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The control of house dust mites in rugs through wet cleaning

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Nine rugs from the bedrooms of seven private homes were cut into strips. Half of the strips were wet-cleaned according to a commercial procedure, and the others were kept as controls. Subsequently the cleaned and noncleaned strips were stitched together again and returned to their respective bedrooms. After 0, 1, and 3 months, parts of the strips were taken to the laboratory for tests. The tests were designed to measure the suitability of the rugs as a habitat for house dust mites. To do this, a number of house dust mites were introduced into fragments of the rugs, and the number of survivors and offspring after 4 weeks was determined. Immediately after cleaning, the habitat was markedly less suitable than before. After 1 month, the habitat suitability was partly but not totally recovered. After 3 months, no effect of cleaning could be discerned. (J Allergy Clin Immunol 1996;97:1214-7.)

Key words: *House dust mites, house dust allergy,* Dermatophagoides, *rugs*

The importance of house dust mites (HDMs) in connection with house dust allergy is well known. Clinical studies have indicated, sometimes quite convincingly, that the reduction of HDM allergens in homes can be beneficial for patients with allergy, particularly patients with asthma.[1-5] HDM-sensitive patients with allergy are often advised to replace any fixed wall-to-wall carpets in their homes with a smooth type of floor. Once this has been done, the contribution of rugs as a source of HDM allergens in the home becomes relatively more important. Like fixed carpets, rugs collect allergen-containing dust.[6-8] It has also been shown that rugs constitute a suitable habitat for HDMs.[6, 9] A rug from the living room floor of a Dutch home was found to contain more than 10,000 mites/m^2 in early April.[9] Presumably, these mites survived the unfavorable winter conditions in this rug. It can be expected that suppression of the reproduction of these mites will strongly reduce the increase in HDM allergen concentration, which is usually observed in the spring and early summer.[10, 11]

In contrast to fixed carpets, rugs can be taken out to be cleaned. The effect of wet cleaning on HDMs and HDM allergens has been studied previously.[6] Roughly 50% of the allergens were removed. Most of the mites survived the treatment. However, the suitability of the rug as a habitat for HDMs was very much affected. Introduced mites thrived much better in fragments taken from rugs before cleaning than in comparable fragments taken after cleaning. Presumably, this is the consequence of the removal of food for the mites. It follows that wet cleaning may result, indirectly, in a significant long-term reduction in HDM allergen concentrations. Whether this is really the case depends largely on the time that is required for the habitat to become more suitable for HDMs again. The experiments described in this article were designed to determine the time it takes for a wet-cleaned rug to recover habitat suitability for HDMs after it has been returned to the home.

Abbreviation used
HDM: House dust mite

METHODS

Processing of rugs

Rugs, which were in normal use, were taken from the bedrooms of seven private homes in Amsterdam (3), Werkhoven (1), Bilthoven (1), Purmerend (1), and Almere (1), all in The Netherlands, during the month of June 1992 and cut into strips of 7 cm or more wide.

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TABLE I. Overview of rugs

Rug no.	Home	Type	Material	Thickness (mm)	Weight (kg/m^2)	Age (yr)	Vacuuming (times/wk)	Beating (times/wk)	Total no. of mites in controls
I	A	Pile on canvas	Synthetic	8.0	1.7	8	1.0	1.0	2180
II	B	Pile	Cotton	3.5	0.8	30	0	1.0	432
III	C	Pile	Synthetic	9.0	1.9	20	1.0	0	1720
IV	D	Pile on canvas	Synthetic	6.0	1.1	4	1.0	0	1692
V	E	Pile on foam	Synthetic	7.0	1.7	2	1.0	0	3393
VI	F	Pile	Wool	21.0	1.7	15	3.0	.5	1462
VII	G	Woven	Cotton	6.0	1.0	5	2.5	2.5	274
VIII	G	Woven	Cotton	6.0	1.2	1.5	2.5	2.5	197
IX	G	Woven	Cotton	5.5	1.3	5	1.0	1.0	1903

Strips were sequentially numbered. If even-numbered strips were wet-cleaned, the odd-numbered ones were kept as untreated controls and vice versa. The experimental strips were commercially cleaned according to a standard procedure, as described previously in detail.[6] Briefly, a solution at room temperature, containing one part of Tapisannass (Vorwerk & Co., Teppichwerke, Hameln, Germany) in 100 parts of water, was rubbed into the carpet strips for approximately 1 minute by rotating brushes. Then the detergents were washed out with plenty of cold water. Subsequently, the strips passed through a mangle, which removed about 75% of the water, and were hung to dry overnight in an aired room that was heated to about 25° C.

