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Sensitivity to Five Types of House Dust Mites in a Group of Allergic Egyptian Children

Thesis

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INTRODUCTION

One of the most important etiological factors of allergies is mites occurring in the closest vicinity of humans, i.e. in the house dust and in the stored foodstuffs. Mites shed an abundance of allergenic proteins. Particularly abundant in allergens are the extracts of mite faeces as well as the extracts of their purified bodies or culture substrate. In humans they may inflict atopic allergies (respiratory and dermal), such as bronchial asthma, rhinitis, or atopic eczema. It has been estimated that 5% of the human population is sensitive to dust mites allergens (*Henszel and Kuzna- Grygiel, 2006*). Mites are more prevalent in humid climates, but are rare or absent in drier climates (*Brugge et al., 2007*).

The most important are the species representing the following families:

- Pyroglyphidae: mainly
 - 1-Dermatophagoides pteronyssinus
 - 2-D. farinae
 - 3-Euroglyphus maynei

- Glycyphagidae
 - 1-Lepidoglyphus destructor
 - 2-Blomia sp

- Acaridae:

- 1-Tyrophagus putrescentia

- 2-Acarus siro

(Henszel and Kuzna- Grygiel, 2006).

The non-pyroglyphid domestic mite *Lepidoglyphus destructor* is a major source of allergen causing respiratory symptoms in farming environments (*Varela et al., 1994*). *Acarus siro* L. (Acari: Acaridida: Acarididae) is an important pest of stored grain because it contaminates the grain by allergens and transfers pathogenic microorganisms (*Krizkova-Kudlikova et al., 2007*). The storage mite, *Tyrophagus putrescentiae* (Schrank), is an important source of airborne allergens, especially in farms. The prevalence of Tp sensitization was higher in elderly subjects, especially in patients with COPD (*Liao et al., 2010 b*).

Skin prick tests (SPT) remain to be the method predominantly used for diagnosis of allergic diseases. Regarding its low cost, rapidity of performance, safety and good correlation with the presence of clinical symptoms, SPTs are often considered sufficient for recognizing allergy and hence determine further therapeutic management (**Semik et al., 2005**).

AIM OF THE WORK

With this as a background we were stimulated to study the frequency of sensitization to 5 different types of house dust mites among asthmatic children +/- concomitant types of allergy in a trial to outline the most frequent sensitizing strains in the Greater Cairo Province.

Chapter I

House Dust Mites

Since 1964 house dust mites (HDM) have been known to be the most common allergen causing asthma and other allergic diseases. HDM (also called domestic mites) are widely distributed in human habitats and work environments. As very powerful allergens, HDM can induce mite asthma, allergic rhinitis, atopic dermatitis, chronic urticaria, and other harmful effects on human health, especially in children (*Feng et al., 2009*).

Structure and life cycle:

The adult HDM are arachnids that are microscopic in size (~0.33mm long). They are white to light tan in colour, their cuticle has numerous fine striations. The mites have plump bodies (not flattened), well developed chelicerae and suckers at the ends of their tarsi.



Fig. (1) House Dust Mite
(*Cross et al., 1998*).

Their life cycle from egg to adult takes 3 to 4 weeks and they live for 6 to 8 weeks. Females produce 40 to 80 eggs during

this time. The most common species are *Dermatophagoides pteronyssinus* (*D. pteronyssinus*) and *Dermatophagoides farinae* (*D. farinae*) (*Baxi and Phipatanakul, 2010*).

Factors affecting HDM:

The major factors affecting dust mite growth are temperature and humidity. The optimum relative humidity for mite growth is 75–95%, at temperatures of 15–30 °C. Mites absorb water in high humidity and get dehydrated when the humidity falls below 50%. Studies have shown that within a room, the relative humidity of the carpet tends to be higher than the room air. Furthermore reducing the relative humidity of the room does not necessarily have an effect in mite microhabitats (carpet, mattress, and upholstery). It has been shown that dust mite exposure in early childhood is an important determinant in asthma development (*Baxi and Phipatanakul, 2010*).

Sources of HDM:

HDM are found in dust and products with woven materials as carpets, stuffings such as mattresses, pillows, stuffed animals and bedding or upholstered furniture. Fecal particles contain most of the allergen and the highest dust mite concentrations are in mattresses (*Baxi and Phipatanakul, 2010*).

Storage mites of the families Acaridae and Glycyphagidae attracted attention as a source of household allergens. Storage mites are often found in dry food items, including dog and cat food. Dry foods contain some amount of moisture (<10%) which makes them susceptible to mold growth providing an optimum breeding ground for the storage mites. Infestations have been found in cheese, grain, seeds, bulbs, straw, dried fruits, cereal, wallpaper and furniture. The fauna of storage mites in house dust was represented by the previous two families (*Zheltikova et al., 1997*).

