
Short-term effects of extermination and cleaning on cockroach allergen Bla g 2 in settled dust

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Background: Although cockroach allergen is an important indoor allergen in poor urban environments, no studies on the effectiveness of measures to reduce allergen levels in indoor environments have yet been published.

Methods: As a model of home extermination, we studied cockroach allergen levels in an urban dormitory that was chronically infested with German cockroaches and that underwent semiannual extermination. Dust samples were collected from 18 bedrooms and 5 kitchens located in the dormitory and were analyzed for Bla g 2 using an immunoassay.

Results: We detected allergen in almost every bedroom, with median levels ranging from 3.0 U/g (units/g) in settled dust on the bed, 4.0 U/g on the carpeted floor, and 2.8 U/g in closets. In the kitchen, we found somewhat higher levels, 10.8 U/g on the floor and 2.8 U/g in floor cabinets. Repeated measures of floor dust were similar (median 4.4 and 4.0 U/g) despite weekly vacuum cleaning. In the 2 weeks before extermination, median levels were 5.2 U/g and in the 2 weeks following extermination and regular vacuuming, median levels fell to 0.95 U/g.

Conclusions: We concluded that successful allergen abatement could be accomplished in cockroach infested indoor environments using routine extermination and vacuuming.

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INTRODUCTION

Cockroach was recognized as an important indoor allergen in poor urban communities by Bernton and Brown almost 30 years ago.¹ Since then Kang and other investigators have documented that 60% to 80% of inner city residents with asthma are sensitized to this allergen and that sensitization can be related to asthma.²⁻⁴ More recently, it has been shown that sensitivity and exposure to cockroach allergens, along with sensitivity and exposure to house dust mite and cat, are risk factors for acute severe asthma.^{4,5} Although there is general agreement that avoidance of

this important indoor allergen should be included in management of any person with asthma, the effectiveness of available methods has not been examined.

Effective methods of cockroach extermination are available. Trials reported in the entomology literature show that currently available pesticide use can reduce populations by 93% to 100% and maintain these reductions for at least 3 months.⁶⁻⁸ These trials have included individual homes and apartments⁸ as well as rural poor populations,⁷ but have not yet been reported in typical inner city housing. None of the reports, however has examined reduction of allergen levels during extermination. Cockroach allergens are found in high concentration in cockroach feces,⁹ skins,¹⁰ and nest debris or "frass,"¹⁰ so extermination alone, without careful cleaning to remove dead insects and associated allergen, is not likely to provide effective abatement. In the present report, we describe our experience with the

effect of pesticide treatment and routine cleaning methods on reducing cockroach allergen levels.

METHODS

The study was undertaken in a dormitory on the Johns Hopkins University medical campus which is situated in the midst of a poor urban community. The dormitory is located in a 9-story brick building which is 39 years old and is centrally heated and air-conditioned. The first four floors of this building contain lounges and university administrative offices, while the dormitory constitutes the upper five floors. On each dormitory floor, 30 bedrooms open on a single long hallway. A bathroom and a small kitchenette with refrigerator, sink, and stove are located on each floor midway in the hallway. Each bedroom is occupied by a single student and includes a bed with a vinyl covered mattress, a desk, a chest of drawers and a free-standing wooden storage cabinet/wardrobe with no door. Bedroom, kitchen and hallway floors are covered with a low pile carpet. The rooms are vacuumed once a week by the maintenance staff with a household vacuum (Eureka #9875) and carpets were shampooed once a year.

The building is chronically infested with cockroaches which we identified as German cockroaches (*Blattella germanica*). Because of this, students are requested to avoid eating in their rooms, but compliance with this rule is poor. In addition, the University contracts with a professional pest control company to treat the building twice a year. Typically, the company uses four insecticides, diazinon, Dursban, Tempo, or Safratin on a rotational basis to prevent emergence of cockroach strains resistant to pesticides. These insecticides, with a flushing agent, are sprayed within each room at the angle

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of the floor and walls. We examined the effects of two exterminations, one in October and the other in February. In these cases, diazinon, 0.5%, or Dursban, 0.25%, were used as the insecticide and the flushing agent was Whitmire PT 3-6-10 (86% trichlorethylene, 1% pyrethrin, 2% piperonyl butoxide, 3.3% n Octyl B cycloheptene dicarboxamide, and 8% petroleum distillates).

