

Distribution and abundance of dust mites within homes

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The distribution and abundance of dust mites can be modelled on three scales: the microhabitat scale (different habitats within homes), the macrohabitat scale (between homes), and the regional scale. This paper focuses on the first. Those parts of a home in which dust mite populations thrive will tend to be homogeneous in respect of key habitat suitability determinants. The more widespread such determinants, the greater the risk of high mite populations and allergen load. Habitat suitability determinants include an adequate textile substratum, optimal temperature and humidity, and food resources of appropriate quality, as well as other, currently unknown, requirements. Each determinant will have a characteristic distribution within any home, and they can be conceptualized as a series of overlays, or three-dimensional Venn diagrams, with the areas of overlap representing the most suitable sites for mite survival. That a population of dust mites is focused by constraining biotic and abiotic determinants means that spatial and temporal distribution and abundance are predictable, because the characteristics of the principal foci define optimal conditions for population growth. This concept, known as “focality”, provides a framework for prediction of sites of high density of mite population and allergen exposure, as well as a basis for manipulating the microenvironment for control purposes.

Key words: allergen; distribution; microenvironment; mites.

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Study of the ecology of house dust mites commenced in 1962 when Spieksma & Spieksma-Boezeman (1) began their investigations of the fauna of dust in houses in Leiden, The Netherlands. Although at the time, the most frequent species of mites considered to occur in houses were acarids and glycyphagids, the Leiden group knew that the house dust allergen was different from the allergens produced by glycyphagid and acarid mites, and, since their theory was that mites were the source of the house dust allergen, they reasoned that house dust must contain other, then unknown, mite taxa. It did: pyroglyphid mites predominantly of the genus *Dermatophagoides* (2). By studying distribution and abundance of dust mites in 150 homes, they demonstrated that human exposure to dust mites is common (3): mites were present in every home, although their abundance was relatively low, compared with more recent reports, due to the extraction method that they used. This first quantitative data on dust mite ecology were essential in demonstrating the association between

mite allergens and asthma, and the study of mite distribution and abundance remains of considerable relevance to research on both allergen exposure and mite eradication (4).

Spatial and temporal scales

The distribution and abundance of dust mites can be modelled on three levels by spatial and temporal scales as follows:

The microhabitat scale: i.e., in different habitats within homes. Important factors include the nature of the microhabitat, its physicochemical characteristics, microclimate, and diurnal variation, and other dust residents and their interactions with dust mites. This scale is the one of most relevance to ecologists.

The macrohabitat scale: i.e., between different homes. Important factors include housing construction, interior design, ventilation, and inter-

Table 1. Abundance of dust mites in "different" habitats, based on published studies

	Beds and bedding (n=58 published studies)	Carpets (n=27 published studies)
Geometric mean of means (mites per gram of dust)	297	118
Range	3-15 600	3-1604
Standard deviation	$\times \div 6.96$	$\times \div 5.67$

home and seasonal variations in indoor climate. It is the scale of most relevance to allergists.

Regional scale: i.e., in different parts of the world. Important factors include regional and seasonal differences in mite populations and the influence of macroclimate. It is the scale of most relevance to epidemiologists.

This paper focuses on the microhabitat scale.

The microhabitat and its characteristics

All the major groups of mites which are found in human dwellings are also found in other, non-synanthropic habitats. Pyroglyphid mites live in nests of birds, acarids are found in the soil and plant litter and associated with insects and small mammals, and glycyphagids mites live in mammal nests also (5). There are few, if any, common species found in house dust that have not been reported from other habitats: no species could be said to be specific to human habitation. It follows that houses have certain characteristics in common with these other habitats that render them suitable for mites. For nests and plumage of birds and pelage of small mammals, these characteristics are more obvious than they are for soil and plant litter. There is adequate heat and moisture, generated by a large, warm-blooded "host", and there is adequate food in the form of remnants of the host's meals, plus its various excretions and secretions (faeces, skin scales, and oils and other lipids) and the fungi and bacteria that colonize these.

