

Asthma after consumption of snails in house-dust-mite-allergic patients: a case of IgE cross-reactivity

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A group of 28 patients from Italy was studied who had asthma after consumption of snail. All patients also had asthma and/or rhinitis caused by house-dust mite. RAST analyses confirmed the combined sensitization to snail and mite. In a few sera, IgE antibodies reactive with other foods of invertebrate origin (mussel and shrimp) were detected. RAST inhibition showed that most IgE antibodies against snail were cross-reactive with house-dust mite. In contrast, the mite RAST was not significantly inhibited by snail. This indicates that house-dust mite was the sensitizing agent. Immunoblot analyses revealed multiple bands in snail extract recognized by IgE. In contrast to what has been described for cross-reactivity between shrimp and mite, tropomyosin played only a minor role as a cross-reactive allergen in these patients. The observations in this study indicate that snail consumption can cause severe asthmatic symptoms in house-dust-mite-allergic patients. It might, therefore, be advisable to screen mite-allergic asthma patients for allergy to snail and other invertebrate animal foods.

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Food allergy caused by invertebrates has been described for patients with house-dust mite allergy in several reports (1–13). Shrimp-reactive IgE antibodies were shown to be cross-reactive with house-dust mite in shrimp-allergic patients (13). The highly conserved muscle protein tropomyosin was identified as a cross-reactive allergen in house-dust mite and shrimp, and was detected in several other invertebrates including snail (13). In shrimp, tropomyosin was shown to be the major allergen, earlier designated Pen a 1 (14, 15). Recently, tropomyosins from both shrimp (15, 16) and house-dust mite (*Dermatophagoides farinae*) have been cloned (17).

Like allergy to shrimp, allergy to snail (and limpet) has also been reported in patients with house-dust mite allergy (1–4, 6–8, 10–12, 18). Many of these patients had asthmatic symptoms after snail consumption. The prevalence of snail allergy in mite-allergic patients is still largely unknown, but is obviously related to the alimentary habits of the geographic area. A recent epidemiologic study per-

formed in the South of France reported a prevalence of 4% (14/163) (19). In Italy, over the past 5 years, at least two fatalities have been reported (personal communications: Dr I. Raimondi, Termini Imerese, and Dr G. Piu, Cagliari). This is consistent with earlier reports of the severity of acute outbreaks of asthma caused by an IgE-mediated, food-allergic reaction in asthmatic patients (20, 21).

In this report, a group of 28 patients with combined allergy to snail and house-dust mite was studied. RAST-inhibition assays and immunoblot analyses were performed to investigate the cross-reactivity of IgE, and the possible involvement of the highly conserved allergen tropomyosin. In addition, cross-reactivity to other invertebrate animal foods (shrimp and mussel) was studied.

Material and methods

Allergen extracts

Dried *D. pteronyssinus* mites were obtained from the Commonwealth Serum Laboratories (Melbourne,

Australia). Shrimp and mussels were obtained from the local fish store. Extracts of both mites and seafood were made as described elsewhere (13). Freeze-dried extracts of three different land snails (*Eobania vermiculata*, *Helix aperta*, and *Cernualla virgata*) and two sea snails (*Bolinus brandaris* and a *Patella* sp.) were obtained from Lofarma Allergeni (Milan, Italy) (2). All these snails are eaten in Italy. Locally, one or another species may be preferred.

Patients/sera

A group of 28 patients (15 male, 13 female) with combined snail and house-dust mite allergy from four different areas of Italy (Ancona: AN1–5, Venice: VE1–8, Messina: ME1–8, and Palermo: PA1 and PA3–8) was studied. The mean age ($\pm$ SD) was 23 ($\pm$ 13). All patients had asthmatic episodes after consumption of snails, and had asthma and/or rhinitis related to house-dust mite. Immunotherapy was used as a treatment for the house-dust mite allergy in 16/28 patients, before or at the time of the occurrence of snail-related symptoms.

In addition, the serum of a snail-allergic patient (NL1) from The Netherlands was included in the study for comparison (8).

