

Clinical Communications

Abatement of cockroach allergens by effective cockroach management in apartments

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Clinical Implications

- This is the first research to demonstrate that an effective cockroach control program alone causes high reduction in cockroach allergens in concealed areas.

German cockroaches, *Blattella germanica* (L.), are one of the most common indoor pests in the United States.¹ Cockroach carcasses, shed skins, hatched ootheca, and feces contain allergens that can cause asthma.² Among the 11 allergens identified from German cockroach, Bla g 1 and Bla g 2 are 2 major allergens that have been used as biomarkers of environmental exposure to German cockroaches in indoor environments.³ Because of the close association between asthma, cockroach allergen levels, and cockroach infestations, a logical approach for asthma prevention is to reduce cockroach infestations and allergen levels in the individual's environment. Arbes et al⁴ reported that insecticide treatment of cockroach infestations caused Bla g 1 concentrations on the kitchen floor, living room floor/sofa, and bedroom floor to decrease by 95%, 81%, and 82%, respectively, after 6 months.⁴ Sever et al⁵ showed that the geometric mean Bla g 1 concentrations decreased 91% and 94% in the kitchen after 12 months in the researcher-treated and professional company-treated apartments, respectively. The above studies on cockroach allergen abatement focused on vacuum or swab dust samples from openly exposed surfaces. Whether high reduction of allergens in concealed, nondisturbed, and hidden areas in apartments would be achieved by cockroach control alone has not been studied. This study's goal was to determine the effectiveness of pest control performed by licensed entomologists in reducing German cockroach allergen Bla g 1 and Bla g 2 levels sampled in concealed locations in German cockroach-infested homes.

The study was conducted at a 188-unit 13-story senior citizen-occupied apartment building in Paterson, NJ. Approval from the Rutgers University Institutional Review Board (protocol no. E16-056) was obtained. Extensive details of the study site and the cockroach control program have been reported elsewhere.⁶ Four sticky traps were placed in each apartment in the kitchen and bathroom for 14 days to detect cockroaches and measure the cockroach infestation level. A total of 30 apartments with more than 20 cockroaches, based on trap counts, were selected to analyze the cockroach allergen levels in the kitchen dust samples over a 12-month period (May 2016 to May 2017). Rutgers University researchers carried out the building-wide cockroach control program during this period.

Floor dust samples were collected at 0, 6, and 12 months. The initial 0-month samples were collected immediately before

cockroach treatment. To collect dust samples, we vacuumed for 1 minute in openly exposed areas at the perimeter of floor in the kitchen and hallway to the bathroom, 30 seconds in concealed areas beneath the stove, 30 seconds in the cabinet beneath the kitchen sink, and 30 seconds beneath the refrigerator using an Atrix backpack vacuum (model VACBP1, Atrix International, Burnsville, Minn). A combined dust sample from these areas was taken in each apartment at each sampling period. A dust collector (Indoor Biotechnologies, Charlottesville, Va) was placed on the distal end of the vacuum's extension wand to collect the dust. The dust samples were sent to the Johns Hopkins University Dermatology, Allergy and Clinical Immunology Reference Laboratory for analysis using documented immunoassay methods. The crude dust was processed through a 50-mesh sieve to collect less than or equal to 300 micron particulate and 5 mg of fine dust was extracted in 2 mL of PBS. Following centrifugation, extracted Bla g 1 and 2 concentrations were then quantified by mAb-based ELISAs purchased from Indoor Biotechnologies.⁷ Changes in log₁₀-transformed allergen concentrations from 0 to 6 months and from 6 to 12 months were analyzed using a paired *t* test.

At the initial 0 month, the average cockroach count per apartment was 148 ± 24 ($\pm$ SE), with a median of 116 (range, 21-480). Mean cockroach counts were reduced by $97.9\% \pm 1.1\%$ and $99.9\% \pm 0.1\%$ at 6 and 12 months, respectively. Figure 1 shows the geometric mean concentrations of German cockroach allergens over the 12-month period of observation. Bla g 1 concentrations were significantly reduced from 0 to 6 months ($t = 4.45$, $df = 29$, $P < .001$) and from 6 to 12 months ($t = 8.48$, $df = 29$, $P < .001$). Similarly, Bla g 2 concentrations were also reduced significantly from 0 to 6 months ($t = 5.75$, $df = 29$, $P < .001$) and from 6 to 12 months ($t = 4.07$, $df = 29$, $P < .001$). From 0 to 12 months, the geometric mean Bla g 1 and Bla g 2 concentrations were reduced by 96% and 90%, respectively.

The percentage of apartments with Bla g 1 concentration above the 3 targeted thresholds is shown in Figure 2.^{2,8} From 0 to 6 months, the percentage of apartments with Bla g 1 above 0.04, 0.2, and 0.8 μ g/g remained the same or decreased slightly. From 6 to 12 months, there was a much greater decrease in the percentage of apartments with Bla g 1 above the 3 thresholds.

