1985

A Survey of House Dust Mites in the Williamsburg Area

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A SURVEY OF HOUSE DUST MITES

in the

WILLIAMSBURG AREA

A Thesis

Presented to

The Faculty of the Department of Biology

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

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by

Mark Timothy Lassiter

1985

APPROVAL SHEET

This thesis is submitted in partial fulfillment of
the requirements for the degree of

Master of Arts

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ACKNOWLEDGMENTS

The writer wishes to express his great appreciation to Dr. Norman J. Fashing for his endless dedication and commitment to guiding the completion of this work. The writer also extends his gratitude to Dr. Bruce S. Grant and Dr. Mitchell A. Byrd for their careful reading of this project.

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ABSTRACT

House dust mites (Dermatophagoides farinae and D. pteronyssinus) have been identified as the major concentrator of dust allergens. This survey sought to identify the mites present in house dust and determine their population densities in the Williamsburg area, an area with a high incidence of allergy. Using a vacuum cleaner fitted with a special nozzle, dust samples were taken from beds, carpets, sofas, and pillows within 22 houses by vacuuming an 18 square inch area of the substrate for one (1) minute.

All houses were found to have dust mites, with D. farinae approximately two and a half times more abundant than D. pteronyssinus. Population densities were calculated on a per gram of dust basis as well as on the actual data. Compared to studies in Europe and other parts of the U.S.A., houses in the Williamsburg area have large populations of dust mites, with two samples from beds yielding estimates of over 14,000 mites per gram of dust.

Beds and sofas (means of 4409 and 4580 per gram of dust respectively) had the highest population numbers and were not significantly different. Carpets (mean=1483) and pillows (mean=471) had fewer mites and were significantly different from each other as well as from beds and pillows.

Few associations could be made between environmental conditions within a house and the number of mites present.

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INTRODUCTION

House dust has been known to contain allergens since 1920 and has been commonly regarded as having antigens responsible for asthma, rhinitis, and other activated immune diseases (Kern 1921 cited in Sinha 1970, Dekker 1928 cited in Wharton 1976, Voorhorst et al. 1964 cited in Wharton 1976, Mulvey 1972 cited in Wharton 1976, Bronswijk 1973). Various studies have sought to investigate the specificity and widespread susceptibility to house dust's main antigenic factors. Voorhorst et al. (1964 cited in Wharton 1976) associated house dust allergy with the mites that inhabitat the microhabitat provided by the dust. He concluded that the cosmopolitan distribution of house dust mites would account for the worldwide specificity of the house dust allergen, and that the dynamics of mite populations would explain the observed fluctuations of the dust sample's antigenicity (Voorhorst 1967). In particular, he found mites of the family Pyroglyphidae to have similar antigenicity and inhabit dust worldwide. These mites, initially found to thrive in bird nests, also feed on skin dander accumulated in house dust, and are abundantly found in areas of the house most frequented by people.

Mitchell et al. (1969) found that more than ninety percent of the patients allergic to house dust showed positive skin reactions to house dust extracts and mite extract. However, recent work has demonstrated that the most important antigenic factors are the dust elements that the mite concentrates in its gut and feces (Mumcuoglu and Rufli 1979, Trovey et al. 1981). During the mite's food digestion, free sugars and glycoproteins, common in house dust arising from dander and dust elements, are brought together in intimate contact and the Maillard reaction occurs to produce allergens. Mites are better confectioners of these dust allergens than other dust inhabitants since the gut is basically neutral (Hughes 1950 cited in Bronswijk 1981) and the food passes through the gut quickly, not

degrading or inactivating the reaction products (Bronswijk 1981). Thus the Maillard reaction conditions are optimized in the mite gut with the reaction products concentrated in fecal material -- the most antigenic dust constituent.

In light of the role mites play in production of dust allergens, it is important to determine the representation, density, and dynamics of mite populations in the home. The most predominant house dust mite species are Dermatophagoides farinae (Hughes 1961) and D. pteronyssinus (Trousessart 1897). Their population sizes are affected by cleaning habits and conditions within the home. The range of temperature and relative humidity within the various microhabitats has a major bearing on population growth and size (Bronswijk 1981). Woodford et al. (1979) point out that the availability of moisture is the major limiting factor, and that mite populations are largest in months with warmer days and higher relative humidities. In addition, certain microhabitats of different sites within a house appear to support higher mite densities than others. However, due to different cleaning habits, different modes of mite collection, and the numerous environmental variables within the home, research efforts have not implicated any one site to consistently support the largest mite population.

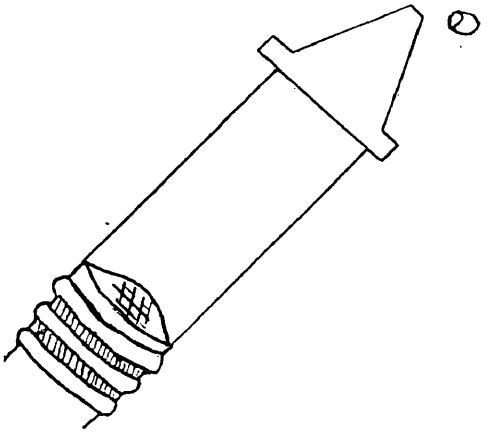
The present study investigated the mite populations of houses in the Williamsburg area, an area with an extremely high incidence of allergy (personal communication to N. J. Fashing from Dr. Scott Pharr). Primarily, I sought to determine the species of mites represented as well as their densities and to compare these data with other studies from different parts of the world. In addition, different sites within the house were sampled to determine which habitat supported the largest population of mites. Finally, a questionnaire was compiled in an attempt to associate population densities with cleaning habits and other environmental conditions within the house.

METHODS

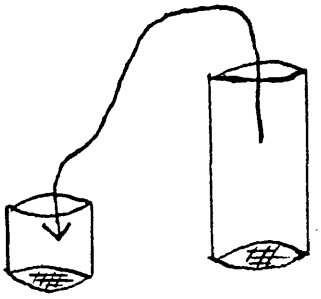
Dust samples were taken from twenty-two middle income, single family houses in the Williamsburg, Virginia area. Mite populations peak during the late summer, typically in August, and a number of researchers have conducted their studies during this time period (Woodford et al. 1979, Arlian et al. 1979, Dusbabek 1979, Bronswijk 1973). By collecting all samples in August, this study provided maximal population estimates which could be compared to the results of several other researchers.