RAST (inhibition)

The radioallergosorbent test (RAST) was performed as described elsewhere (22). The following amounts of dialyzed allergen extract were coupled to 100 mg CNBr-activated Sepharose 4B (Pharmacia, Uppsala, Sweden): 1.2 mg protein for *D. pteronyssinus*, 5 mg dry weight for shrimp and mussel, and 4 mg dry weight for extracts of the three land snails and of both sea snails. Protein concentrations (mg/mg dry weight) of the snail extracts were as follows: land snails *E. vermiculata*: 1.0, *H. aperta*: 1.1, and *C. virgata*: 0.9; sea snails *B. brandaris*: 0.4 and a *Patella* sp.: 0.8). Per test, 1.5 mg Sepharose and 50 μ l serum was used. Results are expressed in percent binding of total counts of radiolabeled (^{125} I) sheep antihuman IgE added.

For RAST inhibition, serum was preincubated for 2 h with allergen extract before addition of Sepharose-coupled allergen. Inhibition was performed with nonsaturating serum concentrations; therefore, sera were diluted when necessary. Results are expressed as percent binding of total counts of radiolabeled sheep antihuman IgE added, or as percentages of the uninhibited value (no inhibitor added).

Immunoblotting

After separation of allergen extracts by SDS-PAGE, electrophoretic transfer to nitrocellulose (1 mA/cm² for 1 h) was performed semidry on a Novablot electrophoretic transfer apparatus (Pharmacia). After blocking with PBS/1.8% (w/v) BSA/0.1% (v/v) Tween 20, the blots were cut into strips of 4–6 mm $\times$ 12.5 cm before immunoprob- ing. Strips were incubated with 150 μ l serum. A tropomyosin-specific monoclonal antibody (1A6) was used to identify tropomyosin (13).

Results

Snail-related symptoms

All patients ($n=28$) had asthmatic episodes after consumption of snail (Table 1). In addition, rhinitis and urticaria were frequently observed ($n=14$ and $n=8$, respectively). In two cases (VE8 and AN3), anaphylactic reactions were observed. In general, the reactions were severe: seven patients had to be taken to a hospital emergency room, and others ($n=21$) needed emergency domiciliary treatment (beta-mimetics by inhalation, or xanthines and especially steroids by the oral or parenteral route).

For most of the patients, *H. aperta*, *C. virgata*, or *E. vermiculata* were the cause of food allergy, but some patients also reported asthmatic reactions after ingestion of limpet and *B. brandaris*.

In most patients (23/28), symptoms occurred 5–60 min after ingestion of snails. In the remaining five patients (ME2, ME6, AN1, AN2, and AN5), a late reaction was reported: symptoms occurred after 1–5 h. Eleven patients reported relapse of asthmatic symptoms after repeated consumption on 1–3 occasions, and five patients on >3 occasions.

In 16/28 patients, mite immunotherapy had been previously performed or was still being performed when adverse reactions to snail occurred. Three patients (AN2, VE4, and ME8) reported sudden erythema and itching at the injection site of previous mite immunotherapy during the allergic reaction to snails.

For assessment of the severity of asthma, non-specific bronchial hyperresponsiveness to methacholine was measured in eight randomly selected patients, and compared to 10 food-allergic patients without sensitization to inhalant allergens. The average PD₂₀ FEV₁ values were 51 μ g ($\pm$ 44 SEM) and 1710 ($\pm$ 394 SEM), respectively ($P<0.001$).

