

Short communication

Cockroach sensitivity in Norway: a previously unidentified problem?

Background: Little is known about cockroach sensitization in Scandinavia, whereas cockroaches are implicated in allergic diseases throughout large parts of the world. In association with the Genetics of Asthma International Network (GAIN) study, we report sensitization to cockroaches and possible association with IgE-mediated diseases in Norway.

Methods: 100 Norwegian families (426 subjects) of 7–35-year-old sibling-pairs with asthma and their parents underwent questionnaire/interview (medical and exposure history), skin prick test (SPT) to common local inhalant allergens and German cockroach, and IgE specific to mites, mosquito, shrimp and cockroach. Cockroach sensitization was defined as positive if there was a positive (≥ 3 mm) skin prick test and/or presence of IgE antibody of class 2 or more.

Results: Thirty-one subjects (7.5%) were sensitized (five monosensitized) to cockroach (27 by skin prick test and seven by IgE antibody, all with additional inhalant allergy). Co-sensitization was most common to grass (in 61%), cat (48%), dog (48%) and mites (42%). Reported allergic diseases in cockroach-sensitized subjects were asthma and rhinitis ($n = 10$), asthma only ($n = 9$), rhinitis only ($n = 2$) and neither asthma nor rhinitis ($n = 10$).

Conclusions: Since cockroach sensitization was relatively frequent in Norwegian atopic families, albeit with unclear clinical implications, we suggest that cockroach allergy should be considered in atopic subjects with respiratory disease.

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Sensitization to cockroaches (CR) is well recognized throughout large parts of the world and contributes to morbidity in subjects of the atopic constitution (1) in many countries (2–9). CR sensitivity is often associated with urban, low-income status, particularly in the USA (2–3, 5, 7, 9). There are even suggestions that exposure to CR may be involved in the development of early 'atopic' manifestation (9).

In Scandinavia, however, there is little information on the possible role of CR in allergic diseases. One study from Sweden detected CR allergens in only one of 123 homes, at levels of 40 ng/g dust (10), whereas we know of no published report on CR sensitization in Norway.

There is hardly any information on the occurrence of CR in Norway. To our knowledge the only previously published report (from 1978) (11) describes the types of

CR identified after receiving samples from insect exterminators, private homes and hospitals and restaurants including German CR (*Blattella germanica*), oriental CR and several other species such as *Ectobius lapponicus* which occurs naturally in woods and fields of Norway.

As part of a multinational study involving families with at least two children with asthma, skin prick testing (SPT) to a panel of worldwide common allergens including CR was performed. As CR sensitization is generally neither investigated nor expected in Norway, we were surprised to find a substantial number of subjects in this Nordic climate sensitized to CR. Thus, the present study reports CR sensitization in 100 families and its possible association with allergic disease.

Material and methods

Design

As part of the GAIN study (Genetics of Asthma International Network) 100 families fulfilling the following criteria were included in the present study in Norway: at least two siblings 7–35 years of age, with diagnosed asthma (symptomatic during the last 12 months in the

* The GAIN study teams consists of principal investigators: Helms P., Aberdeen, UK; Lenney W., Stoke on Trent, UK; Gerritsen J., Groningen, Netherlands; Whyte M., Sheffield, UK; Silverman M., Leicester, UK; Tsanakas J., Thessalonika, Greece; Sly P., Perth, Australia; Sunday J., Durham, USA; Barnes K., Baltimore, USA; Von Berg A., Wesel, Germany.

proband), and both parents willing to participate. Families were excluded if the proband suffered from other serious chronic pulmonary disease or if any parent or sibling had disease (including myocardial infarction or heart failure within the last one or three years, respectively) or treatment (beta-blockers) that would contradict methacholine challenge.

Families were recruited (during 18 months from December 1998) from hospitals, newspaper adverts, through the Norwegian Asthma and Allergy foundation, and from practising pediatricians or pulmonologists, mainly from central south-eastern Norway. All subjects underwent blood tests (including total IgE and IgE antibodies to inhalant allergens), skin prick test (SPT) to common inhalant allergens, as well as a questionnaire and interview including questions on possible presence and severity of allergic diseases and exposure to known allergens.