After cleaning, a portion of each rug, constituting two thirds of the total surface, was remade by stitching the strips together in their previous positions. A clean piece of cloth was used as backing. The then partially restored rug was subsequently placed in its former position in the bedroom. The remaining strips were stored in tightly closed plastic bags at −20° C (time: t_0). After 1 month, that is in July, half of the strips from each restored rug (i.e., one third of the original rug) were taken off and also stored at −20° C (time: t_1 = 1 month). After another 2 months, that is in September, the remaining portion of the restored rug was put into the refrigerator at −20° C (time: t_2 = 3 months). Freezing is needed, not only to conserve the condition of the rug, but also to kill any natural mite population that may be present.[6]

Determination of habitat suitability

Because the sides of cleaned and noncleaned strips had been in contact for 1 (t_1) or 3 (t_2) months, a zone of 1 cm wide was removed from each side before the tests were done. Eighty cultured *Dermatophagoides pteronyssinus* mites of various ages were placed on each fragment by using a fine brush. One cleaned fragment and one adjacent control fragment were simultaneously loaded with mites by transferring groups of five mites alternately to each fragment. This way, undesired systematic differences between cleaned and uncleaned fragments were avoided, and the data can be treated statistically as paired observations (e.g., in the Wilcoxon signed-rank test). To avoid contamination of the fragments with food from the culture medium, an amount of mite culture was first spread out in a Petri dish and placed on a slide warmer at 40° C. After about 15 to 30 minutes, large numbers of clean mites could be picked up from the rim of the Petri dish. The fragments with introduced mites were separately wrapped in dust bags and stored in a climate-controlled room at 25° C and 75% relative humidity. After 4 weeks of incubation, an indication of the number of live mites in each fragment was obtained by using the heat escape method.[12, 13]

The experiments were completed in six independent and totally equivalent series (replicates), each one comprising one pair of fragments from each rug and each time interval t_0, t_1, and t_2.

Statistical evaluation

The distribution of the natural logs of the numbers of mites in the controls resembled a normal distribution, but the variance within groups of replicates was quite different in some cases. A two-way analysis of variance was performed on the controls, but the findings were checked with a nonparametric technique whenever possible.

For each pair of fragments, we calculated $E = (N_{cleaned} + 1)/(N_{control} + 1)$, where $N_{cleaned}$ is the number of mites recovered from the cleaned fragment and $N_{control}$ is the number of mites recovered from the corresponding control fragment. The distribution of E, and also that of lnE, differed quite strongly from the corresponding normal distribution.

RESULTS AND DISCUSSION

The noncleaned controls

The numbers of mites recovered from the noncleaned fragments were very different for the various rugs (Kruskal-Wallis test, $p < 0.001$, $df = 8$). It is perhaps no coincidence that the highest total number was recovered from the only rug with a foam back (Table I). Vacuum cleaning must be less effective in this rug, which does not allow the air flow to go through it. The habitat suitability was

TABLE II. Average ($n = 6$) values of $E = (N_{cleaned} + 1)/(N_{control} + 1)$*

Time after cleaning (mo)	Rug								
	I	II	III	IV	V	VI	VII	VIII	IX
0	0.307†	0.437‡	0.348§	0.413†	0.246†	0.313†	0.877‡	1.06‡	0.326§
1	0.499†	1.23‡	0.579§	1.39‡	0.909‡	0.678‡	0.761§	1.31‡	1.69‡
3	1.54‡	1.31‡	0.441§	1.76‡	1.26‡	2.93‡	1.70‡	1.27‡	1.03‡

