

Bee and wasp sting reactions in current beekeepers

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Background: A majority of subjects allergic to bee venom are beekeepers, their relatives, or neighbors. Predetermining systemic reactivity to honeybee stings and risk assessment through laboratory tests have been unsatisfactory.

Objective: To estimate the prevalence and type of sting reactions, and especially to evaluate potential risk factors of systemic reactions in beekeepers.

Methods: A questionnaire concerning sting reactions and potential risk factors was mailed to all members of the regional beekeepers' association; 191 beekeepers were included in the study.

Results: Systemic bee sting reactions were present in 50 (26%) and large local reactions in 73 (38%) of the beekeepers. Similar reactions following wasp stings were present in 2% and 13%, respectively. Twenty-four (48%) of the systemic reactors and 39 (28%) of the remaining subjects had a history of atopic symptoms (allergic rhinitis, allergic bronchial asthma, or atopic dermatitis). While working at hives, nasal and eye symptoms were present in 54% of the systemic reactors and in 23% of the remaining subjects. Systemic reactors were younger and had been beekeepers for a shorter period than nonreactive subjects. Multiple logistic regression analysis showed that the risk of systemic sting reaction increased fourfold when nasal or eye symptoms were present while working at hives and twofold when the years in beekeeping were less than 15.

Conclusions: The occurrence of systemic and large local reactions after bee stings is high among beekeepers. A history of atopy is associated with systemic reactions. Both the presence of nasal or eye symptoms while working at hives and a history of beekeeping less than 15 years significantly increase the risk of systemic reactions.

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INTRODUCTION

A vast majority of subjects allergic to bee venom are beekeepers, their relatives or neighbors with a high risk of stings, whereas wasp venom allergy seems to be a random event.¹⁻³ The rate of systemic reactions following bee stings has been reported to be 14% to 42% in beekeepers,⁴⁻⁶ while serum bee

venom-specific IgE has been found in 42% to 79% of beekeepers.^{4,5} Increased awareness of possible life-threatening consequences has led to risk assessment with laboratory tests in

predetermining systemic reactivity to honeybee stings. Unfortunately, these tests have been unsatisfactory.⁷

The present study was designed to estimate the prevalence and type of sting reactions by using a specific questionnaire. Potential risk factors for systemic reactions in current beekeepers were evaluated.

MATERIAL AND METHODS

The data for this study were collected by a questionnaire mailed in September, 1993, to all 274 members of the regional beekeepers' association in the Pirkanmaa area of Finland (pop. 450,000). Beekeepers in this area commence working at beehives in May and finish in August. The questionnaire contained questions on bee and wasp (*Vespula* spp.) sting reactions and factors presumed to correlate with them (Table 1 and 2). The severity of systemic sting reactions was graded in four groups according to Müller's classification of anaphylaxis.⁸ A large local reaction was defined as the presence of swelling at the sting site with a diameter of at least 10 cm that lasted 24 hours or longer. The presence or absence of atopy was defined by clin-

Table 1. Characteristics of the Subjects Classified by the Severity of Bee Sting Reactions in History (mean $\pm$ SD)

	None (n = 100)	Large Local (n = 41)	Systemic (n = 18)	Systemic and Large Local (n = 32)	Total (n = 191)
Age, yr	54.9 $\pm$ 12.4	49.0 $\pm$ 12.9	48.3 $\pm$ 10.3	47.9 $\pm$ 10.3	51.8 $\pm$ 12.3*
Number of beehives	18.9 $\pm$ 36.3	19.9 $\pm$ 29.1	24.2 $\pm$ 37.2	31.9 $\pm$ 59.5	21.8 $\pm$ 39.9
Years in beekeeping	17.7 $\pm$ 16.3	17.4 $\pm$ 13.0	12.3 $\pm$ 11.1	12.1 $\pm$ 8.9	16.2 $\pm$ 14.3*
Bee stings in 1993	36.2 $\pm$ 111.1	25.9 $\pm$ 39.5	21.8 $\pm$ 30.5	19.6 $\pm$ 23.2	29.6 $\pm$ 82.3
BMI	26.3 $\pm$ 3.7	25.5 $\pm$ 2.7	25.5 $\pm$ 3.1	25.9 $\pm$ 2.9	26.0 $\pm$ 3.3
Age at beginning of beekeeping, yr	37.5 $\pm$ 12.5	32.3 $\pm$ 10.3	35.7 $\pm$ 11.5	36.0 $\pm$ 11.4	36.0 $\pm$ 11.8

The difference between systemic reactors and others * $P < .01$.
BMI = bodymass-index, length (m)/weight² (kg).

