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The Control of House Dust Mites by Ventilation: A Pilot Study.

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1 Synopsis

The house dust mite inhabits bedding and soft furnishings in homes. It is implicated as a major cause of allergic asthma. Maintenance of indoor humidity below a level of 7 g/kg inhibits the growth of the mite population. A pilot survey was carried out by EA Technology in cooperation with the Building Research Establishment to investigate the effect of mechanical ventilation with heat recovery (MVHR) both on indoor humidity and mite abundances.

The temperature and humidity in the main bedroom of 11 dwellings were measured over a period of 1 month in February 1992, and dust samples taken from living and bedroom carpets and mattresses. Bedrooms in houses with continuously operating MVHR showed significantly lower humidities and significantly lower levels of mite concentration in dust taken from the bedroom carpet, when compared with similar houses where the MVHR was not continuously operated.

The results of the survey support the proposition that the use of MVHR in the British climate can act as an effective means of control of house dust mites. In view of the small sample size, confirmation using a larger sample is desirable.

2 House dust mites and asthma

The incidence of asthma is widespread in many parts of the world. In the UK more than two million people are diagnosed as asthmatic, with 1 in 10 children suffering at one time from the disease. The incidence of asthma show a steady increase. The commonest allergen causing asthma in the UK is the house dust mite. The main problem of allergy is caused not by the mites themselves, but by their faecal pellets. Because of the need to preserve water, mites produce no urine, and their excreta are produced in a dry form. The prime allergen contained in the pellets is termed Der p1. Experimental methods of assessing level of mite population in household dust are described by Colloff [1]. A WHO working party [2] recommended provisional standards for mite concentration in household dust:

	Sensitisation	Acute risk
Allergen (ug Der p1/100 mg dust)	0.2	1.0
Mites (mites/100 mg dust)	10	50

Exposure to a level of less than 10 mites/100 mg dust means that an individual has a low risk of sensitisation and development of asthma. Exposure to the higher level of 50 mites/100 mg dust means that an already sensitised individual has a risk of developing acute asthma.

3 Ecology of the house dust mite

The term house dust mite is applied to several related species of the family pyroglyphidae. The predominant species in the UK is Dermatophagoides Pteronyssinus, and this is normally implied when the term house dust mite is used [3]. The mite is about 0.35 mm long, and is invisible to the naked eye. It is widely, if not universally distributed in the UK, where it inhabits soft furnishings, carpets, cushions and soft toys. Above all, it is to be found in mattresses and bedding, where the combination of warmth, humidity and a ready supply of food provide an ideal environment.

The primary source of food for the mite is human skin. Human skin scale forms the primary constituent of house dust, giving its characteristic grey colour. The mite lives in an environment where there is no liquid water available and moisture balance is critical to its survival. Laboratory studies show that the optimum conditions for mites are 25°C and 80% RH. Lowering the humidity has an adverse effect on mite population.

Many surveys have demonstrated a general relation between humidity and mite population. Houses in low lying areas near rivers have more mites, while houses at high altitudes, where the humidity is low, are virtually mite free. There is also a seasonal variation in mite population, which is lowest in late winter and spring ie at the end of the period when indoor humidities are at their lowest. Korsgaard [4] investigated the relation between humidity and mites in 50 Danish apartments over one year. Those apartments with low winter indoor humidities had low mite counts; these low concentrations were maintained throughout the summer and autumn, even though the indoor humidity inevitably rose. Hart and Whitehead [5] surveyed dust mites in 30 homes in Oxfordshire and found bedroom humidity to be the most important variable affecting mite numbers. Schober [6] surveyed 11 living rooms in the Netherlands and concluded that mite levels stayed below the hygienic level if the absolute indoor humidity did not exceed 7.1 g/kg. Recent work in France [7] concluded that few mites can develop if the internal humidity is below the value of 7 g/kg. There are thus several studies linking dust mite abundances with humidity in climates similar to that of the UK; the studies support the WHO finding that indoor humidities below 7 g/kg will inhibit the growth of mite populations.

4 Control by Ventilation

The humidity in a room is determined by the dynamic equilibrium between moisture production and loss by ventilation. In winter the outdoor temperature, and hence outdoor moisture content, is low. However, many people restrict ventilation during cold weather, allowing the indoor humidity to increase, thus favouring an increase in house dust mites. The use of mechanical ventilation with heat recovery allows ventilation to be maintained with comfort and economy and offers a practical means of dust mite control.

