Evaluation of German Cockroach (Orthoptera: Blattellidae) Allergen and Seasonal Variation in Low-Income Housing


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ABSTRACT Six apartments in a low-income housing project were evaluated for German cockroach, Blatella germanica (L.), infestation and concentration of an allergen derived from these cockroaches (Blag II). Kitchen and living room samples were collected monthly for 1 yr. In addition, airborne sampling was carried out in 3 kitchens. The kitchen had the highest allergen concentration in 60% of visits and the highest number of cockroaches trapped in 60% of visits. In the kitchen, the highest cockroach levels were seen in June, whereas the values for Blag II peaked in August. In keeping with this, the closest correlation was between Blag II (µg/g dust) and the number of cockroaches found 2 mo earlier. Airborne samples were assayed for 3 separate allergens, Blag II and Blag I. No allergen was detectable in the absence of disturbance. By contrast, during disturbance with a vacuum cleaner both Blag II and Blag I were detectable in the air of each apartment. Results suggest that immunochromatographic assay of a major allergen in dust samples from the kitchen floor may be used to monitor exposure to German cockroaches, also that cockroach levels may be used as an indicator or predictor of allergen in dust.

KEY WORDS Blatella germanica, German cockroach, allergen, seasonality

AS THE PREVALENCE and morbidity of asthma continue to increase in the United States, investigators have sought to identify and define risk factors responsible for asthma attacks (Platts-Mills and Chapman 1987). Attention has focused recently on the role of indoor allergens, principally dust mites, cockroaches, and animal danders, as causes of asthma (Sly 1988, CDC 1990, Weiss and Wagener 1990). The increase in asthma in the United States is most marked among persons in lower socioeconomic groups who live in urban or inner city areas, and is prevalent in African-American and Hispanic populations (Sly 1988, CDC 1990, Weiss and Wagener 1990, Call et al. 1992, Weiss et al. 1992, Gelber et al. 1993, Pope et al. 1993). Recent studies suggest that sensitization to cockroach allergens is common in urban areas, and is a risk factor for asthma among people who live in cockroach infested houses (Call et al. 1992, Gelber et al. 1993, Arruda et al. 1995).

Most studies on cockroaches as allergens producers have focused on the German cockroach, Blatella germanica (L.), the species most prevalent in the home environment. Allergens have been identified in fecal as well as whole body extracts (Lerner et al. 1991, Musmann et al. 1995). Many allergens have been identified from this insect, but so far only 2 are identified easily from house dust using enzyme-linked immunosorbent assays (ELISA) (Pollart et al. 1994a, b). These are called Blag I and Blag II according to standard procedures for naming allergens (Helm et al. 1988, Wu and Lan 1998, Schou et al. 1990, Stankus et al. 1990, Pollart et al. 1991b).

For the allergen Blag II, a threshold level of 2 units/mg of house dust has been proposed (Gelber et al. 1993). Recently, this has been shown to represent 80 µg allergen per gram of dust (Arruda et al. 1995). Persons predisposed to sensitization would become allergic to cockroaches if exposed to levels higher than this threshold. It would be helpful to those with allergy to cockroaches to know if the allergen is more prevalent during a certain time of the year, and how cockroach levels in the home affect the presence of allergen.

Because respiratory allergens must be inhaled, their airborne presence is also important. Blag I and Blag II allergens were found in air samples taken directly over living colonies of German cockroaches (Helm et al. 1993), but little work has been done testing for cockroach allergen in residences.

Researchers in the Department of Entomology at Virginia Tech have worked extensively with the managers and residents of an apartment complex administered by the Roanoke Redevelopment and Housing Authority in Roanoke, VA, to understand
Table 1. Mean amount of German cockroach allergen present in the air of apartments before and during disturbance.

