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The HIT study: Hymenoptera Identification Test—how accurate are people at identifying stinging insects?

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ABSTRACT

Background: Stinging insects in the order Hymenoptera include bees, wasps, yellow jackets, hornets, and ants. Hymenoptera sting injuries range from localized swelling to rarely death. Insect identification is helpful in the management of sting injuries.

Objective: To determine the accuracy of adults in identifying stinging insects and 2 insect nests.

Methods: This was a cross-sectional, multicenter study using a picture-based survey to evaluate an individual's success at identifying honeybees, wasps, bald-face hornets, and yellow jackets. Bald-face hornet and paper wasp nest identification also was assessed in this study.

Results: Six hundred forty participants completed the questionnaire. Overall, the mean number of correct responses was 3.2 (SD 1.3) of 6. Twenty participants (3.1%) correctly identified all 6 stinging insects and nests and only 10 (1.6%) were unable to identify any of the pictures correctly. The honeybee was the most accurately identified insect (91.3%) and the paper wasp was the least correctly identified insect (50.9%). For the 6 questions regarding whether the participant had been stung in the past by any of the insects (including an unidentified insect), 91% reported being stung by at least 1. Men were more successful at identifying stinging insects correctly ($P = .002$), as were participants stung by at least 4 insects ($P = .018$).

Conclusion: This study supports the general perception that adults are poor discriminators in distinguishing stinging insects and nests with the exception of the honeybee. Men and those participants who reported multiple stings to at least 4 insects were more accurate overall in insect identification.

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Introduction

Stinging insects in the order Hymenoptera include bees, wasps, yellow jackets, hornets, and ants. The stinging apparatus located at the end of their abdominal segment is capable of injecting 100 ng (fire ants) to 50 μ g (bees) of venom.¹ The spectrum of injury in individuals with insect stings varies from pain and local swelling to rarely death. The lifetime prevalence of a systemic reaction after a sting ranges from 0.4% to 0.8% in pediatric patients^{2,3} to approximately 3.3% in adult patients.⁴ The National Electronic Injury Surveillance System, an ongoing surveillance system used to monitor consumer product-related injuries treated in United States

hospital emergency departments, noted that 25,360 individuals sought medical treatment in emergency departments for signs and symptoms consistent with anaphylaxis after a Hymenoptera sting in 2001 through 2004. Approximately 3.4% of these patients were subsequently hospitalized during the emergency department visit.⁵ Fortunately, Hymenoptera sting fatalities are rare and estimated to occur in approximately 40 individuals annually within the United States.⁶

Insect identification is helpful in diagnosing a Hymenoptera venom allergy, prescribing a treatment, and providing guidance on prevention. In general, the stinging insect cannot be clearly identified and many experts recommend testing to all flying Hymenoptera.⁷ Insects may sting without being seen, are relatively small, and share similar features to other members in the order, complicating identification of the perpetrator in many instances. To the authors' knowledge, no study has ever assessed a patient's ability to correctly identify stinging insects or stinging insect's nests. This study sought to determine the accuracy of the general population

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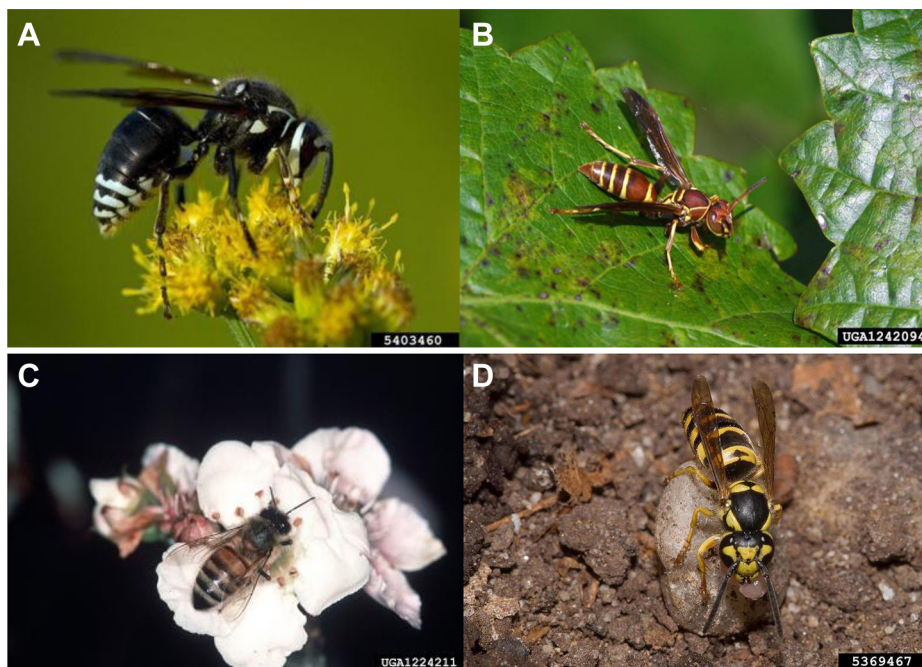