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ical history (allergic rhinitis, allergic asthma, or atopic dermatitis).

Eighty-eight beekeepers responded to the first questionnaire. Nonrespondents were remailed the questionnaire (84) or were contacted by telephone (102) and asked to complete the questionnaire. Finally, 218 subjects responded. The inclusion criterion for the study was active participation in beekeeping in 1993. Twenty-seven respondents were excluded because they had finished beekeeping (17), had never been beekeepers (3), or did not complete the questionnaire (7). The age of 27 female and 164 male subjects ranged from 21 to 83 years with a mean of 52 years. The subjects had been beekeepers for 1–66 years (mean 17). They managed from one to 300 hives (mean 22). Nine of the subjects were professional beekeepers, 28 were farmers, and five were gardeners. For the remaining 149 subjects, beekeeping was a leisure pursuit.

Statistical analyses

The statistical tests used were analysis of variance, Bonferroni's paired *t* test, the chi-square test and multiple logistic regression analyses. Differences were considered significant when $P < .05$. Multiple logistic regression analysis was applied to evaluate the influence of potential risk factors to systemic bee sting reactions. The age of the subject, the number of hives, the number of bee stings in 1993, his/her atopic history as an adult, nasal or eye symptoms when working at beehives, and the years in beekeeping were used as independent variables. The logistic regression analysis started with all independent variables in the model. Only significant variables were kept in the final model. Analyses were performed with a BMDP (BMDP Statistical Software, Inc, Los Angeles, CA, USA) statistical software package.

RESULTS

Systemic reactions after bee stings were present in 26% of the subjects. The most severe reaction was grade I in 13, II in 15, III in 15, and IV in 7 of the 50 systemic reactors. No associa-

Table 2. Results of questionnaire, subjects classified by systemic sting reactions (SR) after bee stings

Questions	No SR n = 141 Number (%)	SR n = 50 Number (%)	Total n = 191 Number (%)
Female	20 (14)	7 (14)	27 (14)
Smokers and ex-smokers	51 (36)	15 (30)	66 (35)
Atopic symptoms (a*)	39 (28)	24 (48)‡	63 (33)
Atopic symptoms (a + c†)	49 (35)	27 (54)‡	76 (40)
Nasal or eye symptoms while working at hives	33 (23)	27 (54)§	60 (31)
Respiratory symptoms while working at hives	7 (5)	11 (22)§	18 (9)
Use of gloves always while working at hives	97 (69)	45 (90)	142 (74)
Use of headprotection always while working at hives	86 (61)	29 (58)	115 (60)
Systemic reaction after a wasp sting	0	3 (6)	3 (1.6)
Large local reaction after a wasp sting	12 (9)	7 (14)	19 (10)

* a = in adulthood, † a + c = in adulthood or in childhood.

The difference between systemic reactors and non-reactors ‡ $P < .05$, § $P < .001$, and || $P < .01$.

tion was found between the severity of systemic sting reactions and any characteristic of the subjects. Of the 50 beekeepers with systemic reactions in their histories, 18 had experienced reactions during the preceding beekeeping season. The remaining 32 systemic reactors had had their last reaction 1 to 12 years earlier (mean 4 years). None of the beekeepers reacted to the latest sting. After their last systemic sting reaction, each subject had been stung by bees from 1 to 360 times (median 3, mean 34). Beekeepers with systemic reactions in their histories were significantly younger ($P = .006$) and had been beekeepers for significantly shorter periods ($P = .005$) than those with no systemic reactions (Table 1). The 50 systemic reactors had more beehives and fewer stings in 1993 than the remaining 141 subjects, but these differences were not statistically significant. The relationship between the frequency of bee stings and the type of sting reaction is illustrated in Figure 1. The mean age at the beginning of beekeeping was 36 years. Body constitution and the age at which beekeeping had began were not associated with the severity of sting reactions.

Forty-five (90%) of 50 beekeepers who had systemic reactions after bee

stings always used protective gloves at the hives. Ninety-seven (69%) of the 141 subjects with no systemic sting reactions always used gloves. With a chi-square test this difference was significant ($P = .006$) (Table 2). Sex and smoking habits were not associated with systemic sting reactions.