RAST analysis

Sera were tested by RAST for three closely related species of land snails of the Helicidae family: *C. virgata*, *H. aperta*, and *E. vermiculata*. Table 1

Table 1. Sex, age, symptoms related to house-dust mite and snail, and RAST results for house-dust mite and snail are listed for all patients. Column "IT" shows whether patients were receiving mite immunotherapy or not. RAST results are expressed in percent binding of radiolabeled polyclonal sheep antihuman IgE. Abbreviations of clinical symptoms: A=asthma; R=rhinitis; U=urticaria; An=anaphylaxis

Code	Patient		House-dust mite			Snail (<i>H. aperta</i>)	
	Sex	Age (years)	Symptoms	IT	RAST	Symptoms	RAST
VE1	M	33	R+A	Y	42.2	R+A+U	13.9
VE2	F	24	R+A	N	39.2	A	9.9
VE3	M	31	R+A	Y	49.6	R+A+U	15.1
VE4	M	31	R+A	Y	45.4	R+A+U	9.9
VE5	F	45	R+A	N	32.9	R+A	8.8
VE6	F	51	R+A	N	32.8	A+U	7.2
VE7	F	26	R	Y	34.4	A	7.1
VE8	F	30	R+A	N	34.1	A+An	3.5
ME1	F	17	R+A	Y	47.0	R+A	14.6
ME2	M	13	R	Y	44.6	A+U	12.9
ME3	F	16	R+A	Y	46.0	A	36.1
ME4	M	14	A	Y	48.9	A+U	10.0
ME5	F	10	A	Y	55.5	A+U	32.0
ME6	F	14	A	N	23.6	R+A	4.4
ME7	M	11	A	N	53.1	A	34.7
ME8	F	13	R+A	Y	41.1	R+A+U	12.9
PA1	M	28	R+A	Y	33.2	A	7.8
PA3	F	9	R+A	N	3.3	A	8.9
PA4	M	10	R+A	N	10.0	A+U	4.3
PA5	M	21	R+A	Y	45.0	A+U	17.2
PA6	M	12	R+A	N	50.9	A	34.7
PA7	M	8	R+A	Y	53.8	A	14.3
PA8	F	19	R+A	Y	35.5	A+U	13.1
AN1	M	31	R+A	N	46.9	A+U	27.7
AN2	M	30	R+A	Y	48.7	A+U	26.3
AN3	F	61	R+A	N	50.2	A+An	21.8
AN4	M	21	R+A	N	51.5	R+A	32.9
AN5	M	19	R+A	Y	50.3	A+U	22.8

lists the results for *H. aperta*. In addition, RAST was performed for both sea snails *B. brandaris* and a *Patella* sp. (limpet), and for mussel and shrimp. The RAST results for the sea snails were almost indistinguishable from those observed for *H. aperta* and both of the other land snails (Fig. 1). Weighted regression analysis of the five (land and sea) snail

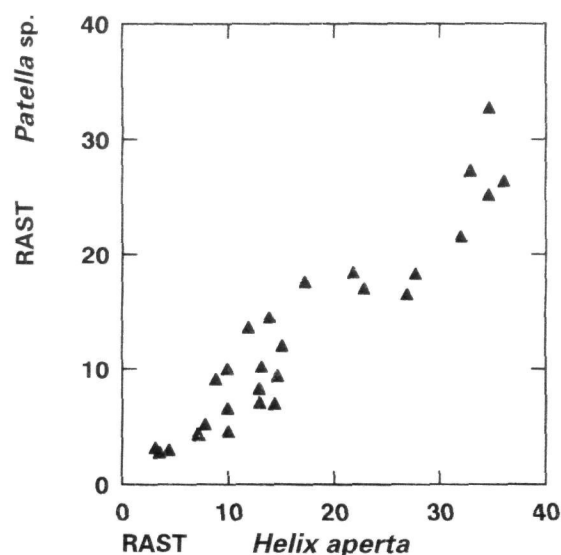


Fig. 1. RAST results for three types of land snails and two types of sea snails were very similar. This is illustrated for land snail *Helix aperta* and sea snail *Patella* sp. Results are expressed in percent binding of radiolabeled sheep antihuman IgE.

RASTs confirmed a strong correlation. The correlation coefficient r was for all combinations >0.9 (95% CI 0.81–1.00). In contrast, only four sera showed clear IgE binding ($>5\%$ binding) to mussel and/or shrimp (Table 2).