HDMs which include species such as *D. pteronyssinus*, *D. farinae*, and *Euroglyphys maynei* (*E. maynei*) feed mainly on human desquamated skin scales; on the contrary, storage mites (most commonly *Acarus siro* (*A.siro*), *Lepidoglyphus destructor* (*L. destructor*), *Glycyphagus domesticus*, and *Blomia tropicalis* in the tropics) feed on plant material, fungi, and organic degradation products but are also frequently found in house dust (*Von Herten and Haahtela, 2009*).

The farm environment appears to be associated with increased exposure to mites in house dust. A comparison of dust mite concentrations in different locales (offices, restaurants, day care centers, schools, markets, paper plants, textile factories, and farm houses) revealed by far the highest mite concentrations (both HDMs and storage mites) in samples

obtained from farms (barns, farmers' homes, and clothing), even during winter time (*Von Hertzen and Haahtela, 2009*).

Geographical distribution in the world:

HDM are the most prevalent source of indoor allergens shown by multicentre studies across Europe, USA, Asia, and South America as well as New Zealand and Australia. Africa also has HDM allergy. Regions with a few months of relative humidity below 50% have low infestations (*Thomas, 2010*).

In temperate regions, *D. pteronyssinus*, *D. farinae*, and *E. maynei* (family Pyroglyphidae) are the most commonly species found, while in tropical and subtropical areas, *Blomia tropicalis* (family Glycyphagidae) and *D. pteronyssinus* are the most frequent species and *D. farinae* is rarely found (*Terra et al., 2004*).

Regions with a few months of relative humidity below 50% have low infestations with HDM. These include high altitudes in temperate regions in New Mexico, the Rocky Mountain states of USA, and European Alps. Low HDM infestation is also found in the deserts of Israel, Saudi Arabia, and Kuwait, although infestation may increase with humidity from air conditioning. Decreased HDM with increased fungal allergy is also documented in Arizona (*Thomas, 2010*).

Geographical distribution in Egypt:

House dust mites were collected from eight different areas in Great Cairo in a study by **Koraiem and Fahmy (1999)**. Nine species of mites were recovered from indoors. In order of abundance, they were *D. pteronyssinus*, *D. farinae*, *Tyrophagous putrescentiae* (*T. putrescentiae*), *A. siro*, *Cheyletus malaccensis*, *Blomia kulagini*, *Acheles graciles*, *Ornithonyssus bacoti* (*O. bacoti*), and *L. destructor*. All these mites were collected mainly from Bolak Al Dakrou (28.8%) and Al Wayly (27.6%). The least number (1.8%) and species (only three) were collected from Madenat Al Salam.

El Arish city in the eastern part of the north coast has subtropical climate and warm humid summer, such situation are favourable to proliferate house dust mites. Acari were found in 34.6 % of the samples collected from El Arish homes (***El-Sherbiny et al., 2010***).

Six house HDM species were isolated from dust of floors and mattresses of allergic patients' houses in Alexandria city. *D. pteronyssinus* was the dominant species in dust of floors and mattresses with average percentages of 68.9% and 78.3% respectively (***Sadaka et al., 2000***).

A study in the Dakahlia Governorate in the Nile delta revealed presence of four mites. These are *D. farinae*, *D. pteronyssinus*, *Acheles gracilis* and *O. bacoti*. Population densities of different live adult mites were investigated in

different house habitats. In urban houses, pyroglyphid mites were the predominant in bedrooms. While in rural houses, *O. bacoti* was the most abundant species followed by pyroglyphid mites (*El-Shazly et al., 2006*).

Three species of mites from house dust of atopic dermatitis patients in the Qalyobia Governorate, to the north of Cairo, were isolated. These mites were *D. pteronyssinus*, *O. bacoti* and *Haemogamasus pontiger*. The former species was the predominant one (*Morsy et al., 1994*).

Effect of HDM on immune system:

HDM sensitization is strongly linked to asthma. The higher the level of dust mite exposure at 1 year old, the earlier the first episode of wheezing occurred. The relative risk of asthma (which includes exposure to indoor allergens as HDM, male gender, family history of asthma, atopy and airway hyperreactivity) was almost 5-times greater in the subjects who were exposed to high levels of dust mite allergen ($>10 \mu\text{g/g}$) (*Baxi and Phipatanakul, 2010*).

HDM are the source of molecules that can influence innate and immune responses in humans. Some of these molecules are allergenic and can sensitize and induce allergic reactions that may manifest as atopic dermatitis, rhinitis (nasal and ocular), or asthma in genetically predisposed individuals. Approximately 20 of these allergens have been characterized. It is likely that there are other bioreactive molecules from

HDM that are not allergenic. Molecules in whole mite extracts or selected allergens (e.g., Der 1 allergen) induce the release of proinflammatory cytokines and the expression of adhesion molecules on many different cell types. Numerous studies have shown that molecules in HDM extracts can affect the function of human fibroblasts, keratinocytes, skin microvascular postcapillary endothelial cells, dendritic cells, macrophages, mast cells, basophils, eosinophils, and lung epithelial cells. Thus, molecules from dust mites may contribute to or amplify immune and inflammatory pathological reactions or the course of allergic reactions (*Arlian et al., 2009*).