There are as yet few studies relating the use of mechanical ventilation directly to indoor humidity and dust mite populations. Korsgaard [8] reports an experiment in which mechanical ventilation with heat recovery units were installed in eight houses and compared with a control group. Mite concentrations fell in the experimental houses following the installation of MVHR; concentrations in mattress dust were reduced by two thirds. An investigation was carried out in Denmark as part of a healthy building project [9]. Relatively high air exchange rates of 1.3 air changes per hour were used. Humidities fell significantly, and 11 out of 16 families registered total disappearance of

mites from old mattresses. Significant improvements in health were found, both in subjective feelings and in objective clinical measures. The improvement was highly correlated with changes in house dust mite counts. The study concluded that the high ventilation rate due to mechanical ventilation was the major cause of low indoor humidity and thus to the disappearance of the house dust mites in 11 of 16 families.

5 Objectives of Pilot Survey

A pilot survey was set up during the 1991/92 winter to test the hypothesis that MVHR during cold weather would reduce indoor humidities by an amount sufficient to inhibit the mite population; a secondary objective was to gain experience in measurements techniques, since it was anticipated that a larger survey would subsequently be required. The survey was carried out in association with the Timber Division of the Building Research Establishment. EA Technology organised the houses to be studied and provided the temperature recording apparatus. BRE carried out the house visits and dust sampling and arranged for the dust samples to be analysed.

6 The survey

6.1 Organisation

The Electricity Industry in the UK promotes all-electric housing under the specifications Medallion and Medallion 2000. Medallion 2000 houses are required to be fitted with Mechanical Ventilation with Heat recovery (MVHR). Regional Electricity Companies were asked to cooperate by providing addresses of suitable houses, and houses in South Wales Electricity area were selected. Occupants were contacted by letter and asked if they were willing to take part in the survey; the purpose of the survey was explained to them. Usable results were obtained from 8 houses fitted with MVHR and 3 houses without.

Each house was visited twice, with approximately four weeks between visits. On the first occasion a simple questionnaire established basic details about the house. Dust samples were taken from three sites: living room floor, bedroom floor and main bedroom mattress. A small data logger was left in the main bedroom to record temperature and humidity. On the second visit, further dust samples were taken from the same sites, the data logger removed and a second questionnaire administered.

6.2 Measurements

Temperature and humidity were recorded in the main (occupied) bedroom using a Squirrel logger, set to record a pair of measurements every 30 minutes. Air temperature and RH were measured by a Vaisala transmitter HMW 30 YB. Temperature and humidity records were obtained from the Met Office weather station at Cardiff, some 20 miles from the houses. Dust samples were collected using a small vacuum cleaner fitted with a special sampling head, dimension 14 x 3 cm. Dust was collected on a cellulose filter and kept in a polyethylene bag before sending for analysis. The sampling technique was to continuously vacuum an area of 100 x 100 cm of the carpet, or 60 x 60 cm of the mattress over a period of two minutes. The identical area was sampled on the second visit. Sampling was carried out by an experienced worker from BRE, who had carried out previous dust mite surveys in homes.

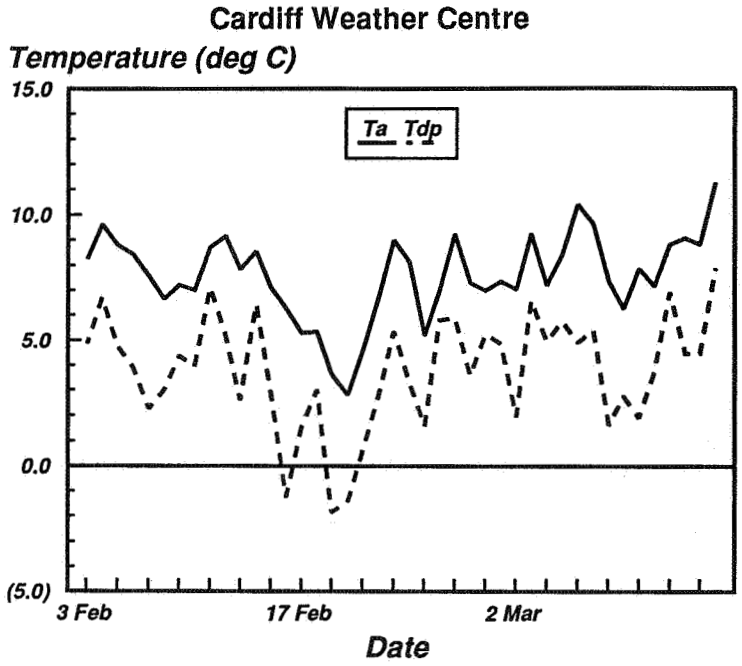

Figure 1. Variation of daily mean air temperature and dew point measured at the Cardiff weather centre during the period of the survey.