Dust samples were collected from four sites within each home: mattress, pillow, sofa, and the carpet beside the bed. Consistent methods of collection were used in order to compare the mite densities at different sites within the house. A plastic vial, 1¼ inch diameter and 4 inches in length, attached to the hose of a General Electric model PIC-200 vacuum cleaner, served as the dust collector. The vial had a dispenser nozzle inserted on one end for concentration of the vacuum, and a 44 micrometer mesh screen over the other end to catch all dust as well as all mites (Figure 1). The mesh end of the vial was connected to the vacuum hose. At each collection site, the collector nozzle (¼" diameter opening) was passed over a 72 inch distance for one minute, providing an 18 square inch collection area as follows:

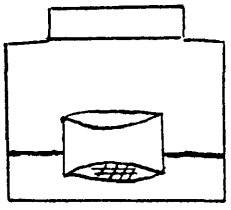
1) Mattress - The top seam of the mattress for 36 inches including a corner at both the head and foot.
2) Pillow - 72 inches around the pillow seam
3) Carpet - 36 inch straight line in the carpet beside the bed (The 36 inch distance was used to approximate the increased surface area of collecting both from the side of piling and the pile mat).
4) Sofa - 72 inches around cushions



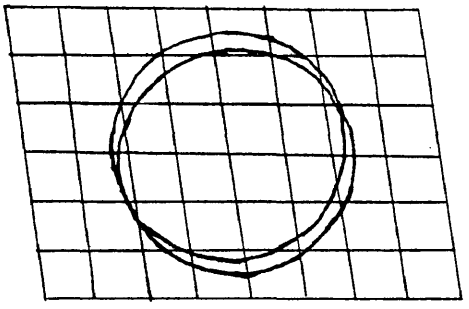
Step 1: A plastic vial, 1¼ inch diameter and 4 inches in length, attached to the hose of a vacuum cleaner, served as the dust collecter. The vial had a dispenser nozzle inserted on one end for concentration of the vacuum and a 44 micrometer mesh screen over the other end to catch all dust and mites.
(nozzle opening ¼")



Step 2: Each dust sample was flushed with distilled water from the collection vial into a 44 micrometer mesh sieve.



Step 3: The sieve containing the sample was stored in a sealed jar with a thin layer of 85% alcohol



Step 4: The sieve was removed from the storage jar and the dust flushed with distilled water into a petri dish for mite separation and counting. The petri dish containing the dust sample was placed under a dissecting scope upon a black surface grid.

Step 5: The mites removed from the sample were first placed in clearing solution and then mounted on a slide for identification utilizing a phase contrast microscope.

Figure 1: Dust Analysis Procedure

Each vial was weighed to the hundreth of a gram both before and after the collection was made in order to determine the dust weight. The collector device provided a selected collection of small dust samples for analysis (less than 0.6 grams).

Each dust sample was flushed with distilled water from the collection vial into a 44 micrometer mesh sieve. The sieve containing the sample was stored in a sealed jar with a thin layer of 85 percent alcohol and analyzed at a later date. To analyze a sample, the sieve was removed from the storage jar and the dust flushed with distilled water into a petri dish. The dust was thus suspended in a thin layer of distilled water. The alcohol left in the jar was then flushed through the clean sieve to remove any mites separated from the sample. The sieve was then placed in another petri dish with a thin layer of water and observed under a dissecting scope. Any mites found in the sieve were put with the sample that had been earlier flushed into the petri dish.

The petri dish containing the dust sample was placed under a dissecting scope upon a black surface grid. The black surface provided a contrasting background for the clear or white mites, and the grids aided in counting and scanning. Small probes were used to break up consolidated debris and clusters of mites. Mites were found floating on the surface, on the bottom of the dish, and associated with dust debris.

In order to reduce analysis time, subsamples of the two predominant species, Dermatophagoides farinae and D. pteronyssinus, were separated out, slide mounted, and examined under a compound microscope to determine the ratio between the species. Such subsamples were separated from square areas of the petri dish, as viewed upon the grided surface. These areas were selected at random until the subsample number totaled approximately fifty adult mites. The whole petri dish was then examined to determine the number of Dermatophagoides remaining in order to estimate their respective numbers in the sample. As the mites were scanned to determine the total count, all mites not detected as D. farinae or D. pteronyssinus were separated out to be slide mounted and identified separately.

Mites were mounted on slides and identified under a phase contrast microscope, utilizing the identification schemes developed by Hughes (1976) and Bronswijk and Sinha (1971).

A questionnaire was developed to obtain information on environmental conditions within each house that could potentially be associated with the mite densities at the collection sites. The questionnaire involved information about the house's physical conditions such as average temperature and type of heat, but dealt primarily with cleaning habits that could be linked with the size of the mite populations in the mattress, pillow, sofa (or padded furnishing used most often in the house), and carpet beside the bed. The questionnaire was completed by individuals responsible for home cleaning and was done immediately following the dust collections in a given home. (See Appendix C for a summary of the questionnaire data.)

RESULTS

Mites Represented

Though some sampling sites within a given house were sometimes void of mites, house dust mites were found in each of the 22 houses sampled. Table 1 specifies the breakdown of the 9,387 total mites found in the dust samples. Four suborders of mites were represented --Astigmata, Mesostigmata, Orbatidae, and Prostigmata. The suborder Astigmata contains Dermatophagoides farinae and D. pteronyssinus, typically referred to as house dust mites, and these two species represented 98 percent of all mites found. Dermatophagoides farinae, the most abundant species, was located in all houses sampled, and represented 70 percent of the mites collected (6,547). Dermatophagoides pteronyssinus, the second most abundant species, was found in 21 houses with a total of 2,649 individuals, making up 28 percent of the total mites sampled. Other astigmatid mites were represented in nine of the houses sampled with a total of 23, most of which were mites of the genus Tryophagus. Prostigmatid mites, the second largest suborder of mites found, represented 1 percent of the total mites sampled. This suborder contained 100 individual mites of several species within the family Cheyletidae, and were found in 16 houses. Mesostigmatid mites were found in ten houses with a total count of 22 individuals. Orbatid mites were found in only five houses. One house had a bed sample of 40 orbatid mites, whereas only six individuals were found in the other four houses combined.

Habitat Comparisons

To determine if densities of Dermatophagoides farinae and D. pteronyssinus differ at different sites within the house, mites were collected from the mattress, sofa, carpet, and pillow. Collection results are given in Appendix A. Collection data can be compared in two ways: (1) actual number of mites observed, and (2) the number of mites present per gram of dust. The latter method is used to

Table 1: Summary of the actual number of mites found in Williamsburg listed in the catagories: percent representation, the percent of houses found to have the mite, and the total count found in the samples.

Taxa Represented	Percent Representation: mites	# of houses	Total Number for the study:
Astigmata:	98.21	100	9219
Acaridae:	0.24	41	23
Tyrophagus spp.	0.23	41	22
other Acaridae	0.01	4.5	1
Pyroglyphidae:	97.96	100	9196
Dermatophagoides farinae	69.74	100	6547
Dermatophagoides pteronyssinus	28.22	96	2649
Mesostigmata:	0.23	46	22
Digamasellidae: *Digamaselus sp*(?)	0.01	4.5	1
Dermanyssidae: *Dermanyssus gallinae* (?)	0.01	4.5	1
Laelapidae: *Hypoaspis sp*(?)	0.01	4.5	1
Orbatidae	0.49	23	46
Prostigmata:	1.06	73	100
Cheyletidae:	1.05	73	99
Acaropsis spp.	0.13	9.1	12
Cheyletus spp.	0.13	23	20
other Cheyletidae	0.71	64	67
other Prostigmata	0.01	4.5	1

compare the results of this study with other studies reported in the literature--unfortunately collection devices and methods vary with each researcher, so the only data suitable for comparison are those standardized to "mites per gram of dust". Table 2 and Figures 2 and 3 summarize both sets of data. The bed and sofa have the highest mite densities, the carpet an intermediate density, and the pillow the lowest density.

