

49. Puerta L, Caraballo L, Fernández-Caldas E, et al. Nucleotide sequence analysis of a complementary DNA coding for a *Blomia tropicalis* allergen. *J Allergy Clin Immunol* 1997; 98: 932-937.
50. Caraballo L, Puerta L, Jiménez S, et al. Cloning and IgE binding of a recombinant allergen from the mite *Blomia tropicalis*, homologous with fatty acid-binding proteins. *Int Arch Allergy Immunol* 1997; 112: 341-347.
51. Puerta L, Fernández-Caldas E, Lockey RF, Caraballo LR. Mite allergy in the tropics: Sensitization to six domestic mite species in Cartagena, Colombia. *J Invest Allergol Clin Immunol* 1993; 3: 198-204.
52. Van Hage-Hamsten M, Johansson SG, Johansson E, Wiren A. Lack of allergenic cross-reactivity between storage mites and *Dermatophagoides pteronyssinus*. *Clin Allergy* 1987; 17: 23-31.
53. Puerta L, Fernández-Caldas E, Lockey R, Caraballo L. Sensitization to *Chortoglyphus arcuatus* and *Aleuroglyphus ovatus* in *Dermatophagoides spp* allergic individuals. *Clin Exp Allergy* 1993; 23: 117-123.
54. Johansson E, Schmidt M, Johansson SGO, Machado L, Olsson S, Van Hage Hamsten M. Allergenic cross-reactivity between *Lepidoglyphus destructor* and *Blomia tropicalis*. *Clin Exp Allergy* 1997; 27: 691-719.
55. Arlian LG, Vyszynski-Moher D, Fernández-Caldas E. Allergenicity of the mite, *Blomia tropicalis*. *J Allergy Clin Immunol* 1993; 91: 1042-1050.
56. Stanaland B, Fernández-Caldas E, Jacinto CM, et al. Sensitization to *Blomia tropicalis*. *Clin Exp Allergy* 1994; 94: 452-457.

Clinical impact of the mite species in atopic patients

C. Carral

Associate Physician, Allergology Section, "Hospital da Costa", Burela (Lugo), Spain

INTRODUCTION

Studies performed in various parts of the world have demonstrated a high prevalence of mites in the indoor house dust^{1,2}. In many places, the dust mites predominate in so-called house dust allergy and appear as the responsi-

ble agents in up to 85% of all cases of asthma³⁻⁶.

Sensitization to mites is directly related to the amount of major *Pyroglyphid* mite allergens in the dust samples, as is also the severity of the symptoms of allergy. It has been demonstrated that the mite levels within the house may change in relation to the seasons or to changes in the house furniture. The mite density is quite variable between the different places sampled within a household, regardless of the sampled homes being within the same geographical area. This within-house variability probably reflects the varying availability of food for the mites (mainly skin scales).

Fernández Caldas has reported, in his work in Cartagena (Colombia)^{7,8}, that Der p 1 levels in excess of 1.14 µg/g are associated to a 95% or greater probability of eliciting positive skin tests or RAST to *Dermatophagoides pteronyssinus*. It is possible that in areas where several different acarine species coexist the Der p 1 levels required for inducing sensitization may be lower.

Besides the *Pyroglyphid* mites, a large number of different allergenically significant mites has been documented, collectively known as "storage mites". These mites may be found in areas where grain is stored, in straw and in grain silos. Among these storage mites, the predominant families are the *Glycyphagidae* and *Acaridae* ones, including the genera and species *Lepidoglyphus destructor*, *Tyrophagus* and *Acarus siro*. Storage mites have been demonstrated to be the cause of bronchial asthma, allergic rhinitis and allergic conjunctivitis, particularly in rural environments with occupational exposure, such as in farms, dairy farms, granaries, bakeries and silos with grain elevators.

Considerable attention has been dedicated in recent years to storage mites in non-occupational environments, and the results point out that sensitization to these agents is not restricted to the cases with occupational exposure^{9,10}.

The lowest relative humidity level at which mites are still able to maintain their water balance and survive is influenced by the ambient temperature and ranges between 55%

and 75% relative humidity (depending on the temperature). A number of studies suggest that in the temperate and humid regions in Europe¹¹ storage mite allergy is caused not only by occupational exposure but also by humid housing environments, and that indoor exposure to storage mites might also be important.

Storage mites require higher humidity levels than house dust mites in order to have optimal living conditions¹². Iversen *et al.*¹³ demonstrated that storage mite allergy is strongly associated to the anamnestic markers of humid housing conditions, such as visible mould growth and condensation on double-glazed window panes in winter.

