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House dust mites, our intimate associates

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Abstract. House dust mites have lived in human contact from time immemorial. Human dander or dead skin constitutes the major organic component of the house dust ecosystem. Because the mites feed on dander, dust mites and human association will continue to co-exist as part of our environment. Efficient house-keeping practice is the best form of control to reduce infestation. However, special precautions are important when individuals are susceptible or sensitive to dust mites. House dust mites are responsible for causing asthma, rhinitis and contact dermatitis. The respiratory allergies are caused by the inhalation of dead or live mites, their faecal matter or other byproducts. Immune factors are of paramount importance in the development of dust related or mite induced respiratory diseases. House dust mites were found in some 1,000 samples of dust taken from approximately 330 dwellings in Peninsular Malaysia and Singapore. Mattresses, carpets, corners of a bedroom, and floor beneath the bed are favourable dust mite habitats. The incriminating species based on studies here and elsewhere, as well as many other species of dust mites of unknown etiological importance are widely distributed in Malaysian homes. Density of dust mites in Malaysia and Singapore is greater than in temperate countries. Prevention and control measures with reference to subjects sensitive to dust mite allergies, including chemical control described in studies conducted in Europe and America are discussed. However, a cost free and most practical way to remove mites, their faecal matter and other products is to resort to sunning the bedding and carpets to kill the living mites, and then beaten and brushed to remove the dust and other components.

INTRODUCTION

Mites living in the dust of houses fall under the classification of acari and their study is known as acarology. The Institute for Medical Research (IMR), Kuala Lumpur as a whole has a long and colourful tradition of conducting research investigations on various aspects of bio-medical science which led to increased understanding of biomedical knowledge and an improved control of endemic diseases.

In the field of acarology also, the medical and veterinary importance of the Malaysian parasitic ticks and mites had led to the publication of some 400 scientific papers by a multitude of authors during the prewar and postwar years, most of whom were British and American scientists. Taxonomic studies conducted through international collaboration had yielded between 450 and 500 species of parasitic or medically important acarines of many families and genera in Malaysia. The Division of Acarology in IMR also served as one of the reference centers for acarology in the Asia-Pacific region.

The purpose of this article is to provide the necessary information for a better understanding on dust mite distribution in Malaysian homes and to provide awareness on prevention and control. The reason for this is also because there have been a number of commercials advertising vacuum-cleaners for the control or elimination of house dust mites; also

commercials advertising dust mite-free mattresses and pillows have appeared in the local media. The author has personal information on a commercial pest control establishment advertising the services to eradicate/control dust mites in houses. Though numerous publications have appeared in scientific journals regarding house dust mites and the progress being made on various aspects involving house dust mites and allergies, such information are not brought to the attention of the lay public. Therefore, this article on the presence and distribution of dust mites in houses is presented in an easily readable format by the author who had devoted some 40 years researching and teaching acarology in Malaysia, Singapore and Hawaii. The other reason for this article is because all of us share our homes with dust mites without being aware of it, or without knowing what they are. It is hoped that the information provided in this article will also be found to be of some assistance to counter unnecessary allergy commercials.

MITES IN GENERAL

Ticks and mites are collectively classified as acari, a name which is the Latinized form of the Greek word for mite. Acari are very diverse in form, habitat and behaviour. Some are exclusively phytophagous, while others have developed complex parasitic relationships with both vertebrate and invertebrate animals. Many are considered beneficial to man in that they prey on undesirable arthropods, others aid in the breakdown of litter and implement nutrient recycling. A number of acari groups are harmful to crops. Animal life, including humans fall victim to the capacity of mites to carry and transmit a variety of disease organisms. In Malaysia as in most other countries ticks and mites have been recognized for a long time for their ability to transmit viral and rickettsial diseases from animals to man. Some of the acari are known to the layperson, e.g. dog-tick and cattle-tick, while others frequently call attention to themselves by their activities, e.g. chigger mites that cause scrub typhus, and larval ticks that cling on to the body or limbs, bite and cause severe irritation. So as not to cause any confusion, chiggers or chigger mites refer to the parasitic larvae of mites of the family Trombiculidae, that bite man and transmit the infective agent of scrub typhus. As to the term of ticks and mites, the saying goes all ticks are mites, but not all mites are ticks. Ticks are better known because they have a somewhat leathery cuticle and are large enough to be seen readily with the naked eye. Other mites are much smaller, as small or smaller then the period at the end of this sentence. As 8-legged arthropods mites are related to spiders and other arachnids than to insects.

DUST MITES AND THEIR LIFE STYLE

For the first time, however, a programme was initiated in 1976 in the Acarology Division of the Institute for Medical Research, Kuala Lumpur to investigate the distribution of the non-parasitic or free-living mites living in houses, alongside continuing studies of parasitic acari (Nadchatram, 1976). These mites generally called house dust mites are the known causative agents in the development of respiratory allergies (including bronchial asthma and rhinitis or hay fever, as well as atopic or allergic dermatitis all over the world. The author served as the project leader of this programme for 5 years before his retirement from the Institute for Medical Research. This article is prepared based on the author's experience having worked on the taxonomy, biology and ecology of house dust mites in Hawaii, Malaysia and Singapore. Prevention and control measures are reviewed from studies conducted by workers in other countries.