Our research extends previous knowledge, demonstrating that high reduction of cockroach allergen levels can also be achieved by cockroach control alone, even in concealed areas that could otherwise be returned into breathing spaces through air movement and resident daily activities. The changes in cockroach allergen levels over time indicate that once cockroaches are eliminated or reduced to very small numbers, cockroach allergens will continue to be present and will need at least a few months to degrade to levels below the proposed asthma morbidity threshold.

We conclude that cockroach infestations can be successfully reduced to extremely low levels in a building if an effective cockroach management program is adopted. Although rarely studied, it is expected that effective cockroach control will also lead to significant health benefits for the building occupants. This is suggested by a recent study that showed that using bait

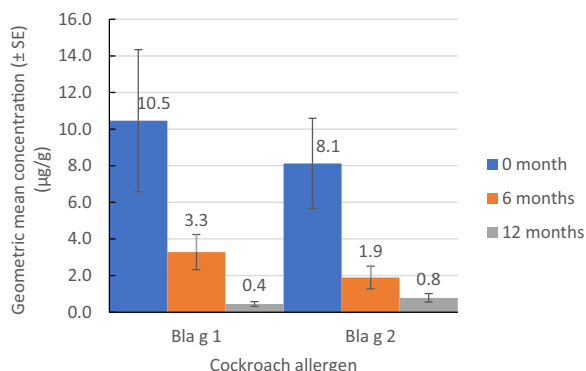


FIGURE 1. Geometric mean allergen concentrations from vacuumed dust samples.

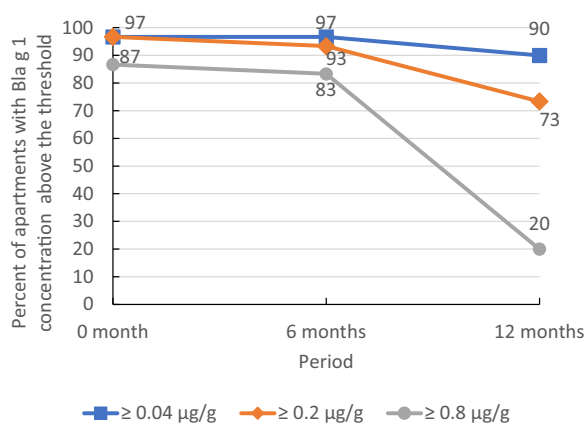


FIGURE 2. Changes in the percentage of apartments with Bla g 1 concentrations above the 3 proposed thresholds (detection threshold, 0.04 µg/g; risk of sensitivity, 0.2 µg/g; and risk of asthma, 0.8 µg/g).

alone to control cockroaches resulted in improved asthma outcomes over a 12-month period.⁹ Therefore, to reduce the health risks and expenses related to cockroach allergen exposure, it is important to put greater emphasis on effective pest management programs in communities suffering from chronic cockroach infestations and high asthma occurrence rates.

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REFERENCES

- Wang C, Bischoff E, Eiden AL, Zha C, Cooper R, Graber JM. Residents attitudes and home sanitation predict presence of German cockroaches (Blattodea: Ectobiidae) in apartments for low income senior residents. *J Econ Entomol* 2019; 112:284-9.
- Rosenstreich DL, Eggleston P, Kattan M, Baker D, Slavin RG, Gergen P, et al. The role of cockroach allergy and exposure to cockroach allergen in causing morbidity among inner-city children with asthma. *N Engl J Med* 1997;336: 1356-63.
- Pollart SM, Mullins DE, Vailes LD, Hayden ML, Platts-Mills TA, Sutherland WM, et al. Identification, quantitation, and purification of cockroach allergens using monoclonal antibodies. *J Allergy Clin Immunol* 1991;87:511-21.
- Arbes SJ, Sever M, Mehta J, Gore JC, Schal C, Vaughn B, et al. Abatement of cockroach allergens (Bla g 1 and Bla g 2) in low-income, urban housing: month 12 continuation results. *J Allergy Clinical Immunol* 2004;113:109-14.
- Sever ML, Arbes SJ Jr, Gore JC, Santangelo RG, Vaughn B, Mitchell H, et al. Cockroach allergen reduction by cockroach control alone in low-income urban homes: a randomized control trial. *J Allergy Clin Immunol* 2007;120:849-55.
- Wang C, Eiden A, Cooper R, Zha C, Wang D. Effectiveness of building-wide integrated pest management programs for German cockroach and bed bug in a high-rise apartment building. *J Integrated Pest Manag* 2019;10:33.
- Huss K, Adkinson NF Jr, Eggleston PA, Dawson C, Van Natta ML, Hamilton RG. House dust mite and cockroach exposure are strong risk factors for positive allergy skin test responses in the Childhood Asthma Management Program. *J Allergy Clin Immunol* 2001;107:48-54.
- Arruda LK, Vailes LD, Ferriani VP, Santos ABR, Pomés A, Chapman MD. Cockroach allergens and asthma. *J Allergy Clin Immunol* 2001;107:419-28.
- Rabito FA, Carlson JC, He H, Werthmann D, Schal C. A single intervention for cockroach control reduces cockroach exposure and asthma morbidity in children. *J Allergy Clin Immunol* 2017;140:565-70.