A history of atopic symptoms (allergic rhinitis, bronchial asthma, or atopic dermatitis) in adulthood was present in 48% of the systemic reactors and in 28% of nonreactive subjects (Table 2). This difference was significant ($P = .014$) with a chi-square test. A history of atopy was highly associated with nasal and eye symptoms when working at beehives ($P < .001$). Twenty-seven (54%) of the 50 systemic reactors and 33 (23%) of the 141 remaining beekeepers had had nasal or eye symptoms when working at beehives ($P < .001$). Respiratory symptoms (cough, dyspnea, or wheezing) during work had been present in 22% of the systemic reactors and in 5% of the remaining subjects ($P = .001$). Multiple logistic regression analysis showed that the most important factors associated with systemic bee sting reactions were nasal or eye symptoms when working at hives and the years in beekeeping (Table 3).

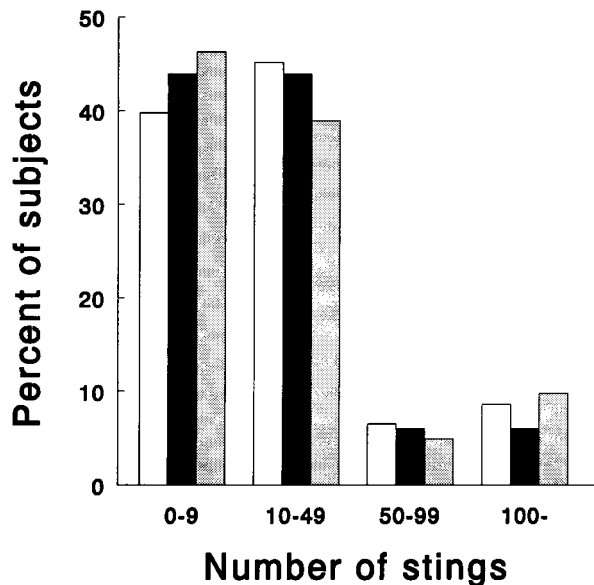


Figure 1. The relationship between the frequency of bee stings in the past beekeeping season and the clinical symptoms after stings. □ None, ■ large local, and ▨ systemic.

Those 67 beekeepers with nasal, eye, or respiratory symptoms while working at beehives had significantly ($P = .003$) more beehives (33) than the remaining subjects (15). The number of yearly stings was 26 and 32, respectively, but this difference was not statistically significant. No difference was found in years spent in beekeeping between those with symptoms of inhalant allergy and those with no inhalant allergy.

In 50% of the systemic reactors, the first systemic bee sting reaction occurred during the first 4 years of beekeeping (Fig 2). Forty-seven beekeepers had no wasp stings in their histories. A history of large local reactions was present after bee stings in 38% and after wasp stings in 13% of the subjects. With a chi-square test a significant association ($P = .009$) was found between large local reactions for bee and wasp stings. Three beekeepers had experienced systemic reactions after wasp stings. Two of them had histories of atopy and all of them also had systemic bee sting reactions in their histories (Table 2). The estimated mean number of past wasp stings was 14 in those having a history of systemic reactions after a wasp sting and 21 in the

remaining subjects. This difference was not statistically significant. No association was found between the severity of wasp sting reactions and any characteristics of the subjects.

Twenty-two subjects had taken bee stings deliberately to reduce sensitivity. In 14 of them, sting reactions had become weaker according to their own evaluation. Five beekeepers had previously received bee venom immunotherapy. The duration of immunotherapy was 3 years for four subjects and 6 years for one of them. Three of the five subjects treated had not experienced systemic sting reactions after the therapy. In one beekeeper systemic sting reactions had changed from grade III to grade I reactions. In another case bee venom immunotherapy had no effect on sting reactions.

DISCUSSION

The present data indicate that first, among Finnish beekeepers the occurrence of systemic bee sting reactions is high and second, the risk of systemic bee sting reactions is increased fourfold when nasal or eye symptoms are present while working at beehives and twofold when the years in beekeeping are less than 15.

Approximately 70% of Finnish beekeepers are members of the national beekeepers' association. The study population consisted of all registered beekeepers in a geographically defined area of Finland. Although it is not a random sample of Finnish beekeepers, there is no reason to believe that it differs markedly from the respective population as a whole. The response rate (80%) was quite high but the non-response may still have caused a minor bias in prevalence estimates.

