ORIGINAL ARTICLE

Allergy to Bee Venom in Beekeepers in Germany

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Abstract

Objective: The aim of this study was to determine the incidence of bee venom allergy in German beekeepers, to explore risk factors for bee venom allergy in this group, and to determine which factors best predicted severe reactions.
Methods: A questionnaire incorporating 2 instruments on beekeepers' physical and mental health and working practice was included in 3 German beekeeping journals. A reference group also completed the questionnaire. Simple descriptive methods, bivariate correlation, cross-tabulation, 1-way analysis of variance, and stepwise discriminant analysis were used to analyze data.
Results: Altogether, 1053 questionnaires were returned. No significant differences were seen between the 2 groups. The mean number of bee stings annually was 57.8 (median, 30; range, 0–1000). Overall, 46 (4.4 %) beekeepers reported systemic reactions to bee stings, 797 (75.6 %) had mild local reactions, and 196 (18.6 %) had no reactions. The study confirmed several risk factors. These were, in descending order of importance, symptoms of upper respiratory allergy while working on the hive, presence of other allergies, time spent as a beekeeper, and more severe nonallergic reactions to bee stings in springtime. These factors identified beekeepers at risk of allergic reactions to bee venom in 85.2 % of cases. Our results also showed an association between allergy and emotional instability. Risk management in allergic beekeepers was not good.
Conclusion: The results of this study will help to identify beekeepers at risk of systemic reactions to bee stings and to inform them about the dangers of bee venom allergy.

Key words: Bee venom. Allergy. Beekeeper. Beekeeping.

Resumen

Objetivo: El objetivo de este estudio fue determinar la incidencia de la alergia al veneno de abeja entre los apicultores alemanes para explorar los factores de riesgo de la alergia al veneno de abeja en este grupo y precisar qué factores eran los mejores para pronosticar las reacciones graves.
Métodos: Se adjuntó un cuestionario que incluía 2 instrumentos sobre la salud física y mental y la práctica del trabajo de apicultor en 3 revistas de apicultura de Alemania. También completó el cuestionario un grupo de referencia. Para analizar los datos se utilizaron métodos descriptivos simples, la correlación entre variables, las tablas de contingencia, el análisis de la varianza de un factor (ANOVA) y el análisis discriminante paso a paso.
Resultados: En conjunto, se devolvieron 1053 cuestionarios. No se observaron diferencias significativas entre los dos grupos. La media anual de picaduras de abeja fue de 57,8 (media, 30; rango, 0–1000). En general, 46 (4,4 %) apicultores notificaron reacciones sistémicas a las picaduras de abeja, 797 (75,6 %) presentaron reacciones locales leves y 196 (18,6 %) no tuvieron ninguna reacción. De este modo, el estudio confirmó diversos factores de riesgo, que correspondieron, en orden de importancia descendiente, a síntomas de alergia de las vías respiratorias altas mientras trabajaban en la colmena, a la presencia de otras alergias, al tiempo que llevaban trabajando de apicultores y a reacciones no alérgicas a las picaduras de abeja más graves en primavera. Estos factores identificaron a los apicultores que presentaban riesgo de tener reacciones alérgicas al veneno de la abeja en un 85,2 % de los casos en los que se sospechaba que podría aparecer una reacción alérgica. Nuestros resultados también mostraron una relación entre la alergia y el desequilibrio emocional. Las prácticas arriesgadas en los apicultores alérgicos fueron desfavorables.
Conclusión: Los resultados de este estudio serán de gran ayuda para identificar los apicultores que presentan riesgo de padecer reacciones sistémicas a las picaduras de abeja y para informarles de los riesgos que conlleva la alergia al veneno de abeja.

Palabras clave: Veneno de abeja. Alergia. Apicultor. Apicultura.

