

ENVIRONMENTAL DETERMINANTS

Prevalence of Sensitization to *Blomia tropicalis* among Young Adults in a Temperate Climate

GABRIEL JULIÀ-SERDÀ, M.D.,^{1,*} PEDRO CABRERA-NAVARRO, M.D.,¹ ORLANDO ACOSTA-FERNÁNDEZ, M.D.,² PEDRO MARTÍN-PÉREZ, M.D.,¹ MIGUEL A. GARCÍA-BELLO, B.SC.,³ AND JOSEP ANTÓ-BOQUÉ, M.D.^{4,5,6,7}

¹Department of Pulmonology, University of Las Palmas, Las Palmas de Gran Canaria, Canary Islands, Spain.

²Department of Pulmonology, Hospital Universitario de Canarias, La Laguna, Tenerife, Spain.

³Research Unit of the Dr Negrín University Hospital, University of Las Palmas, Las Palmas de Gran Canaria, Canary Islands, Spain.

⁴Centre for Research in Environmental Epidemiology (CREAL), Barcelona, Spain.

⁵Department of Experimental and Health Sciences, Universitat Pompeu Fabra (UPF), Barcelona, Spain.

⁶Municipal Institute of Medical Research (IMIM-Hospital del Mar), Barcelona, Spain.

⁷CIBER Epidemiology and Public Health (CIBERESP), Barcelona, Spain.

Background. There are no previous population-based studies assessing the prevalence of *Blomia tropicalis* (BT). This investigation analyzes the prevalence of sensitization to BT and its contribution to asthma and related diseases among young adults in the Canary Islands. **Material and methods.** From a random sample of 9506 adults, aged between 20 and 44, who had previously answered a short respiratory questionnaire, a further 20% random sample was drawn. All participants filled in an extensive questionnaire, and they underwent spirometry and bronchial hyperresponsiveness (BHR) test and skin testing to several allergens as well as the determination of total IgE and specific IgE. **Results.** The prevalence of positive skin tests to BT was 13.8% (95% confidence interval [CI] 10.6–17.9%) and that of BT-specific IgE 17.9% (95% CI 14.2–24.5%). Sensitization to BT (positive skin tests or positive specific IgE) was 20.9% (95% CI 16.9–25.5%). Most of the subjects sensitized to BT were also sensitized to *Dermatophagoides pteronissimus*; however, only 7% displayed monosensitization to BT. Among subjects who exhibited BHR, sensitization to BT reached 46.7% (95% CI 32.7–60.9%), among those with asthma 50% (95% CI 26.8–73.2%), in subjects with rhinitis 37.2% (95% CI 28.1–47.6%), and in those suffering from dermatitis 25.9% (95% CI 18.7–34.5%). A strong association of BT sensitization with BHR and asthma before and after 15 years was found. **Conclusion.** The prevalence of sensitization to BT among young adults in the Canary Islands is high, and it displays a close relationship with allergic respiratory diseases and dermatitis.

Keywords allergic diseases, dust mites, asthma

INTRODUCTION

House dust mites are organisms capable of inducing allergic reactions in humans, such as asthma, rhinitis, or dermatitis (1, 2). In mild climates the species that most commonly colonize house dust are *Dermatophagoides pteronyssinus* (DP), *Dermatophagoides farinae*, and *Euroglyphus maynei* (1). There are, however, other mites well known for their capacity to provoke sensitization in humans. Among them is the species *Blomia tropicalis* (BT) whose natural habitat is found in stored goods and house dust and grows mostly in tropical and subtropical countries (1). Moreover, its ability to sensitize both children and adults, provoking allergic diseases, is well documented (3). In the Canaries, DP is the most prevalent dust mite followed by BT. These data are supported by the high sensitization to these mites observed in asthmatic and rhinitic patients in the Islands (4)

Extensive data concerning the prevalence of sensitization to DP and its relation to asthma, bronchial hyperresponsiveness (BHR), and rhinitis in different regions of the

world have been known since the European Community Respiratory Health Survey (ECRHS) was performed (5). However, so far there are no population-based studies providing information on sensitization to BT and its relation to asthma or other allergic diseases. In addition, in a previous study we reported a higher prevalence of asthma in the Canaries than in the other Spanish centers in the ECRHS, something that was attributed to the temperate climate of the region (6). In order to address this lack of information, and applying the same methodology used in the ECRHS, in this study, we have analyzed the prevalence of sensitization to BT in the Canaries in a random sample of adult subjects, aged 20–44, and its relation to asthma, asthma-related symptoms, rhinitis, and atopic dermatitis.