The study was accepted by the regional medical ethics committee, and written informed consent was obtained.

Subjects

Four hundred and twenty-six subjects (222 males) with a mean age of 27.9 years (SD 15.9), with no difference related to CR sensitization, completed the study. Of these subjects 279 had ascertained diagnosis of asthma, 18 had possible asthma (with symptoms, but not ascertained by clinical and objective evaluation), and 129 had no asthma. Rhinitis was reported in 135 subjects of whom 102 also had asthma, whereas 104 subjects had neither asthma nor rhinitis. Subjects with a positive SPT to common inhalant allergens or with IgE antibodies of class 2 or more were classified as atopic.

Allergological investigation

SPT was performed by two nurses according to European guidelines (12). Antihistamines were suspended for at least 72 h and systemic prednisolone doses exceeding 10 mg/day were suspended 24 h prior to testing. In three subjects SPT could not be performed because for clinical reasons antihistamines could not be suspended for more than 24 h. The following standardized extracts from ALK (Greer Laboratories Inc, Lenoir, NC) were used: *Dermatophagoides pteronyssinus*, *D. farinae*, grass mix, cat dander, dog dander, German CR, *Alternaria alternata*, *Cladosporium herbarum* and silver birch, as well as a saline negative control and a histamine control (10 mg/ml). The mean wheal size (longest plus shortest diameter divided by two) was recorded after 15 min. The SPT was regarded as positive with a wheal size of minimum 3 mm larger than the negative control.

Venous blood was drawn into serum separation tubes (SST) with a clot activator and a gel barrier, and stored for 60 min in room temperature before spinning at 1300 g for 10 min to separate the

serum. Serum for IgE antibodies was frozen at -70°C until analyzed. Serum for IgE antibody (IgE-Ab) was analyzed in one batch on a microtiter plate system from Diagnostic Products Corporation (DPC, CA) according to the manufacturer's specifications. IgE-Ab is reported as class 0 (negative) to class 6 for the following allergens: *D. pteronyssinus*, *D. farinae*, *D. microceras*, shrimp, mosquito and German CR (Greer Laboratory, Lenoir, NC; Sigma Chemical Company, St. Louis, MO; Allergon, Carthage, MO; New England Antigenics, Portland, ME). IgE-Ab class 2 or more was considered positive.

Serum was analyzed for total IgE, and for ECP using the UniCAP fluoroenzyme immunoassay (FEIA) according to the manufacturers instructions (Pharmacia Upjohn, Uppsala, Sweden).

Statistical analyzes

Results are given as mean $\pm$ standard deviation (SD) for demographic data, and otherwise as mean with 95% confidence interval (CI) unless otherwise stated. The statistical package for social sciences (SPSS) edition 9 was used for analyzes. Total IgE is reported as geometric mean with 95% CI, in parentheses. Nonparametric tests (Mann-Whitney) were used for comparisons between groups (e.g., atopic vs nonatopic) for quantitative data, and chi-squared test for comparison of frequencies between groups.

Results

Thirty-one (7.5% of all) subjects were sensitized to CR assessed by SPT ($n=26$), and presence of IgE antibodies (IgE-Ab) ($n=7$). Only three subjects had IgE-Ab levels $\geq$ class 2 as well as $\text{SPT} \geq 3$ mm. However, another 25 subjects had an SPT of 2 mm above negative control to CR, of whom one had IgE-Ab to CR class 1, one class 2 and one class 3. Five subjects with $\text{SPT} \geq 3$ mm were monosensitized to CR, whereas 11 of those with SPT to CR of 2 mm (above negative control) had no other positive SPT. All subjects with IgE-Ab $\geq$ class 2 had at least one additional inhalant allergy, whereas three subjects with IgE-Ab class 1 had no other detected inhalant allergy. At least one positive SPT was found in 235 of the subjects (55.7%), of whom 14% were CR sensitized (Table 1). Age, height and weight did not differ significantly in relation to CR sensitization. Eighteen of the CR sensitized (60%) and 195 (55%) of

Table 1. The number (and percentage) of subjects sensitized to specific allergens (SPT) within groups defined by the presence or absence of respiratory disease

