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Literature Review

House dust mites and cat dander have both been known to induce allergic responses and asthmatic attacks in many individuals. Many researchers have conducted studies which concern these allergens in the home; however, few studies have assessed the "working" or "office" environment in the United States. As a result, this study concentrates on the presence of house dust mites and cat dander in large office buildings in the eastern United States..

There are two species of *Dermatophagoides* that are most commonly found in the home and are frequent sources of house dust allergy: *Dermatophagoides pteronyssinus* and *D. farinae* (1-19). As their name indicates, the main diet of these microscopic organisms is human skin scales; hence, they are frequently found in "high use areas" where there is a great deal of human presence and activity (2, 6,8-12,20,21). In addition to the above nutritional requirement, the *Dermatophagoides* spp. also require proper humidity and temperature for survival and maintenance of homeostasis.

Former studies have stated that humidity is a key factor in controlling mite breeding and numbers (2,4-6,8-14,18,20,22,23-32). Although humidity is difficult to control (6), it remains a crucial tool for controlling mite populations. The microenvironment of these mites contains no liquid water (12); if an absolute indoor humidity of 7g/kg (2,6,8) (equivalent to a relative humidity of 60% at 70°F) (2) is not maintained, water loss and subsequent dehydration can occur. The use of air-conditioners not only lowers room temperatures, but also the indoor humidity by removing water form the air (6,8). Thus, areas that are air-conditioned generally harbor fewer mites than those areas without an air-conditioning system; in one study, mite numbers were reduced by a factor of ten (33). (This is not to say,

however, that mite allergen levels will drop with the use of air-conditioning if mite feces is present in the environment). Due to the fact that humidity is so important for mite survival, mite growth has been correlated with seasonal variations in temperate regions around the world (5,6,8,10,12,21,24,25,30); for example, in North America, mite growth has reached maximum levels in the summer months when the humidity is the highest (2,26).

As aforementioned, temperature is another important factor in maintaining house dust mite populations. Temperatures that are either too high or too low can affect mites. The life cycle from egg to adult for both *D. pteronyssinus* and *D. farinae* is approximately 23-30 days; the duration of this cycle can be shortened by higher and lengthened by lower temperatures (12). Optimal temperature for growth is within the range of 17-25°C (25). Environmental conditions, humidity in particular, also influence the particular species of mite that dominates in the home to some degree. Homes with lower indoor humidity usually contain predominantly *D. farinae* whereas it appears that *D. pteronyssinus* requires higher humidity for survival (1-3, 6,12,18,24,32).

In addition to the climate of the actual room, the microclimate which is provided by carpets and upholstery of furniture is also important. Long pile carpets contain more mites than short pile carpets, and the latter contain more than un-carpeted (tile of wood) floors. Apparently, long pile carpets are able to accumulate and maintain adequate food supplies as well as adequate climactic conditions needed to sustain a mite population (10,12,22). It is also important to note that vacuuming of long pile carpets does not allow full removal of mite bodies and feces that are present. Vacuuming merely removes a fraction of what is present,

particularly the surface dust, as has been determined by studies that yielded equal amounts of dust and allergens after repeated vacuumings (8,10,12,28).

Allergens from the *Dermatophagoides* species of mite are classified into two groups: Group I (Der p I and Der f I) and Group II (Der p II and Der f II) allergens. The first purified group of allergens, Group I, have a molecular weight of 25,000 and are characterized as glycoproteins (2,25). Both Der p I (a cysteine protease) (34) and Der f I display cross reactivity, structural homology, and are associated with mite feces that are carried on particles greater than 10 um in diameter (2,6-8,25,35). Due to their large size, the amount of airborne allergen is small (immeasurable in some studies) unless the room is disturbed; in this particular case, allergen (and particle) levels rise with disturbance (i.e. human activities such as vacuuming and bed-making), and then fall quickly. Certain studies have shown that these large particles fall within a five minute time period. Hence, many individuals who are allergic to house dust mites may only experience symptoms upon entering a disturbed room (36). The Group II allergens have a molecular weight of 15,000 and also display close structural homology and cross-reactivity (25). Der p II and Der f II are associated with the whole body of the mite (7); in addition, a study conducted by Sakaguchi et. al. (7) has suggested that Der II allergens are less prone to float that the Der I allergens.