House dust mites are 8-legged as all acari are, but minute, 0.2 to 0.4 mm, as small or slightly smaller than the period at the end of this sentence, round to oval in

shape and white to yellow or creamy in colour, and barely visible to the naked eye. It takes the common dust mite species approximately 30 days to complete its life-cycle from egg, larva, 3 nymph stages, to adult, based on our laboratory studies. The life-span is approximately 4 months. The common female dust mite will lay from 50 to 80 eggs in its lifetime. Dust mites are not at all parasitic but, are believed to have evolved from mites that lived in nests of birds thousands of years ago. In houses they feed exclusively on human dander or dead skin that an adult human sheds at the rate of one to 1½ g per day, about one pound every year. The average temperature and relative humidity for their optimum development and propagation is around 28ºC and 80% R.H. under Malaysian conditions.

Within a house, the dust in mattresses, carpets, corners of rooms and floor space beneath the bed provide the most favourable niches. The bed is the most intimate human environment and serves as the focus of infestation, because the common house dust mites feed on human dander which is shed mostly in the bed. Also, humans are the most important carriers of dust mites from one place to another through their bodies and clothing. The mites are also wind blown and many different species are carried through the air from building to building.

BRIEF HISTORICAL REVIEW

Ever since the need to protect against rain, wind, heat, excessive light and against predators, man was induced to build houses when caves were not near at hand. The first more or less permanent structures were built in the Near-East about 6,000 BC (Bronswijk, 1981). From time immemorial humans have shared their dwellings with mites, commonly called house dust mites. Today, we have learned to realize that house dust mites are indeed normal co-inhabitants of man's "nest", probably playing a useful role in a biological/ecological chain in this anthropogenous niche (Spieksma, 1992). In other words house dust mites probably have been associated with the development of the human race. In spite of the continuous struggle by housewives, a layer of dust covers the floor, bedding and furniture. Dust has been defined as a collection of particles, from very minute to 1 mm in size that can be airborne. When a beam of light falls at a low angle in a darkened room numerous specters of dust will be seen floating or suspended in the air. House dust is made up of organic substance (hairs, dead skin of humans and animals and various kinds of food particles, etc.) and inorganic material (mostly cotton, synthetic material and paper fibers). Figure 1 illustrates the quantitative composition of airborne dust in Dutch buildings (courtesy Bronswijk, 1981). This figure shows that dead skin make up for less than 50% of total dust content, after cotton fibres. The figure represents as a good guiding example for the illustration of the qualitative and quantitative composition of dust in a house of Euro-American environment. But, the qualitative composition would differ markedly in a house habitat in the tropics compared with that of a temperate country.

The harmful effects of house dust was recognised in the 18th century (Bronswijk, 1973). According to Andrews (1976), in 1698 Floyer published his *Treatise on Asthma* in which he wrote that "all asthmatics were offended by the least dust made by the sweeping of a room or the making of a bed." It was not known then that mites living in dust was the cause. However, the first search for mites in houses was made by a physician in Europe in 1928 (Dekker, 1928). Large numbers of mites, especially dead ones, were found in mattresses. He also found out that his patients got some relief when they were protected from mite-infested rooms. However, the relationship between mites and house dust allergy was not generally accepted at that time. Almost 40 years went by before a convincing account of the involvement of mites in house dust allergy

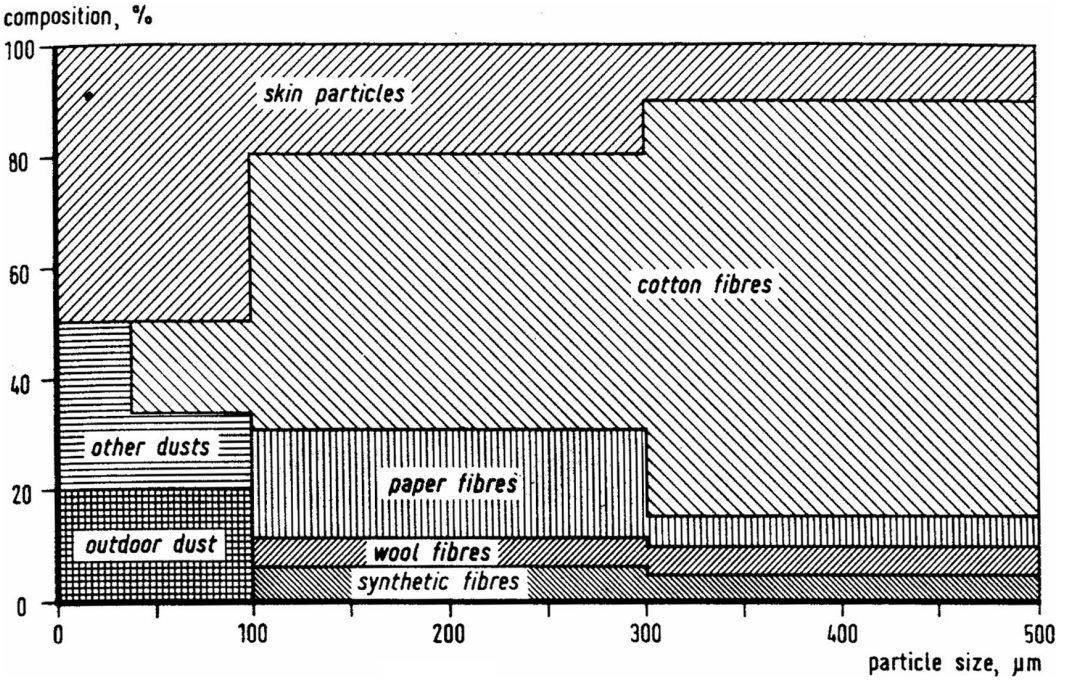

Figure 1. Quantitative composition of airborne dust in Dutch buildings (courtesy Bronswijk, 1981).

was given by a team of Dutch biomedical scientists in the Netherlands in 1964 (Voorhorst *et al.*, 1964). About the same time a Japanese scientist arrived at the same conclusion and his study was published in Japan (Oshima, 1964).

