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Role of Abiotic Factors on House Dust Mite Population: Control and Allergen Avoidance - A Review Article

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Abstract: **House dust mites (HDM's) are an important source of indoor allergens in the house dust and cause various kinds of allergies. They are strongly influenced by abiotic factors such as temperature, relative humidity and seasonal variations. HDM's are present in houses all over the year but their number varies in different seasons and habitats. The moderate environmental temperature, high relative humidity and adequate food sources are the key factors for their proliferation. The season has a great effect on the mite population. In the rainy season, moderate temperature and high relative humidity are the favorable conditions for the growth of mites, and the population of mites reaches a peak level. Whereas, high temperature and low relative humidity during summer season significantly reduce the mite population level and in the winter season, fall in temperature will drastically reduce the mite number because mites perish due to chilling. Relative humidity of a particular place plays an important role in the growth of mites. By controlling the relative humidity of a particular place, the HDM allergens can be reduced in that place. The prevalence of these mites and their allergen content vary within the locations in the home. Mattresses, carpets, sofas are the main reservoir of HDM's, as the dust and shed skin scales accumulate in these places and provide abundant nutrition to dust mites. To reduce the allergen content from houses, frequent cleaning and vacuuming of mattresses and pillows, the use of encasement should be advised for allergic subjects.**

Keywords: Allergen, HDM, Humidity, Season, Temperature

I. INTRODUCTION

House dust mite (HDM) is one of the most important and first suspected allergen in the house dust that has great medical importance (Colloff, 2009). HDM's are the microscopic creatures that are found in those habitats which are more closely associated with a man like a bed, bed linens, sofas, clothing, curtains, window sills, floors and carpets and they feed upon dead skin scales shed by human beings (Dey *et al*., 2014, 2016, 2018, and 2019). Numerous abiotic factors such as temperature, relative humidity and rainfall play determinant role in maintaining the population of mites. The life cycle and productiveness of HDM's depend upon temperature and humidity. The optimal environmental temperature (18-27˚C), relative humidity (45-75%) and plenty food are the chief factors for the endurance and development of mites (Colloff 1987; Arlian *et al*. 1990; Acevedo *et al*. 2019; Zhang *et al*. 2022).

The foremost species are *Dermatophagoides pteronyssinus* and *D. farinae* (Portnoy *et al*., 2013; Fassio and Guagnini, 2018). According to the Intergovernmental Panel on climate change, local rise or fall in indoor humidity are anticipated as an outcome of climate change. With increasing temperature, humidity may also increase and both these factors affect the growth and survival of mites (Acevedo *et al*., 2019).

High ambient air humidity required for dust mites to prevent water loss. Many studies have shown the positive correlations between the mites' number and relative humidity of the home. Previous studies showed that all the homes in humid regions, contain a greater number of dust mites but the homes in drier climates contain a fewer number of mites and the allergen level is also found to be very low (Amoli and Cunnington, 1977; Colloff, 1991; Mailleux *et al*., 2011).

In this review, I will first cite the data that supports the role of abiotic factors such as temperature, relative humidity, effects of season and housing pattern on the mite population. The data very strongly suggests that the growth of mites directly depend upon the environmental factors and environment inside the home. It has been suggested that moderate temperature and high relative humidity and enough food sources the key factors responsible for the mite population growth. With the reduction of any one factor from temperature and relative humidity, the number of mites will decrease. Secondly, I will review the avoidance and control of dust mites' allergens. The cited data proved that by reducing indoor humidity and by using encasement on mattress and pillow, by vacuuming, drying and frequent washing will reduce the allergen content in the houses. The data also suggests that how patients suffering from allergies can avoid allergen and reduce their allergic symptoms.

The aim of this review was to enlighten the effect of environmental conditions such as temperature and relative humidity on dust mites and also to review the various methods to control the HDM's allergens. This review suggests that by reducing the relative humidity of a particular place and by using encasements of mattresses and pillows is an effective method to control the population of dust mites and their allergens which is beneficial for the allergic patients to avoid HDM's allergens.

II. LITERATURE SUPPORTING ROLE OF ABIOTIC FACTORS

HDM's are found in close association with humans and are responsible for allergic diseases. The major HDM's which are found in the house dust belong to the family Pyroglyphidae. Their role in allergic diseases varies with environmental conditions such as climatic factors and degree of exposure. Previous studies have shown their prevalence, in both rise and fall in temperature and humidity, respectively. Some of the studies are discussed in this review which strongly suggests the effect of temperature and humidity on mite populations. Spieksma and Spieksma- Boezeman (1967), Rao *et al*. (1975), Colloff (1987) and Kniest (1995) reported the prevalence of Pyroglyphid mites (HDM) in homes of different European countries.