The 18 bedrooms that we studied were selected by the building manager because they were representative of most dormitory rooms and because the students living there were willing to have the investigators enter their rooms. The kitchenette on each of the five floors was studied as well.

We collected settled dust samples with a hand held vacuum (Douglas Redivac #6735, Scott Fetzer Co, Walnut Ridge, AR) from the bedroom floor, bedding, and closet and from the kitchen floor and cabinet. Floor samples were collected by vacuuming for two minutes from a 1 m² area next to the bed. Bed samples were collected from the mattress, bedding, and bed frame. Closet samples were collected from the entire bottom surface of the wooden closet. Kitchen samples were collected from a 1-m² area in front of the sink and from the cabinet under the sink. The bedrooms were occupied during the time that we collected samples, but the students were not present. Dust samples were extracted and assayed as described previously.^{11,12} Sieved samples were extracted in borate-buffered saline, and the extracts were assayed for Bla g 2, Der p 1, and Der f 1 using two site monoclonal ELISA assays. Monoclonal and polyclonal antibodies were kindly supplied by Dr. Martin Chapman. The Bla g 2 assay detected an allergen that is associated with German cockroaches; allergen content in the reference standard was expressed as Units per milliliter and in samples as Units per gram (U/g) of collected dust. The lower limit of detection was 0.2 U/g, and 0.1 µg/g respectively for Bla g 2 and mite allergens.

Statistical analysis was conducted with nonparametric methods since the cockroach allergen concentrations are not normally distributed.

RESULTS

Cockroach allergen Bla g 2 was widely distributed in settled dust samples (Fig 1). The concentration in the first samples collected in each site is shown in Figures 1 and 2. It can be seen in Figure 1 that Bla g 2 was found in similar concentrations in floors, beds, and closets in the 18 bedrooms. Floor samples contained concentrations ranging from undetectable (one sample) to 31.0 U/g (median 4.0 U/g). In the bedding, concentrations ranged from undetectable (three samples) to 62.6 U/g (median 3.0 U/g). Closet samples contained levels that ranged from undetectable (two samples) to 18.9 U/g (median 2.8 U/g). The concentrations in the various sites were not statistically different (Kruskal Wallis, $P = .74$). Sixty-seven percent of the floor samples contained Bla g 2 concentrations that were higher than 2 U/g, a figure associated with asthma disease activity.⁵ Levels within rooms were roughly correlated. For example, bedroom floor levels were correlated with those in bedding ($R_s = 0.50$, $P = .04$) but not to closet levels ($R_s = 0.02$,

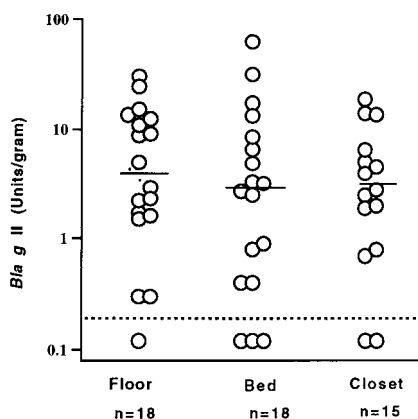


Figure 1. Concentrations of Bla g 2 in dust collected from various locations in the dormitory bedrooms including floor, bedding and the floor of the built-in closet. Horizontal bars indicate medians. The detection limit of the assay, 0.2 U/g dust is indicated by the dotted line.

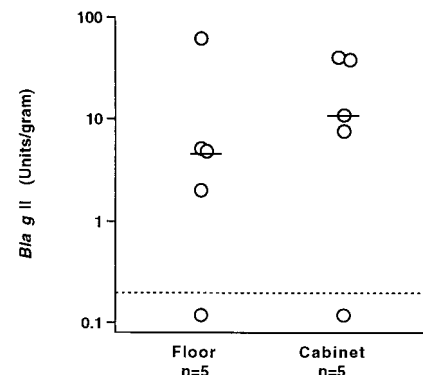


Figure 2. Concentrations of Bla g 2 in dust collected from various locations in the kitchens, including the floor and the storage cabinet. Horizontal bars indicate medians. The detection limit of the assay, 0.2 U/g dust is indicated by the dotted line.

$P = .94$). Only two of 17 bedding samples contained detectable Der p 1 (160 and 120 ng/g). Similarly, these antigens were detectable in one floor sample (510 ng/g Der p I) and in only one of 14 closet samples (200 ng/g Der f 1).

