Benzyl benzoate moist powder: Investigation of acarical activity in cultures and reduction of dust mite allergens in carpets

Mary L. Hayden, RN, Gail Rose, BSc, Kent B. Diduch, MD, Paul Domson, BA, Martin D. Chapman, PhD, Peter W. Heymann, MD,* and Thomas A. E. Platts-Mills, FRCP *Charlottesville, Va.*

Despite advances in the understanding of dust mites, it remains difficult to control exposure to mite allergens, and it is particularly difficult to reduce mites in fitted carpets or sofas. Several chemicals have been demonstrated to kill mites or denature mite allergens, and some of these chemicals have been investigated in carpets. Benzyl benzoate (BB), which has been widely used to kill scabies mites and is known to kill mites of the genus Dermatophagoides, *has been used as a method of treating carpets. The present article describes experiments in the laboratory and in houses in testing two preparations of BB, a moist powder and a foam. The moist powder is composed of two ingredients, a wetted "inert" cellulose, which is designed to act as a cleaning agent, and the active BB adsorbed onto silicates. The active powder kills 90% of mites in culture within 12 hours and 100% in 24 hours, whereas the cellulose is not acaricidal. The moist-powder preparation was highly effective at killing* D. farinae *and* D. pteronyssinus *mites in the laboratory. In carpets the moist powder, applied for 12 hours with repeated brushing, was demonstrated to reduce the concentrations of group I and group II dust mite allergens in dust recovered at 1 month. This decrease in concentration could, in part, be explained by a persistent increased recovery of dust caused by residual white powder. However, when the recovery of group II allergens was calculated as the total allergen recovered, the decrease was highly significant at 2 weeks and 4 weeks after treatment ($p < 0.001$). Application of the powder to carpets for 4 hours or of the foam to sofas was less effective. After 2 months the effect on mite antigen in carpets was still present, but some increase was apparent, suggesting that repeat application after 2 or 3 months would be necessary to control mite-allergen levels. (J ALLERGY CLIN IMMUNOL 1992;89:536-45.)*

Key words: *Dust mites, carpets, acaricides, benzyl benzoate, allergen avoidance*

In 1967, formal evidence was presented that dust mites of the genus *Dermatophagoides* were an important source of allergens in house dust.[1, 2] Since that time, a large and increasing body of evidence has incriminated the combination of immediate hypersensitivity to dust mites and exposure to dust mites as an important cause of asthma.[3-9] Furthermore, good evidence has been demonstrated that reducing exposure to dust mite antigens either in a special environment or at home can lead to improvement in the symptoms of asthma.[10-15] Not surprisingly, these results have led to increased interest in methods for reducing exposure to dust mite antigens in the home. The need for aggressive measures was recognized early,[12] and studies that attempted to use simpler measures[16, 17] demonstrated that nonaggressive measures neither helped asthma nor reduced mite allergens. At present, it is generally agreed that mattresses should be covered

Abbreviations used
BB: Benzyl benzoate
RH: Relative humidity
MAb: Monoclonal antibody

From the Department of Medicine and *Department of Pediatrics, University of Virginia, Charlottesville, Va.
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Reprint requests: Thomas A. E. Platts-Mills, MD, PhD, Division of Allergy and Clinical Immunology, University of Virginia, Box 225, Charlottesville, VA 22908.
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with an impermeable cover, that bedding should be washed in hot water weekly, and that bedroom carpets should be removed if possible. These measures leave unresolved the question of killing mites or reducing allergen levels in carpets and sofas. For these sites two approaches have been recommended: (1) keeping RH <45% and (2) chemical treatment.[18] Dr. Korsgaard in Denmark has been a major advocate of reducing humidity; however, he works in an area in which reducing humidity can be achieved by opening windows.[9, 16] By contrast, in many areas of the world, including the southern part of the United States, the outside absolute humidity is so high (≥12 gm/kg) that keeping indoor RH <45% (or 7 gm/kg) can only be achieved by expensive air conditioning. In these areas there is a case for removing carpets or treating carpets to reduce allergen levels.