A. Effect of temperature, humidity and season on mites

Relatively high humidity and temperature are the ideal conditions for mite growth (Maurya and Jamil, 1980; Harving *et al*., 1993; Kuehr *et al*., 1994; Sundell *et al*., 1995; Custovic *et al*., 1995; Korsgaard, 1998; Hart, 1998; Dautartiene, 2001; Arlian 2002; Terra *et al*., 2004; Singh and Kumar, 1989; Piacentini *et al*., 1993; Nelson and Fernandez-Caldas, 1995 and Piacentini *et al*., 1996. The optimal environmental temperature between 18-27˚C, relative humidity between 45-75% and adequate food sources are the main factors for the growth and survival of mites. To prevent excessive water loss from their body, mites require high ambient air humidity. In previous studies, the positive correlations between the mite number, allergen level and relative humidity have been found. Mites can survive on an extensive range of humidity depending on temperature (Amoli and Cunnington, 1977 and Colloff 1991). When indoor air humidity was above 7gm/kg (45% relative humidity at 20ºC), HDM population was found to be high (Hart 1998). Study done by Sepasgosarian and Mumcuoglu 1979 in Iran showed that 90% of HDM's been from the family Pyroglyphidae and contains 82% of *Dermatophagoides* genus of the total. They also correlate the number of mites with relative humidity.

HDM's and their prevalence in different locations and habitats strongly affected by abiotic factors (Munir 1998; Deschildre 1999; Melson and Brinchl 2001; Arlian 2002; Thomas *et al*. 2004; Podder *et al*. 2008; and Soltani *et al*. 2011). Global or regional change in temperature and relative humidity are probably affecting the growth of and survival of HDM's and their allergen levels and, therefore, increases the frequency and cruelty of allergic diseases (Acevedo *et al*., 2019).

Seasonal variations with a change in temperature and relative humidity affect the growth of mites (Fig.1). Previous studies did by Dautartiene 2001; Arlian 2002; Hervas *et al*. 2013 have shown that HDM's are found in the houses all over the year but their number varies in different seasons and habitats. A study done by Yuan and Zhu (2003) showed the prevalence of Acaroids mites in houses. They found that the number of mites was found to be more in the summer season and less in the winter season. de Oliveira and Daemon (2003) reported the mite

holding rate of houses 100% and found 891 mites in winter (22.97%), and 2,988 in summer (77.03%). In winters, they reported that *D. pteronyssinus* was the most prevalent (55.00%) followed by *Blomia tropicalis* (27.06%), *Euroglyphus maynei* (8.85%) and family Cheyletidae (8.07%) and in summer, the most prevalent species was *B. tropicalis* (47.79%), followed by *D. pteronyssinus* (43.38%), Cheyletidae (6.87%) and *E. maynei* (1.28%). Another study done by Han and Zhao (2005) showed that the number of mites was present in measurable number in March, increased from April and reached at a maximum level during August and September and starts decreasing from December to March.

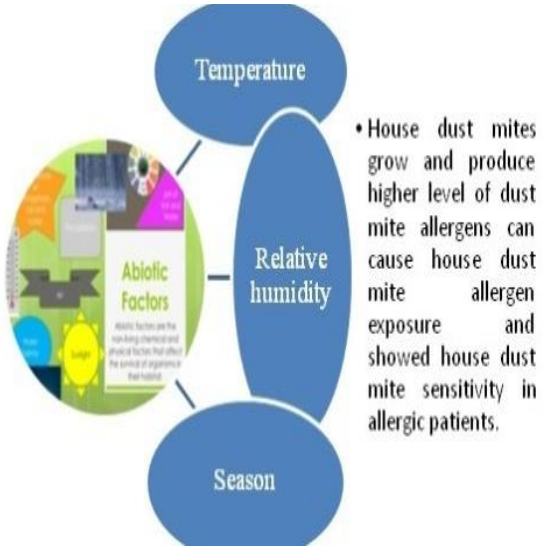

Fig. 1: A simple view of abiotic factors that helps for growth and survival of dust mites.

A similar study was done by Podder *et al.* (2008) in the city of Kolkata for two successive years. Their study observes the higher prevalence of *Dermatophagoides pteronyssinus*, *D. farinae*, *Austroglycyphagus geniculatus* and *Blomia tropicalis* during the pre-monsoon period from March to May, whereas the prevalence of these mites was found to be low in the winter season from December to February. Therefore, their study concluded the effect of season on the relative density of HDM's.