The prevalence of storage mite sensitization among patients with house dust mite allergy has been scarcely assessed in Spain until now. One such study has been performed in a temperate and humid region of North-western Spain, Galicia. Under such conditions, it is not surprising that the *Dermatophagoides* house dust mites have emerged as the most important allergens inducing respiratory symptoms in this region (over 70% of our allergic patients have specific IgE to these mites)¹⁴.

The aim of our study was to determine the prevalence of sensitization to certain storage mites (*Lepidoglyphus destructor*, *Tyrophagus putrescentiae* and *Acarus siro*) among patients with house dust mite allergy. Both rural and urban populations were included, so that this study investigated the relationship between storage mites and the environment in this region.

PATIENTS, MATERIAL AND METHODS

Patients. In this cross-sectional study, a total of 310 patients, 149 males (48%) and 161 females (52%), with a mean age of 20.3 ± 9.6 years (range, 4 to 64 years) were studied in our Allergy Unit between January 1994 and March 1996. All the patients were allergic to house dust mites, as demonstrated by their clinical histories (perennial rhinitis in 287 cases and/or bronchial asthma in 195 cases), and by positive skin prick tests to *Dermatophagoides pteronyssinus* and/or *D. farinae*.

All the patients came from the Health Care Area of Santiago de Compostela (520,000 inhabitants). The climate in this area tends to be rainy, and the indoor and outdoor humidity levels easily exceed 80%. The meteorological data show a mean maximum temperature of 19.8°C and a mean minimum temperature of 9.5°C; the number of rainy days exceeds 200 per year (>55%), and the yearly rainfall is about 1,980 l/m² (data from the Spanish National Meteorology Institute).

Skin prick tests. The skin tests were carried out with commercially-acquired allergen extracts of *Dermatophagoides pteronyssinus*, *Dermatophagoides farinae*, *Lepidoglyphus destructor*, *Tyrophagus putrescentiae* and *Acarus siro* (ALK-Abelló, Spain). Skin tests were also performed with other common airborne allergens, such as pollens (*Hordeum vulgare*, *Lolium perenne*, *Secale cereale*, *Cynodon dactylon*, *Phragmites communis*, *Betula alba*, *Fraxinus excelsior*, *Olea europaea*, *Quercus ruber*, *Plantago lanceolata*, *Parietaria judaica*, *Salsola kali* and *Chenopodium album*) (ALK-Abelló, Spain), moulds (*Alternaria alternata*, *Cladosporium herbarum*, *Penicillium notatum* and *Aspergillus* spp) (Bayer, Spain) and cat and dog danders (ALK-Abelló, Spain). Control tests were performed with 10 mg/ml histamine and with normal saline. The size of the wheal was recorded after 15 minutes, and a reaction was considered to be positive if the size of the wheal was at least similar to that of the positive histamine control and at least 3 mm greater than that of the negative normal saline one.

Total and specific IgE antibodies. The total serum IgE was measured in all cases. For the specific IgE assessment, a Pharmacia CAP immunoassay (Pharmacia, Uppsala, Sweden) was used according to the manufacturer's instructions. CAP results in excess of 0.35 kU/l were considered positive, with a maximum level of 100 kU/l. All the patients had CAP assessments to all the allergens of the storage and house dust mites stated above. CAP tests were also performed with other allergens whenever the skin prick tests yielded positive results.

Housing environment conditions. The housing conditions were assessed with the help of a questionnaire. According to the information collected, high indoor humidity was found to be prevalent in all seasons of the year with the exception of the Summer when no central heating was used and when the patients noted mould growth or water condensation on the inside of the window panes. The presence of household pets (cats, dogs) or domestic animals (cattle, sheep, chickens) was also investigated, as well as the proximity of grain storage facilities.

Dust sample collection. Thirty-one samples of dust were collected in the patients' households, by vacuuming the mattresses and the carpeting (a 2-m² surface) for two minutes. The samples were mixed with 70% ethanol and were later examined for identification of the mite species and for estimation the proportion of each species in the sample at the Parasitology Department of the Universidad Complutense in Madrid.