The microhabitats of dust mites in human homes are found within textiles, including clothing and soft toys, and upholstered furniture. The weave or pile of fabrics is an excellent trap for the accumulation of dust particles, and the structure and composition of dust microhabitats can become quite complex. House dust consists predominantly of shed human skin scales and fibrous material from fabrics, as well as lesser amounts of various mineral particles derived from soil and building materials. Other abiotic components include cellulose fibres from wood and paper, fragments of foam rubber and plastic, food particles (cereal and bread crumbs, lipid droplets from fried food, and so

forth). Carpets tend to contain more heavy, large particulate material than dust from upholstered furniture and mattresses, which is nearly all fine particles of skin scales with some fabric fibre (6).

The constituents of house dust may have a bearing on its suitability as a microhabitat for dust mites from the point of view of its status as a source of food, not only for dust mites but also for fungi. The water-content of individual components will influence not only the amount of dietary water the mites receive but also the water-holding capacity of the dust as a whole.

Distribution and abundance of mites in the home

Dust mites are found in beds, bedding, carpets, and upholstered furniture. To dust mites, all these habitats represent a continuum, viewed only as different entities by us humans. The main criteria that govern whether mites can live in a particular microhabitat are temperature and humidity and the availability of food. Dividing habitats into furniture and different furnishing types is a little unhelpful from an ecologic standpoint, because it ignores the spatial heterogeneity of habitat suitability determinants within the home. Nevertheless, studies within homes have traditionally sampled beds, carpets, and upholstered furniture as the three main microhabitat "types".

There have been no studies that have systematically assessed the population density of mites in different habitats throughout the home. Tovey (7) reported the variance in allergen concentration in 10 rooms divided into half-meter squares. No consistent patterns of distribution could be found, with up to fivefold variance between pairs of sites from opposite sides of lounge rooms. There has been some debate as to whether beds, carpets, or other textile objects form the main foci of dust mite infestation in homes. It has become generally regarded that beds contain most mites and allergens, but this is by no means the rule. Three exceptions are a study from Barbados (8), in which living-room furniture was found to contain the highest concentrations of *Dermatophagoides* Group 1 allergens; one from Israel (9), in which sofas contained the highest population densities of dust mites; and one from Ohio (10), in which living-room carpets contained almost seven times greater density of mites than mattresses.

The abundance of dust mites in beds and carpets, based on published studies, is shown in Table 1. Although there is a tendency for there to be more mites in beds than carpets per unit weight of dust, there is immense variation. Furthermore, abundances expressed per unit weight are not strictly