The involvement of dust mites in human health had aroused the excitement of workers throughout the world, mostly in Europe, North and South America and Japan. In a nutshell, the scientific discovery was that the mites living in the dust of houses was responsible for causing bronchial asthma, allergic rhinitis or atopic or allergic dermatitis to those who are susceptible or sensitive to dust. In the last 40 years it is reasonable to assume that more than 1,000 publications throughout the world have resulted covering various aspects of house dust research and dust mite related problems, as well as in the important field of allergy and immunology. Throughout the world a good proportion of the chronic illnesses of children under 17 years of age is reported to be due to allergies. After pollen allergy, house dust allergy has the highest position in respiratory allergy diseases. Approximately 80% of house dust allergies are mite induced (Wharton, 1976).

DUST MITES RELATED ALLERGY

Respiratory allergies including bronchial asthma are caused by the inhalation of dead or live mites or their products, more importantly their faecal content. Fortunately, only a small proportion of humans are sensitive enough to produce allergic reaction to dust mites. Concerning allergy, it is known that dust mites are found in houses of asthmatic and non-asthmatic subjects. This is indicative of the fact that immune factors are of paramount importance in the development of actual symptoms of asthma and other allergies. This is an important area of investigation. Therefore, for diagnosis and treatment of allergies, an allergist or an immuno-therapist should be consulted. It is important to bear in mind that the

allergenic potency of both live and dead mites is claimed to be equal in strength. Live mites are also believed to produce allergen by the decomposition process of other material in the dust. By this process large concentrations of house dust allergen are produced.

THE MALAYSIAN EXPERIENCE

Approximately 1,000 collections from 300 human dwellings were sampled for house dust between 1976 and 1981 in Peninsular Malaysia in the investigation in which the author was involved. The dwellings sampled included bungalow houses, terrace houses and apartments in five towns and villages from seacoast to highlands (1,500m). The houses were randomly selected. Within each house dust samples were collected from 3 or 4 different niches or sites: bedroom floor, a mattress, floor of living room and or carpet. For scientific analysis, various parameters were taken into account, e.g. age and type of house, floor type, age of mattress, and dust load. The ethnic and socioeconomic level of the house occupants were also recorded. The study of the distribution of mites in two Malaysian collections have been completed and published (Ho & Nadchatram, 1984; 1985).

All the houses investigated in urban areas yielded mites from the dust collected, irrespective of the type of dwellings. Altogether 118 species of mites were found and of these 65 species were recognised as stragglers or accidental visitors. The remaining 53 species were established as true denizens of house dust in Peninsular Malaysia, as follows: 12 species of the medically incriminated family Pyroglyphidae that feed on dead skin of humans and animals; 11 species of the family Glycyphagidae, one species of Chortoglyphidae, four species of Saproglyphidae and nine species of the family Acaridae. Most if not all the species of the last 4 families are associated with stored food, scattered food particles and dead skin, a few of which are known to be allergenic (Wharton, 1976; Bronswijk, 1981; Arruda & Chapman, 1992; Mariana *et al.*, 2000b). Also, sixteen species of mites of the family Cheyletidae which are predaceous on dust mites were found. The commonest species of dust mite was *Dermatophagoides pteronyssinus* (Trouessart 1897), as stated by Nadchatram (1976), Ho & Nadchatram (1984, 1985) & Mariana *et al.*, (2000). It is hoped that a checklist of the mites found in dust in all the five collections in Malaysian houses between 1976 and 1981 will also be published because of their medical and economic importance, as well as to update the Malaysian record, for the benefit of biomedical science in general. The data compiled for publication before the author's retirement was misplaced in transit, though the permanent records remain in the Acarology Unit.

Carpets and mattresses yielded the most number of mites. In 1.0 g of dust collected from a carpet a little over 10,000 mites were counted. On an average around 500 mites were collected from 0.2 g of dust. Mite species that are known allergens of bronchial asthma and rhinitis and other species of mites known to cause allergic dermatitis were found in all the samples of dust collected and examined. The most important taxonomic family Pyroglyphidae was represented by 12 species as compared with the 48 species of this family known from the rest of the world where investigations have taken place. The most common and abundant species of this family is *Dermatophagoides pteronyssinus* (Figs. 2, 3 & 4). Fig. 2 is a scanning electron micrograph, courtesy of Wharton, and Fig. 3 is a micrograph taken through a low power binoculars (x 40) by the author & Fig. 4 is an illustration of a female, ventral aspect. This species has a worldwide distribution and is one of the more proven important causative agents of bronchial asthma and rhinitis. One other species (*D. farinae* Hughes 1961) also incriminated as producers of allergen in temperate countries was less abundant in our collection. Another species of the same