In our study, the rate of systemic reactions to honeybee stings was high (26%), while in most previous studies among beekeepers or their family members, systemic bee sting reactions occurred in 14% to 20%.^{5,6,9,10} Bousquet et al,⁴ however, reported anaphylactic sting reactions in 42% of 250 French beekeepers. In comparison, among the general population the prevalence of systemic reactions to Hymenoptera stings ranges from 0.8% to 3.3%.¹¹⁻¹³ Among forestry workers the prevalence of systemic reactions to Hymenoptera stings was 21%.¹⁴ Furthermore, the occurrence of large local reactions in this study was higher (38%) than the 9% to 12% reported among beekeepers in France and the USA.^{5,6} In our study, most of those who experienced a systemic reaction to a honeybee sting had not reacted to stings during the past beekeeping season. This is in accordance with studies showing that deliberate re-sting challenges result in systemic reactions in only 36% to 52% of bee venom-allergic patients.^{7,15,16} In addition, in some reports no systemic reaction was observed in the sting challenges of bee venom-allergic patients.^{17,18} These data suggest that bee venom allergy is a self-limiting process for some individuals. Studies of natural history of insect sting allergy have shown a lower re-sting reaction rate in children than in adults.^{19,20} In our study, none of the beekeepers had experienced systemic sting reactions in childhood.

A clinical history of atopy was found to be present in 48% of those with systemic reactions in their histories. This is in accordance with the

Table 3. Adjusted Odds Ratios (OR) with 95% Confidence Intervals (95% CI) for Systemic Bee Sting Reaction in History by Nasal or Eye Symptoms while Working at Hives and Years Spent in Beekeeping

Independent Variables	Values	OR	(95% CI)
Nasal or eye symptoms at hives	no	1	
	yes	4.2	(2.0–8.7)
The years in beekeeping	<15years	2.3	(1.1–5.0)
	≥15years	1	
Nasal or eye symptoms at hives and beekeeping less than 15 years		9.6	(2.2–43.0)

studies by Bousquet et al⁴ and Miyachi et al⁹ in which a history of atopy was present in 41% to 47% of beekeepers with systemic sting reactions. In other studies, however, the prevalence of atopy has been lower—20% to 32%—among Hymenoptera venom-allergic patients.^{21–24} Obviously atopic beekeepers more readily become allergic to honeybee venom than non-atopics, and atopy has been shown to predispose towards more severe reactions.^{4,9,25} The difference in the prevalence of atopy described in the literature is partly due to the fact that different populations were studied and that the definition of atopy differs from paper to paper. In the present study, nasal and eye symptoms while working at beehives were common (31%) and these symptoms were associated with a fourfold risk of systemic bee sting reactions. Furthermore, an association was found between a history of atopy and nasal or eye symptoms during work at beehives. The symptoms of inhalant allergy when working around hives were highly associated with the number of beehives, but not with the number of yearly stings. Numerous observations of beekeepers with an inhalant allergy to bee body components have been made.^{10,26–28} During work at beehives, beekeepers are probably exposed to bee venom also via eye, nasal, and respiratory mucous membranes. This exposure is presumably greater when bees are aggressive. Possible sensitization to bee venom via mucous membranes may play a role in the pathogenesis of bee venom allergy in beekeepers. Further, beekeepers are exposed concurrently to other allergens, especially pollen.

Our results suggest that atopic beekeepers develop respiratory allergies to inhalant bee body debris and possibly to venom more frequently than non-atopic beekeepers.

In our study, beekeepers with systemic reactions in their histories were significantly younger and had been beekeepers for a shorter period than nonreactors. This may imply that systemic reactors cease beekeeping earlier than those with no systemic reactions in their histories. The risk of systemic bee sting reactions was twofold when the years spent in beekeeping were less than 15. These data disagree with the finding by Bousquet et al,⁵ who reported that the duration of beekeeping did not influence the symptoms presented by beekeepers. Due to the short beekeeping season in Finland, the natural history of sting reactions may be different than in France. In this study, the risk of systemic sting reactions seemed to be greatest during the first

years of beekeeping, suggesting that spontaneous desensitization occurs later. The number of stings seemed to be smaller after systemic reactions than before them, and reactions after single stings seemed to weaken as the season progressed.