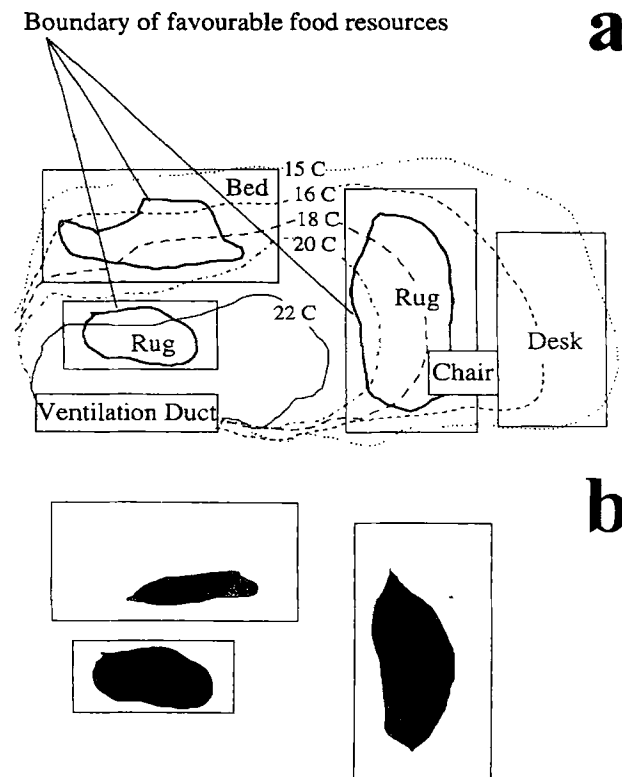


Fig. 1. a) Plan of room and its contents, illustrating hypothetical distribution of three habitat suitability determinants: textile substrates (bed and rugs), temperature, and availability of food resources within textiles. b) Areas of overlap of all three determinants indicate foci where conditions for population growth of dust mites are most favourable.

comparable because carpet dust tends to be more dense than bed dust.

Spatial heterogeneity and habitat suitability determinants – a clue to keeping mite numbers down

Just as we have built homogeneity into the rural landscape in the latter part of this century through removal of natural vegetation and the planting of broadacre monocultures, so we in Western cultures, living in temperate latitudes, have built homogeneity into our homes through our desire for constant temperatures within the human comfort climate of *c.* 18–22°C. This has been achieved through the use of central heating, double glazing, and elimination of draughts. Through our desire to internalize, for comfort and convenience, major sources of moisture (sinks, baths and showers, toilets, washing machines) and cover the insides of our homes with fabrics, carpeting, and upholstered furniture (the “textilization” of the urban home – “feathering the nest”), we have created conditions of high temperature and humidity and low airflow (11). The insulative properties

of wool, cotton, and polyester work well for dust mites as well as humans.

The parts of a dwelling that contain or exhibit those basic requirements for dust mites to develop, reproduce, and maintain healthy populations will tend to be homogeneous in respect of key habitat suitability determinants. The more homogeneity of microhabitat characteristics throughout the home, the greater the risk that that home will contain high dust mite populations and levels of allergens constituting a risk factor for asthma. Habitat suitability determinants include adequate textile substratum, optimal temperature and humidity range, and food resources as well as other, currently unknown, requirements. Each of these factors will have a particular distribution within any home. The presence of one factor does not automatically assume that dust mites can live in that home. Rather, they are like a series of overlays, or three-dimensional (3-D) Venn diagrams, with the areas of overlap representing the most suitable habitats for mite survival (Fig. 1). A similar set of overlapping 3-D spatial conditions will exist for cockroaches, moulds, and any other indoor allergen-producing organisms. Brenner (12) refers to this concept as “focality”: the phenomenon of a population being focused by constraining biotic and abiotic factors. Implicit in focality are the ideas that survival of the population is predictable, as is spatial distribution, and that the characteristics of the principal foci determine optimal conditions for the population.

The concept of focality is very important in relation to allergenic domestic arthropods because it provides a conceptual framework for:

- 1) the prediction of high population density, and thus high allergen concentration, by geostatistical techniques (13)
- 2) the systematic manipulation of the microenvironment to make it hostile to allergenic arthropods.

The selective removal of carpets makes the indoor environment more spatially heterogeneous because it removes not only a textile in which the mites live and lay their eggs and in which their food is trapped and accumulates, but one which provides thermoinsulation and higher humidity than the ambient air of the home, as modelled by Leupen & Varekamp (14). My own house has wool-polyester carpets in four out of seven rooms and in the hall, constituting 48 m², or about 67% of the total floor area, plus another 12 m² of woollen rugs placed on top of the carpets. Removing that carpet would cut the available habitat for dust mites to three mattresses and a lounge suite, an area of about

6 m², or about 9% of the current total surface area of carpets, textiles, and upholstered furniture.

Reduction in habitat area and habitat fragmentation has the tendency to reduce innately the prospects of survival of a population – as has been seen in many studies on removal of forest habitat. The rendering of the indoor environment hostile to dust mites through habitat fragmentation via the reduction in surface area of carpets and other domestic textiles, combined with lowering of indoor humidity, offers an ecologically sound means of mite control.

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