Another study was done by Feng *et al.* (2009) in China showed that the mites were more prevalent in March; their numbers start increasing from April to May, reaches at a peak level during July to August and starts decreasing from October. Their study observed that temperature and relative humidity strongly affect the population of mites.

Population density of HDM's fluctuates dynamically due to temperature, relative humidity and rainfall. These factors play an important role in the population of mites in the allergic patient's dwellings. Hot weather and high relative humidity in the particular region are the main cause of fluctuation of the number of HDM's (Pike *et al.* 2005; Criftci *et al.* 2006; Collins, 2012; Farrokhi *et al*., 2015; He *et al.* 2016). A study done by Jogdand and Ingole (2013) showed that the number of mites was maximum at moderate temperature (25ºC± 2ºC), high relative humidity (around 80 to 90%) and frequent rainfalls which occur during the rainy season. The number of mites was minimum at a higher temperature (around 35ºC to 45ºC), lower relative humidity (around 25% or less) and rainless, clear days which occur during the summer season. In the winter season the number of mites was found to be significantly low because of low temperature (below 15ºC or less), low relative humidity (below 40% or less) and rainless days.

The prevalence of HDM's varies in three different seasons namely summer, rainy and winter season respectively. Study done by Gill and Dhaliwal (2018) showed that the season had a great effect on mite population in Punjab region. In the rainy season, the number of HDM's was more due to moderate temperature (28.65°C) and high relative humidity (87.4%), because these are the favorable condition for the growth of mites. The moderate amount of mites were found in summer season because of higher temperature (32.3°C) and lower relative humidity (58.7%) and in the winter season, lower temperature (17°C) will significantly reduce the mite population (Fig. 2; Fig.3).

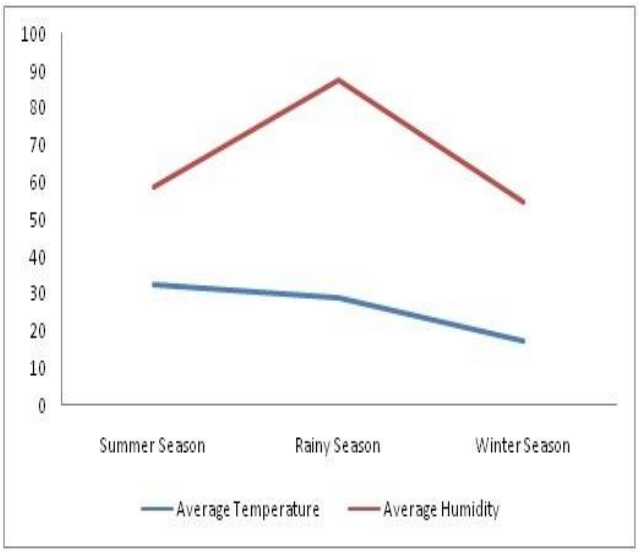

Fig. 2: Average temperature and humidity during three different seasons of Punjab. X-axis denotes three different seasons: Summer, Rainy and Winter Season. Y-axis: Blue line represents average temperatures (ºC) and red line represents average relative humidity (%) of three different seasons.

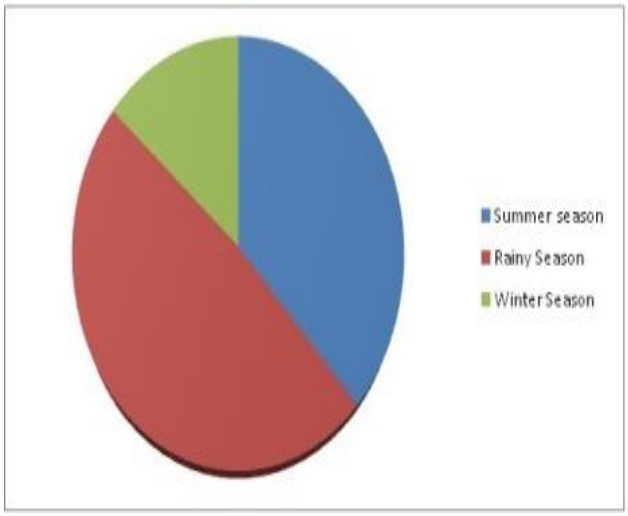

Fig. 3: Prevalence of HDM's in three different seasons: Red color represent rainy season, blue color represent summer season and green color represent winter season.