Both sets of data -- mite number per sample, and the mites per gram -- were subjected to a oneway analysis of variance (ANOVA) to detect if there were significant differences in the numbers of mites found at the different collection sites. These statistical analyses as well as those to be cited later in the text were run on a Prime 9950 computer at The College of William and Mary utilizing the SPSSx statistical package. Since the data were collected in the form of counts, a square root transformation was used to provide a better fit to the ANOVA model (Sokal and Rohlf 1981). A significant difference was found in each case indicating that population size differs with site. To determine which sites differed, a Student-Newman-Keuls test was utilized. In both instances, the mite populations in the sofa and the bed were found to be similar in number, but the mite densities in the carpet and the pillow were found to be significantly different from each other as well as from those in both the bed and the sofa.

Effects of Environmental Conditions

Oneway ANOVAs were used to determine if there was any evidence that mite densities were affected by environmental conditions within houses. The questionnaire was structured to enable houses with similar conditions (e.g. bed age less than or equal to 10 years, or greater than 10 years) to be grouped together, and mite densities under these different conditions could therefore be tested against each other.

Table 3 specifies the different environmental conditions within the homes and the categories tested for significant differences in density. Total mites per gram of dust, total mites collected per sample, number of D. farinae per gram of dust, number of

Table 2: Mean mite densities, standard errors, sample sizes, and 95% confidence intervals for each of the various collection sites. The number of mites collected in the dust samples and the converted number of mites found per gram of dust are given.

Sites	Means	Standard Error	n	95% Confidence Intervals
Mites Collected per Gram of Dust:				
Bed	4409	52.23	22	2638.53 - 6630.32
Sofa	4580	38.45	22	3000.85 - 6491.75
Carpet	1483	30.91	22	725.92 - 2506.58
Pillow	471	9.96	22	229.15 - 798.81
Total Mites Collected per Sample:				
Bed	132	2.63	22	65.99 - 221.19
Sofa	125	1.49	22	75.02 - 188.79
Carpet	59	0.87	22	33.37 - 93.09
Pillow	6	0.09	22	3.22 - 9.14

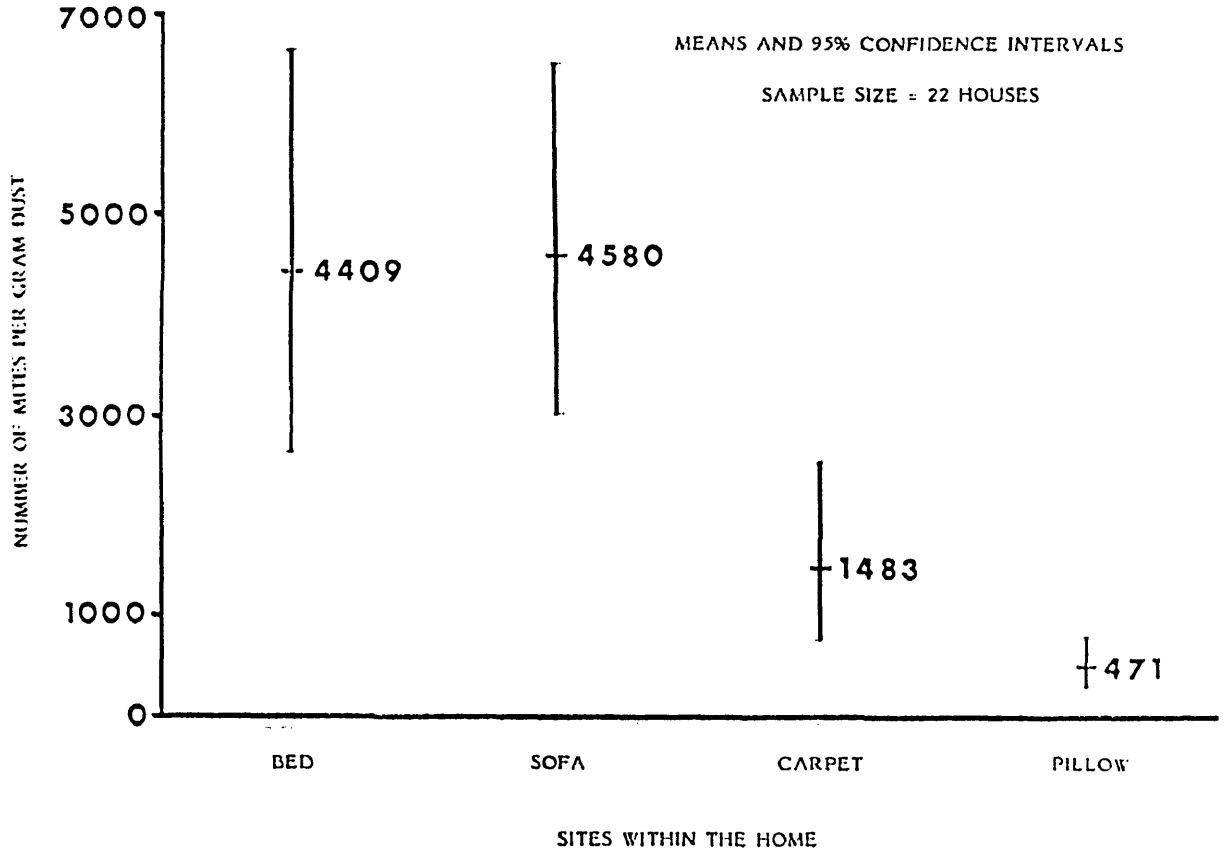


Figure 2: Mean numbers of mites per gram of dust and their 95% confidence intervals for the various collection sites.