<table>
<thead>
<tr>
<th>Apt. no.</th>
<th>Background</th>
<th>Disturbance</th>
<th>Bla g I</th>
<th>Bla g II</th>
<th>Bla g I</th>
<th>Bla g II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;0.01</td>
<td>&lt;1.0</td>
<td>0.19</td>
<td>13.6</td>
<td>0.06</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>&lt;0.02</td>
<td>&lt;1.0</td>
<td>0.30</td>
<td>7.6</td>
<td>0.08</td>
<td>0.9</td>
</tr>
<tr>
<td>3</td>
<td>&lt;0.02</td>
<td>&lt;1.0</td>
<td>0.09</td>
<td>11.6</td>
<td>0.08</td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>&lt;0.02</td>
<td>&lt;1.0</td>
<td>0.20</td>
<td>3.2</td>
<td>0.02</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>&lt;0.01</td>
<td>&lt;1.0</td>
<td>0.07</td>
<td>13.0</td>
<td>0.02</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Each number represents a 20-ns sample with 2 parallel filters before and after 15-n disturbance with libra suction vacuum cleaner. Mean value for 2 filters. Bla g I allergen levels represent mean units allergen per cubic meter of air. Bla g II allergen levels represent mean ammonium of allergen cubic meter of air.

and alleviate their cockroach control problems (Robinson et al. 1981; Zinggoli and Robinson 1994; Robinson and Zinggoli 1985; Thou and Robinson 1987a, b; Zhai and Robinson 1992). This background knowledge in German cockroach biology and control, as well as access to the apartment complex, made it possible to carry out the current study on the seasonality of cockroach allergen and cockroach numbers.

Materials and Methods

Preliminary sampling of cockroach density was done in 11 apartment. Cockroach density in each apartment was determined using Mr. Sticky (Long Island, NY) sticky traps, a tent-shaped cardboard trap with the floor covered with an adhesive substrate (8,015 by 16,015 cm) (30% synthetic rubber, 50% hydrogenated petrosin, 15% plasticizer, and 5% antioxidant). Cockroaches entering this trap are caught in the substrate. One sticky trap was placed in the kitchen near the refrigerator; it was left out for 34 h and then German cockroaches mixed in the substrate were counted. From this pre-sampling, 6 apartments were selected, representing a range of cockroach densities, for a year-long study monitoring both allergen and cockroaches.

The major site of cockroach allergen in a house is known to be the kitchen, with lesser amounts found in the living room and bedrooms (Pollard et al. 1991a, Cali et al. 1992). For this study, the kitchen was considered to be the primary site for sampling. The living room was sampled as a secondary site.

To sample for German cockroach allergen in the air, 5 apartments were sampled. Airborne samples were collected from the kitchens of 5 of the 6 apartments. The 1st was sampled in December 1994, as a pilot study, and the other 4 were sampled in January 1995. Two airborne samplers with glass fiber filters (Millipore, Bedford, MA) were supported 0.6 m above the kitchen floor on a retort stand. Air was sampled for 30 min at a flow rate of 18 liters/min (0.54 m total air sampled) through each filter (Lucyynska et al. 1990). The experiment was then repeated with disturbance. Dust was disturbed artificially for the first 10 min of the 2nd sampling period by vacuuming with a Shop Vac vacuum cleaner (Shop Vac, Williamsport, PA) from which the filter had been removed. The duplicate glass filters were then eluted overnight at 4°C in 1 ml of 0.5% bovine serum albumin in phosphate buffered saline. Extracts were obtained by compress-

![Graph](imageurl)

Fig. 1. Mean micrograms of Bla g II allergen per gram of house dust and mean number of German cockroaches in kitchens, when sampled monthly.
ing the filter in a 3 ml plastic syringe and were assayed by ELISA for Bla g 1 and Bla g II (Pollart et al. 1991b).

To sample for dust carrying allergen, an efficient vacuum with a piece of sheeting material (18 by 18 cm²) inserted between the hose and nozzle was used. The area around the perimeter of the kitchen floor and refrigerator was vacuumed; the dust was placed in a marked plastic bag and refrigerated. The living room perimeter and around any upholstered furniture was also sampled, with dust collected and stored as before. Cockroach populations were evaluated by sticky trap counts in both locations 24 h after dust collection. No pesticides were used during this trial, which eliminated any possible confounding effects of pesticide-allergen interactions.