Unlike the allergens of the above mentioned house dust mites, the major cat allergen, Fel d I, tends to remain airborne for longer periods of time with or without disturbance due to the fact that this particular allergen is carried on particles less than 2.5 um in diameter. Hence, while those individuals who are sensitive to house dust mites may experience little discomfort in an undisturbed setting, those who are allergic to cats may experience a rapid onset of asthmatic and allergic

symptoms in an identical undisturbed environment. Even after disturbance, these smaller particles can remain airborne for many hours (35).

Fel d I, with a molecular weight of 37,000 is characterized as an acidic salivary protein; thus, the main source of this allergen is probably saliva. Nevertheless, further crossed radio-immunoelectrophoresis (CRIE) analysis shows that Fel d I is a dander (superficial skin material) related component. It is also important to note that cat hair has been used to obtain the most complete cat allergen extract (37). Due to the fact that most cats shed quite often, the feline does not have to be present in order to induce an allergic response. It is a reasonable assumption that those individuals who own a cat serve as carriers for the allergen throughout areas where a cat has not been found.

In conclusion, allergies to common house dust are common due to the numerous amount of allergens that are carried on dust particles. Both *Dermatophagoides* spp. and cat allergens have been identified as major allergens. Due to the high number of individuals who are allergic to the substances, a study involving their role in the office building environment is considered.

Introduction

House dust mites and cat dander have both been known to induce asthmatic attacks and allergic responses in many individuals . There have been many studies regarding the major allergens from house dust mites and cats in the home(1-3,5-8,13,24-26,34-37,39-41); however, few studies have been conducted regarding these allergens in the office environment. This study surveys the presence of house dust mites and cat dander in large office buildings.

Materials and Methods

Five office buildings (two located in Philadelphia, Pennsylvania; three located in Washington D.C.) were visited during the first two weeks of August; each building was selected on the basis of previously obtained indoor air information and accessibility.

Ten sites were randomly chosen in each building and sampled in the following manner: approximately, a square meter area of carpet was vacuumed with a vacuum cleaner (Hoover Legacy, model 810) for one minute (to avoid extreme noise disturbance in a working office environment) with the aid if an indoor allergen collection device supplied by ALK laboratories. This device fits onto the hose of a conventional vacuum. Temperature, relative humidity, and carbon dioxide were also measured at the time of collection. At five of the ten sites in each building, the entire surface area of an upholstered chair was sampled in addition to the carpet (bringing the total number of samples in each building to fifteen). In addition to the above, a questionnaire was distributed to approximately five individuals at each sampling site. (A sample copy is attached).

All samples were kept in their original collection containers and sealed in food storage bags until the final analysis (performed 1-2 weeks after collection). The samples were sent to ALK laboratories for immunochemical analysis which measured the concentrations of house dust mite and cat allergens: Der p I, Der f I, and Fel d I by the ELISA method.

The questionnaires used in this study were tabulated. Information such as the percentage of individuals who are allergic to dust mites and cat dander, and the percentage of individuals who own cats was obtained.

Results and Discussion

A total of 75 samples and 211 questionnaires were collected from 50 sites in 5 office buildings. Although the total laboratory data has not yet become available, statistical results were obtained from the questionnaires (Table 1). The table shows the number and percentage of individuals in each building who are allergic to house dust mites and cat dander; the number and percentage of individuals who may be allergic to cat dander; the number and percentage of individuals who own cats; and the total number of cats.

When the individual numbers and percentages are combined, the study reveals that 16.11% of the individuals have been diagnosed as being allergic to house dust mites and that 8.05% of the individuals have been diagnosed as being allergic to cat dander. However, twenty-five of the questioned individuals feel that they are possibly allergic to cat dander; if these individuals are included, the

percentage of individuals allergic to cat dander increases to almost 20%. Hence, according to this study, 1 out of 5 individuals is potentially allergic to cat dander.