Statistics. The statistical analysis of the data was carried out with the Statistical Package for the Social Sciences (SPSS). The χ^2 test, with the Yates' correction when appropriate, was used in the assessment of dichotomic values. The two-tailed Mann-Whitney U-test was used for comparing continuous variables, as none of them fulfilled the criteria for a normal distribution. For the same reason, the results are expressed as means and variances instead of means $\pm$ SD. The correlation between continuous variables was examined with the Spearman rank test. In order to examine the effects of potentially confounding variables, a multiple regression model was developed. The variables and the odd indices were entered into the model, and 95% confidence intervals were calculated from the coefficients. Spearman's rank correlation was used for estimating the power of the relations between the various species of mites, considering those cases in which at least one of the CAP values of a given pair of mites was >0.35 kU/l. CAP values below this cut-off point were considered to be equal to 0, and values higher than the maximum qualification limit were considered as 100 kU/l. *P* values below 0.05 were considered to be statistically significant.

RESULTS

Among the 310 patients with house dust mite allergy, 274 (88.4%) were sensitized to storage mites. This demonstrates that most of our patients reacted to at least one of the storage mites studied by either skin prick tests or CAP specific serum IgE. Most of these patients (252, or 92%) had positive results in both types of test; eight patients had some positive skin tests but negative CAP specific IgE to storage mites, and fourteen had negative skin tests but positive CAP results to some of these mites. The large majority of the patients (227, or 73%) were sensitized to the three mite species; however, 18 patients were positive only for *Lepidoglyphus destructor*, and four only for *Tyrophagus putrescentiae*. No patient was positive for *Acarus siro* alone.

The specific serum IgE levels were similar for *T. putrescentiae* and *A. siro* (mean levels, 2.6 kU/l and 2.2 kU/l, respectively). The highest levels were seen for *L. Destructor* (mean, 4.72 kU/l). With the Pharmacia d71 antigen (*Lepidoglyphus destructor*) the CAP class was higher than 3, corresponding to over 3.5 kU/l, in 56% of the patients. If the skin prick tests are considered, *L. destructor* had the highest proportion of positive results, while *A. siro* had the lowest ones. This last finding is in the line of most published studies, with the exception of those reported by Di Bernardino¹⁵ in children, in which 59% positive skin tests were seen with this mite.

There were no significant differences between the patients with and without storage mite sensitization regarding age, gender, frequency of rhinitis, asthma or dermatitis, presence of pets within or near the home or detection of any other sensitization (to pollens, moulds or animal danders). However, as presented in Table I, the differences were evident in the aspects of indoor humidity, rural or urban environment and presence of cattle and grain storage facilities. In other words: in the group of patients with storage mite allergy (1) higher indoor humi-

dity was more common, (2) these patients more often live in rural areas, as opposed to urban ones, and the storage mite allergy was more common when (3) there were grain storage facilities nearby and when (4) the presence of cattle was recorded. However, when these four parameters were entered into the multi-variable analysis, only the high indoor humidity and the presence of grain storage facilities maintained their statistical importance (OR 2.75, 95% CI 1.3-5.8, $p = 0.03$ and OR 22.6, 95% CI 1.3-379.9, $p = 0.008$, respectively). When both conditions were met, 97% of the patients evidenced specific IgE to storage mites. It should be pointed out, however, that even when neither of the two conditions was met up to 77% of the patients had specific IgE to storage mites. Finally, the patients with storage mite allergy had higher levels of total serum IgE (mean, 374 kU/l, range 22-7548, vs mean, 137 kU/l, range 7-1968, $p = 0.000$), higher levels of Dp-specific IgE (mean, 48.6 kU/l, range 0-100, vs mean, 20.4 kU/l, range 1-100 kU/l, $p = 0.0037$) and higher levels of Df-specific IgE (mean, 28.5 kU/l, range 0-100, vs mean, 10.6 kU/l, range 0-100, $p = 0.002$) than those without that sensitization. The correlation between the CAP values was very strong between the two species of house dust mites and between the three species of storage mites. However, the correlation of the CAP levels between the storage mites and the house dust mites was much weaker.

Among the 31 dust samples collected, storage mites (SM) were present in 20 of the 28 cases with SM sensitization, and in 2 of the 3 cases without SM allergy. The mean proportion of SM to the total number of mites in each sample was 19% (range, 0 to 93%). The most frequently encountered storage mite species was *Lepidoglyphus destructor* (present in 17 samples or 55%; $r = 0.517$, $p = 0.003$).

Further storage mites identified in the dust samples were *Chorthoglyphus arcuatus* ($n = 8$), *T. putrescentiae* ($n = 6$), *Ghohieria fusca* ($n = 4$), *Glycyphagus domesticus* ($n = 2$) and *Acarus siro* ($n = 2$).