Another study was done by Akyazi *et al*. (2018) in Ordu, Black sea coast, Turkey. Their study showed the effect of season on the population of mites in the houses of asthmatic patients. They collected dust samples every month, to study the monthly distribution of dust mites. *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* (Astigmata: Pyroglyphidae) are the most abundant mites. Their study found that dust mites are present in the whole year but the abundance of these mites reached at maximum level in all the houses during August when the temperature is 26-28ºC and relative humidity is between 64-78%. Their study concluded that HDM sensitive patients are discomfort during this month.

B. Effect of housing pattern

In houses, breeding population of mites and their allergens are more abundant in those locations of the house where shed skin scales accumulate. These locations include carpeting, sofas, upholstered chairs and mattresses. Some of the live mites are also found on blankets, bed linens, and curtains. A very small amount of allergens are found on walls and top of the hard surface furniture such as tables, bookcases and dressers etc. A very few numbers of mites and little amount of allergens are found on smooth surface floors (Arlian *et al*., 2001). In study done by Gill and Dhaliwal (2018), collection of dust samples was done from various locations within the home such as mattresses, floors, carpets and sofas. Their results showed that 36.0% of dust samples were positive from mattresses, 32.0% from floors, 14.0% from sofas, and 11.2% from carpets. Their study has been concluded that mattresses are the main reservoir of dust mite allergens in the homes of allergic patients (Fig. 4).

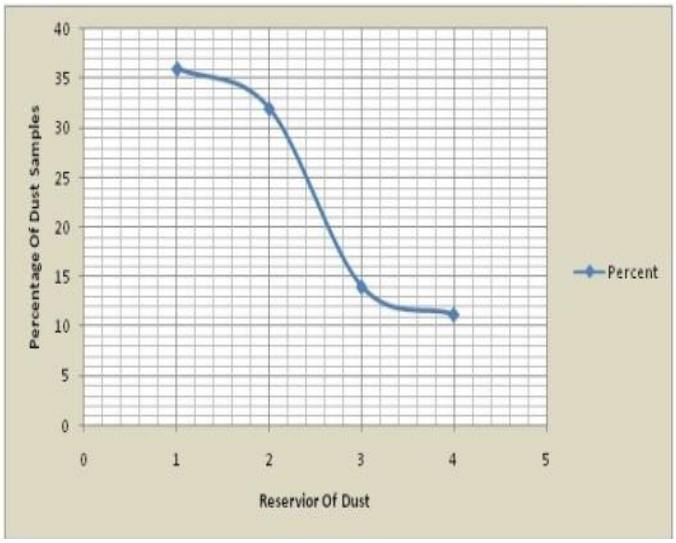

Fig: 4: % prevalence of positive dust samples from different reservoirs of dust. X-axis: 1 denotes mattresses, 2 denote floors, 3 denote sofas and 4 denote carpets; Y-axis: Percentage of dust samples.

Economic eminence, housing pattern, and local environmental factors affect the prevalence and profusion of HDM's (Zock *et al*. 2006; Sharma *et al*., 2011). Munir (1998) found that poor ventilation is the major factors for increasing the rate of allergies. His study observed that carpets and upholstery furniture are the main reservoirs of dust mite allergens. A similar study was done by Edrees (2014). He reported the incidence of dust mites in three different geographic regions of Saudi Arabia: Taif, Al-Baha and Abha. He reported the higher percentage of dust mites namely *T. putrescentiae* (36.73), *B. tropicalis* (23.93) and *A. siro* (8.33) from three different major regions. Their study observed that *T. putrescentiae* was the uppermost mite species in the population of Abha and Taif, while the *B tropicalis* was the main species in Taif. Their study observed that these differences were due to difference in the climatic factors, house age, house condition, population dynamics, living conditions, number of individuals residing, and the most important cleanliness level of house.

III. Control of House dust mites

A. Allergen avoidance: The patients suffering from various allergies should be advised to control their exposure to dust mite allergens. The advice about exposure depends upon the cruelty of disease and on the climatic factors of that particular area where the allergic subjects reside.