Many different chemicals are known to be potent acaricides, and several chemicals have been investigated for domestic use.[19-25] Some insecticides are also potent acaricides. However, most of the chemicals that are used to kill cockroaches, crickets, etc., are believed to have little effect on dust mites in their present mode of use. In addition to the acaricides, tannic acid has been recommended for use on carpets; it acts by denaturing mite allergens without killing the mites.[25] The acaricides that have been considered for domestic use are all of low toxicity. Thus, natamycin (cheeses) and pirimiphos methyl (grain) are both currently being used to treat foods. In addition, BB that has traditionally been used for treating human scabies infections and benzoic acid have also been recommended as a treatment for carpets.[25-28] Recently, a formulation of BB in a moist powder (Acarosan) has been marketed in the United States and several European countries as a method of controlling mites.[26-28] This preparation has been claimed to reduce mite colonization for 6 months or more and also to remove mite allergens by binding fecal particles. This complex mode of action and the large quantities of powder applied to carpets make assessment of the activity of the powder in carpets or sofas surprisingly difficult. The present study reports experiments with mite cultures and in houses that evaluate the effects of the moist powder.

MATERIAL AND METHODS

BB, incorporated into a white powder (Acarosan powder) or as a foam in pressurized canisters, was kindly provided by Fisons Corp., Rochester, N.Y. The ingredients of this powder were kindly provided by Dr. E. Bischoff of Werner & Mertz GmbH, Mainz, Germany. The powder is provided in sealed packages of 750 gm. This powder is referred to in the text as BB moist powder. The powder was applied as recommended at 75 gm/m^2 and brushed in firmly with a stiff bristle broom. In some houses, the powder was left down for 4 hours and then removed by vacuuming. After the results of initial experiments, it was decided to leave the powder down for 12 to 18 hours, that is, overnight. In these houses, the powder was brushed in again before vacuum cleaning. In each house, routine cleaning of carpets was continued, which included weekly vacuum cleaning. A foam preparation of BB was applied to sofas and rubbed in with a rag. The quantity applied was approximately one fifth of a canister per square meter; therefore, each 300 ml canister was sufficient for two sofas. Samples of dust were collected with a hand-held vacuum cleaner for 2 minutes from 1 m^2 of carpet, as described previously.[29, 30] Dust was sieved and weighed, and 100 mg was extracted by rotation for 6 hours with 2 ml of borate-buffered saline. With a hand-held vacuum cleaner for a fixed period (i.e., 2 minutes), the presence of residual powder in the carpet could influence the recovery of carpet dust. Repeated experiments demonstrated that, if recovery of sample was ≤2 gm, recovery of allergen was consistent within the normal variation of carpet samples.

Laboratory experiments were performed with live mites, both *D. pteronyssinus* and *D. farinae* (kindly provided by Hollister-Stier, Inc., Spokane, Wash.). We are grateful to Dr. E. Bischoff, Werner & Mertz, for providing the constituents from which the BB powder is made. Mites were isolated from bulk cultures by centrifugation on a discontinuous gradient of sucrose and subcultured in 45 mm by 6 mm cultures.[23, 29] In experiments to test acaricidal activity, between 40 to 100 mites were added to 8 mm by 2 mm Robinson chambers, covered on one side with Whatman No. 1 filter paper (Whatman, Inc., Clifton, N.J.), and on the other side with a glass slide. All cultures were maintained at 27° C and ~76% RH in the dark. The BB powder was taken from freshly opened bags, and 4 mg was added to the wells. Before mites were added, the powder was removed from some wells to test whether acaricidal activity remained. In all cases, including treated and untreated wells, ~4 mg of food was added. The food used was a mixture of liver powder, yeast, and human shavings, which were ground, sieved, and autoclaved before use. In some experiments, BB powder was stored in a screw cap glass bottle or in an open tray for 1 month or longer before adding to cultures. Cultures were evaluated by microscopy with a binocular incident light microscope at ×45 (Fisher Scientific, Pittsburgh, Pa.). Live mites were judged by movement combined with normal body dimensions, and approximate counts were performed under the microscope. In some experiments the total contents of cultures were extracted in borate-buffered saline to assay for mite-allergen production.