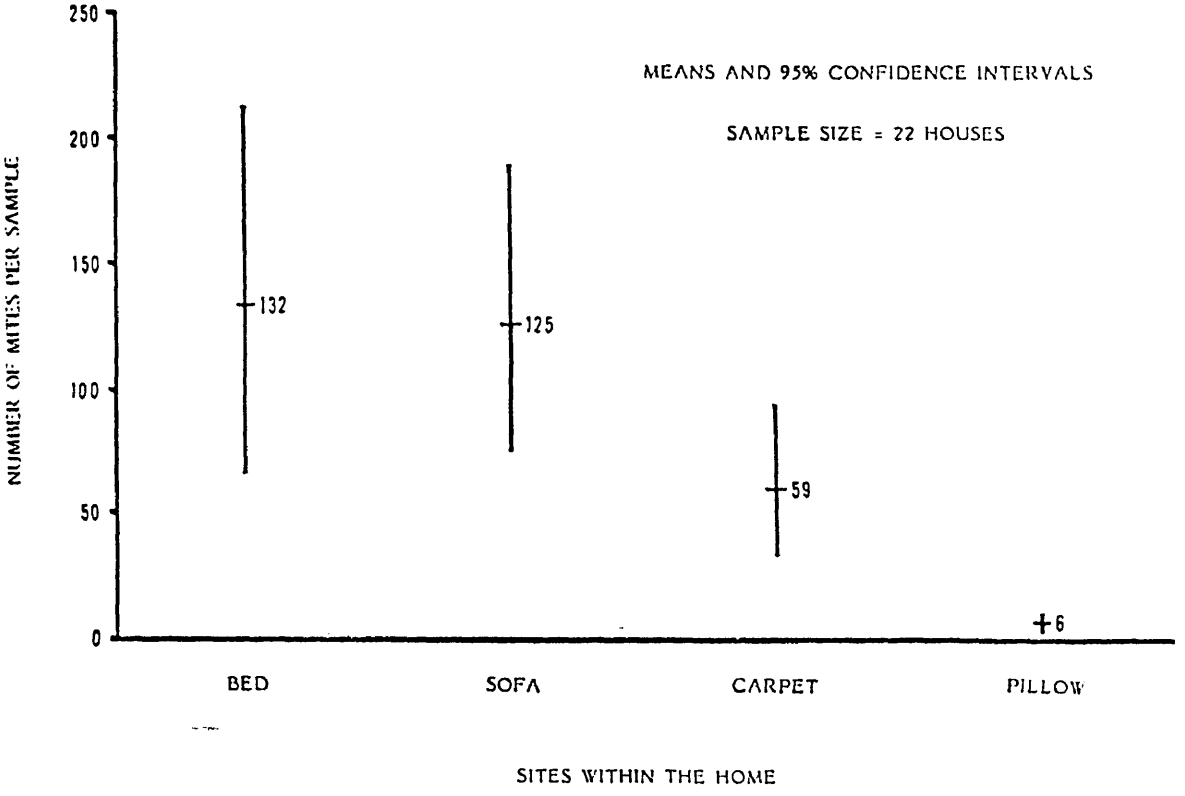


Figure 3: Mean numbers of mites and their 95% confidence intervals at the various collection sites.

Table 3: Environmental Effects. Houses with the same condition (the conditional grouping of houses is listed in the second column under "Environmental Condition") are combined and the probabilities that the mite densities of the catagories considered are not affected by those conditions are provided. (D.f. = Dermatophagoides farinae, D.p. = Dermatophagoides pteronyssinus, /g = per gram)

Environmental Condition		Probability				
		Total /gram	Total /sample	Total D.f./g	Total D.p./g	D.f./ D.p.
Bed Age	≤10 yrs. >10 yrs.	.95	.10	.85	.56	.67
Bed Use	≤ 8 yrs. > 8 yrs.	.25	.17	.65	.04	.31
Sheet Change	1/wk. <1/wk.	.85	.22	.83	.36	.36
Mattress Cleaning	Yes No	.09	.46	.15	.64	.61
Bed Made	<½hr. ≥ ½hr.	.83	.81	.35	.37	.85
Carpet Type	tight pile shag	.99	.40	.35	.10	.19
Carpet Cleaning	≥1/wk. 1/wk.	.38	.77	.62	.44	.82
Sofa Age	≤5 yrs. >5 yrs.	.15	.30	.30	.65	.57
Sofa Use	<5 hrs./day ≥5hrs./day	.01	.23	.12	.13	.47
Sofa Cleaning	Yes No	.64	.91	.20	.26	.09

D. pteronyssinus per gram of dust, and the ratio of D. farinae to D. pteronyssinus per gram of dust were used as variables. Table 3 also presents the probabilities that the categories of conditions considered had no influence upon the mite populations sampled.

With the two exceptions noted below, the results indicate that mite densities are not affected by the different environmental conditions considered. Sofa use was an environmental condition that had a possible effect on mite populations. When considering the total number of mites per gram, houses where the sofa was used less than five hours a day had a significantly lower mite density in the sofa than the houses where the sofa was used five or more hours a day. Additionally, houses where the bed was used greater than eight hours had a significantly larger population of D. pteronyssinus than houses where the bed was used eight hours or less a day. These differences should, however, be interpreted with caution since a large number of comparisons were made and one might expect to find a few such significant differences by chance alone.

Species / Site Associations

To test for a possible association between the species of Dermatophagoides and the collection sites within the house, a chi-square test of independence was performed using the total number of each species collected at each sample site (Table 4). A significant association was found between species and site ($X^2=96.8$, $p<.00001$). Dermatophagoides farinae was found to be more abundant than expected in the bed and less abundant in the carpet, whereas D. pteronyssinus was found in greater numbers than expected in the carpet and smaller numbers than expected in the bed. The sofa yielded populations close to that expected for both species. Data for the pillow indicate larger numbers of D. pteronyssinus and smaller numbers of D. farinae than expected, however the total number of mites collected from pillows was quite small (only 140 out of the total 9196 collected). Therefore conclusions on site preference based on the pillow data should be viewed with caution.

Table 4: Total number of mites of each species observed at each of the four collection sites followed in parenthese by the expected numbers based on independence of events.

	Bed	Sofa	Carpet	Pillow
Dermatophagoides farinae	3023 (2862.9)	2384 (2396.4)	1067 (1190.0)	75 (99.7)
Dermatophagoides pteronyssinus	997 (1157.1)	981 (968.6)	604 (481.0)	65 (40.3)

DISCUSSION

Mites Represented

This study focused on the total mite numbers sampled at each house with special attention given to identifying and quantifying two predominant species -- Dermatophagoides farinae and D. pteronyssinus. In order to collect from as many houses as possible and obtain a reliable density approximation for the Williamsburg area, much work was initially devoted to decreasing the time required for separation and identification. The dust collector allowed concentrated samples to be collected and the separation technique allowed for a relatively quick identification of the Dermatophagoides species represented. It required 350 hours to separate and identify the 9,387 mites found in this study, and therefore limited time was utilized in the identification of the occasional mite species represented. However, the non-Dermatophagoides species were grouped in their representative suborders and identified as far as possible with the reference resources available. It should be pointed out that non-Dermatophagoides species are generally accidentals in the house dust system and therefore of little importance to this study. An exception to this occurs with the family Cheyletidae, members of which are predators on Dermatophagoides and therefore an important link in the house dust community. Table 5 is a compilation of species found in the United States by some of the various researchers (Cunliffe 1958 cited in Bronswijk and Sinha 1971, Fain 1965 cited in Wharton 1976, Wharton 1970, Furumizo 1975, Arlian et al. 1979, Yoshikawa and Bennett 1979). The results of this study add a few new taxa to the list (see Table 1).