DISCUSSION

The role of storage mites in occupational allergy, both in bakery workers and in farmers, workers at silo grain elevators, etc., has been amply demonstrated. More recently, the studies have focused on the importance of storage mite allergy in individuals *not occupationally exposed*¹⁶.

Our study investigated a population of 310 patients with house dust mite allergy in search of specific IgE to *Lepidoglyphus destructor*, *Tyrophagus putrescentiae* and *Acarus siro* in a region of Spain where the climatological conditions might favour the growth of storage mites. No similar epidemiological and immunological studies have been previously carried out in Spain that might have helped clarify the importance of these mites in our country.

We found a very high prevalence (up to 88%) of storage mite allergy among the individuals allergic to house dust mites in the area about Santiago de Compostela. The large majority of our patients, 81%, had positive results in the two tests performed (skin prick tests and CAP specific IgE) for the detection of storage mite allergy, and in 59.6% of the cases the CAP class for at least one of the storage mites detected was higher than 3. The one storage mite most frequently detected was *Lepidoglyphus destructor*, and this mite was also associated to the highest specific IgE levels.

Our results are here coincident with those of other reported studies, particularly in relation to occupational exposure in other areas of Europe and in America. *Lepidoglyphus destructor* is the most frequent storage mite species in farms in Sweden¹⁸, Finland¹⁹, Wales²⁰ and Wisconsin²¹. Cuthbert *et al.*²², in Scotland, found high numbers of *Acarus siro* and *Tyrophagus putrescentiae* in the hay and grain dust samples collected in farms. In Denmark, Iversen *et al.*²³ discovered large quantities of mites in rural dwellings and in farms. *Lepidoglyphus destructor* was the dominant species in grain and straw, and *Acarus siro* the dominant one in hay. Generally, all the countries in northern Europe have the same acarine fauna, probably due to the similar climatic conditions prevailing.

The data available from our study show that the prevalence we have detected is the highest among those reported to date in patients not occupationally exposed.

These data are not surprising, as both the humid dwelling conditions and the presence of grain and cattle are favourable for the growth of storage mites^{18,20}. Iversen and co-workers have pointed out in their studies that the farmers they studied were exposed to storage mites not only during their work but also within their humid dwellings¹³.

Already in 1981, Agha¹⁷ reported the results of a study in which the role and allergenic importance of storage mites in domestic house dust and in other environments had been assessed. This analysis provided clear statistical evidence that excessively humid dwellings and occupational exposure risk were the two main factors associated to allergic sensitization to these species. It further demonstrated that storage mites constitute a group of allergens which is quite distinct from that of house dust mites. Our results are coincident with his.

It remains to be determined whether the frequency of sensitization to the various acarine species is due to cross reaction to the house dust mites, *Dermatophagoides*, or represents a multiple sensitization. While there is ample proof that *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* show important cross reactivity between them, they do not appear to have such cross reactivity to a number of storage mite species^{24,25}. We have also considered the problem of the possible relationship between house dust and storage mites, and have tried to simplify it into two questions: "Does cross allergenicity exist between house dust mites and storage mites?" and "Is there simultaneous exposure to storage mites and house dust mites even outside of an agricultural environment?"²⁶ The available evidence does not provide conclusive answers to these two questions. In many reports, the formulation of the conclusions depends on the previous opinions of the authors. Thus, the connection between concrete sensitizations and the environment and the patient groups has been thought to be perhaps due to intensive exposure in the area where the patients dwell, causing a parallel sensitization, rather than to cross reactivity of IgE antibodies.

When hyposensitization with mite extracts is considered, a knowledge of the possible allergenic cross reactivities between the various mite species is required. However, the allergenic properties and the cross reactivities of the clinically relevant mite species are but little known.

Again considering our present data, a weak correlation index was observed between the CAP response to any storage mite and *D. pteronyssinus* and *D. farinae* in the patients studied. Stronger correlations were observed between *Tyrophagus putrescentiae* and *Acarus siro* than between *Lepidoglyphus destructor* and the other storage mites, indicating a strong allergenic reaction between *T. putrescentiae* and *A. siro*. Our results thus do not suggest a strong cross reactivity between storage mites and house dust mites, in coincidence with the results of other investigators using RAST inhibition or cross immunoelectrophoresis experiments.

There is also controversy, as will be later discussed, regarding the *in vitro* studies of cross reactivity.

