

Kathleen C. Barnes^a
 Richard J. Brenner^b

^a Departments of Anthropology and
 Entomology, University of Florida, and
^b Agricultural Research Service, Medical and
 Veterinary Medical Research Laboratory,
 Gainesville, Fla., USA

Quality of Housing and Allergy to Cockroaches in the Dominican Republic

Key Words

Cockroach
 Allergy
 Atopy
 Skin test
 Housing

Abstract

Fifty-one atopic asthmatic and/or allergic rhinitic children and 23 nonatopic control from Santo Domingo, the Dominican Republic, were skin tested with an extract mix of three cockroach species (*Blattella germanica*, *Blatta orientalis*, and *Periplaneta americana*). Sixteen percent of the atopics and none of the non-atopics demonstrated positive immediate skin reactions to the cockroach mix ($\chi^2 = 4.05$, $p = 0.04$). Hypersensitivity was correlated with the quality of the homes; 22% (8/36) of the atopics who lived in a concrete home were skin test positive to the cockroach mix, while none (0/15) of the atopics who lived in a wood home were skin test positive ($\chi^2 = 4.86$, $p = 0.03$). Although the incidence of cockroach allergy in this study is lower than that found elsewhere, these data support the notion that, in this tropical environment, sensitization to cockroaches is associated with housing quality.

Introduction

Numerous studies have been published that confirm the relationship between cockroach allergens and atopic diseases [1–6]. Cockroach allergens may exceed pollens in importance as etiological agents of chronic respiratory disease among asthmatics who are chronically exposed to the insect secondary to urban residency and/or socioeconomic constraints [6, 7]. The incidence of asthma directly related to cockroach allergens among atopic asthmatic adults has been reported to be as high as 58% and among atopic asthmatic children as high as 69% [3]. More important, asthmatics sensitive to cockroach allergen have more severe disease than the general asthma population, exhibiting higher IgE levels and a higher degree of steroid dependency [6]. This is probably due to the fact that both exposure and sensitivity to cockroach allergens are much greater among the inner-city population [8], and inner-city residents – most of

whom are minorities – experience disproportionately higher asthma morbidity and mortality than their suburban, predominantly Caucasian, counterparts [9, 10].

Although there are over 4,000 species of cockroaches, only about 50 are pestiferous, and of those, 8–10 species are known to adversely affect humans [11]. Cockroaches are abundant in the warm, humid climate of the tropics, from where they originated [12]. Three decades ago, Marchand [13] reported the need for desensitization of cockroach-sensitive patients in Puerto Rico, who were mostly from the middle-to-upper socioeconomic strata, suggesting that, unlike the US, cockroach allergy was *inversely* related to socioeconomic status [SES]. Because infestations of domiciliary cockroaches are largely dependent upon housing conditions [14], and because hypersensitivity is dependent upon exposure [8], we hypothesized the following based on Marchand's findings: (1) chronic exposure to a high, year-round cockroach population in the tropics is common and

KARGER

E-Mail karger@karger.ch
 Fax +41 61 306 12 34

© 1996 S. Karger AG, Basel
 1018–2438/96/1091–0068 \$8.00/0

Correspondence to: Dr. Kathleen C. Barnes, PhD
 Johns Hopkins Asthma and Allergy Center
 The Francis Scott Key Medical Center Allergy and Clinical
 Immunology Division, HE2 5504 Hopkins Bayview Circle
 Baltimore, MD 21224-6801 (USA)

Received:
 February 20, 1995
 Accepted after revision:
 July 11, 1995

Table 1. Clinical profiles of Dominican sample

	Subjects ST+ to CR				Subjects ST- to CR
	asthmatics	rhinitics	atopics	total	
Male	4/24	2/7	6/31	6/47	0/16
Female	0/13	2/7	2/20	2/27	0/7
Mean age in years	8.8±2.5 (6-12)	10.3±4.1 (5-14)	9.5±3.3 (5-14)	9.5±3.3 (5-14)	8.4±3.4 (3-14)
Total	4/37	4/14	8/51	8/74	66/74
CR = Cockroach mix.					

does not discriminate according to SES, or (2) housing features in the tropics unique to the upper socioeconomic strata promote exposure to cockroach allergen. The purpose of this study was to determine the incidence of hypersensitivity to cockroaches among a sample of atopic children in a tropical environment, and to identify any SES and/or housing variables predictive for allergy.