Assay for mite allergens

The group I mite allergens, *Der p* I and *Der f* I, were assayed with MAbs in a two-site immunometric ELISA.[31, 32] The results were obtained from a control curve with laboratory standards (University of Virginia 87/02 and 87/03) substandardized from the international standard of National Institute for Biological Standards and Control 82/518.[33] The group II allergens were assayed by a single assay for cross-reactive epitopes on *Der p* II and *Der f* II

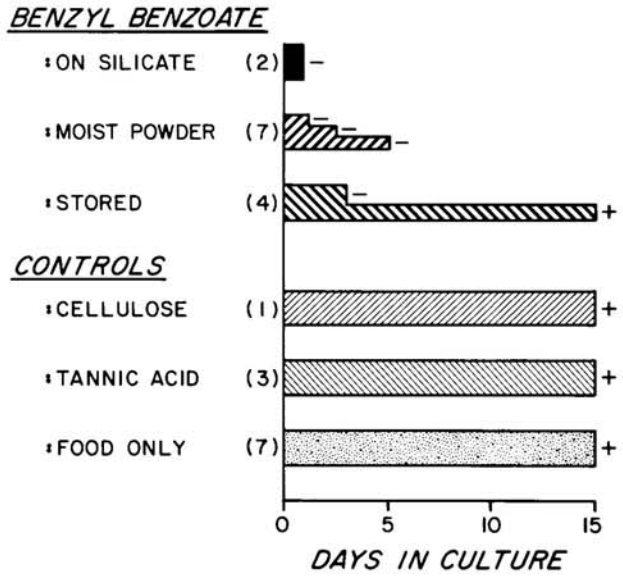

FIG. 1. Survival of dust mites in cultures, established with 40 to 100 mites, was examined at intervals during 15 days. Condition of cultures graded: +, mites alive and well (number equal to or greater than starting number); ±, mites alive but decreased in number or demonstrating less movement; −, no live mites observed.

with two MAbs. In this assay the first MAb was covalently bound to a cellulose disk, and a second radiolabeled antibody was added to quantitate bound group II allergen.[34] Results for group II allergen were obtained from a standard (University of Virginia 88/01), which was substandardized from the Federal Drug Administration *D. farinae* standard (OBRR/Federal Drug Administration E 1-*Df*) and National Institute for Biological Standards and Control 82/518. The international standard is considered to contain 12.5 μg of *Der p* I and 0.4 of *Der p* II. Preliminary experiments, in which different quantities of BB powder were added to dust before extraction, established that the powder had no significant effect on the assays for group I or group II mite allergens (data not presented). Results for each allergen were expressed initially as micrograms per gram of sieved dust, in keeping with a recent international workshop report[4]; however, it became clear that the residual powder added to the weight of dust recovered, and therefore, results were also calculated as the total microgram of allergen in the sample.

RESULTS

Laboratory studies on live mites

The BB moist powder is composed of several different ingredients; however, the final product is made from two powders. The active acaricide is made of silicate combined with BB liquid. This is mixed with three times the volume of a cellulose component wetted with water and mineral oil. When the cellulose is tested separately, it is not acaricidal; mites were alive and vigorous after 15 days with 4 mg of cellulose. By contrast, the silicates with adsorbed BB cause rapid killing of mites, that is, 90% within 5 hours (Fig. 1). Even when as little as ~0.7 mg of the silicate with adsorbed BB was added to a culture, all the mites were dead in 24 hours (data not presented).

Mites cultured with moist BB powder died within 2 to 8 days. By contrast, either *D. farinae* or *D. pteronyssinus* mites, grown on food alone or in wells from which the powder had been removed, grew normally and demonstrated no loss of viability (Table I and Fig. 1). In these cultures the quantity of group I mite-allergen accumulation during 15 days varied from ~0.5 to >10 μg. In seven parallel experiments with live mites, the mean reduction in accumulated group I allergen in culture with BB was 82%. As another control, 3% tannic acid treatment either of the food or of the culture was used, and this treatment did not reduce the viability of the cultures. Experiments with stored powder revealed inconsistent results. In one set of experiments, powder that had been stored was inactive; however, another preparation of the powder that had been stored in a flat, open tin for

TABLE I. The effect of BB moist powder on live mites in culture

	~Mites* added	Live mites at†			
		Day 1	Day 2	Day 5	Day 8
D. pteronyssinus					
Food only					
i	70	~80	65	53	50
ii	50	~50	34	29	25
BB moist powder (+4 mg added)					
i	50	0	0	0	0
ii	50	0	0	0	0
Added and removed‡					
i	50	20	10	22	14
ii	80	30	4	37	36
D. farinae					
Food only					
i	~100	~100	~100	~100	~100
ii	~100	~100	~100	~100	~100
BB moist powder (+4 mg added)					
i	50	10	0	0	0
ii	50	7	0	0	0
Added and removed					
i	42	40	30	74	58
ii	40	30	30	53	50

*Mites were isolated by centrifugation on discontinuous sucrose gradients and cultured with ~4 mg of food with or without 4 mg of BB moist powder.
†Cultures were examined under incident light, and the approximate number of mobile mites was recorded.
‡BB moist powder (4 mg) was added to the wells and then tipped out after 15 minutes adding mites and food.