Positive	Asthma only	Asthma and rhinitis	Rhinitis only	No asthma or rhinitis	% of total*
Total n	177	102	33	104	424
Sensitized n	98	72	14	50	236
Grass mix	61 (34.5)	51 (50.0)	7 (21.2)	18 (17.3)	32.2
Birch	59 (33.3)	44 (43.1)	9 (27.3)	21 (20.2)	31.3
Cat hair	54 (30.5)	51 (50.0)	7 (21.2)	15 (14.4)	30.0
Dog hair	44 (24.9)	46 (45.1)	6 (18.2)	12 (11.5)	25.5
<i>D. pteronyssinus</i>	27 (15.3)	16 (15.7)	5 (15.1)	5 (4.8)	12.5
<i>D. farinae</i>	15 (8.5)	15 (14.7)	3 (9.1)	8 (7.7)	9.7
Mugwort	17 (9.6)	7 (6.8)	0 (0)	13 (12.5)	8.7
Cockroach	10 (5.6)	10 (9.8)	3 (9.1)	8 (7.7)	7.3
<i>Cladosporium</i>	12 (6.8)	9 (8.8)	0 (0)	2 (1.9)	5.4
<i>Alternaria</i>	4 (2.3)	7 (6.8)	0 (0)	2 (1.9)	2.6

* This column refers to all 424 who underwent SPT.

the CR nonsensitized subjects reported having ever seen cockroaches (n.s). Approximately 10% of both CR sensitized and CR nonsensitized subjects were in regular contact with insects in relation to hobbies or work. Living abroad was not significantly different between CR sensitized and CR nonsensitized subjects.

Sensitization and respiratory disease

Seventy-four percentage of the CR sensitized subjects had asthma and/or rhinitis (Table 2). Six of the seven subjects with IgE-Ab class 2 or more to CR had asthma, of which three also reported rhinitis, whereas one subject reported rhinitis only. Five of the eight subjects with IgE-Ab to CR of class 1, had asthma of whom two also reported rhinitis, one had rhinitis only and two reported neither asthma nor rhinitis. Twenty (7.2%) subjects with asthma (279) were sensitized to CR, with the corresponding figures of 10%, 9% and 26% among subjects with asthma plus rhinitis, rhinitis only, and no allergic respiratory disease, respectively. Geometric mean total IgE was significantly higher among CR sensitized subjects 268.9 (161.3–448.5) vs 64.8 (55.9–75.2) ($P < 0.001$) as was mean serum ECP 13.7 (10.2–18.4) vs 10.0 (9.3–10.7) ($P = 0.003$). However, after adjustment for the number of positive skin prick tests (linear regression, data not shown), no significant association between CR sensitization and total serum IgE or serum ECP was detected.

Sensitization to CR and other allergens

Fifty-six percentage (236 subjects) of the participants had one or more positive SPT to inhalant allergens and 15.7% had IgE-Ab to one or more of mites, chironomides, shrimp or CR (Table 1). However, significantly more males ($n = 44$) than females ($n = 23$) ($P = 0.02$) were sensitized as assessed by IgE-Ab, but not by SPT. Sensitization to grass, birch, cat and dog (in that order) was most frequently found among the CR sensitized subjects, with less than half of the CR sensitized subjects sensitized also to *D. farinae* (42%)

and *D. pteronyssinus* (32%), respectively (Tables 2 and 3). Four families had two CR sensitized subjects, the remaining families had only one CR sensitized subject.

Discussion

Ten percent of subjects with both asthma and rhinitis were sensitized to CR in a country where CR has not been considered likely to be involved in allergic diseases. Of subjects with IgE-Ab to CR 85% had asthma, and 75% CR sensitized subjects reported allergic respiratory disease.

We were surprised to find that 7.5% of our study population and 14% of the sensitized subjects in the present study were sensitized to CR since CR sensitization has not been considered relevant to clinical allergy practice in Norway. There are to our knowledge no published reports on CR sensitization in Scandinavia. Our findings of CR sensitization in 7.2% of asthma subjects and in 10% of subjects with both asthma and rhinitis are comparable to a German study in 5- to 11-year-old schoolchildren reporting CR sensitivity (IgE-Ab to German CR) in 4.2% of all children (8.4%, 6.1% and 3.9% in children with current wheeze, asthma and without asthma, respectively) (13). However, our results from high-risk atopic families cannot compare directly to the German study cross-sectional study including healthy schoolchildren.