Introduction

The reported prevalence of systemic allergic reactions to bee venom in the general population ranges from 0.3% to 7.5%, and annual mortality due to bee stings ranges from 0.09 to 0.45 per million inhabitants [1]. These wide variations can largely be explained by climatic differences. In warm climates, bees are active throughout the year and are considered to be more aggressive, whereas in colder climates they are active and numerous only in late spring and summer [2]. According to studies from Italy [3], France [4], and Turkey [5], the likelihood of someone being stung by a bee at least once during his or her lifetime ranges from 55% to 95%.

Beekeepers have a much higher probability of being stung than others in the population and they also encounter other antigens associated with beekeeping, including bee venom, dust from the bee hive containing parts of bees and parasites, and propolis, the resinous substance collected by bees to construct and mend their hives. The greater prevalence of various allergies in beekeepers means that they are considered a high risk group [6]. Studies suggest that between 17% and 43% of beekeepers are allergic to bee venom [6-8]. The following risk factors have been associated with bee venom allergy: concomitant asthma or atopic dermatitis, fewer than 10 bee stings per year, and upper respiratory symptoms of allergy while working with beehives [6,7]. However, the importance of "concomitant atopy" as a risk factor has been disputed by some workers [8].

Data on bee venom allergy in beekeepers are scarce–few epidemiological studies have been undertaken and in those that have the sample size was usually small. We therefore decided to investigate the problem of bee venom allergy in beekeepers as part of a study focusing on various health issues and motivation in this group. We sought to determine the incidence of bee venom allergy in German beekeepers, to explore risk factors for allergic reactions to bee venom, and to determine which factors act as the best predictors of allergy.

Methods

Study Questionnaire

We developed the Questionnaire for the Assessment of Beekeepers' Health (QABH) as a suitable instrument for gathering information based on previous research in beekeepers [7,9-17]. Bee venom allergy was assessed using the classification devised by Mueller [18]. Allergy symptoms were described and beekeepers were asked to choose the condition that best described their situation. For some analyses, we distinguished between beekeepers without any visible response to bee stings (no reaction), those who showed some reaction (redness of the skin and slight pruritus, defined as mild reactions), and those who described any type of allergic reaction (marked local reactions and systemic reactions). We also assessed the following variables: demographic data (sex, beekeeper's age, and body mass index); whether beekeepers had other allergies (including contact allergy to propolis) or suffered from diseases like atopic dermatitis; the number of beehives tended and the number of years spent as a beekeeper; symptoms of upper respiratory allergy while working with beehives; whether reactions to bee stings were more severe in spring than in later months; and the use of protective clothing.

The QABH was combined with the trait version of the Inventory for the Measurement of Bodily Negative Affectivity (INKA-h) questionnaire. The INKA-h provides validated and robust evidence of emotional instability such as neuroticism, negative affectivity, or stress reactivity [19]. It assesses subjective complaints through 20 items that are rated from affirmation to rejection on a scale of 0 to 4. The ratings are then transformed by double logarithm because the values are not normally distributed. Use of the INKA-h questionnaire is important since emotional instability is known to be associated with some somatic symptoms and with subjective bodily discomfort [20-29]. Before the study, the entire instrument (QABH and INKA-h) was piloted in 10 volunteers to ensure its intelligibility.

Subjects

The German Beekeepers Association (Deutscher Imkerbund) comprises 81 818 beekeepers and is organized into regional groups. According to the association, between 90% and 95% of German beekeepers are members. Most members subscribe to journals informing them of regional news. The Deutscher Landwirtschaftsverlag GmbH (www.dlv.de) publishes 3 of these journals–Die Biene, Der Imkerfreund, and ADIZ. Journal readership is particularly high in the following geographic areas: Baden, Bavaria, Hesse, Rhineland-Palatinate, Rhineland, Saarland, and Thuringia. The combined QABH and INKA-h was included in the May 2006 issues of the 3 Deutscher Landwirtschaftsverlag beekeeping journals sent to subscribers in the areas mentioned. The survey therefore reached approximately 35 000 beekeepers (Deutscher Landwirtschaftsverlag GmbH, personal communication). Readers were asked to complete the printed questionnaire and to return it by mail or fax or to complete the electronic questionnaire on the Internet. A copy of the questionnaire is available from KM.