2 months was as active as fresh powder (Fig. 1). This result may reflect incomplete mixing of some batches. However, after testing the moist BB powder from four different batches, we have observed complete killing in all cases, that is, 15/15 cultures.

Treatment of carpets with moist powder

Initially, carpets were treated with moist powder for 4 hours. The results were disappointing in that reductions were modest at 1 month, and levels did not fall further after that (Fig. 2). Since a large proportion of the powder is removed by the first vacuum cleaning, we suspected that the powder was not in contact with the mites for a long enough period. A further series of 13 carpets were treated by allowing the powder to remain for 12 to 18 hours and repeated brushing before vacuum cleaning. The results demonstrate marked reductions in group I and group II allergens expressed as micrograms per gram of dust. When the reduction of concentration of allergen was expressed as a percent, the mean maximum reduction for the 13 carpets was 79.5% for group I and 93% for group II. These differences were significant compared with levels before treatment (Table II) and compared with percent changes in 10 untreated control carpets (data not presented). Data available for eight carpets 2 months after application demonstrated little change in group I allergen, but in seven of eight carpets, the concentration of group II had increased compared with that of the 4-week sample.

When the powder was brushed in twice during a 12-hour period, enough white powder was present in the carpet at 2 weeks and 4 weeks to increase the weight of dust recovered. If results are expressed as micrograms per gram of dust recovered, the addition of white powder can create an artifactual decrease in allergen level by increasing the quantity of dust recovered. In contrast, if the powder binds fecal particles, then the powder would be expected to contain high levels of group I allergen. Given that the powder adds to the weight recovered, it appeared that total group II allergen recovered would be an alternative method for estimating the effect of the chemical on mites in the carpet. The results demonstrate that there were highly significant falls in total group II allergen recovered at 2 weeks and 4 weeks (Table III). At that time, although the white powder was still being re-

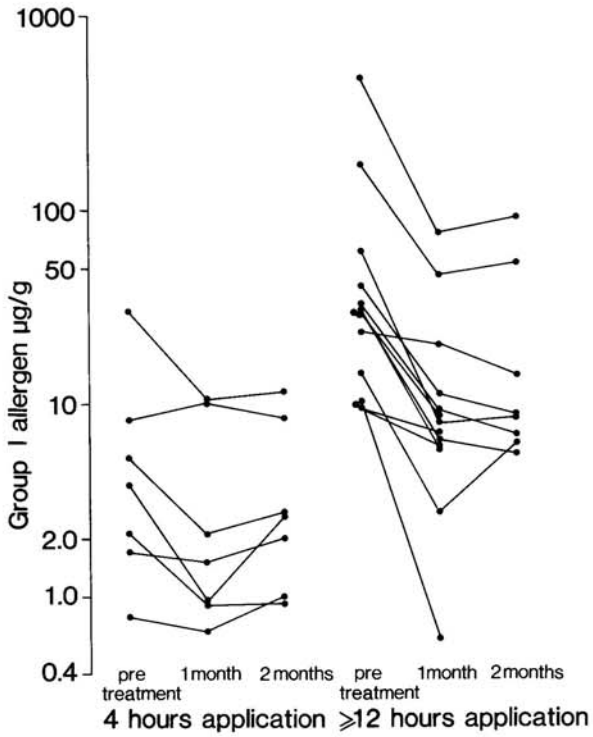

FIG. 2. BB powder was applied to carpets in domestic houses at 75 gm/m². After powder was brushed in, it was either (1) removed by vacuum cleaner after 4 hours or (2) left down for ≥12 hours, brushed in again, and then removed with a vacuum cleaner. Carpets were sampled before treatment, 1 month after treatment, and 2 months after treatment. Group I allergens were assayed by two-site ELISA and represent sum of *Der p* I and *Der f* I.

covered, the total weight of sample was ≤2 gm, which preliminary experiments demonstrated was insufficient to interfere with recovery of dust.

Repeated application of powder to carpets

To evaluate further the actions of the BB moist powder, 17 carpets were treated twice at 1-month intervals. Sequential dust samples at 2-week intervals, five from each carpet, were weighed and assayed for group I and group II allergens. The results for two carpets are presented in Table IV. As with the previous results, the fall in concentration may reflect dilution by residual powder, and the recovery of group I allergens may reflect binding of fecal particles to the cellulose. For all 17 carpets, data for group II microgram per gram, are illustrated in Fig. 3.