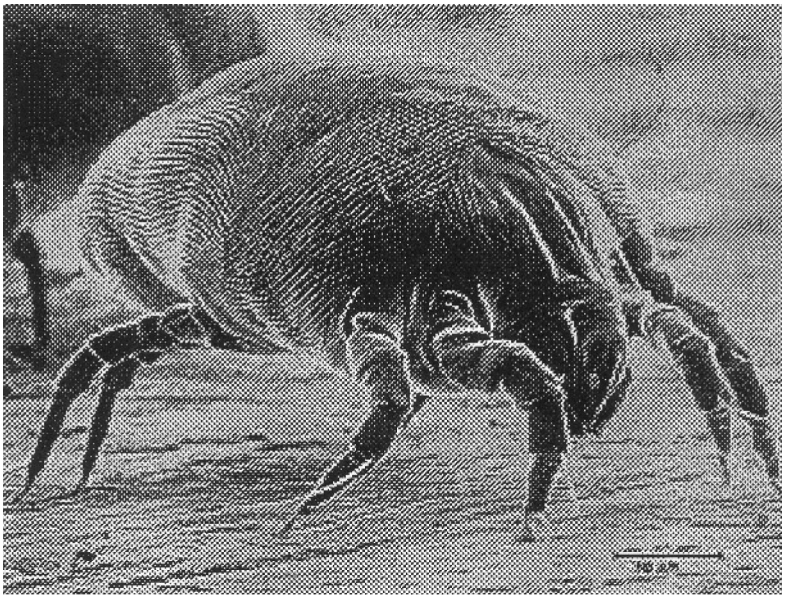

Figure 2. A scanning electron micrograph of *Dermatophagoides pteronyssinus* (courtesy Wharton, 1976).

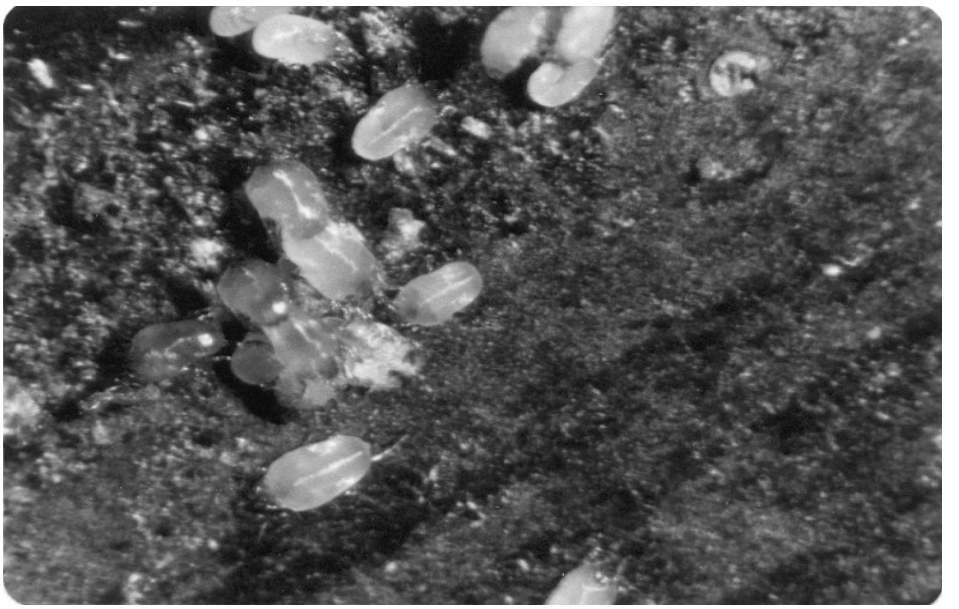

Figure 3. A photomicrograph of *Dermatophagoides pteronyssinus* (40X).

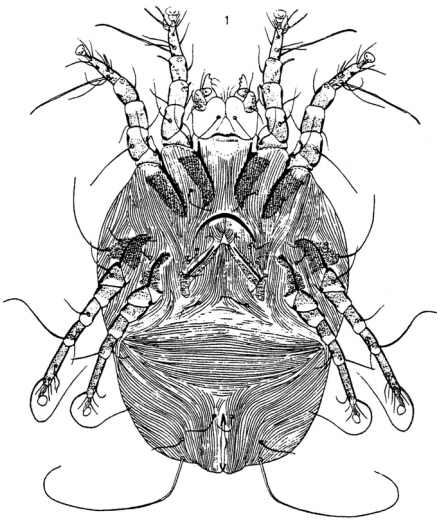

Figure 4. Illustration of female *Dermatophagoides pteronyssinus* (courtesy Fain, 1966).

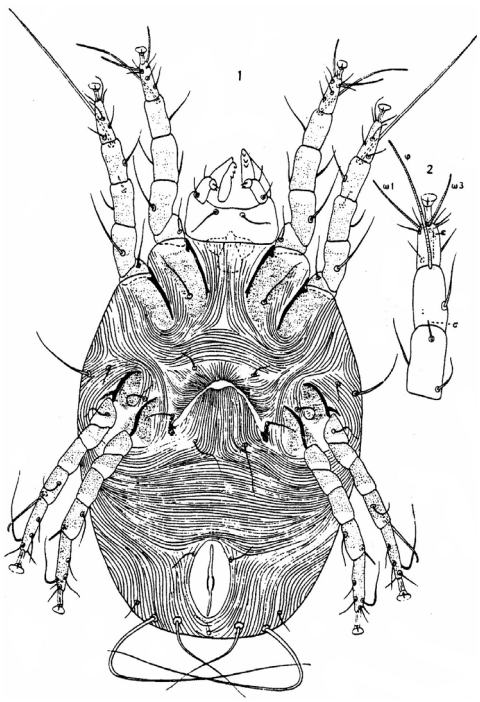

Figure 5. Illustration of female *Malayoglyphus intermedius*, ventral view (Courtesy of Fain *et al*, 1969).