Figure 1. Sample pictures used in Hymenoptera Identification Test questionnaire. Permission to use these photographs was obtained by authors. (A) Bald-faced hornet, by David Cappaert, Michigan State University. (B) Paper wasp, by Russ Ottens, University of Georgia. (C) Honeybee, by Jerry A. Payne, USDA Agricultural Research Service. (D) Yellow jacket, by Susan Ellis, University of Georgia. All images were obtained from the Center for Invasive Species and Ecosystem Health (University of Georgia, Tifton; <http://www.bugwood.org>).

in correctly identifying common stinging insects and 2 nests in a nonthreatening setting.

Methods

Study Design and Participants

This is a cross-sectional, multicenter study using a Hymenoptera Identification Test (HIT) picture-based survey to determine participant accuracy at identifying stinging insects and 2 common stinging insect nests. Four enrollment sites were used to capture different geographic locations throughout the United States. The sites included Andrews Air Force Base (Maryland), Eglin Air Force Base (Florida), Wright-Patterson Air Force Base (Ohio), and Nellis Air Force Base (Nevada). Individuals at least 18 years old, including employees, patients, and visitors, were eligible to participate. The survey consisted of 2 parts: a demographic questionnaire and a 6-question multiple-choice insect-identification test. The demographic questions included age; sex; race; educational level; whether the participant lived in an urban, suburban, or rural area; and whether the participant had ever been stung by a honeybee, hornet, wasp, yellow jacket, fire ant, or flying insect the participant could not identify. Four flying insects (Fig 1) and 2 nests were included in the identification test. Each question had 2 color pictures of a single stinging insect or nest (bald-faced hornet and paper wasp) with 5 answer choices including honeybee, bald-faced hornet, yellow jacket, paper wasp, and imported fire ant (no picture representation, distractor). Participants were informed that each answer choice could be selected once, more than once, or not at all. Participants had unlimited time to make their selection; however, they were not allowed to change a previous answer once they moved on to the next set of pictures. The pictures were taken from the Web site of the Center for Invasive Species and Ecosystem Health (University of Georgia, Tifton, Georgia; <http://www.bugwood.org>) and the photographs used in the survey were reviewed and approved by an entomologist. This study was reviewed and approved by an institutional review board.

Data Analysis

Scores on the identification test ranged from 0 to 6 correct answers and were summarized as mean and SD and median and interquartile range. In addition, the percentage of participants identifying each insect or nest correctly was determined, as was the percentage of participants answering 0 to 6 questions correctly. Associations among sites, demographic variables, and scores were performed with the Kruskal-Wallis or Wilcoxon rank-sum test when comparing mean scores and χ^2 test when comparing proportions answering correctly. For statistically significant differences in scores among at least 3 groups, paired analyses were performed with Bonferroni corrections for multiple comparisons. Comparisons among sites for demographic variables were performed with 1-way analysis of variance or χ^2 test. Some demographics differed by site, and a multiple logistic regression analysis was performed to determine variables that were associated with scores after controlling for site. Adjusted odds ratios and 95% confidence intervals were determined for scores dichotomized as 0 to 3 correct vs 4 to 6 correct. All analyses were performed with IBM SPSS Statistics 21.0 for Windows (IBM Corporation, Armonk, New York).

Results

Six hundred forty participants completed the HIT questionnaire. The number of surveys collected at the individual sites ranged from 128 to 232, with no refusals at any of the sites. Characteristics of the participants are listed in Table 1. The mean age was 35.3 years (SD 11.2) and ranged from 18 to 81 years. Fifty-one percent of participants were men, 60% were white, 44% had completed at least a bachelor's degree, and 69% lived in a suburban area. Except for sex, the characteristics of the participants were significantly different among the sites (Table 1). For the 6 questions regarding whether the participant had been stung in the past by any of the insects (including an unidentified insect), 91% reported being stung by at least 1. Thirty-nine percent were stung by 0 to 1 insect, 41% by 2 to 3 insects, and 20% by 4 to 6 insects.