Angriso¹⁰ does not find a very significant correlation between specific antibodies to storage mites and those to house dust mites, suggesting that each of them has its own specific allergenicity. Van Hage-Hamsten¹⁸, in 1987, did not find a significant correlation between the levels of IgE antibodies to any given storage mite and *Dermatophagoides pteronyssinus*. The mites in this study belonged to three different genera: *Acaridae* (*Acarus siro*, *Tyrophagus putrescentiae*), *Glycyphagidae* (*Glycyphagus domesticus*, *Lepidoglyphus destructor*) and *Pyroglyphidae* (*D. pteronyssinus*). In this study, the presence of allergenic cross reactivity between the four storage mites and *D. pteronyssinus* was investigated. All those farmers who were positive for *Glycyphagus domesticus* were also positive to *Lepidoglyphus destructor*, while only 58.9% of those who had positive RAST to *Lepidoglyphus destructor* reacted to *Glycyphagus domesticus*. According to the correlation coefficients between the RAST results, the allergenic similarity was greater between

Tyrophagus putrescentiae and *Glycyphagus domesticus* or *Lepidoglyphus destructor* than between *Tyrophagus putrescentiae* and *Acarus siro*. These observations were later confirmed and reinforced by RAST inhibition studies which demonstrated that the inhibitory effects of *Acarus siro* on *Lepidoglyphus destructor*, *Glycyphagus domesticus* or *Tyrophagus putrescentiae* systems was as low as that of *Dermatophagoides pteronyssinus*.

These data clearly show that there is no allergenic cross reactivity between *D. pteronyssinus* and the four storage mites *L. destructor*, *T. putrescentiae*, *G. Domesticus* and *A. siro*. Moreover, the first three of these storage mites appear to share common or related allergens. The moderate cross reactivity between *A. siro* and both *L. destructor* and *T. putrescentiae* suggests that the former one shares only a few allergens with the latter two. Finally, each one of the storage mites and of the house dust mites has its own unique allergen or allergens²⁷.

Korsgaard²⁸ carried out an investigation in Denmark in 1982 in which 133 patients were studied because of symptoms of allergy. The diagnosis was at that time established by skin prick tests, bronchial challenge tests and the identification of storage mites in the patients' environments. In this study, 45% of the patients had positive prick tests to one or more storage mites. A mutual positive correlation was observed between the results of the prick tests to the two house dust mites, as well as for those to the three storage mites. No significant correlation was detected between the house dust mites and the storage mites.

In one study reported by Van Hage-Hamsten²⁵ no significant correlation could be detected between *D. pteronyssinus* and *L. destructor* or *Euroglyphus maynei*. In her report, the author also stresses that the most abundant storage mite is *L. destructor* and that it therefore had the greatest RAST prevalence among the study population of farmers. The prevalence data for the *Pyroglyphid* mites *E. maynei* and *D. pteronyssinus* were also rather similar. The RAST inhibi-

tion studies suggest the existence of allergenic components inherent to *E. maynei*, which however appears to be deficient in some allergenic determinants of *D. pteronyssinus*.

Johansson²⁹ has investigated the allergenic similarity between the *Pyroglyphid* mite *Dermatophagoides pteronyssinus* and the *Glycyphagid* one *Lepidoglyphus destructor* using an immunoblot inhibition technique that permits the simultaneous comparison of a number of allergens. This study confirmed the presence of allergenic determinants common to both mites and also that of distinct determinants unique to each of them. The bronchial challenge tests confirmed the relationship between respiratory symptoms and exposure to storage mites in farmers with a positive RAST to *L. destructor*.

Tee, in 1992³⁰, carried out a very interesting study in which he investigated the IgE response (RAST) to *D. pteronyssinus* and to four storage mites (*L. destructor*, *T. putrescentiae*, *Glycyphagus domesticus* and *A. siro*) in 318 bakery workers in the United Kingdom and compared it to that previously observed in 440 Swedish farmers. The storage mites are usually found in stored hay and grain, so that both groups could potentially have encountered them in their work. All those bakery workers who had a positive RAST to one or more storage mites also had RAST positivity to *D. pteronyssinus*. This observation might suggest cross reactivity between this house dust mite and the storage ones, as commented by Griffin *et al.*³² and by Luczynska *et al.*³³, but that possibility is not supported by the present study or by the previous one of Van Hage-Hamsten *et al.*, in which no significant correlation was detected between the response to any storage mite and that to *D. pteronyssinus* either in the bakery workers or in the Swedish farmers. Significant correlations were observed in both groups between *G. domesticus* and *L. destructor* and between *T. putrescentiae* and *L. destructor*, indicating a strong allergenic relationship between those mites. *Acarus siro* appears to differ among the storage mites, as there was no positive correlation in any of the groups between the RAST results with *A.*

siro and those with *G. domesticus*. RAST inhibition was used to study the cross reactivity between the four mites considered. The three storage mites evidenced some degree of inhibitory activity on the RAST to *D. pteronyssinus*, but the inhibition lines were not parallel, suggesting the absence of immunological identity and of allergenic cross reactivity between *D. pteronyssinus* and the three storage mites. Finally, immunoblot studies of the allergenic similarities between *D. pteronyssinus* and *L. destructor* have shown that some allergens are quite similar between the two, while yet other allergens are very different.