family commonly found in Malaysia and Singapore and believed to be allergenic was *Malayoglyphus intermedius* Fain, 1969 (Fig. 5). In Singapore, 35 samples of dust collected from mattresses yielded 9 species and the predominant species was also *D. pteronyssinus*. Likewise, this species was the most common species found in the study conducted by the author and his colleagues in Honolulu, Hawaii (Nadchatram *et al.*, 1981). Three other common species of dust mites regarded as stored food mites found in Malaysia and Singapore belong in two other families. They are *Blomia tropicalis* Bronswijk *et al* 1973 (Fig. 7) and *Austroglycyphagus malaysiensis* Fain & Nadchatram 1980 (Fig. 8 and Fig. 9) of the family Glycyphagidae, and *Tyrophagus putrescentiae* (Schrank 1781) of the family Acaridae. These mites are allergenic, also for contact dermatitis (Bronswijk, 1981). Of the Glycyphagid mites, *B. tropicalis* was found in both study areas whereas *A. malaysiensis* was collected only in the highlands (1,500m), based on our earlier studies. This would suggest that in a 4-5 year old human settlement in open land without vegetation this species had not yet gotten established. Both *B. tropicalis* and *A. malaysiensis* are easily distinguishable from other species of the family in having very long idiosomal setae or body hairs. It is noteworthy that 3 common dust mite species were recent discoveries in Peninsular Malaysia and Singapore: *Malayoglyphus intermedius* described as a new genus and species by Fain et al. (1969), *B. tropicalis* described by Bronswijk *et al.*, (1973) and *A. malaysiensis* described by Fain and Nadchatram, (1980) as compared with most other important dust mite species found in Malaysia. The 3 non-pyroglyphid species, including *T. putrescentiae*, popularly referred to as mites of stored food were found to be common in mattresses in Malaysia. In a recent survey by Mariana *et al.* (2000a), a total of 22 species in 9 families, including these 3 species were identified from dust of mattresses. This would indicate that some species previously regarded as mites of stored food products have a wider range of distribution within houses in the tropics.

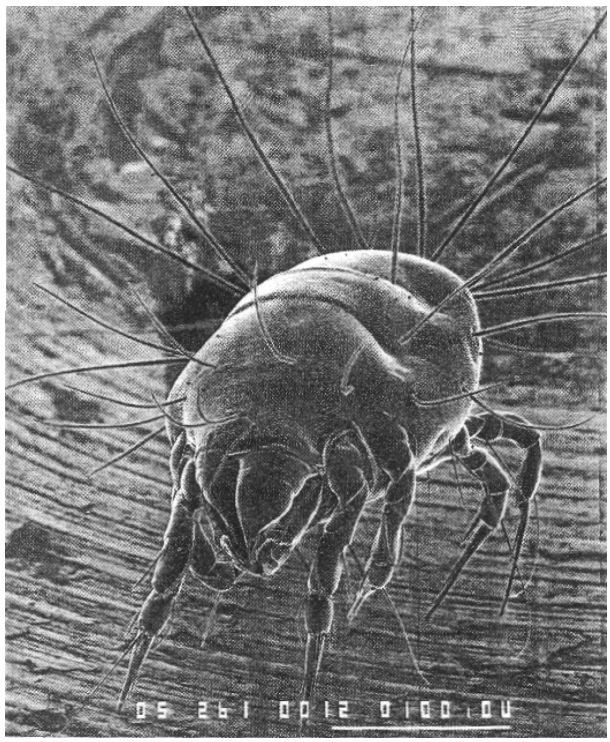

Figure 6. Scanning electron micrograph of *Blomia tropicalis* (courtesy Arruda & Chapman, 1992).

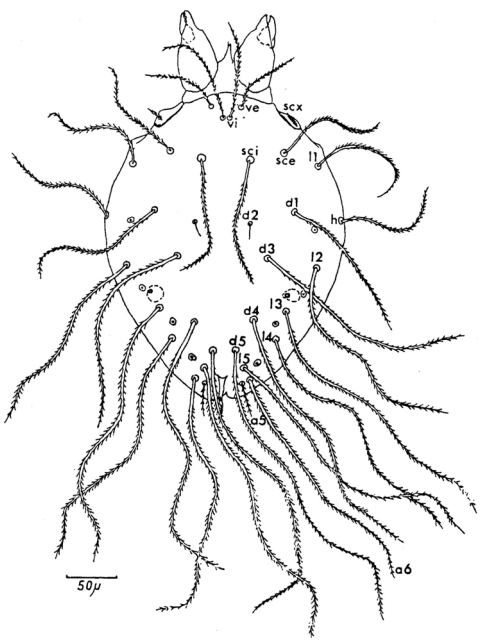

Figure 7. Illustration of dorsal view of female *Blomia tropicalis* (courtesy Fain *et al.*, 1966).