Both of the predominant Dermatophagoides species are found all over the world. Dermatophagoides farinae, however, is found in more sites within the home and appears to be the less ecologically specialized of the two (Bronswijk 1981). Dermatophagoides farinae is

Table 5: Mites Represented in Research within the U. S. A.

Astigmata

Pyroglyphidae:

Dermatophagoides chelidonis (Hull, 1937)
Dermatophagoides evansi Fain, Hughes, and Johston, 1967
Dermatophagoides farinae Hughes 1961
Dermatophagoides pteronyssinus (Trouessart, 1897)
Dermatophagoides microceras Griffiths and Cunnington, 1971
Euroglyphus longior (Trouessart, 1897)
Euroglyphus maynei (Cooreman, 1950)
Pyroglyphus morlani Cunliffe, 1958

Psoroptidae

Analgidae

Acaridae:

Tyrophagus putrescentiae (Schrank, 1781)
Calpglyphus spp.

Chortoglyphidae

Histiostomatidae:

Histiostoma spp.

Orbatei

Mesostigmata

Phytoseiidae:

Typhlodromus spp.

Ameroseiidae:

Kleemania plumosus (Oudemans, 1903)

Ascidae:

Blattisocius dentriticus (Berlese, 1918)

Prostigmata

Tarsonemidae

Cheyletidae:

Cheyletus malaccensis (Oudemans, 1903)
Cheyletus spp.

Tetranychidae

typically thought to be the most abundant in North America, with D. pteronyssinus the most cosmopolitan of the two and found to be predominant in Western Europe (Bronswijk and Sinha 1971). Researchers have confirmed the D. farinae dominance by abundance (Arlian 1979, Bennett et al. 1969 cited in Shamiyeh et al. 1971, Bronswijk and Sinha 1971, Sinha 1970, Wharton 1970). Furumizo's 1975 work, however, has shown that in California D. pteronyssinus appears to be the most abundant species. This study has revealed that D. farinae is the most abundant species in the Williamsburg area, making up 70 percent of all the mites sampled and occurring in all homes sampled.

Habitat Comparisons

Some sites within a house have more optimal microenvironmental conditions for mites than others and therefore support larger populations. This study demonstrates that during August the greatest mite densities are found in the sofa and the bed. These sites have mite populations that are not significantly different from each other, but are significantly different from mite populations in the pillow and carpet, which in turn have mite densities significantly different from each other.

Temperature and relative humidity of the mite's microclimate at a given site have the most profound influence upon population development (Bronswijk 1981, Bronswijk 1979, Bronswijk and Sinha 1971, Dusbabek 1979, Wharton 1976, Woodford et al. 1979). Survival of mite populations requires exposure to sufficient humidity at least part of the time (Wharton 1976). A mite must maintain its water balance, and when the microhabitat has a humidity above the mite's critical limit for water balance, the mite is able to absorb water from the environment (Woodford et al. 1979). Summer and autumn generally provide optimal relative humidities (60 to 80 percent) (Bronswijk 1981, Dusbabek 1979) and peak mite densities therefore coincide with the months having the highest humidities -- typically July through August (Woodford et al. 1979).

Though humidity can greatly change over the course of the day and with the season, most modern houses regulate temperature at a fairly consistent level. The optimal temperature range for common

house dust mites is between 25 and 30 degrees centigrade, and mites are fairly tolerant of the seasonal temperature changes (Bronswijk 1981). However, the major importance of temperature is its effect on relative humidity. Bronswijk (1981) states that mites infesting beds or padded furniture will be provided optimal temperatures during their use, but more importantly, the increase in humidity caused by temperature increase is the major factor contributing to population numbers.

The research of Arlian and his coworkers (1979, 1978 cited in Bronswijk 1981) showed that padded furnishings support the highest populations of mites. The sofa, a padded house furnishing, can serve as a site for mite population development. During use, the temperature and humidity will rise, and the padding allows the humidity to be maintained even after use. Additionally, when there is sufficient use, the furnishing will collect skin dander and other dust elements. In some studies, the sofa is found to have fairly large mite populations (Bronswijk 1973, Woodford et al. 1979, Bronswijk 1981), particularly if used day and night (Wharton 1976). This study showed that the sofa is one of the sites within the house that supports the largest population of mites in late summer.

Many investigations have demonstrated that the bed is the site having the highest mite population (Blythe et al. 1974, Bronswijk 1973, Bronswijk 1981, Mumcuoglu 1976, Sesay and Dobson 1972). The bed provides an excellent microclimate for development of mite populations and can sustain populations throughout the year, though density fluctuations will occur. Skin dander can accumulate, and extended use elevates the temperature and humidity. Layers covering the bed also assist in retaining the humidity and slowing temperature changes. The bed often serves as the breeding site (Wharton 1976, Sesay and Dobson 1972) and acts as a mite reservoir from which mites can spill over into other areas of the house during seasons of peak densities (Bronswijk 1973). The mattress, mattress cover, pillow, and bed coverings all contribute to the bed's microclimate. When the pillow is sampled, it is usually found to have the fewest mites (Sesay and Dobson 1972, Yoshikawa and Bennett 1979). In this study, the pillow yielded little dust and was extremely low in mite

density. However, the mattress appears to be the major infestation site of the bed and contains the highest mite populations (Blythe et al. 1974, Bronswijk 1973, Bronswijk 1981, Mumcuoglu 1976, Sesay and Dobson 1972, Wharton 1976, Yoshikawa and Bennett 1979). Little work has been done to determine the areas of the mattress having the greatest mite density. Areas of dust accumulation would provide the most food, but the preferred sites on the mattress are in areas where temperature and humidity fluctuations are minimal (Dusbabek 1979).

The carpet accumulates dust and increases the difficulty of removing dust from the house. This accumulation of dust supports a mite population when the humidity and temperature are suitable. The carpet usually does not have a mite population year round, but during optimal conditions it supports mites that apparently have spilled over from other sites in the house. The most important carpet sites for high mite populations occur in the bedroom and the family room (Bronswijk 1973, Woodford et al. 1979). This study dealt only with dust samples from carpets beside the bed and the mite density levels were of intermediate numbers in comparison to the other sites investigated.

Effects of Environmental Conditions

Many works confirm that environmental conditions within the house have an impact on the mite population represented. The physical conditions within the house, such as construction, heating, ventilation, and personal cleaning habits, affect the environment of the mite population and thus regulate the mite development (Amoli and Cunnington 1977, Bronswijk 1981, Wharton 1976). Most studies discuss factors involved in density regulation, but it should be pointed out that these conditions are indirectly impacting the mites by affecting the conditions of their microhabitats.

Conditions within the house that affect the mite population generally do so by changing the relative humidity or by preventing dust accumulation. Dust accumulation within the house provides a microhabitat for mites that in itself aids in maintaining the humidity of the microclimate. Mite populations continue to increase in the dust as long as food is available and the environmental conditions

are adequate. Cleaning habits that remove dust directly control mite populations, and, while not removing the total population, regular cleaning can keep the number of mites in various sites at a low level.