Reference Group

Members of a beekeeping association in the Giessen region were asked to serve as a reference group in order to detect or rule out any potential biases between beekeepers who responded to our journal survey and nonrespondents. The Giessen association has 181 members–178 individual members and 3 institutional members. At the same time as the questionnaire was distributed in the journals, individual members of the Giessen association were asked to complete the questionnaire and return it in a prepaid envelope.

Statistical Analysis

Various statistical methods were used in the study, including simple descriptive methods, bivariate correlations (Pearson's correlation coefficient), cross-tabulation, 1-way

analysis of variance (ANOVA), and stepwise discriminant analysis. SPSS version 10.0 (SPSS, Chicago, Illinois, USA) was used for data management and statistical analysis. *P* values of less than .05 were considered significant.

Ethical Approval

The study was approved by the Ethics Committee of Justus-Liebig-University.

Table. Characteristics of the Study Groups

Variable	Entire Group, n = 1053	Journal Survey Group, n = 901	Giessen Beekeeper Association, n = 152
Response rate, %	–	-2.6	84.8
Age, y			
Mean	61.8	61.0	63.7
Median	65	65	66
SD	13.9	14.0	13.3
Range	9-94	4-94	12-90
Sex, %			
Female	7.6	7.8	5.9
Male	92.4	92.2	94.1
Marital status, %			
Single	6.7	6.9	5.3
Married	86.2	86.1	86.8
Widowed	4.2	3.9	6.0
Divorced	2.9	3.0	2.0
Place of residence, %			
Town	25.7	25.4	27.3
Country	74.3	74.6	72.7
Body mass index, kg/m^2			
Mean	26.6	26.3	27.1
Median	25.9	25.8	26.0
SD	3.8	3.7	4.1
Range	15.1-59.2	15.1-59.2	19.5-57.4
Time spent as a beekeeper, y			
Mean	25.9	26.2	24.4
Median	23	24	21
SD	17.3	17.5	16.1
Range	0-91	0-91	1-65
Number of bee hives tended			
Mean	13.9	14.9	8.0
Median	10	10	7
SD	15.5	16.4	5.0
Range	0-240	0-240	1-30

Results

In all, 1053 questionnaires were returned, mainly by mail or fax, with a few via e-mail. Fifty-eight beekeepers responded to the survey on the Internet. The demographic characteristics of the respondents are shown in the table. Statistical analyses by 1-way ANOVA and χ^2 test showed that there were no differences between the beekeepers who participated in the survey via the beekeeping journals and those who were invited to participate as members of the Giessen Beekeeper Association.

Reactions to Bee Stings

Forty-six beekeepers (4.4%) reported systemic reactions to bee stings (allergic reactions), 797 (75.6%) reported mild local reactions (mild reactions), and 196 (18.6%) had no reactions to bee stings. Six beekeepers (0.6%) reported symptoms of upper respiratory allergy during work with beehives. In addition, 266 (25.3%) of the beekeepers reported more severe reactions to bee stings in spring than in later months. The mean number of bee stings received each year was 57.8 (median, 30; range, 0 – 1000). Cross-tabulation showed that a more severe reaction to bee stings in spring was more likely in those beekeepers who experienced symptoms of upper respiratory allergy while working with beehives ($\chi^2 = 5.49$; degrees of freedom [df] = 1; $P = .019$). Of the 6 beekeepers who reported such symptoms, 3 (50%) experienced systemic allergic reactions in the spring. Furthermore, beekeepers who had other allergies or suffered from diseases like atopic dermatitis were more likely to have systemic reactions ($\chi^2 = 54.50$; df = 3; $P < .001$). The rate of systemic reactions was 2.8% in beekeepers without other allergies and 15.2% in those with other allergies. Interestingly, we found no relationship between contact allergy to propolis and allergy to bee venom.