It has been stated in a previous study conducted by Luczynska et. al. (35) that 28% of American homes own at least one cat. The numbers generated by this particular study show that 21.3%, or approximately one out of every five individuals owns a cat. Hence, according to this preliminary study, roughly equal percentages of the population own a cat or are allergic to cat dander.

The portion of laboratory data which has become available is shown on tables 2-6. It is important to note the areas which contain moderate to high concentrations of allergens; all but one of these areas contain no questioned individuals who spoke of allergic reactions in the working environment. Guidelines concerning levels of Der p I, Der f I, and Fel d I are as follows (21,38-40):

<u>Der p I and Der f I</u>		
Less than 2ug/g dust	LOW	
2 to 10ug/g dust	MODERATE	(risk of development of asthma) (2ug/g equals approximately 100 mites/g dust)
Greater than 10ug/g dust	HIGH	(risk for acute asthmatic attack) (10ug/g equals approximately 500 mites/g dust)
<u>Fel d I</u>		
Less than 1ug/g dust	LOW	
1 to 8 ug/g dust	MODERATE	(may be risk factor for sensitization to cats)
Greater than 8 ug/g dust	HIGH	(risk factor for acute asthma)

It has been previously stated that humidity is a crucial tool which controls mite populations; in addition, by removing water from the air, air-conditioning has been known to reduce mite populations. All of the areas sampled in this study are air-conditioned. Although microscopic counts have not yet been performed, it is thought that the air-conditioning may have controlled mite numbers in areas where little or no mite allergen was found. Obviously, further laboratory analysis is needed to confirm this possible conclusion.

Optimal growth conditions for house dust mites is 70°F with a relative humidity of 70% (2). None of the areas whose data has been made available had a relative humidity greater than 66%. However, as the tables show, many areas have temperatures at or greater than 70°F, relatively suitable for mites.

None of the 50 sampled sites whose laboratory data is available contained high concentrations of Der p I allergen. However, two of the sites did contain high levels of Der f I. The questionnaires from these areas showed that two individuals were diagnosed as being allergic to house dust mites. In fact, one individual in one of these areas complained of allergic responses in the working environment. These responses may indicate that house dust mites may be present in offices and able to induce allergic symptoms. Further studies are needed to test the validity of this statement.

There were four sites which had high concentrations of Fel d I: 11.4 ug/g, 13.8 ug/g, 16.7 ug/g, and 30.7ug/g. The number of cats whose allergens could potentially be carried into these office areas are: 0,8,7,and 1 respectively. These results may show, like those of previous studies (41), that the cat need not be present for cat allergens to appear in the environment. This phenomenon is due to the fact

that cat allergens are carried on dust particles less that 2.5 um in diameter (35,36); these particles float easily and may be carried by humans into other areas.

The above are the preliminary results of this study regarding house dust mites and cat dander in the office environment. Further studies are needed to substantiate the data generated from this study.

Table 1

Building	Individuals Questioned	Dust Mite Allergic Individuals	% Allergic to Dust Mites	Cat Dander Allergic Individuals	% Allergic to Cat Dander	Individuals Who May Be Allergic to Cat Dander	% May Be Allergic to Cat Dander	Individuals with Cats	% With Cats
Building 1	43	9	20.9	3	6.9	9	20.93	12	27.9
Building 2	49	8	16.32	5	10.2	8	16.32	9	18.36
Building 3	39	5	12.8	3	7.69	4	23.07	9	23.07
Building 4	35	2	5.71	1	2.85	4	11.42	12	34.28
Building 5	45	10	22.2	5	11.11	3	6.66	3	6.66

Table 2- Building 1

Sample	Der p I	Der f I	Fel d I	CO_2 (ppm)	Temperature (Fahrenheit)	Relative Humidity (%)
01	0.1	0.1	0.9	450	76	38
02	0.2	0.4	6.1	450	76	38
03	0.0b	0.0b	30.7	550	74	48
04	0.1	0.0b	1.1	450	72	46
05	0.0b	0.0b	0.7	450	72	46
06	*	*	*	500	77	39
07	*	*	*	550	78	48
08	0.1	0.5	16.7	500	77	39
09	*	*	*	500	78	39
10	*	*	*	450	72	50
11	0.1	6.9	0.1	450	72	50
12	0.1	15.4	0.0b	400	73	48
13	0.0b	0.6	0.0b	450	72	48
14	0.0b	0.2	0.7	450	72	48
15	0.0b	0.1	0.2	350	75	40