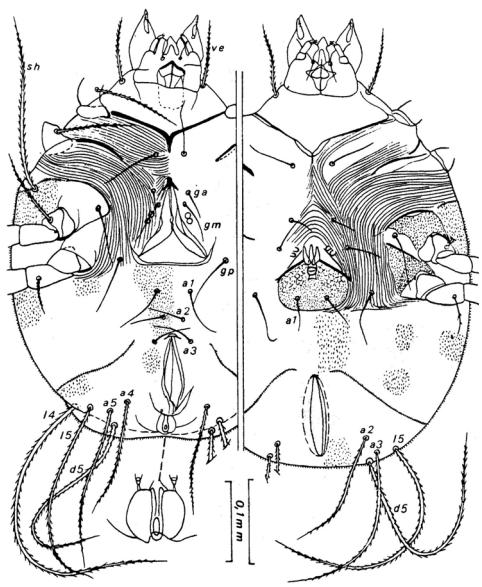

Figure 8. Illustration of female and male *Austroglycyphagus malaysiensis*, both ventral view (courtesy Fain and Nadchatram, 1980).

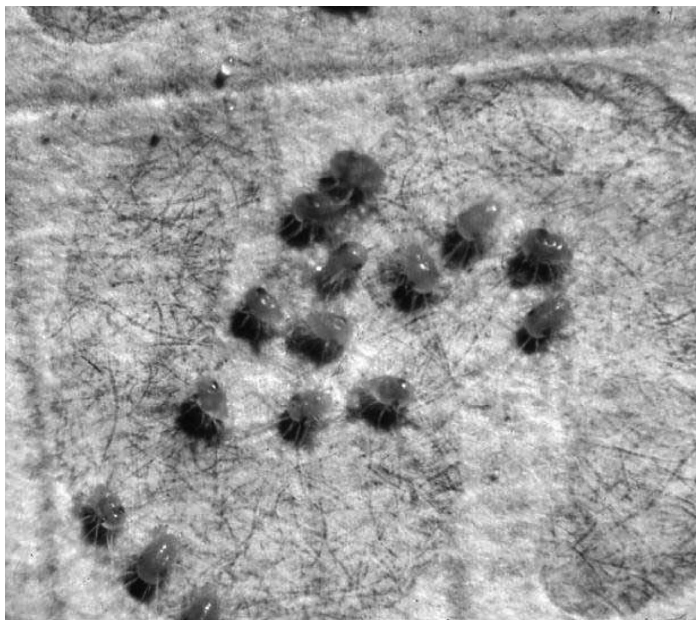

Figure 9. Photomicrograph of cluster of *Austroglycyphagus malaysiensis* taken by the author (40X).

However, the oldest mite species *Acarus siro*, a serious pest of stored food in Euro-American countries, and some other countries wherever investigations had taken place, was not found in our investigations of house dust mites in Malaysia or Singapore. The genus *Acarus* was named by Linneus in 1735 and he named the type species *Acarus siro* in 1758. The absence of this species in our survey was perhaps, due to lack of attention paid to stored food premises. However, the Malaysian climatic conditions are quite suitable for the species to thrive. It is usually associated with grain, cheese, hay, linseed or barley.

The allergenic importance of *B. tropicalis* was reviewed by Arruda and Chapman (1992). More recently, studies in Malaysia have shown that including, *Suidasia pontifica* Oudemans 1905, six additional species were positive for allergens as demonstrated via skin prick tests on patients suffering from respiratory allergy manifested as rhinitis (Mariana *et al.*, 2000b). In the case of *A. malaysiensis* approximately 55.6% of the rhinitis patients demonstrated positive reactions, with 18.1% exhibiting very strong reactions. The allergenic extracts successfully standardized for rhinitis tests for five other species are: *B. tropicalis*, *D. pteronyssinus*, *D. farinae*, *Sternophagoides brasiliensis* Fain 1967 and *T. putrescentiae* (Institute for Medical Research, Malaysia, Annual Report, 2002), and A. Mariana (pers. commun.)

GENERAL ECOLOGICAL CONSIDERATIONS

A very important consideration is that though dust mites were found in almost 100% of the houses investigated in Peninsular Malaysia, Singapore and Honolulu, only those individuals susceptible or sensitive to mites are affected. The infestation level and population density differ between tropical and temperate countries. Our studies in Malaysia and Singapore show that the infestation level is higher here due to two main attributes. Firstly, the tropical climate has no sudden changes in temperature and relative humidity.

Secondly, under these favourable climatic conditions the mites are able to complete at least 12 cycles of development a year and build up large populations, whereas in temperate countries the mites' reproductive rate is slowed down by seasonal changes, with the winter months having an adverse effect on their reproductive rate. In subtropical Hawaii, the incidence of asthma and rhinitis induced by dust mites is twice greater than in mainland U.S.A. (Sharp & Haramoto, 1970). The dust mites in Hawaii are also between 1.5 and 4.5 x greater than that in temperate countries, thus suggesting that there is a correlation between density of mites and respiratory allergies. In Malaysia and Singapore the mite population is approximately twice that prevailing in Hawaii. But the morbidity and mortality of asthma induced by house dust mites is not known. Also, no direct relationship was established between numbers of mites in houses of allergic and non-allergic subjects in our study. However, it has been reported elsewhere that only in cases where high populations of mites prevailed that there was a high level of antibodies of the class IgE, the immunoglobulin or protein involved in allergic reactions (Tan & Thomas, 1978; Mulla & Medina, 1980).