Table 1

Patient characteristics: demographics

	All sites	Andrews Air Force Base	Eglin Air Force Base	Nellis Air Force Base	Wright-Patterson Air Force Base	P value ^a
Age (y), mean $\pm$ SD	35.3 $\pm$ 11.2	36.3 $\pm$ 10.8	35.3 $\pm$ 10.8	31.1 $\pm$ 9.6	37.7 $\pm$ 12.5	<.001
Sex (total), n (%)	640 (100)	232 (100)	142 (100)	128 (100)	138 (100)	.061
Male	324 (50.6)	113 (48.7)	86 (60.6)	60 (46.9)	65 (47.1)	
Female	316 (49.4)	119 (51.3)	56 (39.4)	68 (53.1)	73 (52.9)	
Race (total), n (%)	637 (100)	231 (100)	141 (100)	128 (100)	137 (100)	<.001
White/Caucasian	382 (60.0)	117 (50.6)	84 (59.6)	75 (58.6)	106 (77.4)	
Black/African American	122 (19.2)	68 (29.4)	21 (14.9)	20 (15.6)	13 (9.5)	
Hispanic/Latino	53 (8.3)	19 (8.2)	16 (11.3)	16 (12.5)	2 (1.5)	
Asian	45 (7.1)	15 (6.5)	14 (9.9)	6 (4.7)	10 (7.3)	
Other/multiple	35 (5.5)	12 (5.2)	6 (4.3)	11 (8.6)	6 (4.4)	
Education (total), n (%)	638 (100)	232 (100)	142 (100)	126 (100)	138 (100)	<.001
$\leq$ High school/GED	60 (9.4)	19 (8.2)	10 (7.0)	21 (16.7)	10 (7.2)	
Some college	172 (27.0)	62 (26.7)	47 (33.1)	40 (31.7)	23 (16.7)	
Associate's degree	125 (19.6)	48 (20.7)	30 (21.1)	26 (20.6)	21 (15.2)	
Bachelor's degree	113 (17.7)	43 (18.5)	26 (18.3)	19 (15.1)	25 (18.1)	
$\geq$ Master's degree	168 (26.3)	60 (25.9)	29 (20.4)	20 (15.9)	59 (42.8)	
Setting (total), n (%)	635 (100)	229 (100)	142 (100)	128 (100)	136 (100)	<.001
Urban	135 (21.3)	52 (22.7)	27 (19.0)	38 (29.7)	18 (13.2)	
Suburban	438 (69.0)	152 (66.4)	94 (66.2)	89 (69.5)	103 (75.7)	
Rural	62 (9.8)	25 (10.9)	21 (14.8)	1 (0.8)	15 (11.0)	

Abbreviation: GED, General Educational Development.

^aP values are from 1-way analysis of variance for age and χ^2 test for all other variables.

Overall, the mean number of correct responses was 3.2 (SD 1.3) of 6. Twenty participants (3.1%) correctly identified all 6 stinging insects and nests and only 10 (1.6%) were unable to identify any of the pictures correctly. The honeybee was the most accurately identified insect (91.3%) and the paper wasp was the least correctly identified insect (50.9%). The yellow jacket was identified correctly 72.3% and the bald-face hornet was correctly named 55.2% of the time. Only a small percentage of participants were able to correctly identify the hornet nest (29.5%) or wasp nest (18.3%; Fig 2). For the honeybee, 91.6% of participants who correctly identified it chose the honeybee only once, indicating that the large percentage of correct responses was not due to “guessing” honeybee for multiple questions. For some insects, participants who reported being stung were significantly more likely to correctly identify the insect. The honeybee was correctly identified by 93.9% of participants who had been stung compared with 88.5% of those who had not been stung ($P = .015$). Participants previously stung by a wasp were more likely to correctly identify the wasp (60.9% vs 48.8%, $P = .019$) and the wasp nest (35.7% vs 14.5%, $P < .001$).

Table 2 presents mean and median scores by site and demographics. Men scored significantly higher than women ($P = .001$), and participants who had been stung by 4 to 6 of the insects scored significantly higher than those who were stung by 0 to 3 insects. There were no differences in scores by race, education level, or living in an urban, suburban, or rural setting. In a multiple logistic regression model that included site, sex, and number of different insect stings, all variables remained significantly associated with scores (Table 3).