In the five kitchens, Bla g 2 was detectable in most cabinet and floor samples (Fig 2). Samples from the cabinets ranged from undetectable (one sample) to 40.4 U/g (median 10.8 U/g). Samples from the floors ranged from undetectable (one sample) to 62.3 U/g (median 2.8 U/g). The concentrations in the kitchen samples were somewhat higher than samples from bedroom floors but not significantly so (Mann Whitney, $P = .4$).

The consistency of allergen concentrations was examined in two samples collected in the same area of the floor in seven bedrooms and five kitchens 1 week apart (Fig 3); routine vacuum cleaning was performed during the week by maintenance staff. Levels of Bla g 2 in the first collection ranged from below detection (one sample) to 35.6 U/g (median 4.4 U/g) and in the second collection ranged from undetectable (one samples) to 8.6 U/g (median 4.0 U/g). The two measures were not statistically different (Wilcoxon matched pair $P = .44$). Paired samples were also collected 1 week apart from five beds (data not shown). Levels of

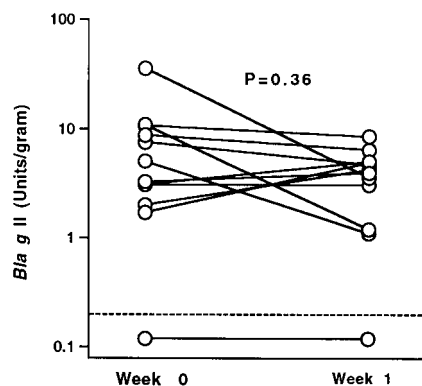


Figure 3. Concentrations of Bla g 2 in dust collected from the floors of five kitchens and seven bedrooms on two occasions 1 week apart. Horizontal bars indicate medians. Median values did not differ statistically ($P = .36$; Wilcoxon matched pair analysis).

Bla g 2 in initial samples ranged from below detection (two samples) to 24 U/g (median 3 U/g). The repeat samples ranged from below detection (two samples) to 5.2 U/g and were not statistically different from the first samples (Wilcoxon matched pair, $P = .45$).

To examine the effects of extermination, we collected samples in the 2 weeks before routine extermination of six bedrooms and five kitchens and compared Bla g 2 concentrations with samples collected in the 2 weeks afterward; in five cases we studied the effects of two exterminations, one in the fall and one in the spring, so that a total of 16 treatments were available for analysis. During this 4-week period, routine vacuuming of the rooms continued and in five rooms, rugs were shampooed as well. The Bla g 2 levels before and after extermination are illustrated in Figure 4. Before extermination, concentrations ranged from undetectable (one sample) to 19.6 U/g (median 5.2 U/g). After extermination and cleaning, Bla g 2 was undetectable in six of 12 samples, and the highest level was 4.2 U/g (median 0.95 U/g); this 85% change in median level was highly significant (Wilcoxon matched pair $P = .00006$). In the five rooms in which the rugs were also shampooed after extermination, allergen reduction was similar to those in which rugs

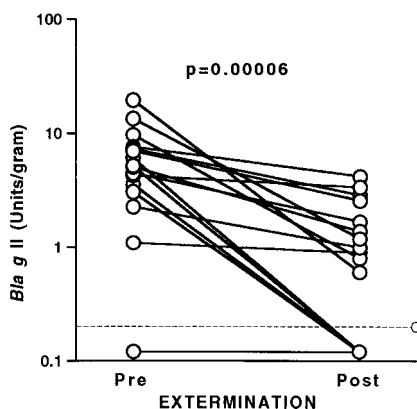


Figure 4. Concentrations of Bla g 2 in dust collected from the floors of five kitchens and 13 bedrooms during the 2 weeks before extermination and during the 2 weeks afterward. The differences are statistically significant ($P = .00006$; Wilcoxon matched pair analysis).

were only vacuumed. The median level before extermination and shampooing was 6.1 U/g, while allergen was detectable in two of five samples afterward (2.6 and 2.9 U/g). Before and after extermination and vacuuming, median levels were 5.1 and 1.0 U/g, respectively. Allergen concentration in the five rooms exterminated in both the fall and the spring were 4.5 U/g before extermination in the fall and 7 U/g in the spring (Wilcoxon matched pair $P = .63$).