Studies conducted in Malaysia and Singapore confirm that there is (a) an intimate association between humans and house dust mites, (b) that house dust mites are abundant in Malaysian houses, irrespective of the type of dwelling and that the density of dust mites is greater in the tropics than in temperate countries, (c) the mites are found in homes of asthmatic and non-asthmatic subjects, and (d) that the practice of effective house-keeping hygiene will reduce, but not completely eliminate mite populations.

PREVENTION AND CONTROL

A good number of publications were reviewed, and among the more pertinent publications on prevention and control are that by Wharton (1976), Mulla & Medina (1980), Tovey (1992), and Bronswijk (1981). Our studies in Malaysia have shown that various species of dust mites are found in all or almost all dwellings sampled. With the practice of improved house-keeping hygiene the mites can be controlled to low levels, and the following recommendations are especially focussed on individuals who are allergic to dust mites. There have been little or no research conducted into the development of practical preventive and control measures of dust mites in Malaysia. However, there is increasing evidence that reducing exposure to house dust mites of sensitive individuals is a practical proposition in many houses, and that this can reduce allergic symptoms. Various measures were recommended in U.S.A., Europe, Japan and Colombia. At the present time the only practical measure available to specialist physicians in the treatment of house dust allergy is to reduce sensitivity with extracts of specific mite antigens or extracts of house dust containing the mites. The most practical and least expensive approach is to reduce the source of the allergen, i.e. the mite population and minimize re-infestation. This is the most direct treatment of allergic asthma and rhinitis. An important consideration is that both live and dead mites are allergenic or cause allergic reactions. Thus, the removal of live mites alone will be ineffective if the house environment is not cleared of the debris (mite faecal matter, food material, dead skin, hairs, wind-blown pollen, fungi, etc.). Studies on fungi have not begun in earnest in a Malaysian situation. However, the Acarology Unit of the IMR is in the process of pursuing investigations to evaluate local fungi and pollen extracts to determine their allergenic significance (Mariana *et al.* (2000b), IMR Annual Report, 2002). This is an important area of investigation. It is known from research studies undertaken elsewhere that various species of xerophilic fungi (plants associated with dry humid conditions) are abundant in tropical countries and are also allergenic (Bronswijk, 1981). As said earlier the main

source of food of house dust mites is the dead skin we shed, but in its raw state, this is too tough and dry for mites to eat. So, they rely on mould or fungi of numerous genera, one of which genus is *Aspergillus*, to make the skin soft and moist. The fungi need a warm, humid atmosphere, precisely the conditions found in Malaysian homes.

Our studies in Malaysia, Singapore and Hawaii re-affirm that the primary focus of dust mite production is the mattress. This is where an individual adult spends between 6 and 8 hours of the time and shed enough dead skin to feed thousands of mites. The vacuuming procedure has some benefits of not only removing the live mites, but also other biomass of the allergens, such as dried faeces and cast-off skin of mites plus the human and animal dander, and other organic matter on which the mites might feed. When vacuuming the surface of the mattress particular attention need to be paid to the cording and buttons of the mattress. The depressions and folds demand concentrated effort to successfully reduce or eliminate the mites and debris, since dead mites and their fragments tend to lodge tightly in the crevices of the mattress and fabric. Vacuum cleaning is only useful to remove surface dust items. Though vacuuming showed reductions of dust and mites by repeated cleaning, such treatment is not an effective method for adequately controlling either dust or mites in the whole mattress, carpet or soft furnishing. Even after a long and rigorous cleaning time, both live mites and dust remain. All types of mattress (inner spring, kapok and foam) can develop high mite populations. Mites are found deep inside mattresses and pillows which serve as a source of re-infestation, and are inaccessible to most control measures. Allergic subjects are vulnerable to exaggerated claims made by agents dealing with vacuum cleaners, as seen in some allergy commercials. Studies in other countries have shown several fold increases in airborne allergen after regular dry vacuuming. Another vacuum cleaner employing a water trap disperses an allergen aerosol of a size suitable for inhalation. A few vacuum cleaners are fitted with high efficiency (HEPA) filters that do not increase airborne allergen (Tovey, 1992). These cleaners cost a little over a thousand Malaysian Ringgit. Subjects with asthma who have to perform vacuuming should choose such a cleaner, and/or advised to at least wear an efficient dust mask whilst house cleaning.

Machine washing of clothes and bedding is an essential component as it kills mites and removes both soluble allergens and the sources of mite nutrition. All mites are killed in 10 minutes in water at 55°C. Most households in developing countries do not own washing machines with hot water dispensers. Machine washings in cold water or washing the old-fashioned way is sufficiently adequate, because drying the washings in direct sun is likely to be as effective to kill the mites. Subjects allergic to dust mites and associated components are advised to encase mattress and pillows in permeable plastic covers to avoid discomfort with waterproof covers. Permeable covers allow the passage of water vapour but not mites, skin scales or allergen. It is important that when mattress and pillow covers are used, regular hot washing of bedding, especially blankets, is maintained (Tovey, 1992).

Encasing the mattress with plastic serves to reduce the surface humidity which affects the mites and prevents the accumulation of food material on the mattress surface. Dust from the floor of the bedroom especially under the bed and corners of the room contain mites. This indicates the need for source reduction of infestation in the entire room or house, not the mattress alone. This will lower population densities, eliminate breeding sources and help prevent re-infestation. Carpets in the bedroom of a dust or dust mite sensitive individual is a hazard, and not recommended for reasons mentioned earlier, because a carpet is the other main focus of infestation.