With some exceptions (13) most of the literature reports CR sensitization among various selected populations, ranging from 12.7% of Italian 'atopic' children (American and/or German CR) (4), and 26% of subjects with asthma and/or rhinitis (90% 'atopic') in Madrid (6) to 79% of children and young adults with asthma and/or rhinitis in Brazil (14). Few studies have included nonatopic controls (7, 15–18), that can indicate the prevalence of CR sensitization in general populations. Our finding of CR sensitization in 25% of the subjects without allergic respiratory disease (although high-risk families) as well as the German study of 3.9% CR

Table 2. Number of subjects (percentage of group) with positive SPT to allergens in 424 subjects

	CR + ($n = 32$)		CR - ($n = 393$)		<i>P</i> -value	% of all subjects with positive SPT
	<i>n</i>	%	<i>n</i>	%		
Grass mix	19	(61.3)	118	(30.0)	0.001	32.3
Birch	14	(45.2)	120	(30.5)	0.07	31.6
Cat hair	15	(48.4)	113	(28.8)	0.02	30.2
Dog hair	14	(45.2)	95	(24.2)	0.01	25.7
<i>D. pteronyssinus</i>	10	(32.3)	44	(11.2)	0.003	12.7
<i>D. farinae</i>	13	(41.9)	40	(10.2)	<0.001	12.5
Mugwort	2	(6.5)	36	(9.2)	0.45	9.0
<i>Cladosporium</i>	4	(12.9)	19	(4.8)	0.07	5.4
<i>Alternaria</i>	2	(6.5)	11	(2.8)	0.24	3.1

Significance assessed by Pearson's chi-squared test. SPT positivity: wheal size of minimum 3 mm larger than negative control.

Table 3. The number of subjects (% of group) with IgE antibodies to allergens in 426 subjects (skin prick test in 423 subjects)

	CR sensitized (n=32)		CR nonsensitized (n=393)		P-value	% of all subjects with positive SPT
	n	%	n	%		
<i>D. pteronyssinus</i>	13	(40.6)	46	(11.7)	<0.001	13.8
<i>D. farinae</i>	15	(46.9)	40	(10.2)	<0.001	12.9
<i>D. microcaeras</i>	9	(28.1)	37	(9.4)	0.004	10.8
Mosquito	5	(15.6)	0	(0)	<0.001	1.2
Shrimp	3	(9.4)	0	(0)	<0.001	0.7

Significance assessed by Pearson's chi-squared test. Specific IgE positive if class 2 or more.

sensitization among nonasthmatics shed some light on this, although no direct generalization to a normal population can be made. Thus, although lower than the reported 23% sensitization to American CR among 328 enrolled Afro-American subjects in a similar genetics study of families with sibling-pairs with asthma (17) in the USA, a significant number of subjects in the cold Nordic climate were sensitized to CR, not unlike that found in central and southern Europe.

Our study could not identify likely allergens associated with cross reactivity to CR. The IgE antibody analyses to standardized commercially available allergens were chosen, as they have been suggested to cross react with CR (mites (14, 18), shrimp (14) and mosquito (chironomide) (19)). However, the most frequently found sensitizing allergens (by SPT) in our CR sensitized subjects were grass-mix in around 60% of subjects, followed by cat and dog dander as well as birch in less than 50% of subjects. Although strong associations (5) or cross-reactivity between mites and CR (4, 14, 18), have been suggested, others have found CR specific allergens not cross-reacting with mites (8). Co-sensitization with mites in only 30–42% of our CR sensitized subjects, renders cross-reactivity between mites and CR an unlikely explanation for the SPT results. Supporting this, recent studies suggest that CR sensitization is closely associated with CR exposure (2, 7, 20–21). Gold et al. found that during infancy CR, but not mite exposure, was significantly associated with an increased risk of recurrent wheeze, which held true after adjusting for socioeconomic factors.