All sera were also tested by RAST for IgE to *D. pteronyssinus* (Table 1). With the exception of two sera (PA3 and PA4), percentages of binding were $>20\%$. Only for one serum (PA3) was the RAST for snail higher than the RAST for mite.

RAST inhibition

The cross-reactivity of IgE between snail and house-dust mite was investigated by RAST inhibition.

Table 2. RAST results are shown for patients who demonstrated $>5\%$ binding in RAST for mussel and/or shrimp. Results are expressed in percent binding of radiolabeled sheep antihuman IgE

Serum	Mite	Snail	Mussel	Shrimp
AN4	51.5	32.9	6.1	11.4
AN4	47.0	14.6	2.9	5.3
PA4	10.0	4.3	2.2	13.1
PA6	50.9	34.7	6.4	11.6
NL1	33.8	19.9	7.7	1.6

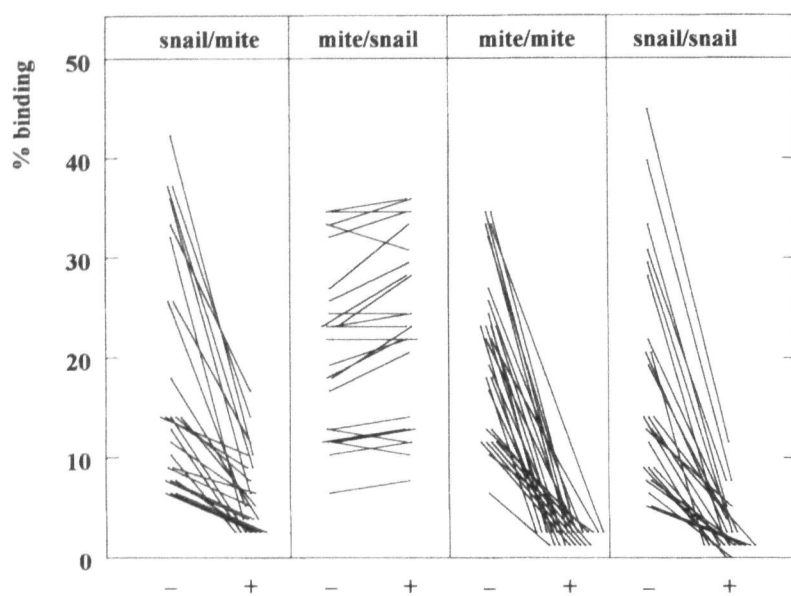


Fig. 2. Snail (*H. aperta*) and mite (*Dermatophagoides pteronyssinus*) RAST were both inhibited with snail and mite extract, 235 μ g per test and 12.5 μ g per test, respectively. Uninhibited values are marked by -; inhibited by +. Results are expressed in percent binding of radiolabeled sheep antihuman IgE.

RAST inhibition was performed for all sera that had demonstrated $>5\%$ binding to snail and/or mite. Binding of IgE to snail was strongly inhibited by mite extract (Fig. 2), the average percentage of binding falling from 18.2% to 6.3% ($P < 0.001$). Binding to mite, however, was not inhibited by snail extract (20.9% to 22.5%). At the same concentration, the snail RAST was clearly inhibited, the average percentage of binding falling from 17.9% to 2.9% ($P < 0.001$). The homologous mite inhibition demonstrated a fall in the average percentage of binding from 20.9% to 2.5% ($P < 0.001$).

Since complete inhibition of the snail RAST with mite was not reached for a number of sera, higher concentrations of inhibitor were used for five sera. For 4/5 of these sera, dose-dependent inhibition of the snail RAST was observed. Although mite concentrations were still not high enough for complete inhibition, it was shown that IgE to snail was largely cross-reactive with mite (Fig. 3), except for IgE from serum PA3. Binding of IgE from PA3 to snail was hardly affected by incubation with mite extract.