Griffin³² has explored the allergenic and antigenic relationship between the house dust mite *D. pteronyssinus* and three storage mite species, *G. domesticus*, *Tyrophagus longior* and *Acarus siro*. Cross immunoelectrophoresis demonstrated that all the mite extracts contained multiple allergens, but there was only limited cross reactivity between the different species.

Luczynska *et al.*³³ investigated 196 individuals from an urban environment who worked at a coconut and coffee grain processing plant. A 24% prevalence of specific IgE antibodies to *D. pteronyssinus* was detected, together with a 14% prevalence of RAST positivity to at least one of the three storage mites studied (*A. siro*, *L. destructor* and *T. longior*). The RAST inhibition studies disclosed a considerable cross reactivity between *D. pteronyssinus* and the storage mites *A. siro* and *T. longior*, and a limited cross reactivity between the former and *L. destructor*.

Puerta *et al.*³⁴ carried out a study in Cartagena collecting sera from 77 atopic subjects who evidenced skin sensitization either to *D. farinae* or to *D. pteronyssinus*. RAST and RAST inhibition studies were performed in order to assess the prevalence of specific IgE antibodies to *Blomia tropicalis*, *Lepidoglyphus destructor* and *Dermatophagoides farinae*. Among the study population of atopic subjects, 89.6% were positive for *D. farinae* and 59.7% were positive for *Blomia tropicalis*. The authors concluded that *B. tropicalis*, *D. farinae* and *L. destructor* have

allergens that are unique and specific for each one, and also common allergens. These observations therefore lend support to the idea that sensitization to storage mites is generally associated to that to house dust ones. However, later studies both *in vitro* and *in vivo* comparing the IgE responses to *Blomia tropicalis* and to *Dermatophagoides pteronyssinus* demonstrated that the former has unique allergens that cause specific responses, and that it is an independent cause of sensitization.

These observations are at contrast with those of Van Hage-Hamsten and co-workers³⁵, who found no or almost no cross reactivity between the four species of storage mites and *D. pteronyssinus*. Van Hage-Hamsten reported the results of a RAST inhibition cross reactivity study with two species from the family *Glycyphagidae*, namely *Lepidoglyphus destructor* and *Blomia kulagini*. Her data clearly showed that marked differences are found in the cross reactivity patterns when sera from different populations are used. This work compared the clinical significance and the allergenic cross reactivity of these two storage mites in Sweden and Brazil, using RAST and RAST inhibition techniques. The highest RAST levels were observed for *Lepidoglyphus destructor* in the sera from Brazil. The RAST inhibition studies showed that the *L. destructor* extract was able to inhibit the *Blomia kulagini* system in Swedish sera, but not in the Brazilian ones. In contrast, the *B. kulagini* extract could inhibit the *L. destructor* system only in the Brazilian sera, but not in the Swedish ones. Thus, the conclusions derived regarding cross reactivity depend on the populations tested, and conclusions on the possible presence or absence of cross reactivity between two mite species may be contradictory. However, the presence of subjects with positive RAST exclusively to one of the mites tested (either *L. destructor* or *B. kulagini*) strongly supports the notion of the presence of a single allergen, or of a number of allergens, unique to either species. There was no cross reactivity between *L. destructor* and *D. pteronyssinus*;

furthermore, *L. destructor*, *G. domesticus* and *T. putrescentiae* appeared to be more closely related to each other than to *A. siro*. This was confirmed when the cross reactivity between *L. destructor* and *D. pteronyssinus* was studied *in vivo* using bronchial challenge tests.

The results of the analyses of dust samples collected from the patients' mattresses support the idea of multiple sensitizations, as suggested by Platts-Mills and Ford³⁶, as storage mites were detected in at least 28 of the 31 samples provided. The species more frequently detected were *Lepidoglyphus*, *Tyrophagus* and *Ghohieria*.