* Data not yet available
b Below detection limit

Table 3- Building 2

Sample	Der p I	Der f I	Fel d I	CO_2 (ppm)	Temperature (Fahrenheit)	Relative Humidity (%)
01	*	*	*	550	77	48
02	0.0b	0.3	0.4	550	77	48
03	*	*	*	450	75	47
04	0.1	0.1	1.4	450	75	47
05	*	*	*	500	74	50
06	*	*	*	500	75	47
07	*	*	*	550	78	48
08	0.1	0.4	0.4	550	78	48
09	0.1	0.0b	0.1	500	79	50
10	*	*	*	600	77	45
11	0.0b	0.1	13.8	600	77	45
12	*	*	*	550	76.5	45
13	*	*	*	450	72.5	47
14	*	*	*	650	69	50
15	0.1	0.3	11.4	650	69	50

* Data not yet available
b Below detection limit

Table 4- Building 3

Sample	Der p I	Der f I	Fel d I	CO_2 (ppm)	Temperature (Fahrenheit)	Relative Humidity (%)
01	*	*	*	550	73	57
02	*	*	*	600	74	54
03	*	*	*	600	74	54
04	*	*	*	350	72	60
05	0.1	0.0b	0.0b	450	72	57
06	0.6	0.5	0.3	450	72	57
07	*	*	*	600	72.5	57
08	*	*	*	400	71	61
09	0.1	0.1	0.2	500	73	46
10	0.6	1.5	1.0	500	73	46
11	0.1	2.5	0.3	500	76	42
12	0.6	2.9	0.7	500	76	42
13	*	*	*	450	72.5	47
14	0.7	3.0	0.4	450	72.5	47
15	0.2	4.6	0.2	550	72	52

* Data not yet available
b Below detection limit

Table 5- Building 4

Sample	Der p I	Der f I	Fel d I	CO_2 (ppm)	Temperature (Fahrenheit)	Relative Humidity (%)
01	*	*	*	350	71	64
02	2.4	0.7	7.3	350	71	64
03	*	*	*	300	72	60
04	*	*	*	400	70,5	60
05	0.7	0.5	0.5	400	70.5	64
06	*	*	*	350	74	64
07	*	*	*	350	71	64
08	0.1	2.1	2.4	350	71	64
09	0.1	0.5	0.0b	400	73.5	57
10	*	*	*	400	73	59
11	0.1	0.4	0.8	400	73	59
12	*	*	*	400	76	54
13	0.1	0.4	0.3	400	76	54
14	0.0b	0.1	0.5	350	74	54
15	*	*	*	300	67.5	64

* Data not yet available
b Below detection limit

Table 6- Building 5

Sample	Der p I	Der f I	Fel d I	CO_2 (ppm)	Temperature (Fahrenheit)	Relative Humidity (%)
01	*	*	*	350	67	57
02	0.1	0.1	0.2	350	67	57
03	*	*	*	550	70.5	58
04	*	*	*	550	70	60
05	0.0b	0.3	0.1	600	70	60
06	0.2	1.2	0.4	600	70	60
07	*	*	*	550	70.5	55
08	0.4	0.3	0.7	550	70.5	55
09	0.0b	6.8	0.3	550	67	55
10	*	*	*	550	67	55
11	*	*	*	550	71	56
12	*	*	*	550	70	51
13	0.0b	1.7	0.0b	600	71.5	50
14	0.1	1.3	0.2	600	71.5	50
15	*	*	*	350	71	52

* Data not yet available
b Below detection limit

References

1. Schwartz, B., Lind P., Lowenstein, H.; Levels of Indoor Allergens in Dust from Homes of Allergic and Non-Allergic Individuals. Int Archs Allergy appl Immun 1987; 82: 447-449.