Table 1. Mean Air and Dew Point Temperatures

Group	Code	Means over month Ta	Tdp	g/kg
A	1	17.8	6.6	6.0
	2	17.6	6.6	6.0
	10	18.9	5.8	5.7
	11	19.9	7.	
	Mean over group	18.6	6.5	5.9
B	3	19.8	9.9	7.5
	4	17.4	6.4	5.9
	5	20.2	7.8	6.5
	9	17.4	8.1	6.6
	Mean over group	18.7	8.1	6.6
C	6	16.6	7.4	6.3
	7	18.4	7.9	6.5
	8	19.5	9.5	7.3
	Mean over group	18.2	8.3	6.7

Measurement intervals were 26 or 29 days, within period 1 February to 10 March 1992.

Humidities differ significantly between Groups A and B. $P<0.05$ on a one tailed t test. one tailed t test.

The dust samples were sent to the Scottish Agriculture Science Agency at East Craigs, Edinburgh for analysis. Analysis of the dust was carried out by flotation and staining of the mites [9]. Results are quoted in mites per 100 mg of dust. Mite species were identified and mites were classified as alive or dead at the time of sampling on the basis of the intactness of the body.

7 Results

7.1 Questionnaires

Two questionnaires were administered. The first asked for general information about house type and occupancy; the second questionnaire was administered during the second visit and asked about conditions in the house during the experimental period. House type varied from 4 bedroom house to 2 bedroom flat. The MVHR systems fitted are designed to be used 24 h per day. It was found that use was varied. The respondents were classified into three groups:

A	MVHR used continuously	4 dwellings
B	MVHR fitted, not used continuously	4 dwellings
C	No MVHR	3 flats

Respondents were asked to score the atmosphere in their house on two seven point scales marked "Stuffy/Fresh" and "Dry/Humid". Statistical tests found no significant difference between the groups. The flats in Group C were all about one year old, while those in Groups A and B were about 3 years old.

7.2 Temperature and Humidity

The water vapour content of air may be expressed as relative humidity (RH) or as the absolute water content. It is the absolute water content which is the parameter which is the primary influence on house dust mite viability. It may be expressed as the dew point Tdp or as the moisture content in g/kg. Figure 1 shows the daily external air temperatures and humidities for the duration of the measurement period.

Table 1 summarises the mean bedroom air temperatures and humidities averaged over the experimental period. The mean temperatures ranged from 17.4 to 20.2°C. The mean temperatures for the three groups were similar. The humidity for group A was lower than the two unventilated groups B and C. Humidity in Group A tested significantly lower than in Group B using a one tailed t test ($P<0.05$).

7.3 Dust mites

Table 2 shows the sample analysis received from SAS at Edinburgh. The overwhelming majority of mites were Dermatophagoides Pteronyssimus, which is the species implicated in the production of allergens. A $\log(1+x)$ transformation has been used for analysis. In effect it produces a geometric mean of the values; the addition of 1 is to cope with samples with zero counts. Values of mite concentrations in the tables are given as

Table 2. Results of Mite Analysis

Counts expressed as mites per 100 mg of dust.
Counts transformed as log (1 + x)

	Code	First round			Second round		
		LR1	BR1	MAT1	LR2	BR2	MAT2
Group A	1	0.681	0.531	0.000	0.342	0.342	1.164
	2	1.736	0.756	0.491	2.119	1.086	2.425
	10	1.068	1.164	2.448	1.571	1.567	1.555
	11	0.886	1.182	1.447	0.613	1.522	0.708
	Mean	1.093	0.908	1.097	1.161	1.130	1.463
Group B	3	0.716	2.103	1.489	1.199	miss	1.301
	4	1.238	1.787	0.000	0.633	1.344	2.022
	5	2.343	2.691	3.116	2.312	2.915	2.774
	9	1.369	2.390	1.220	0.806	1.996	1.504
	Mean	1.417	2.243	1.456	1.237	2.085	1.900
Group C	6	0.663	0.892	0.591	1.623	1.233	2.108
	7	0.000	0.851	0.447	0.079	0.279	1.164
	8	0.982	1.898	1.061	1.623	1.470	0.000
	Mean	0.548	1.214	0.700	1.109	0.994	1.091

LR Living room; BR Bedroom; MAT mattress.