Di Bernardino, in 1987¹⁵, studied the epidemiological incidence of a number of allergens, and mainly of mites, in IgE-mediated respiratory diseases in children, and found no statistically significant association between the various acarine families. The *Pyroglyphidae* were both positive in 73% of the cases, and the *Acaridae* only in 28%. Among the latter, *Acarus siro* (alone) yielded positive skin tests in 59% of the cases. Moreover, only in 11 cases were negative tests to *Pyroglyphidae* together with positive ones to *Glycyphagidae* and/or *Acaridae* observed. In this author's opinion, these results might reflect the presence of favourable conditions for the growth of storage mites in modern dwellings. Furthermore, the simple positive reactions and the casual associations between the various families appear to support the idea of multiple colonisation of the dwellings rather than that of a high allergenic affinity between the different species.

In conclusion, the prevalence of storage mite sensitization appears to be quite high in the area encompassed by our study, and the mechanism proposed is that of multiple sensitization rather than that of cross reactions to the *Dermatophagoides* spp., although further, more detailed analyses are required in order to confirm this. High indoors humidity together with the proximity of grain storage facilities in the homes of some of the patients appear to be the most important environmental factors influencing the deve-

lopment of allergy to storage mites in the patient population studied.

REFERENCES

1. Platts-Mills TAE, de Weck AL. Mite Allergy wide problem. Bad kreuznach, The UCB Institute of Allergy. September 1987.
2. Colloff MJ, Spiesksma ThM. Pictorial keys for the identification of domestic mites. Clin Exp Allergy 1992; 22: 823-830.
3. Platts-Mills TAE, Thomas AE. Dust mite allergens and asthma: report of a second international workshop. J Allergy Clin Immunol 1992; 89: 1046-1060.
4. Zimmermann T, Mayer J. Frequency of sensitization to *Dermatophagoides pteronyssinus* or *Dermatophagoides farinae* in children with perennial bronchial asthma. Monatsschr Kinderheilkd 1985; 133: 214-218.
5. Armentia A, Pérez Santos CA, Fernández R, de la Fuente P, Sánchez E, Sanchís J, Méndez JA, Tapias R, Castrodeza FP. Estudio de prevalencia de los ácaros productores de alergia en la provincia de Valladolid. Rev Esp Alergol Immunol Clin 1993; 8: 199-210.
6. Arlian Larry G, PhD: Biology and Ecology of House Dust Mites, *Dermatophagoides* spp and *Euroglyphus* spp. Immunology and Allergy Clinics of North America 1989; 9: 2.
7. Fernández Caldas E, Puerta L, Mercado D, Lockey RF, Caraballo LR. Mite fauna, Der p 1, Der f 1, and *Blomia tropicalis* allergen levels in a tropical environment. Clin Exp Allergy 1993; 23: 292-297.
8. Fernández Caldas E, Puerta L, Caraballo L, Mercado D, Lockey RF. Sequential determinations of *Dermatophagoides* spp allergens in a tropical city. J Invest Allergol Clin Immunol 1996; 6: 98-102.
9. Ebner C, Feldner H, Ebner H, Kratt D. Sensitization to storage mites in house dust mite (*Dermatophagoides pteronyssinus*) allergic patients. Comparison of rural and an urban population. Clin Exp Allergy 1994; 24: 347-352.
10. Angrisano A, Bernardino LD, Fregoso A, Zatta G, Bagliani G, Compostella R. *Dermatophagoides* and storage mites: statistical analysis of RAST results. Ann Allergy 1990; 64: 358-361.
11. Arlian LG. Humidity as a factor regulating feeding and water balance of the house dust mites *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus* (Acari: Pyroglyphidae). J Med Entomol 1977; 14: 484-488.