Only three subjects (all CR sensitized) also had IgE-Abs to shrimp in the present study. Thus, even if cross-reactivity to shrimp cannot be out ruled in these three subjects, a shrimp-CR cross-reactivity (14) cannot explain the vast majority of CR sensitization in our subjects.

CR exposure has been regarded as a risk factor for asthma (9, 22–24), and CR sensitization has been associated with increasing morbidity of asthma (5, 24). The finding that total IgE as well as serum ECP were significantly higher among CR IgE-sensitized subjects, compared to CR nonsensitized subjects, indicates that CR IgE sensitization is associated with more active disease. On the other hand, subjects without reported

asthma or rhinitis were also CR sensitized, so that the interpretation of the relevance of a positive SPT to CR for disease activity in this population remains unclear.

A low correlation between SPT and presence of IgE-Ab to CR found in the present study has been found also in other studies (6, 25), whereas others have described a stronger association (4, 8). Peruzzi found that in Italy 73% of the SPT CR-positive subjects also had IgE-Ab to CR (4), whereas Tsai et al. in Singapore found that 20% CR IgE-Ab-positive subjects could not be detected by SPT and 18% vice versa (8). Other studies have reported species-specific allergen sensitization, where the majority of, but not all, CR positive subjects were sensitized to both American and German CR (4). However, for the present study only German CR was studied, as this was the allergen chosen in advance for the international study. It is noteworthy that CR sensitization was found more commonly than mugwort, *Cladosporium* and *Alternaria* all of which are part of routine screening tests for inhalation allergens, whereas CR is not. The study presented implies that CR allergens should be considered in routine allergy testing.

Furthermore although possible exposure to CR was assessed by questionnaire only (without finding significant differences between CR sensitized and nonsensitized subjects), the finding of sensitization in 7.5% of the study population implies that exposure to CR should be measured also in Norwegian homes; this has indeed been suggested with respect to European homes by de Blay et al. (26). No such survey has to our knowledge been performed so far.

In conclusion, positive SPT to CR was more frequent than to commonly assessed allergens like *Cladosporium* in Norway. We could not identify the likely cross-reactivity nor did the questionnaire reveal exposure that could explain our findings. Further studies are clearly needed to evaluate exposure to CR and the possible role of CR in allergic diseases in a cold, Nordic climate.