Relationships With Age, Body Mass Index, and Number of Hives

Bivariate correlation showed inverse relations between the severity of the reaction to bee stings and the beekeeper's age ($r = –0.195$, $P < .001$), body mass index ($r = –0.076$, $P = .017$), and the number of beehives tended ($r = –0.135$, $P < .001$). The beekeeper's sex had no influence on the severity of the reaction. These findings were confirmed by 1-way ANOVA (for age, $F = 23.31$, df = 2, $P < .001$; body mass index, $F = 4.47$, df = 2, $P = .012$; number, $F = 10.86$, df = 2, $P < .001$). Thus, younger and less obese beekeepers were more likely to experience allergic reactions, and they looked after fewer bee hives. We also found a significant inverse relationship between the number of years spent as a beekeeper and the probability of suffering from an allergic reaction ($\chi^2 = 62.96$, df = 6, $P < .001$; Figure 1).

Risk Management

The beekeepers were asked about their use of protective clothing. Figure 2 shows that allergic individuals more often wear protective clothing but not to the desired extent. Only half of the allergic beekeepers wore full protective clothing, and some did not wear protective clothing at all.

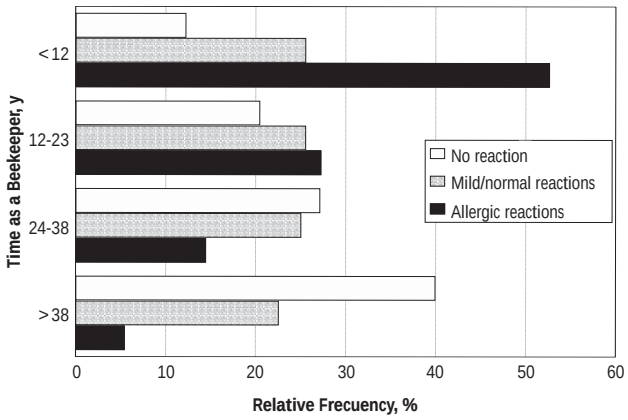

Figure 1. Time spent as a beekeeper in relation to the reported rate of experiencing an allergic reaction to bee stings ($\chi^2 = 62.96$, degrees of freedom = 6, $P < .001$).

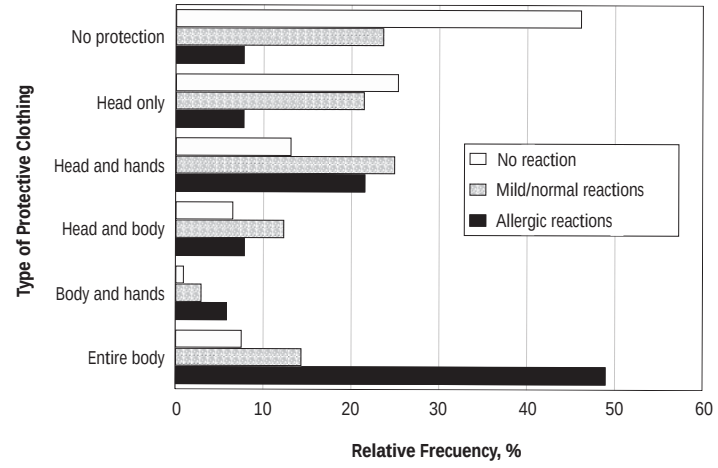

Figure 2. Relationship between the types of protective clothing worn by beekeepers with reaction to bee stings.