MATERIALS AND METHODS

Populations

The study was performed following the ECRHS methodology (7). The initial phase of the ECRHS assessed a random sample of 10,000 individuals (5000 subjects on Gran Canaria Island and another 5000 on Tenerife Island), aged between 20 and 44. A short questionnaire was sent by mail with 12 questions about symptoms suggestive of

*Corresponding author: Dr. Gabriel Julià-Serdà, Department of Pulmonology, University of Las Palmas, Hospital Dr Negrín, Barranco de la Ballena s/n, 35020 Las Palmas de Gran Canaria, Canary Islands, Spain; Fax: +34-928-450083; E-mail: gjserdà@hotmail.com

asthma, use of asthma medication, and nasal allergies. Of the 10,000 people selected, 9506 were considered eligible (non-eligible subjects were those who have died, had moved out of the Islands, or were institutionalized). For the current study, a further 20% random sample—also drawn from both islands—was selected from the initial sample. Together with this random sample, all those subjects (not included in this second random sample) who had been classified as asthma symptomatic following the short questionnaire that had been filled in during the first stage of the study were also invited to participate. A subject was classified as asthma symptomatic if he had answered affirmatively at least one of the following questions: (1) Have you woken up during the night with shortness of breath during the past 12 months? (2) Have you had an asthma attack during the past 12 months? (3) Are you currently taking any asthma medication (including inhalers, aerosols, and pills)?

The subjects selected who agreed to participate came to the hospital, where they filled in an extensive questionnaire, the same employed in the second phase of the ECRHS (6). They underwent spirometry and BHR testing; skin sensitivity tests were also performed, as well as blood analysis to measure total and specific IgE. All tests were done on the same day. The hospital's ethics committee had previously approved the protocol, and subjects gave their written consent.

Spirometry and Methacholine Test

Spirometry was performed employing a screen pneumotachograph (Erich Jaeger, Wuerzburg, Germany). Both the spirometer and the technique used in this test followed American Thoracic Society (ATS)/European Respiratory Society (ERS) criteria (8). BHR was assessed through a methacholine test (9). This test was performed using a Jaeger dosimeter (Erich Jaeger). The test ended when the maximum accumulated dose of methacholine (1 mg) was reached or when a drop in Forced Expiratory Volume in 1 second (FEV_1) $\geq 20\%$ was observed. Subjects were considered to exhibit BHR when there was a 20% or greater drop in FEV_1 in relation to the best post-diluent FEV_1 associated with a methacholine dose of 1 mg or less (9).

Skin Tests

Skin sensitivity was assessed by means of prick tests. The most common allergens in the Canaries were used: house dust mites (*DP*, *BT*), cat epithelium, cockroaches, pollens (Gramineae, *Artemisia vulgaris*, *Parietaria judaica*), and fungi (*Alternaria alternata*) (ALK Abelló, Madrid, Spain). Histamine and saline solutions were used as controls. Skin reaction was regarded as positive if the papule's diameter was greater than 3 mm.

Total and Specific Immunoglobulin

Total IgE and specific IgE (*DP*, *BT*, cat epithelium, cockroaches, *A. vulgaris*, *A. alternata*) were determined using the capsulated hydrophilic carrier polymer method (Kabi Pharmacia, Upsala, Sweden). Total IgE was considered positive when it was greater than 100 kU/L, and specific

IgE when it was greater than 0.35 kU/L. Subjects were considered sensitized to *BT* when skin prick tests for *BT* were >3 mm or when exhibiting a specific IgE > 0.35 kU/L.

Asthma Definition

To study the relation between *BT* and asthma, the latter was classified into two different ways. Asthma defined by symptoms was considered when in the long questionnaire subjects answered affirmatively to one of the questions listed above, in the section "Populations". According to the second definition, subjects were considered asthmatics when, having answered affirmatively to one of the mentioned questions, they also exhibited positive BHR. In addition, asthma defined by symptoms was classified according to the age of onset before or after 15 years.