Immunoblotting

All sera were analyzed by immunoblot with house-dust mite (*D. pteronyssinus*), snail (*H. aperta*), and shrimp (*Crangon crangon*), after separation by SDS-PAGE. Most of the sera demonstrated IgE recognition of the major mite allergens Der p 1 and/or Der p 2, and multiple bands >25 kDa (Fig. 4A). In snail extract, multiple bands were recognized (Fig. 4B), mainly at 20–30 kDa and above 50 kDa, by all but two sera (ME1 and PA3). ME1 (and, to a lesser extent, AN4) bound to an allergen of 35 kDa, also recognized by the tropo-

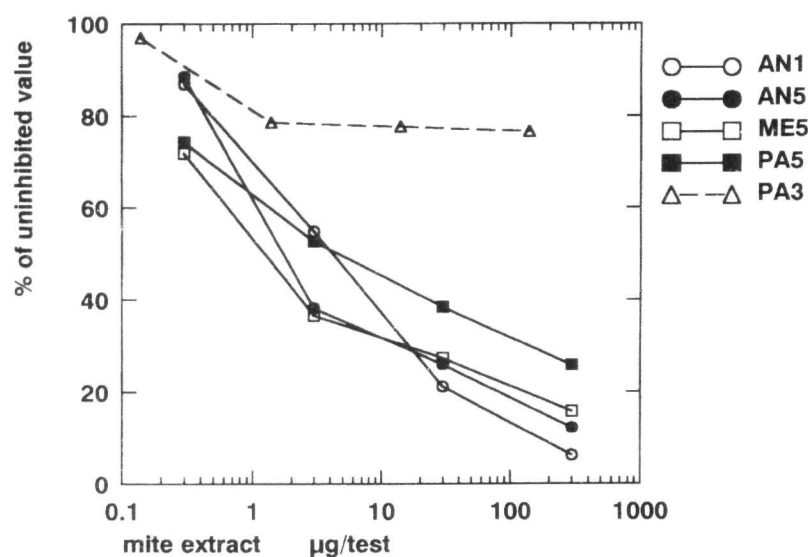


Fig. 3. In five sera, snail RAST was inhibited by mite extract ≤ 300 μ g per test. Only binding of PA3 was hardly affected. Results are expressed as percentage of uninhibited value (Table 1).

myosin-specific monoclonal antibody 1A6 (not shown). Serum PA3 demonstrated IgE binding to a band around 30 kDa. Only five sera recognized allergens in shrimp extract (Fig. 4C), of which ME1 and AN4 showed reactivity with tropomyosin. VE3 (shrimp RAST: 3.7%), PA4, and PA6 recognized bands around 25 kDa. PA6 also bound to multiple bands >65 kDa.

Cross-reactivity to mussel and shrimp

Most sera did not contain IgE (cross-)reactive with mussel or shrimp: mite-reactive IgE was found to be cross-reactive only with snail (Fig. 5A). IgE binding ($>5\%$) to mussel was observed in two sera (AN4 and PA6). The mussel RAST of both sera was largely inhibited by snail extract, but hardly affected by mite extract (Fig. 5B and C). The same experiment was performed with serum NL1 from a mite/snail-allergic patient from The Netherlands. In this case, both snail and mite extract inhibited the mussel RAST (Fig. 5D).

IgE binding ($>5\%$) to shrimp was observed in four sera (AN4, PA4, PA6, and ME1). For AN4, PA4, and PA6, RAST inhibition was performed with snail and mite extract. Snail hardly affected the shrimp RAST, whereas mite extract resulted in clear inhibition (Fig. 5B and C).

Discussion

Allergy to snail was studied in a group of 28 patients. As reported in several other studies (2–4, 8, 10, 12), most patients suffered from severe asthmatic attacks after ingestion of snails. All patients studied were allergic to house-dust mite as well. This coexistence of two allergies was explained by cross-reactive IgE. In most cases, IgE reactivity to