Mite concentrations in bedroom dust samples were significantly lower in Group A than in Group B ($P<0.01$, 1 tail t test)

Geometric mean concentrations:

Group A bedrooms 9.4 mites/100 mg dust
Group B bedrooms 144 mites/100 mg dust

Table 3. Correlation between first and second samples

Living room carpet	$c2 = 0.27 + 0.85\ c1$.	$r^2 = 0.51$. $n = 11$
Bedroom carpet	$c2 = 0.12 = 0.89\ c1$.	$r^2 = 0.74$. $n = 11$
Mattress	$c2 = 0.42 + 0.56\ c1$.	$r^2 = 0.44$. $n = 7$

c1 and c2 are the mite concentrations in the first and second samples, log (1 + x) transform used. Turned mattresses excluded from analysis.

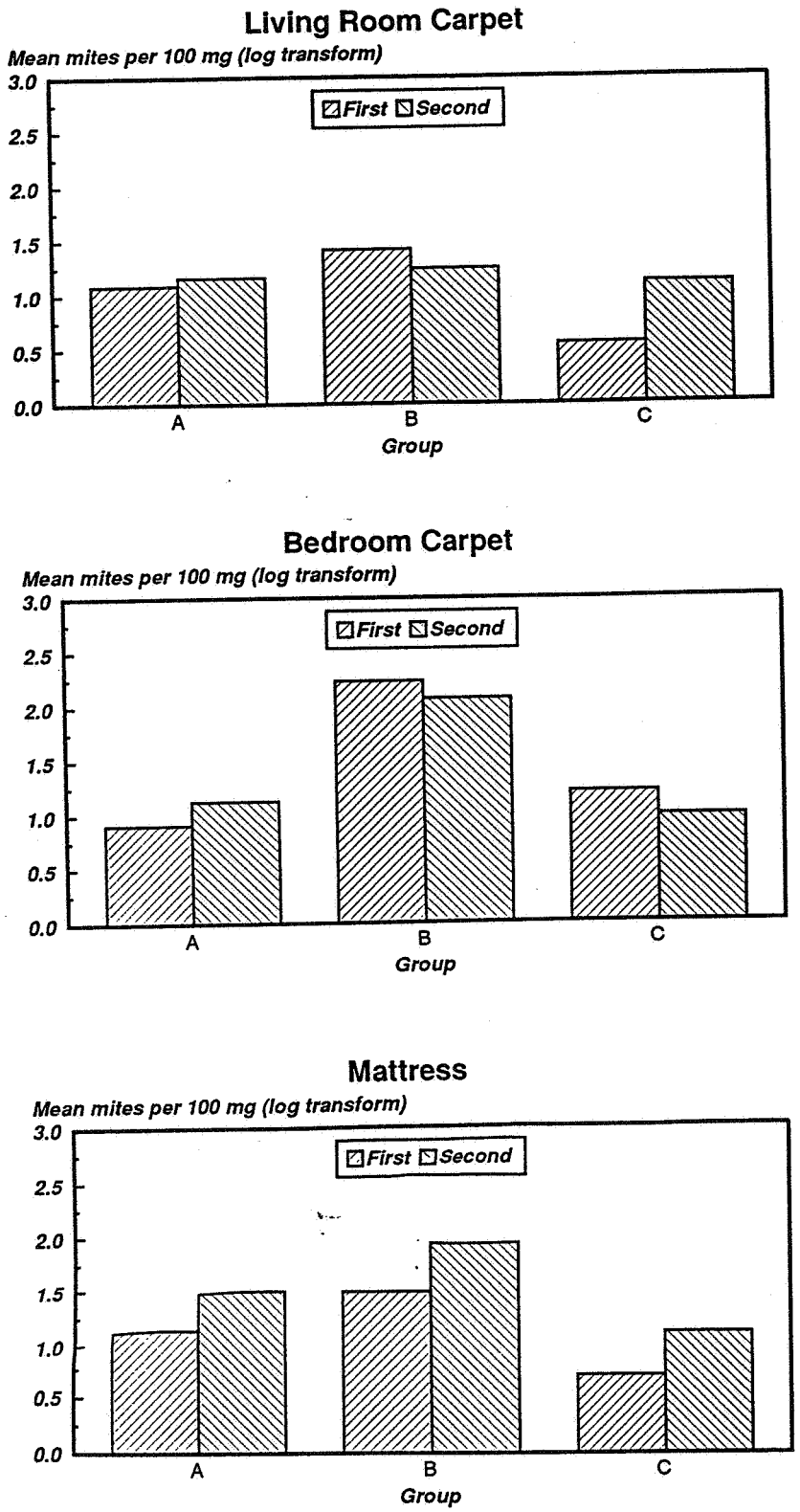

Figure 2. Mean mite counts shown by experimental group. The mite counts for the bedroom carpet in Group B (MVHR not used) are significantly higher than the counts in Group A (continuous MVHR). Group C houses had new carpets with a consequent low mite count.

transformed values. The transformed value of 0 corresponds to 0 mites per 100 mg of dust, 1 to 9, 2 to 99 and 3 to 999.