The variable habitat was set up to gather several questions from the questionnaire that made reference to the home environment (presence of carpets, rugs, curtains in the bedroom or elsewhere, air conditioning, presence of damp or mould). The variable genetic predisposition includes the parental history of asthma and other allergic diseases.

Statistical Analysis

Statistical analysis was performed using SPSS version 15.0. (SPSS Inc., Chicago, IL, USA). The random sample was used to assess the prevalence of sensitization to *BT* and its relation to BHR, asthma symptoms, asthma, rhinitis, and dermatitis. Confidence intervals (CIs) for prevalence estimates were calculated using the Wilson score interval test. The chi-square test was used to determine significant differences between prevalences. Tetrachoric correlations were used to assess the relationship between sensitizations to *BT*, *DP*, cat, and pollens. The random plus the symptomatic samples were employed to examine the association of the prevalence of sensitization to *BT* with asthma and BHR by means of odds ratios, using logistic regression analysis. This test was also employed to examine the risk factors related to *BT* sensitization. For this last analysis only the random sample was used. A $p < .05$ was considered as significant.

RESULTS

In this study, there were 1181 participants aged 20–44 years, of which 751 (63%) came from Gran Canaria and 430 (37%) from Tenerife. This group included both the random sample ($n = 593$, representing 31.1% of the initial random sample of 1901) and the additional symptomatic sample ($n = 588$, representing 47.7% of the total of symptomatic subjects). The random sample comprised 44.4% of women and 50.6% of men. Figure 1 shows the different stages of the study with the subjects that participated in each stage.

Analysis Performed with the Random Sample

The prevalence of positive skin tests to *BT* was 13.8% (95% CI 10.6–17.9%) and specific IgE to *BT* was 17.9% (95% CI 14.2–24.5%). When sensitization to *BT* was considered (skin test > 3 mm or specific IgE > 0.35 kU/L)

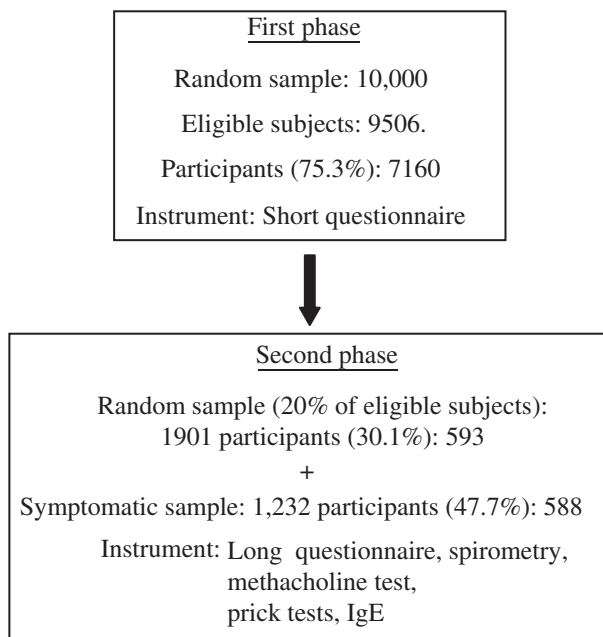


FIGURE 1.—Flow diagram of the first and second stages of the study, showing the number of participating subjects and instruments used.

prevalence was 20.9% (95% CI 16.9–25.5%). The distribution of sensitization to *BT* by age, sex, island, asthma, rhinitis, and dermatitis is summarized in Table 1; in the 20–24 and 25–29 age groups prevalence was significantly greater than in the rest. There were no significant differences in the prevalence of sensitization to *BT* between men and women or between islands. Among the subjects with allergic rhinitis, 37.4% (95% CI 28.1–47.6%) exhibited sensitization to *BT*, while 14.9% of the non-rhinitics showed this sensitization ($p < .001$). Regarding subjects with atopic dermatitis, 25.9% (95% CI 18.8–34.5%) were sensitized to *BT*, as opposed to 17.4% of subjects without dermatitis ($p < .032$). Among BHR-positive subjects, 46.7% (95% CI 32.7–60.9%) exhibited sensitization to *BT* while 15.7% BHR-negative subjects were sensitized to this mite ($p < .001$). Among patients with asthma (defined by symptoms), 33.3% (95% CI 21.4–47.9%) displayed sensitization to *BT*, as opposed to 18.8% ($p < .025$) of those who did not suffer from asthma. Regarding patients with asthma (asthma symptoms and positive BHR test) sensitization to *BT* was 50.0% (95% CI; 26.8–73.2%) while among subjects without asthma sensitization to *BT* was 18.8% ($p < .005$). Eleven of the patients sensitized to *BT* did not have asthma, rhinitis, or dermatitis, nor did they have respiratory symptoms.