Materials and Methods

Skin Testing

During a 6-week period (June–August, 1988), 51 unrelated atopic children (male:female ratio = 1.7:1) between the ages of 3 and 14 years (mean = 8.1±3.1) were selected from the allergy clinic at the Hospital de Niños, Robert Reid Cabral (RRC), in Santo Domingo, Dominican Republic. Twenty-three nonatopics (male:female ratio = 2.3:1) between the ages of 3 and 14 years (mean = 9.4±3.9) were selected from the Well-Child clinic as control subjects. All children were skin tested with a standardized cockroach mix (*Periplaneta americana*, *Blatta orientalis*, and *Blattella germanica*) extract (Hollister-Stier, Division of Miles Laboratories, Elkhart, Ind., USA). Extracts were used at 1:10 w/v concentration for skin prick tests (using the Wyeth bifurcated needle) and at 1:500 w/v for intradermal skin tests (0.05 ml injected). A positive test was defined as a wheal of a diameter ≥5 mm greater than the negative control, as recommended by Krouse and Klaustermeyer [15]. The majority of patients resided within the urban sector of Santo Domingo; a smaller proportion resided in the rural districts, as far as 100 km away from the clinic.

A structured, open-ended questionnaire was administered to obtain data pertaining to the physical attributes of the home. A 'concrete' home was defined as a dwelling constructed in part or entirely of concrete, as opposed to a 'wood' home, which was constructed entirely of wood. Questions were asked regarding household income and the number of occupants in the home. All participants were presented with a written informed consent, in Spanish (read to patients who were illiterate). The study had been approved by the University of Florida Institutional Review Board prior to commencement.

Entomological Survey

Cockroaches were collected using the sticky, tent-style trap in a sample of randomly selected homes (urban and rural) within a 20-mile radius of Santo Domingo, and public sites (food-packing industry and the RRC Hospital). All specimens were identified at the USDA-Agricultural Research Service laboratory in Gainesville, Fla., USA, according to morphological traits in dichotomous keys.

Statistical Analyses

Data from the interviews and biomedical tests were coded and entered into a data base program [16]. Frequency distributions, and bivariate (Pearson's R, χ^2 , and Student's t test) analyses were produced for further interpretations, using logistic analysis procedures for personal computers [17].

Results

Of the 74 children, 16% (8/51) of the atopics and none of the nonatopics demonstrated positive immediate skin reactions to the cockroach mix ($\chi^2 = 4.05$, $p = 0.04$). Among the 51 atopic subjects, 10.8% (4/37) of the subjects with asthma and 28.6% (4/14) of the subjects with allergic rhinitis were sensitive to cockroach by the skin test [ST] (NS, $p = 0.12$). There was no significant difference between ST+ and ST- patients according to age or sex (table 1).

Within the atopic sample, 36/51 (70.6%) lived in concrete homes; 12/23 (52.2%) of the controls lived in concrete homes (NS, $p = 0.13$). All participants (100%) lived in homes with indoor running water, 97% had indoor kitchens, and 50% had indoor toilets. The presence of concrete in the home was correlated with the following: an indoor toilet ($\chi^2 = 7.41$, $p = 0.006$), an indoor kitchen ($\chi^2 = 3.87$, $p = 0.05$), and a concrete (as opposed to wood or dirt floor ($\chi^2 = 17.94$, $p < 0.001$; fig. 1). A positive ST response to cockroach was correlated with the presence of concrete in the home ($\chi^2 = 4.86$, $p = 0.03$); 22% (8/36) of the atopics who lived in a concrete home were ST+ to cockroach, while none (0/15) of the atopics who lived in a wood home were ST+ (fig. 2).