12. Tee RD. Allergy to storage mites. *Clin Exp Allergy* 1994; 24: 636-640.
13. Iversen M, Dahl R. Allergy to storage mites in asthmatic patients and its relation to damp housing conditions. *Allergy* 1990; 45: 81-85.
14. Alergológica: factores epidemiológicos, clínicos y socioeconómicos de las enfermedades alérgicas en España. Sociedad Española de Alergia e Inmunología Clínica y Alergia e Inmunología. ALK-Abelló S.A., Madrid, Spain; 1995.
15. Di Berardino LD, Angrisano A, Gorli L, Cattaneo M, Lodi A. Allergy to house dust and storage mites in children: epidemiologic observations. *Ann Allergy* 1987; 59: 104-106.
16. Cuthbert OD, Brostoff J, Wraith DG, Brighton WD. Barn allergy: asthma and rhinitis due to storage mites. *Clin Allergy* 1979; 9: 229-236.
17. Agha M. Gnanasalthy. A cluster analysis of the effects of storage mites as allergens in relation to certain occupations and living conditions. *Clin Allergy* 1981; 11: 499-504.
18. Van Hage-Hamsten M, Johansson E, Wirén A, Johansson SGO. Storage mites dominate the fauna in Swedish barn. *Allergy* 1991; 46: 142-146.
19. Terho EO, Husman K, Vohlonen I, Rautalahti M, Tukiainen. Allergy to storage mites or cow dander as a cause of rhinitis among Finnish farmers. *Allergy* 1985; 40: 23-6.
20. Griffith DA, Wilkin DR, Southgate BJ, Lynch SM. A survey of mites in bulk grain stored on farms in England and Wales. *Ann Appl Biol* 1976; 82: 180-184.
21. Marx JJ, Twiggs JT, Ault BJ, Merchant JA, Fernández Caldas E. Inhaled aeroallergen and storage mite reactivity in a Wisconsin farmer nested case-control study. *Am Rev Respir Dis* 1993; 147: 354-358.
22. Cuthbert OD, Jeffrey IG, Mc Neil HB, Wood J, Topping MD. Barn allergy among Scottish farmers. *Clin Allergy* 1984; 14: 197-206.
23. Iversen M, Korsgaard J, Hallast T, Dahl R. Mite allergy and exposure to storage mites and house dust mites in farmers. *Clin Exp Allergy* 1990; 20: 211-220.
24. Miyamoto T, Oshima S, Mizuno K, Sasa M, Ishizaki E. Cross antigenicity among 6 species of dust mites and house dust antigens. *J Allergy* 1969; 44: 228.
25. Van Hage-Hamsten M, Johansson SGO. Clinical significance and allergenic cross-reactivity of *Euroglyphus maynei* and other nonpyroglyphid and pyroglyphid mites. *J Allergy Clin Immunol* 1989; 83: 581-589.
26. Spieksma FThM. Domestic mites: their role in respiratory allergy. *Clin Exp Allergy* 1991; 21: 655-660.
27. Van Hage-Hamsten M, Johansson E, Wiren A. Lack of allergenic cross-reactivity between storage mites and *Dermatophagoides pteronyssinus*. *Clin Allergy* 1987; 17: 23-31.
28. Korsgaard J, Dahl R, Iversen M, Hallas T. Storage mites as a cause of bronchial asthma in Denmark. *Allergol Immunopathol* 1985; 13: 143-149.
29. Johansson E, Johansson SG, Van Hage-Hamsten M. Allergic characterization of *Acarus siro* and *Tyrophagus putrescentiae* and their crossreactivity with *Lepidoglyphus destructor* and *Dermatophagoides pteronyssinus*. *Clin Exp Allergy* 1994; 24: 743-751.
30. Tee RD, Gordon DJ, Van-Hamsten M, et al. Comparison of allergenic responses to dust mites in U.K. bakery workers and Swedish farmers. *Clin Exp Allergy* 1992; 22: 233-239.
31. Griffin P, Ford AW, Alterman L, et al. Allergenic and antigenic relationship between three species of storage mite and the house dust mite, *Dermatophagoides pteronyssinus*. *J Allergy Clin Immunol* 1989; 84: 108-117. Artículo.
32. Griffin P, Ford AW, Alterman L, et al. Allergenic and antigenic relationship between three species of storage mite and the house dust mite, *Dermatophagoides pteronyssinus*. *J Allergy Clin Immunol* 1989; 84: 108-117.
33. Luczynska CM, Griffin P, Davies RJ, Topping MD. Prevalence of specific IgE to storage mites (*Acarus siro*, *L. destructor* and *T. longior*) in an urban population and crossreactivity with the house dust mite (*D. pteronyssinus*). *Clin Exp Allergy* 1990; 20: 403-406.
34. Arruda LK, Vailes LD, Platts-Mills TA, Fernández 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.
35. Van Hage-Hamsten M, Machado L, Barros MT, Johansson SGO. Comparison of clinical significance and allergenic cross-reactivity of storage mites *Blomia kulagini* and *Lepidoglyphus destructor* in Sweden and Brazil. *Allergy* 1990; 45: 409-417.
36. Ford AW, Platts-Mills TAE. Standardized extracts, dust mite and other arthropods (inhalants). *Clin Rev Allergy* 1987; 55: 49-73.