2. Platts-Mills, Thomas A.E., Chapman, Martin D.; Dust Mites: Immunology, allergic disease, and environmental control. J Allergy Clin Immunol 1987; 80: 755-775.

3. Ransom, James H., Leonard, Judith; Dust mite assays in clinical allergy practice: mite antigen exposures among skin positive patients in Kansas. Ann Allergy 1990; 65: 292-296.

4. Swanson, Mark C., Campbell, Anderw R., Klauck, Michael J., Reed, Charles E.; Correlations between levels of mite and cat allergens in settled and airborne dust. J Allergy Clin Immun 1989; 83: 776-783.

5. Tilak, S.D., Jogdand, S.B.; House dust mites. Ann Allergy 1989; 63: 392-396.

6. Pollart , Susan, M., Ward, George W., Platts-Mills, Thomas A.E.; House Dust Sensitivity and Environmental Control. Immun Allergy Clin 1987; 7: 447-462.

7. Sakaguchi, M., Inouye, S., Yasueda, H., Irie, T. Susumu, Y., Shida, T.; Measurement of Allergens Associated with Dust Mite Allergy. Int Arch Allergy Appl Immunol 1989; 90: 190-193.

8. Pollart, Susan M., Chapman, Martin D,. Platts-Mills, Thomas A.E.; House Dust Mite and Dust Control. Clin Rev Allergy 1988; 6: 23-33.

9. Vyszenski-Moher, D.L., Arlian, L.G., Bernstein, I. L., Gallagher, J.S.; Prevalence of house dust mites in nursing homes in southwest Ohio. J Allergy Clin Immunol 1986; 77: 745-748.

10. Arlian, L.G., Bernstein, I.L. Gallagher, J.S.; The prevalence of house dust mites, *Dermatophagoides* spp, and associated environmental conditions in homes in Ohio. J Allergy Clin Immunol 1982; 69: 527-532.

11. Olkowski, W., Daar, S., Olkowski, H. Common Sense Pest Control. Newtown, CT: The Tauton Press, 1991: 159-164.

12. Arlian, Larry G.; Biology and Ecology of House Dust Mites, *Dermatophagoides* spp. and *Euroglyphus* spp.. Immun Allergy Clin 1989; 9: 339-355.

13. Smith, Thomas, F., Kelly , Linda B., Heymann, Peter W., Wilkins, Susan R., Platts-Mills, Thomas A.E.; Natural exposure and serum antibodies to house dust mite of mite-allergic children with asthma in Atlanta. J Allergy Clin Immunol 1985; 76: 782-788.

14. Lang, James D., Mulla, M.S.; Seasonal Dynamics of House Dust Mites, *Dermatophagoides* spp., in Homes of Southern California. Environ Ent 1978; 7: 281.

15. Arlian, L.G., Brandt, R.L., Bernstein, R.; Occurrence of House Dust Mites, *Dermatophagoides* spp., During The Heating Season. J Med Entomol 1978; 15: 35-42.

16. Arlian, L., Veselica, M.; Reevaluation of the Humidity Requirements of the House Dust Mite *Dermatophagoides farinae*. J Med Entomol 1981; 18: 351-352.

17. Mulla, M.S., Harkrider, J.R., Galant, S.P., Amin, L.; Some House Dust Control Measures and Abundance of *Dermatophagoides* Mites in Southern California. J Med Entomol 1975; 12: 5-9.

18. Lang, James D., Mulla, M.S.; Distribution and Abundance of House Dust Mites, *Dermatophagoides* spp., in Different Climactic Zones of Southern California. Environ Ent 1977; 6: 213.

19. Lang, James D., Mulla Mir S.; Spatial Distribution and Abundance of House Dust Mites, *Dermatophagoides* spp., in Homes in Southern California. Environ Ent 1978; 7: 121.

20. Wharton G.W.; House Dust Mites. J Med Entomol 1976; 12: 577-621.

21. Platts-Mills, Thomas A.E.; Dust mite allergens and asthma- A worldwide problem. J Allergy Clin Immunol 1989; 83: 416-427.