Analysis of the cellular infiltrate in upper airways, bronchial biopsies and bronchoalveolar lavages, together with the histopathology of atopic dermatitis skin lesions, reveal that allergic rhinitis, atopic asthma and dermatitis share common immunological mechanisms. Accumulating data demonstrated connections between upper and lower airway inflammation, usually referred to as ‘united airways’. All these three forms of allergic inflammation are characterized by intense cell infiltrates with degranulated mast cells, eosinophils, dendritic cells (DCs) and allergen-specific Th2 lymphocytes producing cytokines such as interleukin IL-4, IL-5, IL-9 and IL-13. Marked epidermal hyperplasia is commonly observed in atopic dermatitis, whereas airway allergy also leads to airway

hyperactivity in both the nose and the lungs as well as to histological changes of the epithelium and thickening of the basal membrane. It is increasingly considered that the allergic inflammation results not only from an exacerbated Th2-biased adaptive immune response but is heavily influenced by the direct activation of the innate immune cells such as bronchial epithelial cells, keratinocytes, DCs, mast cells, basophils and eosinophils by both the allergens themselves and danger signals present in the allergen sources (*Jacquet, 2011*).

Detection of HDM allergens:

Allergens of these mites have been purified, identified and characterized by biochemical and immunological techniques, including: isoelectric focusing; gel filtration; cross-radioimmuno-electrophoresis (CRIE); immunoblotting; and affinity chromatography, using monoclonal antibodies. The complementary deoxyribonucleic acid (cDNA) of some of these allergens has subsequently been cloned. Measurement of allergen concentrations in dust samples, mite cultures or commercial allergen extracts can be performed either by nonspecific methods, i.e. radioallergosorbent test (RAST) inhibition that measures total allergen content, mite counts or measurement of guanine concentration, or by allergen-specific techniques such as enzyme-linked immunosorbent assay (ELISA), immunodiffusion, inhibition radioimmunoassay (RIA), immunoelectrophoresis or monoclonal assays.

Techniques using monoclonal antibodies are also widely employed (*Roche et al., 1997*).

Classification and types of HDM:

HDM consists of various species of Astigmata, Cryptostigmata, Prostigmata and Mesostigmata (*Ree et al., 1997*).

Table(1): Various species of house dust mites:

Suborder & Family	Species
- Astigmata: Pyroglyphidae	Dermatophagoides farinae Dermatophagoides pteronyssinus Euroglyphus maynei
Acaridae	Tyrophagus putrescentiae Acarus siro Rhizoglyphus sp. Sancassania phyllophagianusa Suidasia sp.
Glycyphagidae	Chortophagus domicola Chortophagus arcuatus Glycyphagus domesticus Lepidoglyphus destructor Blomia species
Saproglyphidae	Calvolia domicola
- Prostigmata: Cheyletidae	Cheyletus malaccensis Cheyletus trouessartia Cheyletus eruditus Unidentified Cheyletidae
Bdellidae	Spinibdella sp.
Cunaxidae	Neocunaxoides whartoni
Tenuipalpidae	Brevipalpus sp.
Cryptostigmata:- Cosmochthoniidae	Cosmochthonius reticulatus
Haplochthoniidae	Haplochthonius simplex
Oribatulidae	Oribatula sakamorii Incabates sp. Scheloribatus latipes Zygoribatula truncate Zygoribatula sp.
Oribatellidae	Oribatella sp.
Nothridae	Nothrus biciliatus
Achipteridae	
Eremaeidae	
Oppiidae	
Tectocepheidae	
- Mesostigmata:	Ornithonyssus bacoti

Quoted from *Ree et al., (1997)*.

Dermatophagoides species:

Predominance in nature:

D. farinae (Der f 1) and *D. pteronyssinus* (Der p 1) are common allergy-causing mites found in homes worldwide. Mites are more prevalent in humid climates, but are rare or absent in drier climates as in the deserts of Saudi Arabia and Kuwait (*Brugge et al., 2007*).

Structure:

Two major groups (1 and 2) of *Dermatophagoides* allergens have been identified; they are considered to play a major role in human diseases because most mite-allergic patients (i.e. 70–100%) demonstrate immediate hypersensitivity to them. Their molecular weights are 25 and 14 kDa, respectively. Other groups have been identified, but seem to be less frequently involved in human sensitization. Within each group, allergens have common physicochemical characteristics (e.g. molecular weight) and amino acid sequences, making them structural homologues. Most of them are actually digestive enzymes of the mites, which are secreted in their faeces (*Roche et al., 1997*).