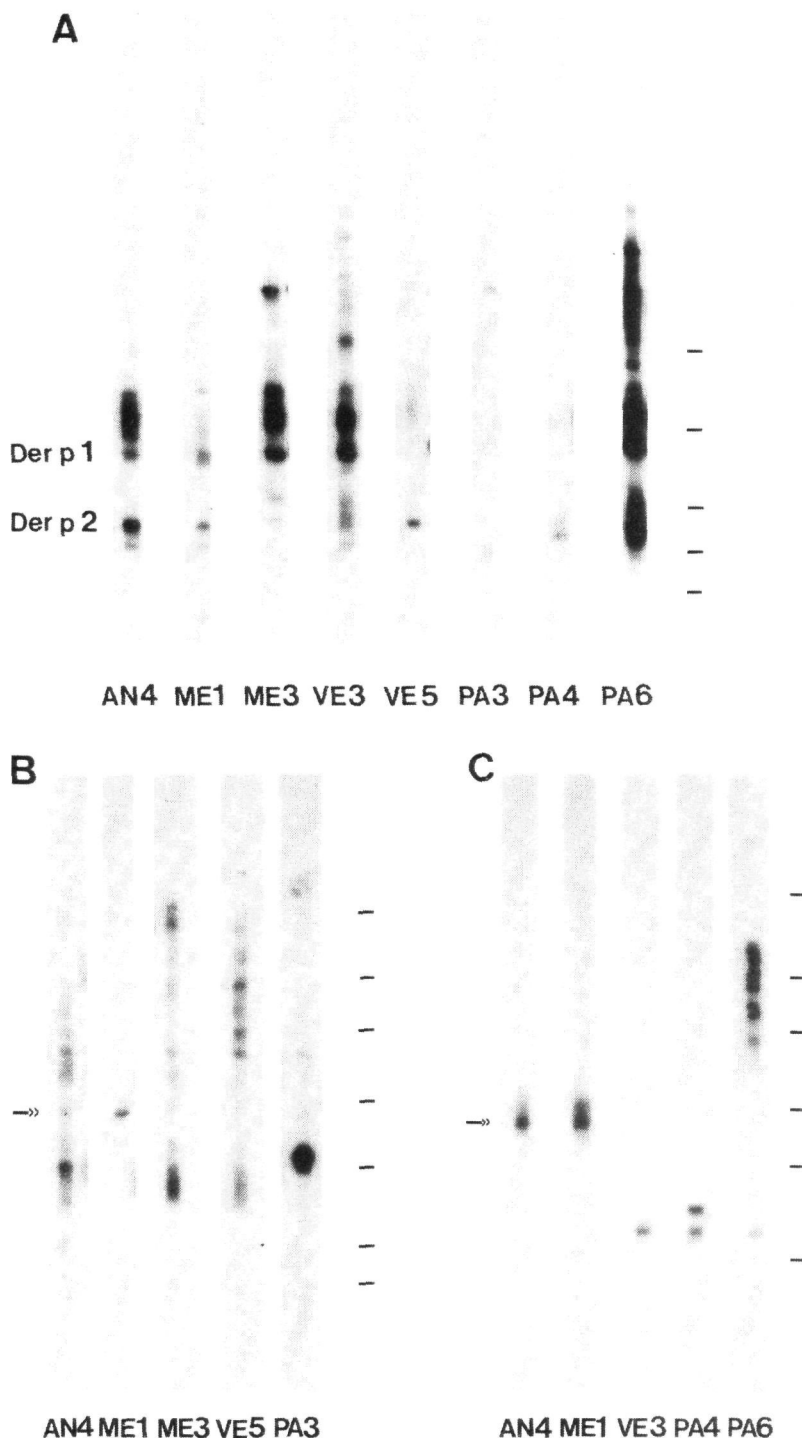


Fig. 4. Immunoblot analysis. A) House-dust mite. Molecular mass markers are indicated on right side, from top to bottom: 43, 29, 18.4, 14.3, and 6.2 kDa. PA3 did not recognize Der p 1 and Der p 2, but only band of 50–60 kDa that was recognized by several other patients as well (e.g., ME3). B) Snail. Molecular mass markers are indicated on right side, from top to bottom: 200, 97.4, 68, 43, 29, 18.4, and 14.3 kDa. Tropomyosin is indicated by arrow. C) Shrimp. Molecular mass markers are indicated on right side, from top to bottom: 206.4, 110.9, 70.6, 43.7, 28.4, and 17.9 kDa. Tropomyosin is indicated by arrow.