22. Lang, James D., Mulla Mir S.; Abundance of House Dust Mites, *Dermatophagoides* spp., Influenced by Environmental Conditions in Homes in Southern California. Environ Ent 1977; 6: 643.

23. Van Bronswijk, J.E.M.H., Sinha, R.N.; Role of Fungi in the Survival of *Dermatophagoides* in House-Dust Environment. Environ Ent 1973; 2: 142.

24. Hart, B.J., and Witehead L.; Ecology of house dust mites in Oxfordshire. Clin Exp Allergy 1990; 20: 203-209.

25. Van Bronswijk, J.E.M.H.; *Dermatophagoides pteronyssinus* in Mattresses and Floor Dust in A Temperate Climate. J Med Entomol 1973; 10: 63-70.

26. Platts-Mills, Thomas A.E., Hayden, Mary L., Chapman, Martin D., Wilkins, Susan R.; Seasonal variation in dust mite and grass-pollen allergens from the houses of patients with asthma. J Allergy Clin Immunol 1987; 79: 781-791.

27. Korsgaard, Jens; House Dust Mites and Absolute Indoor Humidity. Allergy 1983; 38: 85-92.

28. Korsgaard, Jens; Preventive Measures in House Dust Allergy. Am Rev Respir Dis 1982; 125: 80-84.

29. Arlian, Larry G.; Humidity as a Factor Regulating Feeding and Water Balance of the House Dust Mites *Dermatophagoides farinae* and *D. pteronyssinus*. J Med Entomol 1977; 14: 484-488.

30. Arlian, L.G., Woodford, P.J., Bernstein, I.L., Gallagher, J.S.; Seasonal Population Structure of House Dust Mites, *Dermatophagoides* spp.. J Med Entomol 1983; 20: 99-102.

31. Arlian, Larry George; Dehydration and Survival of the European House Dust Mite, *Dermatophagoides pteronyssinus*. J Med Entomol 1975; 12: 437-442.

32. Vervloet, D., Penaud, A., Razzouk, A., Senft, M., Arnaud, A., Boutin, C., Charpin, J.; Altitude and house dust mites. J Allergy Clin Immunol 1982; 69: 290-296.

33. Carpenter, G.B., Win, G.H., Furumizo, R.T., Massey, D.G., Ortiz, A.A.;Air conditioning and house dust mite. A Allergy Clin Immunol 1985; 75: 121.

34. Sporik, R., Holgate, S., Platts-Mills, T., Cogswell, J.; Exposure to house dust mite allergen and the development of asthma in childhood. N Engl J Med 1990; 323: 502-507.

35. Luczynska, Christina M., Lin Y., Chapman, Martin D., PLatts-Mills, Thomas A.E.; Airborne Concentrations and Particle Size Distribution of Allergen Derived from Domestic Cats. Am Rev Respir Dis 1990; 141: 361-367.

36. Naspitz, Charles K., Tinkelman, David G. eds.; Childhood Rhinitis and Sinusitis. New York: Marcel Dekker, Inc., 1990; 37-62.

37. Wallenbeck, I., Einarsson, R.; Identification of dander-specific and serum-specific allergens in cat dandruff extract. Ann Allergy 1987; 59:131-134.

38. Lintner, T.J., Brame, K.A., Guralnick, M.W.; Indoor Climate Control and The Prevalence of Mite and Cat Allergens. 1991: submitted for publication.

39. Chapman, M.D., Pollart, S.M., Luczynska, C.M., Platts-Mills, T.A.E.; Hidden Allergic Factors in The Etiology of Asthma. Chest 1988; 94: 185-190.

40. Platts-Mills, T.A.E., Chapman, M.D., Pollart, S.M., Heymann, P.W., Luczynska, C.M.; Establishing Health Standards for Indoor Foreign Proteins Related to Asthma. Toxicology and Industrial Health 1990; 6: 197-208.

41. Sears, M.R., Herbison, G.P., Holdaway, M.D., Hewitt, C.J., Flannery, E.M., Silva, P.A.; The relative risks of sensitivity to grass pollen, house dust mite and cat dander in the development of childhood asthma. Clin Exp Allergy 1989; 19: 419-424.