Discussion

Hymenoptera stings occur commonly and can be lethal in strongly allergic individuals. Unfortunately, avoidance is not always possible or practical, which results in thousands of individuals seeking medical attention for sting injuries annually.⁵ Approximately 91% of participants reported being stung at least once, and in most instances participants performed poorly in distinguishing the potential culprits. It would be ideal if patients could adeptly report the specific stinging insect responsible for a systemic reaction because then individualized testing and treatment could be provided. Some experts have noted that with the exception of beekeepers and their families, patients are frequently unable to

identify the stinging insect that caused harm.⁸ This study also found that most participants were skilled at identifying the honeybee with an overall accuracy of 91.3%. Of this group, only 9% chose the honeybee for another question item, strongly suggesting that participants were not presuming every insect to be a honeybee.

Although no similar insect identification studies exist, similarly structured studies have been published on successful patient identification of peanuts and various tree nuts, with peanut being most successfully recognized at a frequency of 52% to 98% (unshelled) to 89% to 98.1% (shelled).^{9–11} Authors of these studies have advocated for increased education and have recommended health care providers take time to teach patients and families techniques on discriminating tree nuts and peanuts using visual devices.^{9–11} Similarly, using insect identification boxes or pictures may be useful as an educational tool to assist with guidance on avoidance practices for patients with insect hypersensitivity.

To the authors' knowledge, this is the first study to look at accuracy of participants in identifying stinging insects and common nests. There are several strengths to be noted in this study. Many surveys were used in various geographic locations. This increases

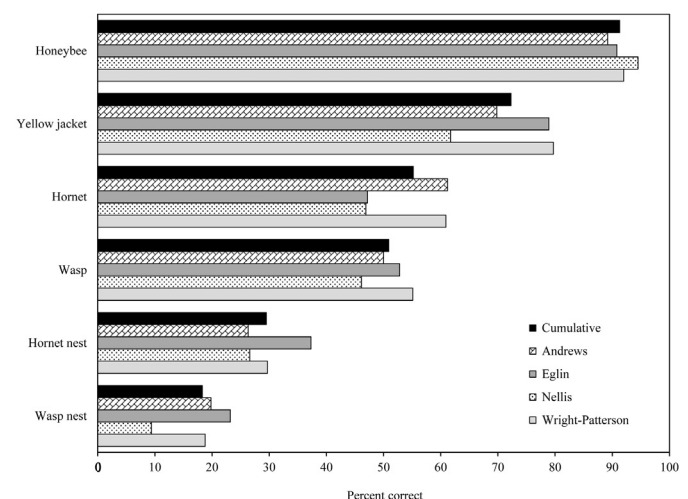


Figure 2. Correct responses (percentage) from the Hymenoptera Identification Test questionnaires at each of the study sites.