Treatment of sofas with foam

Fourteen sofas were treated with BB in a foam formulation that was rubbed into the fabric. No change in color or other damage was demonstrated in any of the treated sofas. The results demonstrated a modest effect in that nine of the sofas had reduced levels of allergen at 2 weeks; however, the reductions were not maintained at 1 or 2 months, and overall the results were disappointing.

DISCUSSION

Given the large number of dust mite-allergic patients who have symptoms of rhinitis, asthma, or atopic dermatitis, it is not surprising that there is considerable demand for new techniques for reducing dust-mite allergens in houses. In considering a chemical proposed to reduce mite allergens, there are two primary concerns: first, is the chemical sufficiently nontoxic, and second, can it be delivered in such a way as to kill mites within a carpet or furniture. BB has been used for many years as a topical treatment for scabies and is still recommended for this purpose. The major toxicity recognized is an irritant effect on

TABLE II. Reduction in concentration of group I (I) and group II (II) mite allergens* after application of BB moist powder to carpets for 12 or more hours

	Pretreatment		2 weeks		4 weeks		2 months†	
House	I	II	I	II	I	II	I	II
P. D.	30.8	31.5	25.4	1.0	6.4	0.7	5.5	0.9
C. D.	32.7	27.7	23	1.3	9.1	1.6	6.9	2.5
S. P. Den	40.2	10.1	1.5	<0.2	11.3	0.38	8.8	1.9
S. P. BR	23.3	31.3	13.1	1.5	20	2.8	14.7	9.0
M. H.	≥250	256	14.7	0.24	92	1.14	182	5.3
S. T.	9.2	8.6	3.2	0.28	6	2.5	ND	
Vig. FR	30.5	10.0	5.5	<0.2	5.8	<0.2	ND	
Vig. St.	29.8	20.4	7	0.5	8.6	0.84	ND	
S. P.	14.3	1.88	0.98	<0.2	2.7	<0.2	6.2	1.6
Th.	171	66	12	<0.2	46	0.9	53	18
H.	10.1	1.2	<0.3	<0.2	<0.3	<0.2	ND	
D.	60	18	ND		7.8	0.28	8.4	0.26
J. R.	9.7	0.74	3.9	0.2	7.0	0.6	ND	

ND, Not done; indicates sample was not obtained.
*Values in micrograms per gram of sieved dust are for group I allergen (I) calculated from *Der p* I plus *Der f* I, or for Group II allergen (II).
†At 2 months, seven of eight samples had higher levels of group II allergen than the sample taken at 1 month.

TABLE III. Effect of BB treatment on total recovery of group II mite allergen (micrograms)*

		Treatment		
House	Before	2 weeks†	4 weeks†‡	2 mo
P. D.	15.5	1.41	0.56	1.3
C. D.	16.3	1.47	2.3	2.1
S. P. Den	2.63	0.12	0.14	0.27
S. P. BR	10.6	0.61	0.81	1.11
M. H.	130	0.32	1.73	4.13
S. T.	1.9	0.27	1.05	ND
Vig. FR	2.3	0.35	0.24	ND
Vig. St.	3.14	0.37	0.83	ND
S. P.	0.54	0.21	0.08	—
Th.	20.2	0.25	0.46	—
H.	0.4	<0.42	<0.4	—
D.	3.6	—	0.22	0.16
J. R.	0.167	<0.38	0.53	—

*Values calculated from the concentration of group II allergen per gram of dust multiplied by the weight of dust in grams.
†Values less than pretreatment levels, $p < 0.001$, Wilcoxon's signed-rank test.
‡Mean percent change at 4 weeks (72% decrease) significantly different from the mean change (38% increase) observed in 10 untreated sites (Wilcoxon's rank-sum test, $p < 0.01$).

the eyes or mucosal surfaces. Thus, it is considered that the risk of BB applied in a powder to carpets is very low. Benzoates are known to have toxicity for cats, if they are eaten, and have been removed from pet foods; cats should probably be kept away from the fresh powder, but the chances of cats consuming the powder are remote. The preparation used here, Acarosan, consists of two types of particles, the cellulose particles that act as a cleaning agent and smaller silicate particles that have the BB incorporated into them. The theory is that as the powder dries out the small particles fall into the carpet and act as a persistent source of acaricide (Bischoff E. Personal communication).