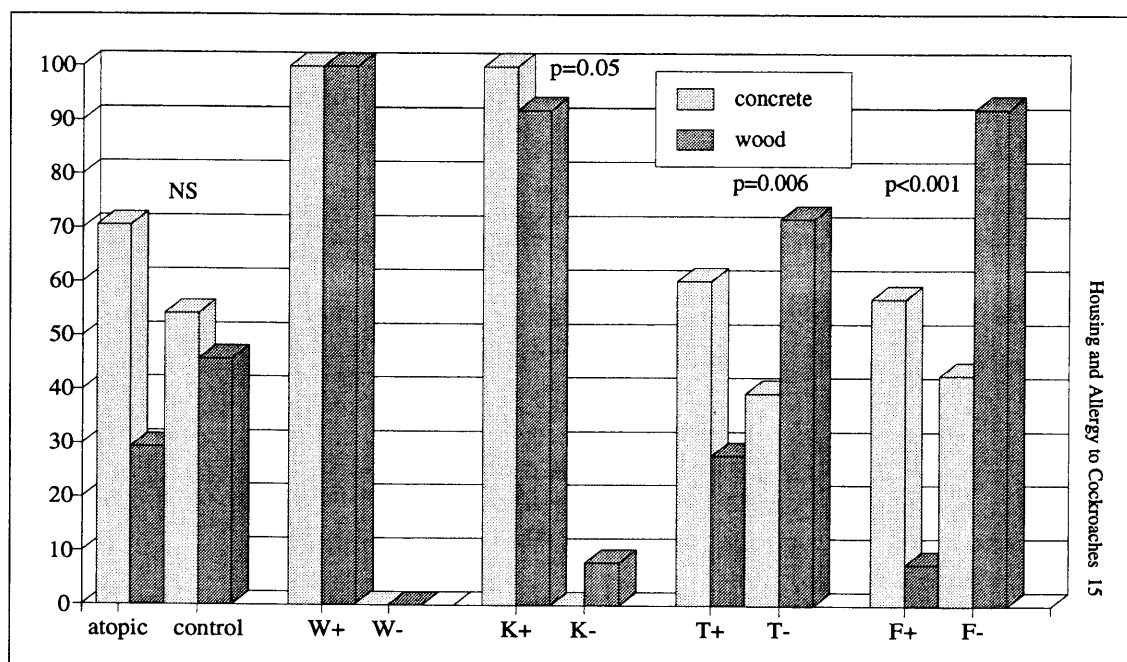


Fig. 1. Correlations of concrete and wood housing with the χ^2 test. Comparisons are to atopic/control (sample classification), W+/- (indoor water/no indoor water), K+/- (indoor kitchen/no indoor kitchen), T+/- (indoor toilet/no indoor toilet), and F+/- (concrete floor/no concrete floor).

The average number of residents per household was 6.1 (median = 6), range = 2–16). Only 54/74 of the informants divulged monthly income for the purpose of calculating per capita income for the household; therefore, this variable could not be used definitively in the study. The mean per capita income of those who answered the question was RD\$131.40 $\pm$ 77.90 (median = 114.00, range = 13.00–375.00; note, in 1988, US\$1.00 = about RD\$ 3.00). Despite the absence of income data from 27% of the sample, the presence of concrete in the home was correlated to income according to the Student's test ($t = 2.19$, $p = 0.03$).

The predominant species of cockroach in and around Santo Domingo was the American cockroach, *P. americana*. Others included *Periplaneta australasiae* (Australien), *B. orientalis* (Oriental), *Supella longipalpa*, and *Blaberus giganteus*. *Pycnoscelus surinamensis* (Surinam) and *Pan-chloris nivea* (Cuban) were regularly found in leaf litter in the rural district, and *Pycnoscelus surinamensis* was trapped in a metropolitan home and reported as a frequent pest in the courtyard and kitchen. All 75 informants reported seeing cockroaches in their homes.

Discussion

Cockroach hypersensitivity in this tropical setting (16%) was considerably lower than in US inner cities, where ranges from 53–69% have been reported [3, 4]. Cockroach allergy is a particular problem in American inner cities [3, 8, 18], and the incidence is typically much higher in those populations than in suburban populations [18, 19]. In the US, the higher incidence among individuals from low-income environments is probably related to greater cockroach infestations in poor housing and is therefore a function of the duration of exposure [8, 20, 21].