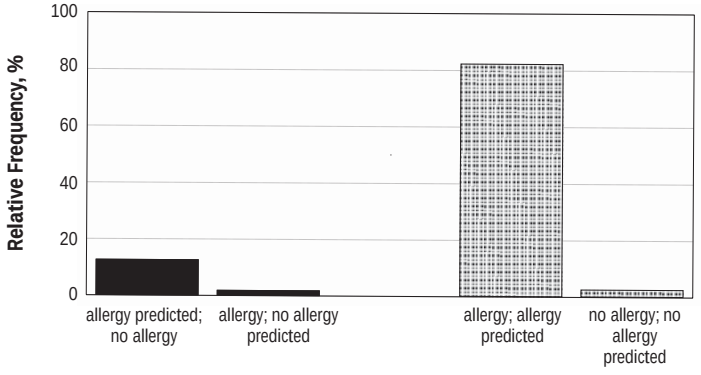

Figure 3. Relative frequency of true and false predictions of allergy based on the following factors related to bee venom allergy: symptoms of upper respiratory allergy during work in the beehive, allergies in general, time spent as a beekeeper, and more severe nonallergic reactions to bee stings in spring.

Relationship With Mental Health

We also investigated whether bee venom allergy was associated with higher scores on the INKA-h scale. One-way ANOVA revealed significant differences between beekeepers with no reactions, mild reactions, and allergic reactions to bee stings ($F = 7.272$, $P = .001$). Since other diseases might have affected emotional stability and mood, the analysis was repeated after excluding all beekeepers who had reported other diseases. The 10 subjects who reported allergic reactions to bee venom (mean [SD] score on the INKA-h questionnaire, 2.08 [0.82]) were compared with 65 who reported no reaction (INKA-h score, 1.50 [0.82]) and 280 with mild reactions (INKA-h score, 1.80 [0.77]). One-way ANOVA in these groups showed that beekeepers with bee venom allergy had significantly higher mean scores for the INKA-h scale ($F = 4.73$, $P = .009$).

Relative Importance of Risk Factors

Stepwise discriminant analysis was used to determine the relative importance of potential risk factors in order to analyze their ability to discriminate between beekeepers with allergy and those with no allergic reaction. The results showed that symptoms of upper respiratory allergy while working with hives was the most important predictor of bee venom allergy, followed by allergies in general, time spent as a beekeeper, and greater sensitivity to bee stings in spring. Body mass index, age, number of bee hives tended, and the INKA-h score were not confirmed in this multifactorial analysis as predictive of allergic reaction in beekeepers. Using the predictive factors identified in this study, the probability of an allergic reaction to bee venom could be correctly classified by stepwise discriminant analysis in 85.2% of the cases (Figure 3).The standardized canonical coefficients of the discriminant functions were 0.690 for symptoms of upper respiratory allergy during work in the beehive, 0.487 for allergies in general, –0.380 for time spent as a beekeeper, and 0.224 for more severe nonallergic reactions to bee stings in spring (canonical correlation = 0.343, Wilks Lambda = 0.879, $\chi^2 = 109.9$, df = 4, $P < .001$).

Discussion

This study provides the first data on the incidence of bee venom allergy in beekeepers in Germany. It also confirms the following as previously established risk factors for allergy to bee venom in beekeepers: a more severe reaction in spring, a history of atopic dermatitis or allergy, and symptoms of upper respiratory allergy while working with beehives. In addition, we found relationships between bee venom allergy and the following variables: age, body mass index, number of beehives tended, and number of years as a beekeeper. Since these factors might well have been influenced by

the assumed likelihood that some affected beekeepers will give up bee keeping, we used discriminant analysis to determine the importance of each factor. This analysis revealed that the most significant factors, in descending order of importance, were symptoms of upper respiratory allergy while working with beehives, allergies in general, time spent as a beekeeper, and more severe nonallergic reactions to bee stings in spring. Other important findings are, firstly, that some beekeepers do not seem to recognize the source of their problem and continue to work with bees without wearing adequate protective clothing and, secondly, the influence of psychological factors on allergy.