Surprisingly, the Bla g 2 levels in dust collected from bedding also decreased after extermination. Bedding samples were collected in five rooms; before extermination Bla g 2 concentrations ranged from nondetectable (one sample) to 15.4 (median 5.2 U/g). After extermination and cleaning, allergen was undetectable in four of five samples and fell from 13.8 to 7.2 U/g in the fifth; this difference was significant (Wilcoxon matched pair $P = .045$).

DISCUSSION

This study demonstrates that cockroach allergen Bla g 2 is widely distributed in this inner city dormitory. In addition, the extermination and cleaning procedures employed by the institution are effective in reducing cockroach allergen in settled dust on the floor and in bedding. To our knowledge this is

the first examination of the effectiveness of allergen removal procedures.

Allergen was present in all rooms, but the levels found in floor dust samples were somewhat lower than reported in poor urban homes^{4,5,12} perhaps because of the routine pesticide treatment of the building. As other investigators have noted^{5,12} we found concentrations to be highest in kitchens. Likewise, we found surprisingly high levels in bedding, as first described by Pollart and colleagues.¹² It is not clear how the allergen reached the bedding. We could speculate that airborne allergen settled onto the bed, but our preliminary studies¹³ suggest that cockroach allergen is carried on relatively large particles which are not likely to become airborne. Another possibility is that allergen was transferred through contact with contaminated clothing, but it is also possible that it occurred because insects were actually in the bedding. The fact that allergen levels in bedding also fell with extermination does not support any particular source of contamination of the bedding. The presence of cockroach allergen in beds allows intimate and prolonged contact, so it is likely to be an important source of both sensitization and chronic symptoms, and this makes the question worth further study. Clearly, in clinical recommendations for cockroach allergen abatement, patients should be told to wash bedding carefully and to install mattress covers.

We found surprisingly low house dust mite allergen concentrations in all samples. A likely explanation for this is that the building is air conditioned so that humidity is maintained at levels that are lower than would be optimal for mite growth.¹⁴ Other explanations are that we sampled from October to March, a time of year when mite numbers and allergen levels are typically lowest.¹⁵ Finally, the study was carried out in an apartment building; apartments have lower mite allergen concentrations than do individual homes.¹⁶

The insecticides used here, diazinon and chlorpyrifos, are widely used in the pest control industry, and have

been shown to be 93% to 100% effective in reducing the numbers of live roaches in homes.^{6,7} They are both organophosphate compounds that inhibit acetyl cholinesterase and interrupt neural transmission. Other commonly used agents such as hydroprene⁸ and abamectin⁶ are equally effective in trials. In practice, most insecticides are used in conjunction with "flushing agents" which increase the activity of the insects and increase the effectiveness of the insecticide by increasing exposure. A number of factors control the effectiveness of extermination, including the original insect population in the home, whether extra food sources are available so that the treated bait is not eaten by the insects and the care with which the pesticide is applied to crevices and other hiding places. Reinfestation is a function of the residual activity of pesticides, the availability of food sources in the home, and access points (ie, cracks and crevices around plumbing) through which insects can gain access. Most pesticides are unstable, which is a desirable property in the sense of human toxicity but a problem in terms of reinfestation. In the case of the dormitory studied by us, reinfestation is an obvious problem, since allergen levels were substantial despite short term reduction twice a year.

The clinical relevance of these data is as yet unclear. The 85% reduction in allergen is likely to be clinically significant because reductions in mite allergen of this magnitude have been demonstrated to be effective in decreasing asthma disease activity in several controlled clinical trials.¹⁷⁻¹⁹ In 75% of cases, we were able to reduce settled dust concentrations of cockroach allergen below 2 U/g, a level that has been suggested to be related to asthma morbidity.⁵ This was a short study, however, and the students who occupied the rooms were not evaluated for symptoms. It is also not clear how long the allergen reduction we achieved would have lasted. Clearly it did not last until the next extermination 6 months later since levels were still detectable in every room. Furthermore, it is unclear whether the data from this

dormitory will be applicable to home environments. In the dormitory, the fact that all rooms in the building could be treated simultaneously could make our treatment more effective since reinfestation was less likely from neighboring rooms that had not been treated. On the other hand, the burden of infestation in this building is substantial, as evidenced by the presence of cockroach allergen in virtually every room sampled, and the practice of eating and preparing foods in most bedrooms may be particularly favorable for cockroach growth. Similar studies in home environments are clearly needed, ideally with long term follow-up of allergen levels.

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