It appears that an opposite phenomenon exists in the tropics. Although only 54/74 informants divulged monthly per capita income in their household, the presence of concrete in the home was correlated to income. Furthermore, participants living in concrete homes were more likely to enjoy amenities such as an indoor kitchen ($p = 0.05$) and indoor toilet ($p = 0.009$) than wood dwellers, who were more likely to rely on outdoor water and sewerage. These two factors imply a relationship between concrete housing and SES. Elsewhere in the tropics, the quality of housing has been found to be a reliable indicator of SES [22, 23]. More important, atopics residing in concrete homes were signif-

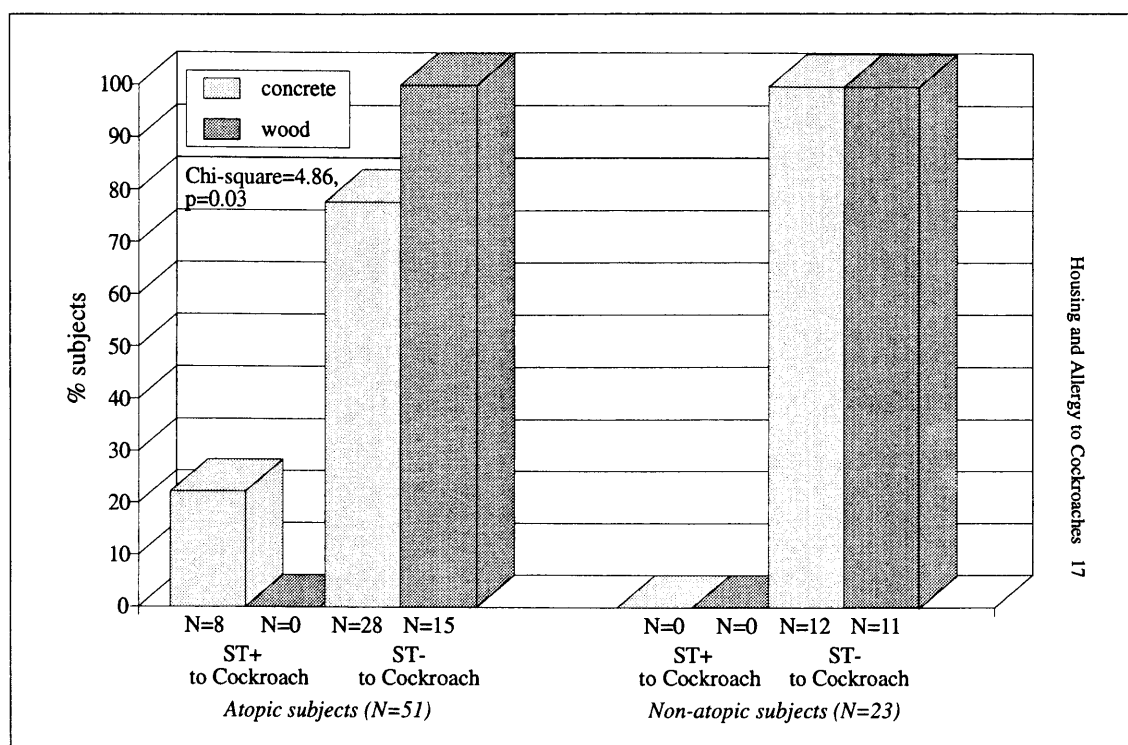


Fig. 2. Correlation between skin test (ST) results (+/-) to cockroach mix (*B. germanica*, *P. americana*, and *B. orientalis*) among 51 atopics and 23 nonatopics (n = 74) and building construction (concrete, n = 48; wood, n = 26) of the home. Twenty-two percent (8/36) of the atopics who lived in a concrete home were ST+ to cockroach, while none (0/15) of the atopics who lived in a wood home were ST+ ($\chi^2 = 4.86$, $p = 0.03$).

icantly more likely to demonstrate a positive ST to cockroach than atopics residing in wood homes ($p = 0.05$); this supports the notion that, in this tropical environment, sensitization to cockroaches is associated with housing quality. Although the incidence of hypersensitivity to cockroach among Dominican atopics (16%) was substantially lower than that reported by Marchand [13] in Puerto Rico, it is important to note that his study was based on subjects from the middle-to-upper socioeconomic strata, who presumably resided in well-built homes.