Beekeepers with systemic sting reactions seemed to have more beehives and fewer stings than others. This is in accordance with the findings of Bousquet et al⁵ who found that beekeepers stung more than 50 times in a season do not develop any allergic reaction. It is suggested that a short interval between two consecutive stings is a risk factor for the onset of a Hymenoptera venom allergy.²⁹ Beekeepers are stung by bees several times at short intervals during the beekeeping season. Our results indicate that systemic reactors protect themselves better against bee stings than others. Exposure to bee venom might have been greater before the first systemic sting reaction, but reliable retrospective evaluation of that exposure is difficult. Furthermore, marked sensitization may occur by inhalation of bee venom at beehives and by unnoticed stings through protective clothing, suggested by our finding that beekeepers having systemic reactions in their history have more hives but fewer stings than others.

The exposure of beekeepers to wasp stings may be greater than in the normal population, because honey-eating

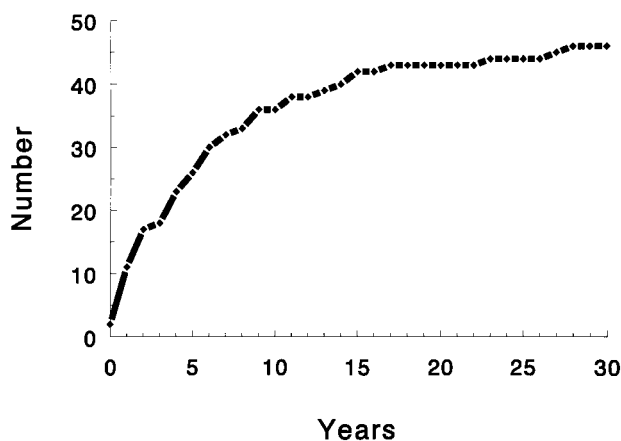


Figure 2. The cumulative prevalence of subjects with systemic reactions following a honeybee sting after commencing beekeeping (n = 47, for three subjects the years of reactions were unknown).

wasps are present in many hives. A slight association was found between systemic reactions to bee and wasp stings. In addition, an association was found between large local reactions to bee and wasp stings. Major antigens in vespoid and bee venoms are shown to be unique to each family but several minor cross-reacting antigens have been observed.³⁰ The slight association between bee and wasp sting reactions may be explained by personal characteristics.

In conclusion, incidences of systemic and large local reactions are high among beekeepers. A history of atopy is associated with systemic sting reactions. In addition to stings, beekeepers may become sensitized to bee venom via the mucous membranes of the respiratory tract and the eyes. In the present study, the risk of systemic bee sting reactions increased fourfold when nasal or eye symptoms were present while working at hives and twofold when the years spent in beekeeping were less than 15.