Of the subjects who exhibited sensitization to *BT*, only 7.0% of them showed monosensitization to this mite; 93.0% were also sensitized to *DP*, cat epithelium, *A. vulgaris*, or cockroach. When these last four antigens were considered separately, 87.3% of those sensitized to *BT* were also sensitized to *DP*, 39.4% to cat epithelium, 14.1% to *A. vulgaris*, and 4.2% to cockroach. The correlation between *BT* and *DP* sensitization was 0.655 ($p < .001$); between *BT* and cat epithelium sensitization, 0.683 ($p < .001$); and between *BT* and *A. vulgaris*

TABLE 1.—Prevalence of sensitization to *Blomia tropicalis* (*BT*) by age, gender, island, asthma, rhinitis, and dermatitis in the random sample of young adults.

	Sensitization <i>BT</i> ^a prevalence (%) (95% CI)	<i>p</i>
Age		<.001
20–24 ^b	37.5 (22.9–54.7)	
25–29 ^b	33.8 (24.2–44.9)	
30–34	17.6 (11.1–27.1)	
35–40	16.3 (9.7–25.8)	
40–44	7.6 (3.8–16.5)	
Gender		.443
Male	19.2 (13.9–25.8)	
Female	22.5 (16.9–29.3)	
Island		.258
Gran Canary	22.7 (17.7–28.6)	
Tenerife	17.4 (11.6–25.3)	
Asthma (symptoms) ^c		.011
Yes	33.3 (21.4–47.9)	
No	18.5 (14.4–23.4)	
Asthma (symptoms + BHR) ^d		.005
Yes	50 (26.8–73.2)	
No	18.8 (14.7–23.7)	
Rhinitis		<.001
Yes	37.4 (28.1–47.6)	
No	14.9 (11.0–19.9)	
Dermatitis		.032
Yes	25.9 (18.8–34.5)	
No	17.4 (12.9–22.9)	

Notes: BHR, bronchial hyperresponsiveness; CI, confidence interval.

^aSensitization to *BT* was defined as prick test > 3 mm or specific IgE > 35 kU/L.

^bRange of age where prevalence was significant.

^cAsthma defined by symptoms.

^dAsthma defined by symptoms and positive BHR.

TABLE 2.—Prevalence of sensitization to other allergens according to sensitization to *Blomia tropicalis* (*BT*) with 95% confidence interval (95% CI) in the random sample of young adults.

Allergen ^a	<i>BT</i> sensitization ^b prevalence (%) (95% CI)	No <i>BT</i> sensitization prevalence (%) (95% CI)	<i>p</i>
<i>DP</i>	87.3 (77.6–93.2)	23.8 (19.1–29.2)	<.001
Cat	39.4 (28.9–51.1)	6.0 (3.6–9.4)	<.001
<i>Artemisia vulgaris</i>	14.1 (7.8–24.0)	3.7 (2.0–6.7)	.003
Cockroach	4.2 (1.5–11.7)	0 (0–1.4)	.009

Notes: *DP*, *Dermatophagoides pteronyssinus*.

^aSensitization to *BT* was defined as prick test > 3 mm or specific IgE > 35 kU/L.

^bSensitization to *DP*, cat, *A. vulgaris*, and cockroach were defined as prick test > 3 mm or specific IgE > 35 kU/L.

sensitization, 0.248 ($p < .015$). In the group of subjects not sensitized to *BT*, 23.8% were sensitized to *DP* ($p < .001$), 6.0% to cat epithelium ($p < .001$), 3.7% to *A. vulgaris* ($p < .003$), and none to cockroach ($p < .009$) (Table 2). Among several risk factors considered (age, gender, siblings, habitat, maternal smoking, infection before 5 years of age, and genetic predisposition) only age under 30 was significantly associated with sensitization to *BT* (Table 3).