Limited work provides some regulation of mite density in the bed. Sheet changing lowers the mite population level, and protected dust that filters through the sheets and accumulates on the mattress edge can be removed by vacuuming (Bronswijk 1981). Repeated vacuuming of the mattress for several months can bring the population to an extremely low level (Wharton 1976).

Bronswijk (1973) observed some conditions that affected the mite population size in the sofa. Sofa cleaning habits and the intensity of cleaning can reduce the density of the mite population. In addition, humidity at the sofa site showed a direct correlation to population size. This humidity was changed not only due to seasonal fluctuations, but also by the amount of use and the presence of a sofa covering (Bronswijk 1973).

The carpet is a site of regular cleaning and therefore a partial removal of the mite population often occurs. Shag rugs provide an excellent microhabitat and support a greater mite population than any other floor covering (Arlian et al. 1979). However, carpets of any type respond much more rapidly to the seasonal changes of humidity than the other house sites because of direct exposure to these conditions.

It must be considered, however, that there are a great many uncontrollable factors involved within the house, and it is extremely difficult to target conditions that lead conclusively to an effect on mite populations. The work of Arlian et al. (1979) shows no correlation between mite density and the following conditions: mattress age, mattress use, sofa age, sofa use, bedroom and family room carpet age, sheet change frequency, mattress pad cleaning, house age, and inhabitant's age. The present study also found no conclusive results that the categories of house environmental conditions considered in Table 3 have an effect on mite populations, though the data is limited by the small number of houses sampled. However, in light of the above discussion, it can be postulated that any environmental condition

affecting the humidity or dust accumulation within the mite's microhabitat should influence population size.

Species / Site Associations

Though D. farinae and D. pteronyssinus are found in the same habitat, they do not share very similar niches--in fact their behavior is quite different. Dermatophagoides farinae is found to forage on the surface of the substrate and D. pteronyssinus under the substrate (Wharton 1973 cited in Bronswijk 1981). Competition, therefore, may not dictate in which habitat one species dominates. However, humidity and temperature changes in a collection site may allow one species to do better than the other. Dermatophagoides farinae has a lower critical humidity (the point where it can still absorb water from its environment) than does D. pteronyssinus, and its optimal temperature is also higher (Bronswijk 1981, Arlian et al. 1979). Bronswijk and Sinha (1971) state that D. pteronyssinus is the more cosmopolitan of the two species, but that D. farinae is found in more habitats and is therefore possibly less ecologically specialized. In the Williamsburg area, D. farinae dominates in all the sites examined, but has a larger than expected population in the bed, and a smaller than expected population in the carpet. In contrast D. pteronyssinus has larger populations than expected in the carpet and smaller than expected in the bed. It is possible that this demonstrates a difference in site performance between the two species, but more research is needed to substantiate this.

Density Comparisons

Samples for this study were collected during August at peak population times in an attempt to make a general comparison to other works possible. Due to the lack of standardization in the collection and separation of house dust samples in various surveys, it is difficult to make direct comparisons of mite densities found in this study with the works of others. Therefore the standardized variable "mites per gram of dust" was used to make comparisons with collections from the maximum density sites of other researchers. Table 6 lists the figures from other studies at different locations around the world

Table 6: Comparison of population densities obtained from the literature. Relative comparisons are made using the number of mites per gram of dust. The geographic location, season, and collection sites are given for the below examples.

Location	Mean no. mites/gram	Time Collected	Site	References
United Kingdom:				
London	2568			Wraith et al. 1969
Glasgow	1539		bed	Sesay and Dobson 1972
Birmingham	2960	Aug.-Sept.	bed	Blythe et al. 1974
Switzerland	6000-8000	-	bed	Mumcuoglu 1976
Japan	1054	-	mixed	Oshima 1970
Belgium:				
Neverlee	4293			Gridelet de Saint Georges 1975 cited in Bronswijk 1981
British West Indies: Barbados	2962			Pearson and Cunnington 1973 cited in Bronswijk 1981
U. S. A.:				
Ohio-Dayton Cincinnati	few-3000+	July-Sept.	mixed	Arlian et al. 1979
Ohio-Dayton Cincinnati	2780	July-Sept.		Woodford et al. 1979
Ohio-Columbus	753	summer	mixed	Yoshikawa and Bennett 1979 cited in Broswijk 1981
Tennessee-Knoxville	0-1500		mixed	Shamiyeh et al. 1971
Virginia-Williamsburg	4409	Aug.	bed	present study

to provide relative comparisons of maximum mite densities.

It is interesting to note that though this study is limited to only 22 houses, the mean mite densities in the sofa and bed are extremely high in comparison with other research in the U. S. A. These numbers are exceeded only by the mite densities of Switzerland which range commonly from 6,000 to 8,000 mites per gram (Mumcuoglu 1976). Mumcuoglu speaks of his largest sample being 11,600 mites per gram from an eider insulated garment. This Williamsburg study has seven sites with estimated mite densities greater than the Switzerland sample, and has a mattress sample estimated to contain a population density of 14,500 mites per gram of house dust. However, even this number of mites is small in comparison to the tremendous numbers of mites that can occur in dust samples. Bronswijk (1981) reported a sample of mixed house dust collected in Nigeria with a mite density estimated to be 93,000 mites per gram (Hunponu-Wusu and Somorin 1978 cited in Bronswijk 1981).

CONCLUSION

The common house dust mites, Dermatophagoides farinae and D. pteronyssinus, are the dominant species in the Williamsburg area with D. farinae being the most abundant. The environmental conditions of this area, especially the high humidity, enable mite populations to reach high levels. The mean mite densities of the sofa and bed, 4580 and 4409 respectively, indicate these sites are the locations with the greatest mite densities and that they have population sizes high in comparison to other studies conducted in the United States as well as to other surveys from around the world.

