds
___ Avoid living in basements

Instructions: Record date in space provided when each measure is initiated. Bring form back on next visit.

washing in hot water, precautions should be taken to prevent the possibility of scalding. Washing in warm or cold water does not kill most mites but probably removes most allergens because allergens are water soluble.[71,73] Adding benzyl benzoate (0.03%) and eucalyptus oils (0.2%) to the wash cycle also kills mites.[74-76] However, eucalyptus oils leave an odor in clothing that lasts for 2 to 3 days.

The key to killing mites in a tumble dryer is to maintain the lethal temperature for a sufficient time. Tumble drying blankets can kill all mites if a temperature greater than 55°C (130°F) is maintained for 10 minutes.[77] Chang et al[78] found that the thermal death point and time required to kill mites was about the same in air as in water and reported that mites exposed to air at 60°C died within 10 minutes.

Dry cleaning of fabrics is effective in killing mites, but it does not destroy all allergens.[71,79]

Replacing carpets, draperies, and upholstery

Carpets, draperies, and upholstery fabrics collect detritus and hold moisture, providing an ideal habitat for mite breeding. In humid climates it is recommended that carpets be removed in favor of hard surfaces. Likewise, draperies and curtains can be replaced with blinds or shades. To further reduce infestations, fabric upholstery can be replaced with vinyl or leather covering on cushions. Wooden furniture with no fabric is also recommended.

Vacuuming carpets

In homes with carpeting where the owners are not willing to remove the carpeting or are unable to afford to do so, regular vacuuming of the carpets at least weekly and frequent replacing of the vacuum bags is recommended. Vacuum bags with 2 layers or a high-efficiency particulate air filter or central vacuum cleaners exhausted to the outside are recommended to prevent allergens from being aerosolized during the vacuuming process.[4,80,81] Regular vacuum cleaning removes surface mites and allergens, but it does not remove deeply imbedded allergens or reduce the number of live mites. After a mite population has been killed, regular vacuuming of carpets is required to remove mites and allergen.[61,82] Two studies suggest that mites and allergens may be more easily removed from low pile height and less dense carpets.[27,83]

If temperatures are sufficiently hot, steam cleaning can kill mites and remove allergens on surfaces.[84] However, steam cleaning usually does not penetrate deep enough into the carpet, into carpet padding, or into furniture fiber, where large mite populations exist and in fact may leave sufficient residual water to promote mite population growth, which produces the exact opposite effect of what is desired (Arlian LG, unpublished observations).[84,85]

Freezing soft toys and small items

Freezing (–17°C to –20°C) soft toys and small items (pillows and special clothing) for at least 24 hours is an effective method of killing mite populations on these objects (Arlian LG, unpublished observations).[87] After freezing in a domestic freezer, these items can then be washed to remove the dead mites and allergens. Leaving mattresses and pillows outside for at least 24 hours is a recommended method for killing mites in cold climates.

Air cleaning/filtration

Mite allergens are mainly associated with dust particles that are greater than 20 μm in diameter. These particles may become airborne as a result of disturbances, but they settle quickly.[41,87-89] Therefore air cleaning or filtration in undisturbed spaces probably captures little mite allergen and should not be generally recommended.

Duct cleaning

No extensive studies have been performed to justify the use of duct cleaning as a remediation for household

dust mites and their allergens. This procedure is likely unnecessary to remove dust mites or mite allergen because mites do not normally reside in HVAC systems. A recently reported preliminary study found little allergen in dust collected from intake and return vent filters.[90] However, thorough studies are still needed to determine whether duct cleaning is beneficial for reducing mite allergen in the air blown from heating vents. Duct cleaning may be beneficial for removing dust, debris, and possibly mold and mold allergens from HVAC systems.

Using ozone generators

Studies are also needed to determine the efficiency and safety of ozone generators in killing mites or denaturing mite allergen. At present, there have been no published studies to show that ozone can influence mite allergen.

Using chemicals

Controlled studies have given mixed results on the use of chemicals in controlling dust mites and their allergen. Some studies show a reduction in allergen concentrations,[91-93] and others show insufficient reduction.[81,94-96] The key considerations in the use of chemicals indoors relates to their safety, the efficacy of the active ingredient, and the formulation of the product. Products must be formulated properly so that they deliver active ingredients directly to where the mites live. Experiments with acaricides, such as benzyl benzoate, disodium octaborate tetrahydrate, sumethrin, and permethrin, and denaturants (tannic acid) have shown that a good active compound does not necessarily equate with good mite or allergen control.

DUST MITE AVOIDANCE AS AN INTEGRAL PART OF THE TREATMENT OF ALLERGIC DISEASE

Patients who have perennial rhinitis, asthma, or atopic dermatitis that is not controlled by simple topical or inhaled treatment and who are allergic to dust mites should be advised to control their exposure to mite allergens. Advice about exposure should be adapted according to the severity of the patient's disease, the climatic conditions of the area where the patient is living, and personal circumstances.

In most cases the advice given should include prioritization of the measures, as well as education about the problem and the objectives of the treatment (Table III). In all areas the patients need education, and it is helpful to develop some form of a checklist. The checklist will encourage patients to make decisions about which interventions they will take first, can afford, or both and also provides an incentive for them to record their progress.

Typically, all patients should be advised to cover pillows and mattresses, as well as change bedding so that it can be washed in hot water. The bedroom should be modified as much as is reasonable to decrease sites for mite growth and accumulation of allergens. Controlling humidity levels is not simple but should be discussed with patients as a medium- or long-term objective. In addition, patients should be advised to make simple control of dust mites and other allergens a desirable feature of a new house when they are planning to move. Finally, it is important to remember that in all the successful controlled trials of mite avoidance for asthma, controlling mites in the bed and bedroom has been the primary measure.

CONCLUSION

In most temperate humid areas of the world, dust mites are the single most important source of allergens in house dust. Dust mite allergens are strongly associated with asthma, perennial rhinitis, and atopic dermatitis. Interventions to reduce mite populations and their allergens in the home can be worthwhile, especially when residents suffer from moderate-to-severe symptoms. The closest attention should be given to reducing mites and allergens where there is the greatest exposure in bedding. Other interventions should address control of mites and allergens in carpeting and furniture, but the advice needs to be tailored for individual patients.

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