*$N_{cleaned}$ = number of live mites recovered from the cleaned fragments after 4 weeks of incubation; $N_{control}$ = number of live mites recovered from the equivalent uncleaned control fragments after 4 weeks of incubation. The significance of the difference between $N_{cleaned}$ and $N_{control}$ was tested with the Wilcoxon signed-rank test.
†$p \approx 0.05$, two-sided.
‡p = not significant.
§$0.05 < p < 0.10$, two-sided.

not significantly different for the different sampling times t_0 (June), t_1 (July), and t_2 (September) (Kruskal-Wallis test, $p \approx 0.09$ for rug VIII and $p > 0.2$ for all others, $df = 2$). This is interesting because HDM allergen concentrations in Dutch homes have been observed to decline, starting in mid August.[10] A possible explanation is that the increasing number of HDMs run out of food during that time of the year. This hypothesis is not supported by our current findings. In contrast, the newest rug (no VIII, 1.5 years old) seems to become more suitable for HDM survival and reproduction with time (38, 77, and 82 mites for t_0, t_1, and t_2 respectively, Friedman's test: $p < 0.01$), which may reflect the ongoing accumulation of food in this rug.

Short-term effect of cleaning (t_0)

If cleaning has no influence on habitat suitability, the value of $E = (N_{cleaned} + 1)/(N_{control} + 1)$ equals unity on average. The value of E is smaller (i.e., closer to zero) if the habitat-destroying effect of cleaning is stronger. The average values of E are given in Table II. The values of E at t_0 indicate that immediately after cleaning, the habitat suitability for HDMs is much less (Wilcoxon signed-rank test, $p < 0.001$, two-sided). This is a confirmation of the results of an earlier study,[6] which was done with *D. farinae* instead of *D. pteronyssinus*. Differences between rugs regarding the effect of cleaning are not great (Kruskal-Wallis test, $p = 0.23$, $df = 8$). As expected, the effect of cleaning was relatively small for rugs that displayed poor habitat suitability before cleaning (Kendall test, $p < 0.005$, one-sided). However, for every rug, the number of mites recovered from the cleaned fragments tended to be smaller than the corresponding control, with the exception of rug no. VIII, the newest one (Table II). On the other hand, some rugs (e.g., nos. I, V, and VI) appeared to be more suitable for HDMs after cleaning than others (e.g., nos. II, VII, and VIII) were before cleaning, indicating that the habitat is not completely destroyed through wet cleaning.

Recovery of the habitat after 1 and 3 months

After 1 month (t_1), the effect of cleaning can still be observed (Wilcoxon signed-rank test, $p < 0.005$, one-sided). However, an improvement of habitat suitability, relative to t_0, can also be seen (Mann-Whitney U test, comparing E values: $p < 0.001$, one-sided). After another 2 months (t_2), the habitat suitability has again improved significantly relative to t_1 (Mann-Whitney U test, $0.001 < p < 0.01$, one-sided), and no effect of cleaning can be observed (Wilcoxon signed-rank test, $p \approx 0.30$, one-sided); that is, conditions for HDMs are back to normal again or almost so.

On the basis of these findings, it can be expected that the effect of wet cleaning will depend strongly on its timing. If cleaning is done in April or May, the effect must be rather limited. Allergen concentrations are low at this time of the year anyway, and the habitat suitability will be restored by July, when the physical conditions for the growth of HDM populations are excellent. If wet cleaning is done in between June and September, the effect is presumably stronger. On average, about 50% of the allergens will be removed,[6] and the subsequent increase in allergen concentrations will be strongly suppressed. However, it is difficult to say whether the peak in allergen concentrations, which is normally seen in late summer,[10, 11, 14, 15] will be suppressed or merely shifted to a later date.

Wet cleaning of rugs is costly and also a little hazardous. Not many patients with allergy will be motivated to do this more than once every year.

However, wet cleaning can be combined with other mite control methods. If acaricide products are used, these should not be applied too soon after wet cleaning. The HDM population increase is suppressed anyway, and therefore the mite killing agent will have a limited effect. After about 1 or 1½ months, the acaricides will be much more effective in suppressing the accumulation of HDM allergens.

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