APPENDIX A

Data Table:

The following table lists the data from this work. The data for each house is given in a segment divided into the four sampling sites at that house. The designation of sites within each house is as follows: 1 = Bed, 2 = Carpet, 3 = Sofa, 4 = Pillow. Gram # equals the number of mites found per gram of dust, D.f. = Dermatophagoides farinae, D.p. = Dermatophagoides pteronyssinus, Total # equals the number of mites actually found in the sample, and the section - Total D.f.+D.p. includes immatures that were not identified as to which of the two species they belong. (* = immatures)

(House # 2 was discarded due to inconsistent collection techniques)

House w/ sites	Grams of dust	Total mite #	Total Gram #	Total (+*) D.f.+D.p.	Subsample D.f./ D.p.		Total D.f.#	Total D.f. gram#	Total D.p.#	Total D.p. gram#
1. 1	.07	272	3886	272	56	74	117	1674	155	2212
2	.07	153	2186	151	52	21	108	1537	43	621
3	.07	613	8757	611	97	40	433	6180	178	2549
4	.01	3	300	2	1	0	2	200	0	0
3. 1	.01	39	3900	38	12	0	38	3800	0	0
2	.01	90	9000	89	12	0	89	8900	0	0
3	.08	420	5250	419	126	12	383	4782	36	455
4	.02	12	600	12	1	0	12	600	0	0
4. 1	.06	15	250	15	2	4	5	83	10	167
2	.04	31	775	31	2	19	3	74	28	701
3	.02	188	9400	183	1	25	7	352	176	8798
4	.01	0	0	0	0	0	0	0	0	0
5. 1	.12	446	3717	446	11	12	213	1778	233	1939
2	.27	57	211	57	16	5	43	161	14	50
3	.14	314	2243	309	4	6	124	883	185	1324
4	.01	4	400	4	1	1	2	200	2	200
6. 1	.01	84	8400	84	33	0	84	8400	0	0
2	.01	97	9700	96	38	0	96	9600	0	0
3	.03	293	9767	293	27	3	264	8790	29	977
4	.01	3	300	3(*)	0	0	0	0	0	0

House w/ sites	Grams of dust	Total mite #	Total Gram #	Total (+*) D.f.+D.p.	Subsample D.f./ D.p.		Total D.f.#	Total D.f. gram#	Total D.p.#	Total D.p. gram#
7. 1	.01	43	4300	36	16	5	27	2743	9	857
2	,56	341	609	334	13	12	174	310	160	286
3	.01	64	6400	56	25	6	45	4516	11	1084
4	.01	29	2900	28	3	5	11	1050	17	1750
8. 1	.01	60	6000	58	0	19	0	0	58	5800
2	.03	8	267	7	0	5	0	0	7	233
3	.01	32	3200	27	3	5	10	1013	17	1688
4	.01	8	800	8	0	4	0	0	8	800
9. 1	.10	117	1170	115	26	11	81	808	34	342
2	.12	157	1308	156	17	12	91	762	65	538
3	.01	122	12200	121	13	10	68	6839	53	5261
4	.01	1	100	1(*)	0	0	0	0	0	0
10. 1	.02	290	14500	290	49	1	284	14210	6	290
2	.01	5	500	5	3	0	5	500	0	0
3	.01	23	2300	23	11	1	21	2108	2	192
4	.01	9	900	9	0	2	0	0	9	900
11. 1	.01	7	700	7	3	0	7	700	0	0
2	.11	8	73	8	0	4	0	0	8	73
3	.02	50	2500	47	27	3	42	2115	5	235
4	.01	1	100	1	1	0	1	100	0	0

House w/ sites		Grams of dust	Total mite #	Total Gram #	Total (+*) D.f.+D.p.	Subsample D.f./ D.p.		Total D.f.#	Total D.f. gram#	Total D.p.#	Total D.p. gram#
12.	1	.06	33	550	33	16	2	29	489	4	61
	2	.02	30	1500	30	14	1	28	1400	2	100
	3	.01	147	14700	147	88	0	147	14700	0	0
	4	.01	2	200	2(*)	0	0	0	0	0	0
13.	1	.07	817	11671	800	29	13	552	7891	248	3537
	2	.01	58	5800	57	4	15	12	1200	45	4500
	3	.11	247	2246	234	30	9	180	1636	54	491
	4	.01	7	700	6	0	1	0	0	6	600
14.	1	.01	141	14100	141	28	0	141	14100	0	0
	2	.08	248	3100	248	55	0	248	3100	0	0
	3	.01	32	3200	32	17	0	32	3200	0	0
	4	.01	3	300	3	2	0	3	300	0	0
15.	1	.02	99	4950	97	7	57	11	531	86	4320
	2	.01	11	1100	9	0	4	0	0	9	900
	3	.03	0	0	0	0	0	0	0	0	0
	4	.01	1	100	1	0	1	0	0	1	100
16.	1	.13	988	7600	978	44	2	935	7196	43	327
	2	.07	75	1071	75	27	0	75	1071	0	0
	3	.02	113	5650	111	13	1	103	5154	8	396
	4	.01	40	4000	40	12	1	37	3692	3	308

House w/	sites	Grams of dust	Total mite #	Total Gram #	Total(+*) D.f.+D.p.	Subsample D,f./	D.p.	Total D.f.#	Total D.f. gram#	Total D.p.#	Total D.p.gram#
17.	1	.13	93	715	93	42	0	93	715	0	0
	2	.02	9	450	9	4	1	7	360	2	90
	3	.10	255	2550	255	26	2	237	2368	18	182
	4	.02	3	150	3(*)	0	0	0	0	0	0
18	1	.01	43	4300	3	0	2	0	0	3	300
	2	.03	27	900	26	3	13	5	163	21	704
	3	.01	88	8800	84	1	45	2	183	82	8217
	4	.01	0	0	0	0	0	0	0	0	0
19.	1	.01	121	12100	120	42	13	92	9164	28	2836
	2	.06	40	667	40	9	13	16	273	24	394
	3	.07	179	2557	162	48	13	127	1821	35	493
	4	.01	10	1000	10	0	3	0	0	10	1000
20.	1	.02	274	13700	272	41	11	214	10723	58	2877
	2	.02	114	5700	108	5	37	13	643	95	4757
	3	.01	68	6800	68	4	22	11	1046	57	5754
	4	.01	7	700	7	1	2	2	233	5	467
21.	1	.03	34	1133	30	14	11	17	560	13	440
	2	.18	53	294	49	1	38	1	7	48	265
	3	.02	86	4300	84	40	6	73	3652	11	548
	4	.01	7	700	4	0	4	0	0	4	400

House w/ sites	Grams of dust	Total mite #	Total Gram #	Total (+*) D.f.+D.p.	Subsample D.f./ D.p.		Total D.f.#	Total D.f. gram#	Total D.p.#	Total D.p. gram#
22. 1	.06	76	1267	74	25	2	69	1142	5	91
2	.07	8	114	8	4	0	8	114	0	0
3	.17	50	294	49	24	0	49	288	0	0
4	.01	2	200	2(*)	0	0	0	0	0	0
23. 1	.01	22	2200	18	8	2	14	1440	4	360
2	.05	78	1560	78	16	12	45	891	33	669
3	.01	54	5400	50	13	12	26	2600	24	2400
4	.01	5	500	5	1	0	5	500	0	0

APPENDIX B

House Conditional Effects:

The probability of house conditions not influencing the mite population is considered in the following table using both the data for the total mites found per sample, and the number of mites found per gram of dust. Specified comparisons of the house conditions are listed in the column titled "Comparison Groupings". An analysis of variance was used to test for differences.