REFERENCES

- Ewan PW, Deighton J, Wilson AB, Lachmann PJ. Venom-specific IgG antibodies in bee and wasp allergy: lack of correlation with protection from stings. *Clin Exp Allergy* 1993;23:647-60.
- Green-Graif Y, Ewan PW. Diagnostic value of the skin-prick test and RAST assay in insect sting allergy. *Clin Allergy* 1987;17:431-8.
- Wilson AB, Deighton J, Lachmann PJ, Ewan PW. A comparative study of IgG subclass antibodies in patients allergic to wasp or bee venom. *Allergy* 1994;49:272-80.
- Bousquet J, Coulomb Y, Robinet-Lévy M, Michell FB. Clinical and immunological surveys in bee keepers. *Clin Allergy* 1982;12:331-42.
- Bousquet J, Ménardo JL, Aznar R, et al. Clinical and immunologic survey in beekeepers in relation to their sensitization. *J Allergy Clin Immunol* 1984;73:332-40.
- Light WC, Reisman RE, Wypych JI, Arbesman CE. Clinical and immunological studies of beekeepers. *Clin Allergy* 1975;5:389-95.
- Day JH, Buckeridge DL, Welsh AC. Risk assessment in determining systemic reactivity to honeybee sting in sting-threatened individuals. *J Allergy Clin Immunol* 1994;93:691-705.
- Müller HL. Diagnosis and treatment of insect sensitivity. *J Asthma Res* 1966;3:331-3.
- Miyachi S, Lessof MH, Kemeny DM, Green LA. Comparison of the atopic background between allergic and non-allergic beekeepers. *Int Arch Allergy Appl Immunol* 1979;58:160-6.
- Yunginger JW, Jones RT, Leiferman KM, et al. Immunological and biochemical studies in beekeepers and their family members. *J Allergy Clin Immunol* 1978;61:93-101.
- Charpin D, Birnbaum J, Lantenaume A, Vervloet D. Prevalence of allergy to hymenoptera stings in different samples of the general population. *J Allergy Clin Immunol* 1992;90:331-4.
- Golden DBK, Marsh DG, Kagey-Sobotka A, et al. Epidemiology of insect venom sensitivity. *JAMA* 1989;262:240-4.
- Settipane GA, Newstead GJ, Boyd GK. Frequency of hymenoptera allergy in an atopic and normal population. *J Allergy Clin Immunol* 1972;50:146-50.
- Shimitzu T, Hori T, Tokuyama K, et al. Clinical and immunologic surveys of Hymenoptera hypersensitivity in Japanese forestry workers. *Ann Allergy Asthma Immunol* 1995;74:495-500.
- Blaauw PJ, Smithuis LOMJ. The evaluation of the common diagnostic methods of hypersensitivity for bee and yellow jacket venom by means of an in-hospital insect sting. *J Allergy Clin Immunol* 1985;75:556-62.
- Van der Linden PWG, Hack CE, Struyvenberg A, van der Zwan JK. Insect-sting challenge in 324 subjects with a previous anaphylactic reaction: current criteria for insect-venom hypersensitivity do not predict the occurrence and the severity of anaphylaxis. *J Allergy Clin Immunol* 1994;94:151-9.
- Nüsslein HG, Baenkler HW. Spontaneous loss of hypersensitivity in patients allergic to bee or wasp stings; detection by venom induced histamine release. *Ann Allergy* 1985;54:516-20.
- Goldberg A, Confino-Cohen R, Mkori YA. Deliberate Hymenoptera sting challenge as a diagnostic tool in highly selected venom-allergic patients. *Ann Allergy* 1994;75:30-2.
- Reisman RE. Natural history of insect sting allergy: relationship of severity of symptoms of initial sting anaphylaxis to re-sting reactions. *J Allergy Clin Immunol* 1992;90:335-9.
- Valentine MD, Schuberth KC, Kagey-Sobotka A, et al. The value of immunotherapy with venom in children with allergy to insect stings. *N Engl J Med* 1990;23:1601-3.
- Lantner R, Reisman RE. Clinical and immunologic features and subsequent course of patients with severe insect sting anaphylaxis. *J Allergy Clin Immunol* 1989;84:900-6.
- Lockey RF, Turkeltaub PC, Baird-Warren IA, et al. The Hymenoptera venom study I, 1979-1982: Demographics and history-sting data. *J Allergy Clin Immunol* 1988;82:370-81.
- Neuman I, Ishay JS, Creter D. Hyper-reactivity to bee stings: reevaluation. *Ann Allergy* 1983;50:410-2.
- Przybilla B, Ring J, Grieshammer B. Association of features of atopy and diagnostic parameters in hymenoptera venom allergy. *Allergy* 1991;46:570-6.
- Settipane GA, Klein DE, Boyd GK. Relationship of atopy and anaphylactic sensitization: a bee sting allergy model. *Clin Allergy* 1978;8:259-65.
- Light WC, Reisman RE, Rosario NA, Arbesman CE. Comparison of the allergenic properties of bee venom and whole bee body extract. *Clin Allergy* 1976;6:293-300.
- Ostrom NK, Swanson MC, Agarwal, Yunginger JW. Occupational allergy to honeybee-body dust in a honey-processing plant. *J Allergy Clin Immunol* 1986;77:736-40.
- Reisman RE, Hale R, Wypych JI. Allergy to honeybee body components: distinction from bee venom sensitivity. *J Allergy Clin Immunol* 1983;71:18-20.
- Pucci S, Antonicelli L, Garritani MS, Bonifazi F. Shortness of interval between two stings as risk factor for developing Hymenoptera venom allergy. *Allergy* 1994;49:894-6.
- Reisman RE, Müller UR, Wypych JI, Lazell MI. Studies of coexisting honeybee and vespoid-venom sensitivity. *J Allergy Clin Immunol* 1984;73: 246-52.

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