Dust mites are susceptible to desiccation. They will only be active and proliferate when the relative humidity

(RH) is high enough to allow water to be gained from the surrounding air (Wharton, 1976). The temperature and RH for the optimum development and propagation of house mites is around 28ºC and 80% RH under Malaysian conditions as mentioned earlier. Lowering the temperature and RH in the bedroom will restrict the activity of the mites. However, it is emphasized that it is not sufficient to kill the mites, because dead mites and their products are allergenic and should also be removed. Vacuuming seems to be one of the weapons for removing dust and mites from hard floors, and is partially effective to remove allergens from the surface of mattresses.

CHEMICAL CONTROL

Numerous chemicals with different modes of action have been tested in developed countries to control mite populations and so reduce the production of allergens. While these compounds completely kill mites *in vitro*, there is difficulty in applying them effectively under natural conditions in mite populations in the matrix of mattresses, carpets and soft furnishings. All the chemicals have low human toxicity, but there is always concern over adverse reactions to chemicals in close physical contact, in enclosed spaces with repeated applications for extended periods. There is always the additional possibility of mites developing resistant strains. However, three acaricides or pesticides used against mites, Paragerm, benzyl benzoate and pirimiphos methyl, have passed from successful *in vitro* assessment onto trials in houses (Tovey, 1992). It showed some effect, but did not achieve complete control of mites. They eliminated surface mites in mattresses applied to, but subsurface mites survived. Another biocide named Acarosan reduced mite allergens in carpets, but not on mattresses. The use of tannic acid to denature allergens was found to be effective at treating surface dust. When combined with an acaricide and applied to beds the results have been disappointing, as in less than a month denatured surface allergens are replaced by dust and mites from deeper in the matrix. Numerous other disinfectants have been screened without identifying any with potent activity. Wharton (1976) reported that of 30 chemical material tested only one of them killed mites. The material was lindane at the rate of 10%. A 1% rate was also found to be 100% effective. The formulation of safe and effective chemical control agents is, however, said to be complex and requires expert pharmacological advice.

Numerous plant species are being used to treat diseases of infectious origin, but not as biological agents. Biological control to repel allergenic organisms or to denature the allergens produced by organisms in the house dust ecosystem is an issue that is worthy of consideration for investigation. The importance of natural products for the control or management of diseases is being actively pursued by various investigators in Malaysia. There are numerous species of herbal plants that are reputed to be efficacious in the practice of herbal medicine in the Malaysia. One such plant is the Nim or Neem plant, *Melia indica* or *Mambu* in Malay and *Vepa* in Tamil. It grows wild in Indonesia and India, and though not native to Malaysia it thrives in gardens and Malaysian roadsides. It has long been known for its medicinal values. In India it is considered a valuable tree. The famous Margosa oil comes from it, and the leaves are used to keep away insect pests. It has the potential to be developed as either a biological or chemical control agent. Its usefulness as a biological agent, if found to be promising, could, for example, be modified genetically or otherwise, to produce extracts that could be used as a weapon for the protection of individuals highly sensitive to dust mite and other allergies.

In conclusion, it is to be stated that faecal matter of house dust mites is far more allergenic to susceptible individuals and can provoke asthma as well as other

allergenic reactions when inhaled. The fact that waste products are capable of sensitizing those sensitive to dust mites is an unfortunate circumstance, but is principally not the fault of the dust mites (Wharton, 1976; Fain *et al.*, 1988; Platts-Mills & de Weck, 1989 and Spieksma, 1992). House dust mites have lived in human contact from time immemorial. Because the mites feed on human dander, house dust mites and human association will continue to co-exist as part of our environment. Effective, efficient house-keeping practice is the best form of control to reduce infestation in a normal household. Individuals susceptible to allergic reactions would have to resort to other precautionary measures to prevent exposure. Some of these measures have been discussed above. The removal of the faecal matter as well as the source, i.e. the mites should be considered as of paramount importance. The measures mentioned above for their control are usually taken when standards of living are relatively high and effective vacuum cleaners are affordable.

A measure that is cost free, yet the most practical way to remove mites, their fecal matter and other products is to resort to the age-old practice employed by our grandparents. The practice is to sun the bedding, carpets, linen, soft furniture and soft toys to kill the living mites, and then beat and brush them to remove the dust containing the dead mites and their products, insects, fungi, pollen and other food material. Malaysia is blessed with sunlight all year round. Long before scientific knowledge established the involvement of dust and dust mites on human health, our forefathers over many generations knew that when the bedding and linen were dried in the sun, a good night's sleep was assured. Exposing a carpet flat in the sun is an extremely efficient way to kill all mites which would take about 3 hours. On a day with ambient conditions of 30°C and 60% RH, direct sunlight raises the temperature under the carpet to more than 50°C and reduces the RH to less than 15% (Tovey, 1992).

Figure 10. From the title page of Electra, a journal of the Dutch sellers of vacuum cleaners (courtesy Bronswijk, 1981).

In the final analysis, the total removal of dust is the paramount purpose of the homemaker. For them one or more of the following factors starts them cleaning: unpleasant sight, the necessity to remove insect and other pests, and the desire to diminish the allergen content of the house. In general a clean house, where dust is not visible is considered to be the purpose of all cleaning. With the kind permission of Professor Johanna van Bronswijk the importance of house-keeping efficiency is illustrated in this cartoon (Fig. 10) which is from the title page of Electra, a journal of the Dutch sellers of vacuum cleaners (Bronswick, 1981).

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