House Conditional Effects:

House Condition	Comparison Groupings	Number of Houses w/ the condition	# of mites per sample			# of mites per gram		
			Prob.	Mean	Conf. int.	Prob.	Mean ($X 10^2$)	Conf. int. ($X 10^2$)
Mattress Age	less/=10 yrs.	13	0.10	85.5	47.0-135.3	0.95	44.6	21.3-76.4
	greater/10	9		217.6	45.5-517.9		43.4	14.8-87.0
Bed Use	less/= 8 yrs.	16	0.17	102.1	52.8-167.5	0.25	37.4	18.1-63.8
	greater/8	6		231.6	9.1-752.1		64.5	25.3-121.8
Sheet Change	1 a wk.	16	0.22	105.2	55.6-170.6	0.85	43.0	20.4-72.2
	less/1 a wk.	6		219.1	5.23-746.3		47.1	14.6-98.2
Mattress Cleaning	not cleaned	9	0.46	100.3	31.3-208.2	0.09	26.8	7.5-57.8
	cleaned/turned	13		156.9	52.4-317.3		58.6	32.3-92.8
Bed Made	within ½ hr.	9	0.81	121.5	33.5-264.3	0.83	41.6	12.0-89.3
	greater/ ½ hr.	13		139.9	45.8-285.2		45.8	23.7-75.3
Carpet Type	tight pile	9	0.40	45.5	16.6-88.5	0.99	14.7	4.3-31.5
	shag	13		70.3	29.3-128.9		14.7	4.5-31.4
Carpet Cleaning	1 + a wk.	11	0.77	64.0	21.8-128.2	0.38	11.2	3.0-24.9
	less/ 1 a wk.	11		55.2	23.0-101.2		18.9	6.1-38.8

House Condition	Comparison Groupings	Number of Houses w/ the condition	# of mites per sample			# of mites per gram		
			Prob.	Mean	Conf.int.	Prob.	Mean ($X 10^2$)	Conf. int. ($X 10^2$)
Sofa Age	less/= 5 yrs.	9	0.30	92.9	16.4-232.2	0.15	32.4	13.4-59.7
	greater/5	13		150.8	93.1-222.4		56.4	32.9-86.3
Sofa Use	less/ 5 hrs./day	11	0.23	94.3	42.8-165.9	0.01	28.2	10.4-50.4
	greater/=5/day	11		161.1	69.8-290.1		67.6	43.3-97.4
Sofa Cleaning	not cleaned	5	0.91	119.9	13.4-332.7	0.64	53.6	14.6-117.1
	cleaned	17		127.1	68.2-204.2		43.6	25.7-66.4

APPENDIX C

Questionnaire Summary:

The questionnaire data are summarized in the following tables. The data are coded and the column - "Information Code" explains the data compilation. An asteric (*) is placed by the catagories used in tests for conditional affects on mite populations in the paper (Table 3).

Questionnarie Summary

Catagories of Questionnaire	House Number (1-12) 1	3	4	5	6	7	8	9	10	11	12	Information Code
Age of House	8	17	40	10	8	16	18	6	15	14	15	Actual age in years
Residence	8	17	40	9	8	10	2	6	3	14	6	Years of residence
Type of Heat	1*	1	2	4	1	4	2*	3	2*	2	2	1)electric, 2)oil, 3)heat pump 4)natural gas *add wood
Air Conditioner	2	2	2	2	2	2	2	2	2	2	1	1) no 2) yes
Pets (Dogs/Cats)	2	1	1	1	2	1	1	2	2	1	1	1) no 2) yes
*Mattress Age	20	9	18	15	6	8	20	8	9	17	6	Actual age in years
*Bed Use	1	1	1	1	1	2	2	1	1	1	1	1)less than or = 8 hrs. /day 2)greater than 8 hrs. / day
Mattress Cover	2	2	2	2	2	2	1	2	1	2	1	1)not cleaned 2)cleaned *plastic
Bed Coverings	3	2	3	3	3	3	3	3*	3	3*	3	1)one 2)two 3)greater than 2 *with electric blanket
*Sheet Change	1	1	1	1	1	2	2	1	1	1	1	1)once a wk. 2)less than 1 a wk.
*Mattress Cleaning	1	2	2	1	2	2	1	2	2	1	1	1)not cleaned 2)cleaned/turned
*Bed Made	1	1	1	1	1	2	2	2	1	1	1	1)within ½ hr. 2)greater/=½hr.
*Carpet Type	2	2	2	2	2	2	1	1	2	2	1	1)tight pile 2)shag
*Carpet Cleaning	1	2	1	1	1	1	2	1	1	1	1	1)1+ a wk. 2)less than 1/wk.
*Sofa Age	5	18	25	13	7	8	5	8	3	13	6	Actual age in years
*Sofa Use	2	2	1	2	2*	2*	2*	2*	2	1	2*	1)less than 5hr. 2)greater than or = 5 hr. /day * slept on
*Sofa Cleaning	2	1	2	2	2	2	1	2	2	1	1	1)not cleaned 2)cleaned

Questionnaire Summary

Catagories of Questionnaire	House Number (13 - 23)											Information Code
	13	14	15	16	17	18	19	20	21	22	23	
Age of House	26	7	11	30	-	12	20	5	8	20	20	Actual age in years
Residence	25	7	11	12	4	12	5	5	8	5	13	Years of residence
Type of Heat	2	3	1	4	1	4	2	3*	1	4	1	1)electric, 2)oil, 3)heat pump 4)natural gas *add wood
Air Conditioner	2	2	2	2	2	2	1	2	2	2	2	1) no 2) yes
Pets	1	1	1	2	1	1	2	1	1	2	1	1) no 2) yes
*Mattress Age	25	14	10	15	8	6	10	9	8	30	10	Actual age in years
*Bed Use	2	1	1	2	1	1	2	1	2	1	1	1)less than or = 8 hrs. /day 2)greater than 8 hrs./day
Mattress Cover	2	1	2	2	2	2	2	2	1*	2	2	1)not cleaned 2)cleaned *plastic
Bed Coverings	2	3*	3	3	3*	2*	3	3	3	3*	3	1)one 2)two 3)greater than 2 *with electric blanket
*Sheet Change	2	1	1	2	2	1	1	1	1	1	2	1)once a wk. 2)less than 1 a wk.
*Mattress Cleaning	2	1	2	2	1	2	2	2	1	1	2	1)not cleaned 2)cleaned/turned
*Bed Made	2	2	2	2	2	2	2	1	2	2	2	1)within ½ hr. 2)greater/=½hr.
*Carpet Type	1	2	1	1	2	2	1	1	2	1	2	1)tight pile 2)shag
*Carpet Cleaning	2	2	1	2	2	2	2	2	1	2	2	1)1+ a wk. 2)less than 1/wk.
*Sofa Age	6	4	3	15	4	7	5	5	10	25	5	Actual age in years
*Sofa Use	1*	1*	1	1	1*	2	1*	2	1*	1	1	1)less than 5hr. 2)greater than /= 5 hr./day *slept on
*Sofa Cleaning	2	2	2	2	2	2	2	2	1	2	2	1)not cleaned 2)cleaned

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