Analysis Performed with the Random and Symptomatic Samples

Sensitization to *BT* was independently associated with the presence of asthma before and after the age of 15 years. In

TABLE 3.—Comparison between presence of risk factors in subjects with *Blomia tropicalis* (BT) sensitization versus subjects with no BT sensitization, odds ratio (OR), and 95% confidence interval (95% CI).

Risk factor	BT sensitization, n (%) (n = 71)	No BT sensitization, n (%) (n = 269)	p	OR (95% CI)
Age < 30	38 (53.5%)	71 (26.4%)	.001	3.2 (1.9–5.5)
Gender (female)	32 (45.1%)	135 (50.2%)	.443	0.81 (0.48–1.38)
Siblings ^a	3.0 ± 2.2	3.36 ± 2.3	.246	0.93 (0.81–1.05)
Maternal smoking	9 (12.7%)	30 (11.4%)	.760	1.13 (0.51–2.51)
Habitat ^b	2.04 ± 1.7	2.08 ± 1.7	.836	1.02 (0.87–1.18)
Infection before the age of 5 years	7 (9.9%)	19 (7.1%)	.430	1.44 (0.58–3.57)
Genetic predisposition ^c	76 (28.3%)	21 (29.6)	.826	1.07 (0.60–1.89)

Notes: This table has been calculated with the random sample.

^aNumber of siblings (mean ± SD).

^bHabitat is a discrete variable ranging from 0 (no home environmental factors that favor BT growing) to 5 (maximum home environmental factors that favor BT growing); it is expressed as mean ± SD.

^cGenetic predisposition includes the parental history of asthma and other allergic diseases.

TABLE 4.—Association of asthma defined by symptoms (onset at 15 years or before and onset after 15 years) and bronchial hyperresponsiveness (BHR) with several risk factors in *Blomia tropicalis* (BT)-sensitized subjects, adjusted odds ratio (OR), and 95% confidence interval (95% CI).

Risk factor	Asthma onset ≤ 15 years, OR (95% CI) (n = 120/306)	Asthma onset > 15 years, OR (95% CI) (n = 53/306)	BHR, OR (95% CI) (n = 110/292)
Gender (female)	0.71 (0.47–1.1)	0.77 (0.43–1.38)	0.62 (0.40–0.97)*
Sensitization to DP	6.9 (4.2–11.2)***	5.6 (2.9–10.7)***	7.68 (4.5–13.0)***
Sensitization to cat	5.1 (3.1–8.6)***	4.8 (2.5–9.4)***	6.1 (3.6–10.2)***
Genetic predisposition ^a	1.9 (1.2–2.9)**	2.1 (1.1–3.8)*	2.2 (1.4–3.5)***
Infection before the age of 5 years	5.4 (3.0–9.9)***	1.2 (0.39–3.6)	3.1 (1.6–5.8)***
Age < 30 years old	—	—	2.6 (1.6–4.1)***
Habitat	1.1 (0.98–1.26)	1.4 (1.2–1.7)***	1.0 (0.9–1.2)

Notes: DP, *Dermatophagoides pteronyssinus*. This table has been calculated put together the random and the symptomatic samples.

^aGenetic predisposition includes parental history of asthma and/or other allergic diseases.

* $p < .05$, ** $p < .02$, *** $p < .001$.

addition to BT, both categories of asthma were associated with a family history of allergic diseases and sensitization to DP and cat. Asthma before age 15 was also related to lower respiratory tract infection before age 5 and asthma after 15 years to the habitat (Table 3). BHR was associated with all these factors with the exception of habitat (Table 4).