B. *Control of relative humidity:* HDM's depend on the relative humidity for their growth and survival (Arlian, 1992). The most effective method to reduce the mite allergen level in a particular place is to control the relative humidity of that place. Relative humidity should be maintained within 45% to 50%, in houses or reservoirs in which individuals reside (Arlian *et al*., 1999; Singh and Jaiswal, 2013). Relative humidity of a home where the allergic patients reside can be reduced by many different methods such as by using the air conditioner and by the use of high-efficiency dehumidifiers. Some previous studies have shown that houses in the arid or semiarid areas, which are not considered as challenging area, can also become challenging with the presence of dust mites under certain conditions like the use of evaporative coolers (Ellingson *et al*., 1995; Prasad *et al*., 2009; Johnston *et al*., 2018)

C. Mechanical Control

The main reservoir of allergens such as carpets, mattresses, sofas and stuffed toys are to be avoided (Van Strien *et al*., 1994; Sidenius *et al*., 2002). The faecal pallets of the dust mites become easily airborne when their reservoir is disturbed. Therefore, vacuuming and dusting have a slight effect on the reduction of these allergens because low-efficiency vacuum bags unable to remove all the dust mites as the mites and their faecal pellets easily pass through these bags and widely spread in the whole room. Therefore, it is recommended to the allergic patients to avoid the use of carpets in a bedroom or living room as these are the main reservoir of dust. A study done by Babe *et al*. (1995) found that the dust mite prevalence in a hospital was very low as compared to the employee's homes. This is due to the lower relative humidity, use of low-pile carpets, good condition of the building and frequent cleaning and washing of laundry.

Another study done by Wickens *et al.* (1997) reported that *Der p* 1 levels were much lower in public places than in domestic dwellings. Their study found that these differences were due to the use of floor covering in houses because carpets are the main reservoir of dust. A study done by Wu **a**nd Takaro (2007) found that by the use of encasements of mattresses, frequent cleaning and washing of bedding material, cleanliness of the house, use of high-efficiency air vacuum cleaners, and parental education are considered as significant to reduce the asthma triggers and improved health outcomes for asthmatic children. Their study further suggests that education alone has not an effective measure in changing parental behaviors such as smoking in the home.

A study done by Tsurikisawa *et al*. (2016) found that environmental and bedding maintenance program is helpful for the management of allergic asthma. Impermeable covers for bedding reduce emergency hospital attendance with severe asthma attacks in children (Custovic *et al*. 2019). Encasing mattresses and pillows in protective covering is an effective method to reduce the exposure to HDM's and their allergens, therefore, these encasements are recommended for allergic subjects. The encasements used for covering may be made from material like plastic, vapor-permeable, finely woven fabrics or nonwoven synthetics. Recently, micro porous covers which allow the passage of water vapor but exclude mites and their allergens are recommended to allergic patients. Aggressive cleaning of the blankets, sheets and mattress covers would also produce a significant reduction in mite allergens. The successful controlled trials to reduce allergen level also included physical barriers such killing of mites with heat, added use of tannic acid to denature mite allergens (Morgan *et al*., 2004; Miller *et al*., 2007; Choi *et al*., 2008; Wilson *et al*., 2017; Miller, 2017).

IV CONCLUSION

Moderate temperature and high relative humidity are favorable conditions for the propagation of dust mites and their allergens. By reducing the relative humidity below 45% at a particular place is an effective method to reduce the population of dust mites. The review also suggests that allergic patients can reduce their allergic symptoms by using encasements of mattresses and pillows as these are main dust reservoirs which provide habitat to dust mites and their allergens for proliferation.

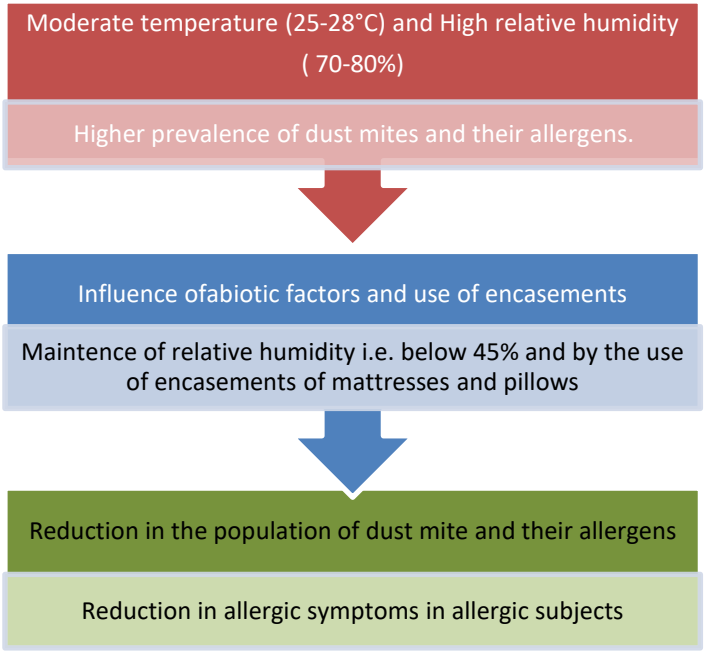

Fig. 5. A simple view of overall conclusion of the manuscript.

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