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References

- JOHANSSON SG, O'B HOURIHANE J, BOUSQUET J, et al. A revised nomenclature for allergy. An EAACI position statement from the EAACI nomenclature task force. *Allergy* 2001;**56**:813–824.
- EGGLESTON PA, ROSENSTREICH D, LYNN H, et al. Relationship of indoor allergen exposure to skin test sensitivity in inner-city children with asthma. *J Allergy Clin Immunol* 1998;**102**:563–570.
- GERGEN PJ, MORTIMER KM, EGGLESTON PA, et al. Results of the National Cooperative Inner-City Asthma Study (NCICAS) environmental intervention to reduce cockroach allergen exposure in inner-city homes. *J Allergy Clin Immunol* 1999;**103**:501–506.
- PERUZZI M, DE LUCA M, NOVEMBRE E, DE MARTINO M, VIERUCCI A. Incidence of cockroach allergy in atopic Italian children. *Ann Allergy Asthma Immunol* 1999;**83**:167–171.
- SARPONG SB, KARRISON T. Skin test reactivity to indoor allergens as a marker of asthma severity in children with asthma (and Erratum in *Ann Allergy Asthma Immunol* 1998;**81**(2):126). *Ann Allergy Asthma Immunol* 1998;**80**:303–308.
- SASTRE J, IBANEZ MD, LOMBARDERO M, LASO MT, LEHRER S. Allergy to cockroaches in patients with asthma and rhinitis in an urban area (Madrid). *Allergy* 1996;**51**:582–586.
- SPORIK R, SQUILLACE SP, INGRAM JM, RAKES G, HONSINGER RW, PLATTS-MILLS TA. Mite, cat, and cockroach exposure, allergen sensitisation, and asthma in children: a case-control study of three schools. *Thorax* 1999;**54**:675–680.
- TSAI JJ, KAO MH, WU CH. Hypersensitivity of bronchial asthmatics to cockroach in Taiwan. comparative study between American and German cockroaches. *Int Arch Allergy Immunol* 1998;**117**:180–186.
- WILSON NW, ROBINSON NP, HOGAN MB. Cockroach and other inhalant allergies in infantile asthma. *Ann Allergy Asthma Immunol* 1999;**83**:27–30.
- MUNIR AK, BJORKSTEN B, EINARSSON R, et al. Cat (Fel d 1), dog (Can f 1), and cockroach allergens in homes of asthmatic children from three climatic zones in Sweden. *Allergy* 1994;**49**:508–516.
- MEHL R. Henvendelse angående skadedyr, ektoparasitter og andre plagsomme dyr i 1972–76. *Fauna* 1978;**31**((5)):250–267.
- DREBORG S, FREW A. Position paper. Allergen standardization and skin tests. *Allergy* 1993;**47**:48S–82S.
- HIRSCH T. Indoor allergen exposure in west and East Germany: a cause for different prevalences of asthma and atopy? *Rev Environ Health* 1999;**14**:159–168.
- SANTOS AB, CHAPMAN MD, AALBERSE RC, et al. Cockroach allergens and asthma in Brazil: identification of tropomyosin as a major allergen with potential cross-reactivity with mite and shrimp allergens. *J Allergy Clin Immunol* 1999;**104**:329–337.
- HIRSCH T, STAPPENBECK C, NEUMEISTER V, et al. Exposure and allergic sensitization to cockroach allergen in East Germany. *Clin Exp Allergy* 2000;**30**:529–537.
- GALANT S, BERGER W, GILLMAN S, et al. Prevalence of sensitization to aeroallergens in California patients with respiratory allergy. *Ann Allergy Asthma Immunol* 1998;**81**:203–210.
- HIZAWA N, FREIDHOFF LR, EHRLICH E, et al. Genetic influences of chromosomes 5q31-q33 and 11q13 on specific IgE responsiveness to common inhaled allergens among African American families. Collaborative Study on the Genetics of Asthma (CSGA). *J Allergy Clin Immunol* 1998;**102**:449–453.
- CHEW FT, LIM SH, GOH DY, LEE BW. Sensitization to local dust-mite fauna in Singapore. *Allergy* 1999;**54**:1150–1159.
- AALBERSE RC. Allergens from mites: implications of cross-reactivity between invertebrate antigens. *Allergy* 1998;**53**:47–48.
- PLATTS-MILLS TA, WARD GW Jr, SPORIK R, GELBER LE, CHAPMAN MD, HEYMANN PW. Epidemiology of the relationship between exposure to indoor allergens and asthma. *Int Arch Allergy Appl Immunol* 1991;**94**:339–345.
- GOLD DR, BURGE HA, CAREY V, MILTON DK, PLATTS-MILLS T, WEISS ST. Predictors of repeated wheeze in the first year of life: the relative roles of cockroach, birth weight, acute lower respiratory illness, and maternal smoking. *Am J Respir Crit Care Med* 1999;**160**:227–236.
- CALL RS, SMITH TF, MORRIS E, CHAPMAN MD, PLATTS-MILLS TA. Risk factors for asthma in inner city children. *J Pediatr* 1992;**121**:862–866.
- GELBER LE, SELTZER LH, BOUZOUKIS JK, POLLART SM, CHAPMAN MD, PLATTS-MILLS TA. Sensitization and exposure to indoor allergens as risk factors for asthma among patients presenting to hospital. *Am Rev Respir Dis* 1993;**147**:573–578.
- ROSENSTREICH DL, EGGLESTON P, KATTAN M, 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**:1356–1363.
- LEE SY, KIM DS, KIM KE, JEAUNG BJ, LEE KY. IgE binding patterns to German cockroach whole body extract in Korean atopic asthmatic children. *Yonsei Med J* 1998;**39**:409–416.
- DE BLAY F, SANCHEZ J, HEDELIN G, et al. Dust and airborne exposure to allergens derived from cockroach (*Blattella germanica*) in low-cost public housing Strasbourg (France). *J Allergy Clin Immunol* 1997;**99**:107–112.