DISCUSSION

Our research provides for the first time data regarding the prevalence of sensitization to BT in a sample of young adults aged between 20 and 44. It also describes the relation between BT and other house dust mites (i.e., DP) and the role that BT plays in BHR, asthma symptoms, rhinitis, dermatitis, and asthma. This study shows that in our population BT is a prevalent antigen in mite-induced allergic diseases only surpassed by DP. We are not aware of previous epidemiological studies that have dealt with the problem of BT in large random population samples. Although in the ECRHS there was a chance to examine sensitization to BT in some temperate climate regions, this was not carried out. However, in the previous survey, a high prevalence of sensitization to DP as well as a strong association of this allergen with asthma and rhinitis was found, emphasizing the role of mites as triggers of allergic diseases (5). Several studies have addressed the capacity of

BT to cause allergic diseases (10, 11). As expected, most of these investigations have been carried out in regions with tropical or subtropical climates, although the presence of sensitization to BT in patients with asthma and/or rhinitis has also been detected in colder climates (12, 13). Moreover, all these studies have been performed on non-random populations of subjects with allergic diseases, sometimes mixing adults and children, in general involving samples with no control groups. For this reason it is difficult to estimate the real prevalence of sensitization to BT among a certain population based on the strength of these studies, and conclusions cannot also be reached from an epidemiological point of view as to the role of BT in specific allergic diseases such as asthma, rhinitis, or dermatitis.

In our study, we have shown that the prevalence of sensitization to BT in a population of young adults is considerable and that it is accompanied by a high prevalence of sensitization to DP. However, we have detected a low prevalence of monosensitization to BT, as has been the case with other studies (13). This finding might be explained by the existence of a possible cross-reactivity between BT and DP antigens, a condition present not only among dust mites but also among pollens and food allergens (14). Cross-reactivity between BT and DP antigens is mainly associated with group 5 allergens of these two dust mites: *Blo t 5* and *Der p 5* (15–17). Although this phenomenon is supported by other authors (12, 18), their findings

indicate that cross-reactivity between these two mites is partial and cannot of its own explain the high correlation between sensitization to *BT* and to *DP*. Furthermore, our study also records a high correlation between sensitization to *BT* and to cat epithelium, which can only with difficulty be attributed to cross-reactivity between both allergens. We are aware that cross-reactivity as an explanation for the high correlation between mites is somewhat speculative. It would have been necessary analysis at molecular level of mite antigens to test this hypothesis. Since *BT* and *DP* sensitizations show a high prevalence in the Canaries, multiple sensitivities may be an alternative explanation for this finding. Although multiple sensitivities have mainly been described with chemicals (19), mites could also be a reasonable cause of this phenomenon.

In our work we have found that sensitization to *BT* is significantly greater in the case of younger age ranges (between 20–24 and 25–29). There is no clear physiological explanation for this phenomenon, but it has been corroborated by other studies. Wüthrich et al. (20) reported that in a large sample of 8344 adults the prevalence of positive IgE and of positive prick tests dropped with age. The ECRHS (21) also recorded that among the 30–34 and 35–44 age groups the prevalence of IgE was less than in the 20–24 and 25–29 age ranges.

As happens in other regions with tropical or subtropical climates, our patients with rhinitis and/or asthma (defined both by symptoms and by symptoms plus positive methacholine challenge) exhibit a high prevalence of sensitization to *BT*—only sensitization to *DP* shows a higher prevalence—which is considerably greater than the prevalence of sensitization to other antigens such as cat epithelium or pollens. Additionally, this is the first time that reference is made to the relationship between BHR and sensitization to *BT*. In the ECRHS, a relation between BHR and sensitization to *DP* (22) was detected, but until now there had been no reporting of data demonstrating that sensitization to *BT* was associated with high BHR. There are scant data on the role *BT* plays in atopic dermatitis; most of the studies that associate dermatitis with mites make reference to *DP* (23, 24). We observed a high prevalence of sensitization to *BT* in patients with dermatitis reflecting the capacity of this mite to induce allergic skin reactions.

We found a strong association of asthma with sensitization to *BT*, other perennial allergens (*DP*, cat), and genetic predisposition. These findings are similar to those reported in the ECRHS (24) and show the relevance of atopy and heredity in the pathogenesis of allergic asthma. Asthma after 15 years was also related to the habitat variable, suggesting that a combination of environment and atopy can trigger symptoms in susceptible subjects.

Although there are many studies that have examined risk factors for asthma (25, 26), there are few epidemiological studies that have analyzed the variables that determine sensitization to dust mites. In our work, the only risk factor associated with *BT* was age. In contrast, Kidon et al. (27) found a number of risk factors related to *BT* besides age in children with allergic rhinitis. This difference may

lie in the fact that our work was carried out in a random sample of the general population avoiding the bias of selecting subjects according to a specific disease.