snail was inhibited by mite, whereas IgE reactivity to mite was not significantly inhibited by snail. These results indicate that mite is usually the sensitizing agent. In only one case (PA3) was the RAST for snail higher than for mite, and the snail RAST was hardly affected by inhibition with mite. Some earlier reports (3, 12) speculated that parasitic mites (species *Riccardoella limacum*) in the lungs of land snails might cause the apparent cross-reactivity between snails and house-dust mite. The close correlation between the RAST for land snails and sea

snails argues against this hypothesis, because sea snails are not parasitized by *R. limacum* lung mites. A group of allergens is probably shared by snails, limpets, and *B. brandaris*, and the different reports on allergic reactions to these Gastropoda can be united in a single syndrome.

Sixteen of the 28 patients were treated with immunotherapy for their mite-related symptoms. In several other reports on combined mite-snail allergy, many of the patients received immunotherapy as well (3, 6). Snail-related symptoms were often reported to occur after prolonged immunotherapy. In three patients, sudden urticaria appeared at the site of previous immunotherapy injections. This phenomenon was also described by Banzet et al. (3). These observations suggest that in some patients mite immunotherapy is involved in the induction of snail allergy. We recently tested sera of mite-allergic patients, at the start of immunotherapy and 1 year later, for IgE reactivity with snail (23). A clear increase in IgE reactivity with snail was observed, suggesting active induction of IgE by immunotherapy.

Tropomyosin was identified as a cross-reactive allergen in mite and shrimp, and several other invertebrate animal foods, including snail (13). However, in this group of snail-allergic patients, tropomyosin did not play an important role. Only two patients (AN4 and ME1) demonstrated binding to tropomyosin on immunoblot. Most sera recognized many other bands in snail extract, illustrating that no single allergen is responsible for cross-reactivity between snail and mite.

When sera ($n=20$) from The Netherlands were selected by positive RAST for mite combined with shrimp and/or mussel, all demonstrated positive RAST for snail (not shown), suggesting the existence of common IgE-binding structures in mite, shrimp, mussel, and snail (e.g., tropomyosin). Selection of patients by allergy to snail resulted in a totally different picture: only a few sera had IgE antibodies against shrimp and mussel. RAST inhibition showed that the reactivity to shrimp was cross-reactive with mite but hardly with snail. This indicates that the cross-sensitization from mite to shrimp and from mite to snail may occur independently. Surprisingly, RAST for mussel of AN4 and PA6 was inhibited by snail but hardly by mite, in contrast to what was observed for the mite/snail-allergic patient from The Netherlands (NL1).

This study has demonstrated that allergy to snail is closely linked to house-dust-mite allergy. Cross-reactivity patterns between mite and invertebrate animal foods can clearly differ, suggesting that there are many cross-reactive structures. In contrast to what was described for some shrimp-allergic patients (13), mite seems to cause the primary