As the structural quality of the home increases (e.g., the integration of concrete and subsequently indoor plumbing), so too does the quality of the microhabitat preferred by this arthropod, and, theoretically, the amount of cockroach allergen. Because kitchens provide the four basic necessities for cockroach survival (warmth, moisture, food and harborage), homes without indoor kitchens probably have far fewer indoor cockroach populations. Elsewhere, kitchens exhibit the highest levels of allergen [18, 19]. Unfortunately, the number of patients in this study with an outdoor kitchen was so small (3%) that we were unable to determine a significant relationship between the presence of an indoor kitchen

and cockroach allergy. Another probable relationship between concrete housing and exposure to cockroach allergen is airflow; it is expected that higher-quality homes constructed of masonry result in lower airflow patterns than wood structures, and cockroaches are sensitive to airflow [24, 25]. This possible factor warrants further study.

The Dominican Republic, situated in the balmy tropics, with seasonal temperatures that seldom vary from a summer average of 29°C and a winter average of 24°C, and a rainfall range of 19 mm (March) to 185 mm (June), provides an ideal environment for the year-round proliferation and subsequent exposure to cockroaches. The species that was most abundant in this study, *P. americana*, a peridomestic species, was included in the ST mix. Under suitable conditions, the American cockroach is capable of enormous populations due to its longevity (about 1,000 days) and a female reproductive potential of over 67,00 cockroaches in 1 year [12]. *B. orientalis*, also included in the mix and found in this study, is an important domiciliary species, which survives in a wide range of climates and prefers moist, dark places (e.g., crawl spaces) and sources of water within and around the house [12]. Although *B. germanica* was included in the mix

but not found in the study, it is relevant to this sample, because cross-reactivity between the American and German cockroach has been well-established [26–28].

Cross-reactivity among various cockroach species and the presence of at least five other cockroach species among Dominicans in this study warrants the investigation of hypersensitivity to the nontraditional species, especially those found in large numbers in and around Dominican homes. The finding that better-built homes present a risk factor to atopics sensitive to cockroaches warrants the need for interventions aimed at reducing allergen loads in concrete homes. Finally, the finding that atopics from better-built homes are at greater risk for hypersensitivity to cockroaches

indicates that the indoor environment (e.g. the home) is more critical than the outdoor, or *macroenvironment* (e.g., a tropical climate in which cockroaches are abundant year-round), and supports the contention that SES indirectly affects the level of risk for hypersensitivity.

Acknowledgements

The research on which this paper is based was supported in part by a Vining Davis Field Research Grant and by a research grant from S.C. Johnson & Son. The authors wish to thank Dr. Erwin Cruz-Bournigal for the use of his allergy clinic, and Drs. Roberto García and Yira Sano for their technical assistance.