In short, this study demonstrates a high prevalence of sensitization to *BT* in a random sample of young adults in the Canaries. *BT* and *DP* are the two most important allergens associated with allergic diseases in the Canaries. Despite certain cross-reactivity between both mites, we believe that *BT* should be considered an important allergen in the pathogenesis and prevention of asthma and other allergic diseases, as well as a possible antigen for immunotherapy.

CONCLUSION

To our knowledge, this is the first study in the English literature describing the prevalence of sensitization to *BT* in a large randomly selected population of young adults between 20 and 44. We have found a high prevalence of sensitization to *BT* in the Canary Islands that shows a strong association with asthma and other allergic diseases.

ACKNOWLEDGEMENTS

This study was supported by grant no. 98/1473 issued by the Fondo de Investigaciones Sanitarias (FIS) and grant no. 113/98 issued by the Fundación Canaria de Investigación y Salud (FUNCIS).

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

REFERENCES

1. Arlian LG, Platts-Mills TA. The biology of dust mites and the remediation of mite allergens in allergic disease. *J Allergy Clin Immunol* 2001; 107:S406–S413.
2. Arlian LG, Morgan MS. Biology, ecology, and prevalence of dust mites. *Immunol Allergy Clin N Am* 2003; 23:443–468.
3. Fernández-Caldas E, Lockey RF. *Blomia tropicalis*, a mite whose time has come. *Allergy* 2004; 59:1161–1164.
4. García Robaina JC, Sánchez Machín I, Fernández-Caldas E, Iraola Calvo V, Vázquez Moncholi C, Bonnet Moreno C, de la Torre Morín F. Skin tests and conjunctival and bronchial challenges with extracts of *Blomia tropicalis* and *Dermatophagoides pteronyssinus* in patients with allergic asthma and/or rhinoconjunctivitis. *Int Arch Allergy Immunol* 2003; 131:182–188.
5. Janson C, Antó J, Burney P, Chinn S, de Marco R, Heinrich J, Jarvis D, Kuenzli N, Leynaert B, Luczynska C, Neukirch F, Svanes C, Sunyer J, Wjst M. The European Community Respiratory Health Survey: what are the main results so far? *European Community Respiratory Health Survey II. Eur Respir J* 2001; 18:598–611.
6. Juliá-Serdá G, Cabrera-Navarro P, Acosta-Fernández O, Martín-Pérez P, Losada-Cabrera P, García-Bello M, Carrillo-Díaz T, Antó-Boqué J. High prevalence of asthma and atopy in the Canary Islands, Spain. *Int J Tuberc Lung Dis* 2011; 15:536–541.
7. Burney PG, Luczynska C, Chinn S, Jarvis D. The European Community Respiratory Health Survey. *Eur Respir J* 1994; 7:954–960.

8. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, Crapo R, Enright P, van der Grinten CP, Gustafsson P, Jensen R, Johnson DC, MacIntyre N, McKay R, Navajas D, Pedersen OF, Pellegrino R, Viegi G, Wanger J; ATS/ERS Task Force. Standardisation of spirometry. *Eur Respir J* 2005; 26:319–338.
9. Chinn S, Burney P, Jarvis D, Luczynska C. Variation in bronchial responsiveness in the European Community Respiratory Health Survey (ECRHS). *Eur Respir J* 1997; 10:2495–2501.
10. Puccio FA, Lynch NR, Noya O, Noda A, Hagel I, López E, López R, Caraballo L, Mercado D, DiPrisco MC. Importance of including *Blomia tropicalis* in the routine diagnosis of Venezuelan patients with persistent allergic symptoms. *Allergy* 2004; 59:753–757.
11. Li J, Sun B, Huang Y, Lin X, Zhao D, Tan G, Wu J, Zhao H, Cao L, Zhong N. A multicentre study assessing the prevalence of sensitizations in patients with asthma and/or rhinitis in China. *Allergy* 2009; 64:1083–1092.
12. Casas R, Ferrándiz R, Wihl JA, Fernández B, Dreborg S. Biologic activity of *Dermatophagoides siboney* and *Blomia tropicalis* allergens in exposed and unexposed mite-allergic individuals. Effect of patient selection on the biologic standardization of mite extracts. *Allergy* 1999; 54:392–396.
13. Simpson A, Green R, Custovic A, Woodcock A, Arruda LK, Chapman MD. Skin test reactivity to natural and recombinant *Blomia* and *Dermatophagoides* spp. allergens among mite allergic patients in the UK. *Allergy* 2003; 58:53–56.
14. Vieths S, Scheurer S, Ballmer-Weber B. Current understanding of cross-reactivity of food allergens and pollen. *Ann N Y Acad Sci* 2002; 964:47–68.
15. Arruda LK, Vailes LD, Platts-Mills TA, Fernandez-Caldas E, Montealegre F, Lin KL, Chua KY, Rizzo MC, Naspitz CK, Chapman MD. Sensitization to *Blomia tropicalis* in patients with asthma and identification of allergen Blo t 5. *Am J Respir Crit Care Med* 1997; 155:343–350.
16. Kuo IC, Cheong N, Trakultivakorn M, Lee BW, Chua KY. An extensive study of human IgE cross-reactivity of Blo t 5 and Der p 5. *J Allergy Clin Immunol* 2003; 111:603–609.
17. Cheong N, Soon SC, Ramos JD, Kuo IC, Kolortkar PR, Lee BW, Chua KY. Lack of human IgE cross-reactivity between mite allergens Blo t 1 and Der p 1. *Allergy* 2003; 58:912–920.
18. Tsai JJ, Tsai JJ, Wu HH, Shen HD, Hsu EL, Wang SR. Sensitization to *Blomia tropicalis* among asthmatic patients in Taiwan. *Int Arch Allergy Immunol* 1998; 115:144–149.
19. Bernstein DI. Multiple chemical sensitivity: state of the art symposium. The role of chemical allergens. *Regul Toxicol Pharmacol* 1996; 24(1 Pt 2):S28–S31.
20. Wüthrich B, Schindler C, Medici TC, Zellweger JP, Leuenberger P. IgE levels, atopy markers and hay fever in relation to age, sex and smoking status in a normal adult Swiss population. SAPALDIA (Swiss Study on Air Pollution and Lung Diseases in Adults) Team. *Int Arch Allergy Immunol* 1996; 111:396–402.
21. Burney P, Malmberg E, Chinn S, Jarvis D, Luczynska C, Lai E. The distribution of total and specific serum IgE in the European Community Respiratory Health Survey. *J Allergy Clin Immunol* 1997; 99:314–322.
22. Chinn S, Jarvis D, Luczynska C, Burney P. Individual allergens as risk factors for bronchial responsiveness in young adults. *Thorax* 1998; 53:662–667.
23. Kuljanac I. The role of *Dermatophagoides pteronyssinus* in atopic dermatitis. *Acta Dermatovenereol Croat* 2006; 14:86–89.
24. Pónyai G, Hidvégi B, Németh I, Sas A, Temesvári E, Kárpáti S. Contact and aeroallergens in adulthood atopic dermatitis. *J Eur Acad Dermatol Venereol* 2008; 22:1346–1355.
25. Sunyer J, Antó JM, Kogevinas M, Barceló MA, Soriano JB, Tobías A, Munozguren N, Martínez-Moratalla J, Payo F, Maldonado JA. Risk factors for asthma in young adults. Spanish Group of the European Community Respiratory Health Survey. *Eur Respir J* 1997; 10:2490–2494.
26. Foliaki S, Annesi-Maesano I, Tuuau-Potoi N, Waqatakirewa L, Cheng S, Douwes J, Pearce N. Risk factors for symptoms of childhood asthma, allergic rhinoconjunctivitis and eczema in the Pacific: an ISAAC Phase III study. *Int J Tuberc Lung Dis* 2008; 12:799–806.
27. Kidon MI, Chiang WC, Liew WK, Lim SH, See Y, Goh A, Tan JP, Chay OM, Balakrishnan A. Sensitization to dust mites in children with allergic rhinitis in Singapore: does it matter if you scratch while you sneeze? *Clin Exp Allergy* 2005; 35:434–440.

Copyright of Journal of Asthma is the property of Taylor & Francis Ltd and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.