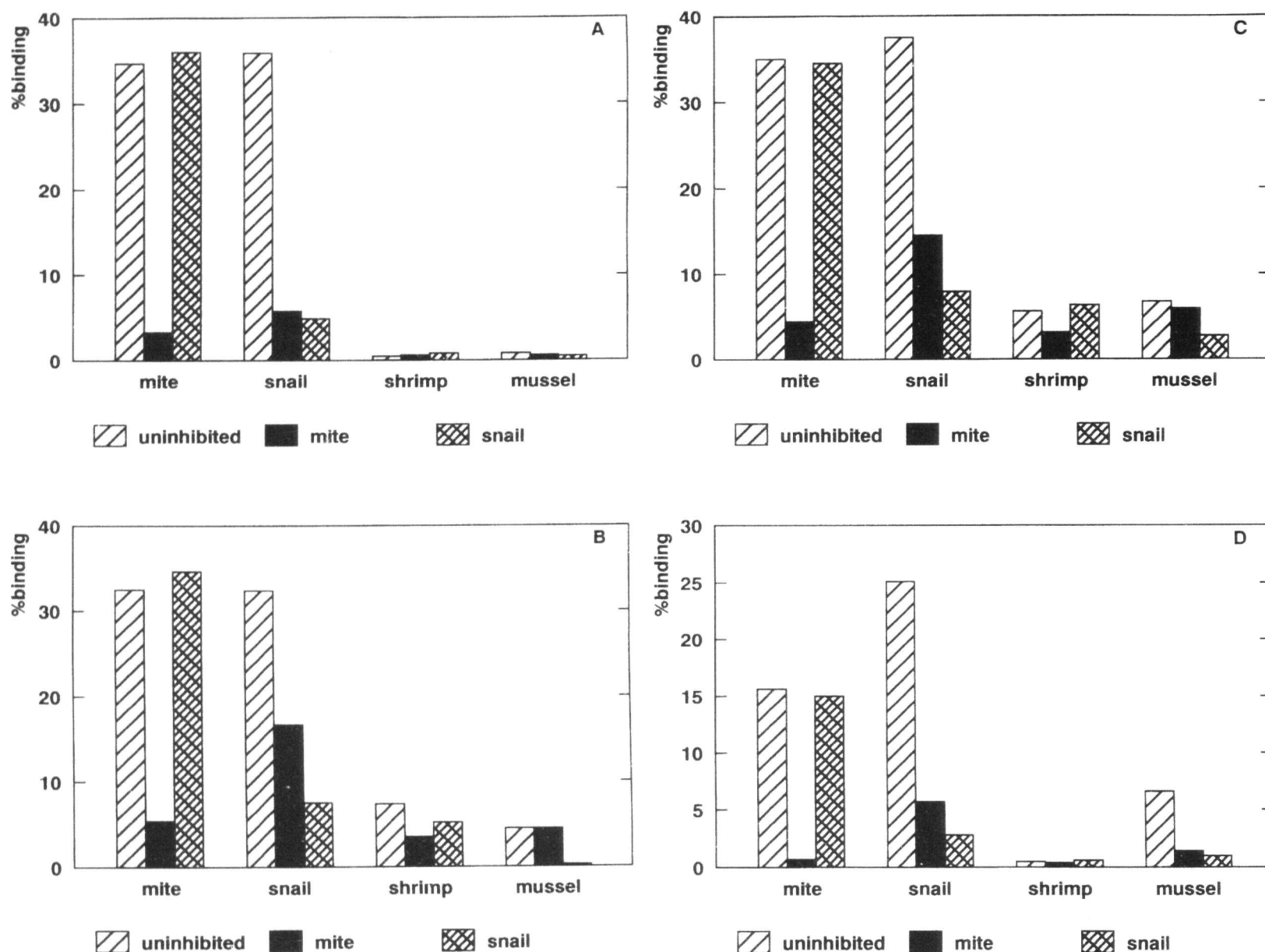


Fig. 5. RAST inhibition was performed with house-dust mite (70 µg/test) and snail (235 µg/test) extract: A) serum (ME5) representative of most sera in study; B and C) two sera with positive RAST for mussel (AN4 and PA6); D) RAST inhibition for NL1. All results are expressed as percent binding of radiolabeled sheep antihuman IgE.

sensitization in most snail-allergic patients. The role of immunotherapy for inhalant allergens, in patients suffering from respiratory and food allergy caused by cross-reactive allergens, is not very clear. A positive effect on food allergy has been reported in some studies (24–26). In the light of our observations, however, mite immunotherapy might be considered a risk factor for the development of snail allergy. The observed symptoms after snail ingestion closely agree with the symptoms caused by the sensitizing inhalant allergen, i.e., mainly asthma. The high level of bronchial hyperresponsiveness is consistent with the severity of the asthmatic reactions observed in these patients. It is perhaps worthwhile to include measurement of IgE to invertebrate animal foods for mite-allergic asthma patients, especially when they are undergoing immunotherapy.

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