This study undoubtedly had shortcomings. The first was the low response rate to the questionnaire published in the beekeeping journals. However, this level of response was not unusual for such a study; it was similar to the rate achieved by another questionnaire included in the same journals [30]. In order to assess the potential for bias created by this type of study, we also evaluated data collected from a reference group, the Giessen Beekeeper Association. Comparison of the results showed that there were no significant demographic differences between the groups. In addition, the characteristics of the beekeepers in a study on beekeeping traditions from Rhineland-Palatinate and the data provided by the Deutsche Imkerbund survey in relation to age and number of beehives tended suggested that there was no appreciable bias in our study group [31]. A general source of potential bias is the possibility that beekeepers with particularly strong views or problems in a particular area might respond more frequently. However, since the survey addressed numerous different aspects of beekeeping, we do not believe that those readers would have been more likely to respond than others. Thus, we assume that the study is not unduly biased. We are also aware that we had to rely on the respondents' descriptions and did not have any laboratory data to support the diagnosis of allergy. However, many beekeepers seem not to have recognized the problems of bee venom allergy and thus we assume that in most cases this had not been diagnosed before.

There have been few epidemiological studies on the prevalence of bee venom allergy in beekeepers–one from Finland [8] and another from the Canary Islands [29]. There seem to be striking differences between the results of those studies and ours. The greatest difference is in the proportions of beekeepers who are allergic to bee venom. In the Finnish study it was 14% [8,9] and in the study carried out in the Canary Islands it was 32% [32], but in our sample it was only 4.4%. This disparity may be partly explained by age differences, since the incidence of allergy seems to decline with increasing age. In the sample from the Canary Islands, the mean age of the beekeepers was 41.8 years [32] and in the Finnish sample it was 50.6 years [8,9]–these means are 20 years and 10 years lower, respectively, than the mean age in our sample. In the other studies, unlike ours, no information was elicited on whether beekeeping was a hobby or a way of earning a living. Perhaps professional beekeepers are obliged to continue their work despite potential adverse influences on their health because of economic pressures. Such a hypothesis is supported by the data presented by Annila et al [9]. That study showed that beekeepers with systemic and large local reactions tended more beehives but were stung less frequently than beekeepers without allergy [9,33]. Why beekeepers continue their occupation in spite of allergic reactions cannot be explained. Possibly, they wear protective clothing but continue working with bees, again making economic reasons the most likely explanation. This hypothesis should be addressed in future studies.

We were able to confirm previous findings that more advanced age and greater obesity are protective factors, but our results on the number of beehives tended differ. Our study confirms most other conclusions associated with the development of allergy [7]. With regard to the finding that bee sting allergy is more common in allergic beekeepers, our data agree with findings from Myachi et al [34] and Bousquet et al [35], but again contrast with the findings of Annila et al [8]. Why the results of Annila et al differ from those of other groups in this respect also remains unclear. Perhaps some form of selection bias occurred when the 103 study subjects were chosen from the original 274 beekeepers contacted at the beginning of their survey.

In this study we used the INKA-h questionnaire to assess emotional instability (neuroticism or negative affectivity). Our analysis showed that those beekeepers who were allergic to bee venom were more emotionally unstable and nervous and more likely to complain about pain and to suffer from anger and fears. They were also more likely to respond to stress more quickly but recover from it more slowly than healthy beekeepers. Personality variables may thus influence the development of allergies. This has also been shown for patients suffering from other conditions that are considered to be allergy related, including asthma [36]. Although this factor was not selected as significantly predictive by stepwise discriminant analysis, our study provides some evidence that psychological variables may contribute to the development of allergic reactions. However, there may be other explanations. Beekeepers who are less emotionally stable are more likely to continue beekeeping in spite of allergic reactions. This issue needs to be addressed in future studies. Interestingly, and contrary to expectations, many beekeepers seem to be unaware of the dangers associated with bee venom allergy. Some did little or nothing to protect themselves, especially regarding the use of protective clothing. Our study provides data that can be used to identify beekeepers at high risk of developing an allergy to bee venom, thereby allowing them to take protective measures. Since there is a good chance of successful desensitization, providing this information to beekeepers is crucial if future problems are to be prevented.

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