In designing regimens to reduce exposure to dust-mite allergens, some issues have been solved, but the

TABLE IV. Effects of repeated treatment with BB on mite-allergen concentrations and mite-allergen recovery*

	Before	Treatment					
		1st	2 wk	4 wk	2d	6 wk	8 wk
Den carpet							
Group I (μg/gm†)	83	*	0.9	8.6	*	0.5	0.7
Group I (total)	7.1	*	3.0	8.0	*	1.6	2.1
Group II (μg/gm)	15.7	*	<0.5	<0.5	*	<0.5	<0.5
Bedroom carpet							
Group I (μg/gm)	167	*	25.3	22.4	*	0.88	5.3
Group I (total)	35.3	*	4.3	3.2	*	0.8	3.3
Group II (μg/gm)	27.5	*	4.7	5.5	*	<0.5	<0.5

*Samples were obtained before the first treatment and then at intervals of 2 weeks. The second treatment was applied directly after the 4-week sample.

†Group I allergen was calculated from assay of *Der p* I plus *Der f* I.

treatment of fitted carepts remains a problem. There are considerable methodologic problems in assessing the effects of an acaricide on carpets. It would be useful to be able to count the live mites; however, this is not simple without removing segments of carpet. Vacuum cleaners are a very poor method of recovering live mites from carpets; therefore, counting live (or dead) mites in recovered dust would probably not be helpful. Alternative techniques have been described to evaluate live mites.[26] Adhesive tape placed on a carpet for 24 hours can elicit an estimate of live mites by counting the mites that randomly reach the surface of the carpet; however, this method would elicit misleading results if the mites simply became less mobile or withdrew to the bottom of the carpet. The heat-escape technique can better define the number of live mites but has not been adapted for use on domestic carpets.[26] In addition, measuring allergen levels is more relevant to symptoms. Since there is a considerable reservoir of mite allergens in the carpets, killing mites will not cause an abrupt fall in mite allergen in the dust. In the past with the acaricide pirimiphos methyl, we have observed an 80% fall in group I mite allergens within 6 weeks.[23] With the BB moist powder, there are additional problems evaluating its effects because it acts as a "cleaning" agent to remove allergen and also because of the residual powder that remains in the carpets. If there was a constant rate of removal of allergen from the carpet, then the residual powder would dilute it. In contrast, if the cellulose acts as a cleaning agent, it will bind allergen-containing particles and may act to increase the rate of removal of allergen from the carpet. The most likely explanation of our results is that the powder produces three effects: killing of mites, dilution of dust, and removal of allergen. The presence of residual powder could have interfered with the recovery of dust by the hand-held vacuum cleaners. However, the quantity of total dust at 4 weeks was only 1.5 to 0.2 gm, and separate experiments demonstrated that recovery of dust would not be reduced by the quantity of residual powder present at 2 weeks or 4 weeks. Thus, we believe that the decrease in total quantity of group II allergen recovered at 1 month is a good marker of the acaricidal effects of the powder. The objective of killing mites is both to reduce allergen exposure and to reduce reinfestation of bedding, clothing, furniture, etc. Clearly, mite allergen has to become airborne to be inhaled, and it has not been demonstrated that BB treatment (or any other treatment) of carpets reduces airborne dust-mite allergen.

The present results confirm the acaricidal action of BB but raise some questions about the preparation and the mode of use. The laboratory experiments suggest that the powder may sometimes lose the acaricidal activity when it is stored. We have had some cultures of dust mites flourishing on the white powder once it is dry. In keeping with this finding, our results on carpets do not support previous claims that it is effective for 6 months or more, and our results would be best explained if the maximum acaricidal activity of the powder only lasted for a short period of time. Furthermore, white powder may be visible in vacuum cleanings for up to 2 months, that is, at a time when some recovery of mite antigens is apparent.