Dust was sieved through a brass, 50-mesh sieve, and 100 mg was mixed with 2 ml of phosphate-buffered saline containing 0.05% Tween 20 at room temperature for 2 h. Water-soluble proteins containing allergen dissolved into this saline solution with a small amount of detergent. The mixture was centrifuged at 750 X g to separate liquid and dust, with the liquid drawn off and frozen until analysis (Call et al. 1992). A 2-site monoclonal antibody-based ELISA was used to detect and measure the Bla g II allergen in the extract (Pollart et al. 1991a, b).

Results and Discussion

Air sampling results are found in Table 1. Allergen levels were never more than the lowest detectable amount until the air was disturbed. This is similar to house dust mite (Dermatophagoides spp.) allergen, which is also dependent on disturbance to become airborne (de Blay et al. 1991).

![Diagram](image-url)

Fig. 2. Correlation comparing micrograms of Bla g II allergen per gram of dust with the number of cockroaches in sticky traps 2 mos previous.

Table 2. Correlation of German cockroaches and Bla g II allergen in kitchens and living rooms

<table>
<thead>
<tr>
<th>Correlation between monthly avg Bla g II and monthly avg cockroaches</th>
<th>Kitchen</th>
<th>Living room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site/score</td>
<td>r</td>
<td>P</td>
</tr>
<tr>
<td>2 mos later</td>
<td>0.0016</td>
<td>NS</td>
</tr>
<tr>
<td>1 mos later</td>
<td>0.072</td>
<td>NS</td>
</tr>
<tr>
<td>Same month</td>
<td>0.27</td>
<td>0.05*</td>
</tr>
<tr>
<td>1 mos previous</td>
<td>0.41</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td>2 mos previous</td>
<td>0.02</td>
<td>&lt;0.001***</td>
</tr>
<tr>
<td>Mean no. total cockroaches</td>
<td>32 ± 5</td>
<td></td>
</tr>
<tr>
<td>Mean Bla g II levels (µg/g dust)</td>
<td>24.6 ± 3.2</td>
<td></td>
</tr>
</tbody>
</table>

* Kitchens had more cockroaches collected in 46/71 visits and higher Bla g II levels in 46/71 visits. ** NS, not significant, * P < 0.05, ** P < 0.01, *** P < 0.001.
The numbers of German cockroaches found in sticky traps and the units of Bla g 2 allergen per gram of dust in the kitchens were averaged for each sampling date (Fig. 1). There is an obvious peak for numbers of cockroaches and allergen, but they do not appear at the same time (June for cockroaches and August for allergen). Regression analysis comparing allergen levels and cockroach numbers show a correlation coefficient of 0.57 ($P = 0.02$).

The buildup of allergen could logically lag behind a peak in cockroach numbers. Focus, cast skins, and dead bodies, as well as living German cockroaches, all have significant amounts of allergen (Lehre et al. 1991, Memon et al. 1991). This debris, which results from the presence of cockroaches, builds up slowly in a residence infested with these insects.

There is a correlation (Table 2) between allergen levels and cockroach numbers at the same time, 1 or 2 mo previous and 1 or 2 mo earlier. For data collected in kitchens, the best correlation coefficient ($r = 0.52, P < 0.001$) is found when the allergen level is compared with cockroach numbers 2 mo previous. Fig. 2 shows allergen levels compared with cockroach numbers 2 mo previous.

Future studies, including more residences, and incorporation of other factors such as cleaning habits and conditions in the residence (carpeted or not, type of heating or cooling systems) will help determine the factors that affect allergen levels.

Acknowledgment

This work was partially funded by National Institutes of Health grants AI 30365 and U31 AI-34607.

References Cited


Received for publication 12 June 1996; accepted 16 November 1996.