References

- Bernton HS, Brown H: Insect allergy: The allergenicity of the excrement of the cockroach. *Ann Allergy* 1970;28:543–547.
- Kang B: Study on cockroach antigen as a probable causative agent in bronchial asthma. *J Allergy Clin Immunol* 1976;58:357–365.
- Kang B, Sulit N: A comparative study of prevalence of skin hypersensitivity to cockroach and house dust antigens. *Ann Allergy* 1978;41:333–336.
- Kang B, Chang JL: Allergenic impact of inhaled arthropod material. *Clin Rev Allergy* 1985;3:363–375.
- Lan J, Lee D, Wu C, Chang C-P, Yeh C-L: Cockroach hypersensitivity: Preliminary study of allergic cockroach asthma in Taiwan. *J Allergy Clin Immunol* 1988;82:736–740.
- Kang BC, Wu CW, Johnson J: Characteristics and diagnoses of cockroach-sensitive bronchial asthma. *Ann Allergy* 1992;68:237–244.
- Schwartz HJ: Inhalant allergy to arthropods. *Clin Rev Allergy* 1990;8:3–13.
- Kang B, Jones J, Johnson J, Kang JJ: Analysis of indoor environment and atopic allergy in urban populations with bronchial asthma. *Ann Allergy* 1989;62:30–34.
- Carr W, Zeitel L, Weiss K: Variations in asthma hospitalizations and deaths in New York City. *Am J Pub Health* 1992;82:59–65.
- Gerstman BB, Bosco LA, Tomita DK: Trends in the prevalence of asthma hospitalization in the 5- to 14-year-old Michigan Medicaid population, 1980 to 1986. *J Allergy Clin Immunol* 1993;91:838–843.
- Cornwell PB: *The Cockroach*. London, Hutchinson, vol 1, 1968.
- Ebeling W: *Urban Entomology*. Los Angeles, University of California Press, 1975.
- Marchand AM: Allergy to cockroaches. *Assoc Med Puerto Rico* 1966;58:49–53.
- Koehler PG, Patterson RS, Brenner RJ: German cockroach (Orthoptera: Blattellidae) infestations in low-income apartments. *J Econ Entomol* 1987;80:446–450.
- Krouse HA, Klaustermeyer WB: Immediate hypersensitivity skin testing: A comparison of scratch, prick and intradermal techniques. *Immunol Allergy Pract* 1980;2:94–101.
- Symantec Corporation: Q&A Database. Version 4.0 ed. Cupertino, Symantec Corporation, 1991.
- SAS Institute: SAS/STAT Guide for Personal Computers, version 6.4 ed. Cary, SAS Institute, 1988.
- Gelber LE, Seltzer LH, Bouzoukis JK, Pollart SM, Chapman MD, Platts-Mills TAE: Sensitization and exposure to indoor allergens as risk factors for asthma among patients presenting to hospital. *Am Rev Respir Dis* 1993;147:573–578.
- Pollart SM, Mullins DE, Vailes LD, Hayden ML, Platts-Mills TAE, Sutherland WM, Chapman MD: Identification, quantitation, and purification of cockroach allergens using monoclonal antibodies. *J Allergy Clin Immunol* 1991;87:511–521.
- Bernton HS, Brown H: Cockroach allergy. II: The relation of infestation to sensitization. *South Med J* 1967;60:852–855.
- Twarog FJ, Picone FJ, Strunk RS, So J, Colten HR: Immediate hypersensitivity to cockroach. isolation and purification of the major antigens. *J Allergy Clin Immunol* 1977;59:154–160.
- Dann G: *The Quality of Life in Barbados*. London, MacMillan Caribbean, 1984.
- Barnes KC: *The Role of Household Pests in the Epidemiological Transition of Allergy: Modernization of the Domestic Environment in Barbados*. Gainesville, University of Florida, 1992.
- Brenner RJ: Focality and mobility of some peridomestic cockroaches in Florida (Dictyoptera: Blattaria). *Ann Entomol Soc Am* 1988;81:581–592.
- Brenner RJ, Barnes KC, Helm RM: Arthropod allergens in the urban environment. *Proc Nat Urban Entomol Conf*, College Park, Feb. 1990.
- Helm RM, Squillace DL, Jones RT, Brenner RJ: Shared allergenic activity in Asian (*Blattella asahinai*), German (*Blattella germanica*), American (*Periplaneta americana*), and Oriental (*Blatta orientalis*) cockroach species. *Int Arch Allergy Appl Immunol* 1990;92:154–161.
- Schou C, Lind P, Fernandez-Caldas E, Löwenstein H: Identification and purification of an important cross-reactive allergen from American (*Periplaneta americana*) and German (*Blattella germanica*) cockroach. *J Allergy Clin Immunol* 1990;86:935–946.
- Stankus RP, Horner WE, Lehrer SB: Identification and characterization of important cockroach allergens. *J Allergy Clin Immunol* 1990;86:781–786.