Table 2

Total test scores by demographics and history of insect stings

	n	Total score, mean (SD)	Total score, median (IQR)	P value ^a
Site				.004
Andrews Air Force Base	232	3.2 (1.3)	3.0 (2.0)	
Eglin Air Force Base	142	3.3 (1.3)	4.0 (2.0) ^b	
Nellis Air Force Base	128	2.9 (1.2)	3.0 (2.0)	
Wright-Patterson Air Force Base	138	3.4 (1.3)	4.0 (2.0) ^b	
Sex				.001
Male	324	3.4 (1.3)	4.0 (2.0)	
Female	316	3.0 (1.3)	3.0 (2.0)	
Race				.331
White/Caucasian	382	3.3 (1.3)	3.0 (2.0)	
Black/African American	122	3.0 (1.3)	3.0 (2.0)	
Hispanic/Latino	53	3.1 (1.2)	3.0 (2.0)	
Asian	45	3.2 (1.3)	3.0 (2.0)	
Other/multiple	35	3.2 (1.3)	3.0 (2.0)	
Education				.538
≤High school/GED	60	3.3 (1.1)	4.0 (1.0)	
Some college	172	3.2 (1.3)	3.0 (2.0)	
Associate's degree	125	3.2 (1.3)	3.0 (2.0)	
Bachelor's degree	113	3.0 (1.3)	3.0 (2.0)	
≥Master's degree	168	3.2 (1.3)	3.0 (2.0)	
Setting				.353
Urban	135	3.1 (1.2)	3.0 (2.0)	
Suburban	438	3.2 (1.3)	3.0 (2.0)	
Rural	62	3.4 (1.3)	4.0 (2.0)	
Stung by honeybee?				.308
No	312	3.1 (1.2)	3.0 (2.0)	
Yes	328	3.2 (1.3)	3.0 (2.0)	
Stung by hornet?				.168
No	477	3.1 (1.3)	3.0 (2.0)	
Yes	163	3.3 (1.3)	4.0 (2.0)	
Stung by flying insect?				.294
No	397	3.1 (1.3)	3.0 (2.0)	
Yes	242	3.3 (1.2)	3.0 (2.0)	
Stung by wasp?				.001
No	525	3.1 (1.2)	3.0 (2.0)	
Yes	115	3.6 (1.4)	4.0 (3.0)	
Stung by yellow jacket?				.002
No	393	3.1 (1.2)	3.0 (2.0)	
Yes	247	3.4 (1.4)	4.0 (2.0)	
Stung by fire ant?				.175
No	308	3.1 (1.3)	3.0 (2.0)	
Yes	332	3.3 (1.3)	3.0 (2.0)	
Stings by different insects				.003
0–1	248	3.0 (1.2)	3.0 (2.0)	
2–3	265	3.2 (1.3)	3.0 (2.0)	
4–6	126	3.5 (1.3)	4.0 (2.0) ^{c,d}	

Abbreviations: GED, General Educational Development; IQR, interquartile range.

^aP values for variables with 2 levels are from Wilcoxon rank-sum test; P values for variables with at least 3 levels are from Kruskal-Wallis 1-way analysis of variance.^bP < .05 compared with Nellis Air Force Base.^cP < .05 compared with 0 to 1 insect.^dP < .05 compared with 2 to 3 insects.**Table 3**

Adjusted odds ratios and 95% confidence intervals for variables associated with total scores of 4 to 6 vs 0 to 3

	AOR (95% CI)	P value
Site		
Nellis Air Force Base	1.00 (reference)	
Andrews Air Force Base	1.57 (0.99–2.50)	.056
Eglin Air Force Base	2.31 (1.39–3.83)	.001
Wright-Patterson Air Force Base	2.28 (1.37–3.79)	.002
Sex		
Female	1.00 (reference)	
Male	1.71 (1.23–2.39)	.002
Stings by different insects		
0–1	1.00 (reference)	
2–3	1.03 (0.72–1.48)	.869
4–6	1.63 (1.03–2.58)	.038

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.

Third, not every stinging insect that a patient might encounter was represented in this study. Despite these limitations, this study underscores that even in an ideal setting patients are unreliable at visually identifying most stinging insects and especially nests. Future studies using actual insect specimens may be useful in further assessing the accuracy of stinging insect identification.

Overall, this study supports the general perception that adults are poor discriminators in distinguishing stinging insects with the exception of the honeybee. Men and those participants who reported multiple stings to at least 4 insects were found to be more accurate overall. This suggests that for patients with a clear history of anaphylaxis or worrisome reaction to a stinging insect, broad testing to all flying Hymenoptera may be the best choice given the difficulty with insect identification. This is consistent with prior guidelines, which suggest an additional benefit of protecting individuals against other venoms to which they may be sensitized from previous stings and possibly at greater risk for anaphylaxis to subsequent stings.⁷

Further studies using an insect box may be helpful in comparing accuracy with real specimens. The authors further recommend using visual aids as an educational tool when teaching about avoidance and recognizing stinging insects.

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the likelihood that the results of this study are more representative of a broader population. Furthermore, the military population is a unique group with members frequently moving to new areas of the country or world every 2 to 4 years. Also, the patients had unlimited time to study detailed, enlarged color photographs of the stinging insects in a protected setting, offering an optimal environment to correctly classify individual insects. Moreover, no one declined participation in the study, minimizing selection bias (ie, only those who feel confident identifying stinging insects would participate).

However, this study has several limitations to consider. First, the insects were enlarged in all photographs and not scaled to actual size. This is not reflective of a patient's actual experience when being stung by a flying insect. Second, there are many color variations among the stinging insects that participants may have been more familiar with that were not represented from the photographs used in the study. For example, the coloring of paper wasps varies and can include brown, red, black, or varying striped patterns.