In general, the treatment did not produce irritation. In early experiments a scented powder was used that caused more irritation. With the unscented preparation used for most of these experiments, the smell of the powder was not considered a problem, and occasional sneezing was the main side effect. Indeed, subsequent studies to evaluate the possible irritant effect on pa-

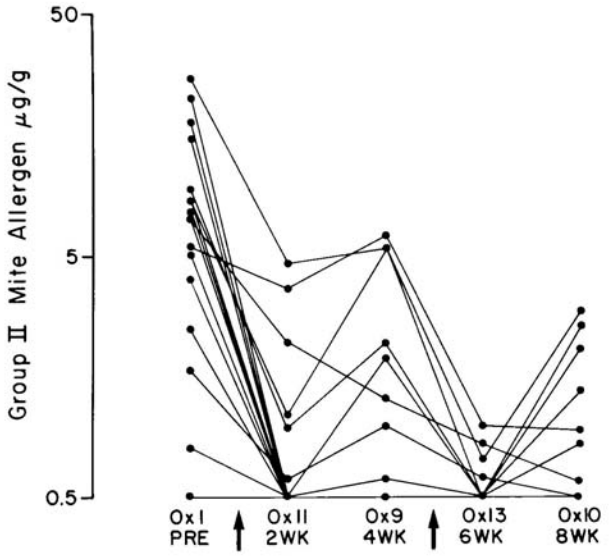

FIG. 3. Group II mite-allergen levels in dust samples collected at 2-week intervals from 17 carpets, which were treated twice with BB moist powder. First treatment was applied directly after first sample, and second treatment was applied directly after 4-week sample.

tients with asthma have demonstrated very little problem (results to be published).

The results reveal a larger percent reduction in group II than in group I allergens. This finding is compatible with the fact that group II allergens are derived predominantly from mite bodies, whereas the group I allergens are predominantly fecal.[34-36] Thus, killing the live mites may have a more rapid effect on the antigens derived from mite bodies than on antigens in fecal particles. The results could also be explained if group I allergens were more stable and therefore persisted longer in dust. However, this is most unlikely since group II allergens are more stable to temperature, pH, and reduction.[37]

Demonstrating statistically significant reductions in mite allergens in dust does not reveal whether these reductions are sufficient to help patients with asthma. Proving that this preparation of BB can benefit asthma will require controlled trials. Our current view is that such a controlled trial should be performed comparing placebo powder to a combination of an active acaricide *and* physical measures to reduce mite-allergen levels.

The studies reported here were performed at different times of the year both in the summer and winter, that is, both at times when the levels would have been rising or relatively stable.[30] The results demonstrate that significant reductions in both concentration and total allergen recovered can be achieved when results are compared either to that of untreated controls or pretreatment levels. If the objective is to reduce levels <10 μg of group I allergen per gram of dust,[4] this was achieved in most of the carpets. However, if the object is to reduce levels <2 μg/gm, then additional measures may be necessary. Additional reductions could be achieved either by repeat treatment, combination with tannic acid, or controlling indoor humidity.[16, 25] Clearly, more studies are necessary to evaluate the relative roles of different methods of reducing mite allergens in carpets. Control of mite allergens in sofas remains a problem. Our results do not support the role of BB in a foam; however, it may be that different methods of applying the foam or repeated application would be more successful. Many studies on BB in Europe have used different techniques for evaluating efficacy. Those studies either counted live mites or assayed guanine in the house dust. Guanine is the main purine breakdown product of acarids. However, the assay for guanine that was being used (ACAREX test, Werner & Mertz) is only semiquantitative and may not reflect changes in some allergens accurately.[38] Guanine assays would also not detect changes after tannic acid treatment. Thus, al-

though guanine assays have the advantage of simplicity, quantitative assays of specific allergens reveal more accurate information and are easier to relate to previous results on risk factors.[4] Two recent studies with this preparation of BB have elicited conflicting results; however, we believe that the mode of application of the powder was suboptimal and that these authors did not allow for the effects of residual powder.[27, 28]

There is abundant evidence that indoor allergen exposure contributes to the symptoms of asthma and rhinitis and that avoidance can reduce both symptoms and bronchial reactivity.[9-14] Many of these studies have involved moving patients out of their houses and, in some cases, have been demonstrated to involve reductions of mite allergen of 98%, for example, 13 μg of *Der p* I/gm $- \leq \sim 0.2$ μg of *Der p* I/gm.[14] Controlled trials of mite avoidance in houses have produced confusing results. However, some of the studies that have reported unsuccessful results did not achieve reduced levels of mite allergens or mite numbers.[16, 17] The present results together with other results suggest that there are, now, methods that could be combined to achieve a consistent reduction in mite levels in houses with very low toxicity. However, all chemical treatments proposed need additional study both of the techniques necessary to get the chemical to penetrate into carpets or sofas and on their clinical effectiveness.

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