The repetition of sampling within a four week period served as a check of the sampling and analysis techniques. No changes were made to the environment of the mites during the experimental period so there was no reason to expect any systematic change in abundance. Table 3 shows the correlation within sample site between the first and second dust analysis. The agreement between measurement at the two carpet sites shows reasonably good agreement, which is typical of the reliability found with this technique. Comparison of first and second samples for the mattresses showed initially no correlation at all. The householders were asked if the mattress had been turned between visits. When turned mattresses were eliminated, the correlation improved, though still worse than the carpet sites.

Figure 2 shows the mean log concentration of mites for the different sites, by experimental group and divided by first and second measurements. The mattress measurements have been included for completeness, though as observed above the variation in results makes it impossible to draw reliable conclusions. The results for the living room carpet show that the samples from Groups A and B have similar abundances, while the samples from Group C showed lower counts; the carpets in Group C were under 1 year old. The mite counts in the bedroom carpets were found to be significantly higher in Group B than in Group A, using a one tail t test ($P<0.01$, 6 df). Again, the counts in Group C with new carpets were lower than in B, even though the dew points were comparable.

7.4 Analysis

The mean absolute humidity in Group A bedrooms over the measured period was 5.9 g/kg, which is lower than the 7.0 k/kg suggested by the WHO working party as the critical value above which mites will proliferate. The control group B had a mean humidity of 6.7 g/kg, close to the critical value. The geometric mean mite concentrations in the bedroom carpets were 9.5 in Group A, and 147 mites/100 mg of dust in Group B. The houses with MVHR thus had a mite concentration in the bedroom carpet dust of below the 10 mites/100 mg level recommended by the WHO as below the level at which sensitisation occurs. The Group B level was above the 100 mites/100 mg dust suggested by the WHO as significantly increasing the likelihood of acute asthma. The low levels of mites in Group C has been considered as of little consequence, notwithstanding the higher humidity levels. The carpets in the these houses were all less than one year old, and we would not expect to find high levels of mites.

The relation between bedroom humidity and the dust mite abundance in the bedroom carpet dust are thus in agreement with the hypothesis that MVHR will reduce internal humidity levels, and that dust mite abundance will be reduced by a humidity level below 7 g/kg. Both these findings were statistically significant.

8 Discussion

This study confirmed the expectation that the use of MVHR would reduce house dust mite abundance. It did this for the population in the bedroom carpet, which was the room in which the humidity was measured. The mites in the living room carpet did not show a significant difference between groups; humidity was not measured in this room.

Bedrooms are normally considered the more sensitive site, because of the more favourable conditions for mite growth, of temperature humidity and food supply. The measurements of mites in mattresses proved unreliable. Work is required to establish satisfactory experimental methods before moving on to a larger survey.

The study was designed as a pilot survey and has successfully fulfilled its objectives in giving lessons for a larger survey. The eight houses included in the analysis, although showing significant differences in mite populations, can not be considered a large enough sample to prove an unarguable case for MVHR. It is clear that many variables affect dust mite populations; either these variables must be controlled in an experiment, or the sample must be large enough to ensure randomisation of confounding variables. The intended comparison between MVHR and non-MVHR houses was rendered void by the fact that all the Group C (non MVHR) houses had new carpets.

More work is now needed to confirm the results with a larger sample and to include the effect of ventilation rates, which were not measured in this study. The findings also need to be related to local climatic conditions to establish the geographic applicability of this technique of mite control.

9 Conclusions

The use of mechanical ventilation with heat recovery, used continuously, reduced humidity measured in the bedroom below that in a similar group of houses where the MVHR was not used continuously.

The abundance of house dust mites in the bedroom carpets of the houses with continuous MVHR was significantly lower than the houses with non-continuous MVHR. In the first case the level was below that considered to present a risk of sensitisation to the mite allergen.

The sampling and analysis technique employed did not give reproducible results on mattresses.

Over 85% of the mites were Dermatophagoides Pteronyssimus, which is the species implicated in the causation of allergic asthma.

Additional work, using improved sampling techniques and a larger sample of houses, is necessary to consolidate these findings.

10 Acknowledgements

This project was carried out in association with Dr C A Hunter of the Timber Division, Building Research Establishment, who was responsible for the collection and analysis of the dust samples.

The mite analysis was carried out by Mr I G Jeffrey of the Scottish Agricultural Science Agency, East Craigs, Edinburgh. Additional analysis was done by Dr J Korsgaard of Aarhus, Denmark.

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