

Killer Bees: What the Allergist Should Know

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ABSTRACT

Africanized honey bees (AHB), often referred to as “killer bees,” extended their northern range to the United States in the fall of 1990. Although the venom components of AHB and European honey bees (EHB) are similar,^(1,2) more human-bee contact and reactions are expected because of the general increase in total bees per geographic area (in established regions of AHB), increased aggressive-defensive behavior,⁽³⁾ and continued northward spread, which exposes an increasing population.⁽⁴⁻⁶⁾ Even though AHB do not establish well in freezing climates, much of the continental United States could be threatened to some degree by AHB during warm seasons because of transport, i.e., trucking, rail, and shipping. Many multiple stinging incidents and several massive (100+ stings) stinging incidents have occurred in south Texas. Children present an increased risk group to massive attacks of AHB due both to their decreased ability to recognize potential imminent stinging situations and to the toxicity of large amounts of venom relative to their smaller bodies. Testing and treatment of patients with IgE-mediated reactions caused by AHB and EHB should be the same.⁽¹⁾ Treatment of toxic and combined allergic-toxic reactions is supportive, occasionally necessitating aggressive intervention, and is relatively predictable based on the number of stings, bee venom allergic status, victim's body size, and general health. Allergists likely will become a source of information and treatment for patients, the public, and the media. This will become increasingly important when AHB are identified in new geographic locations, especially as stinging incidents occur.

INTRODUCTION

THE AFRICAN honey bee (*Apis mellifera scutellata*) was introduced in Brazil in 1956 in an effort to have a productive honey bee adapted to the tropical climate. In 1957, escaped colonies established in the wild (Fig. 1), increasing the number of their colonies dramatically and interbreeding with European honey bees (*Apis mellifera*, multiple subspecies). The result was the Africanized honey bee (AHB). Further historical background of the African and Africanized honey bee is well documented.⁽⁷⁻⁹⁾ Because the AHB aggressive-defensive and unpredictable behavior has caused many people to be attacked by large numbers of bees, their notoriety has propagated the “killer bee” name.⁽⁸⁾ Some, especially beekeepers, feel that this name

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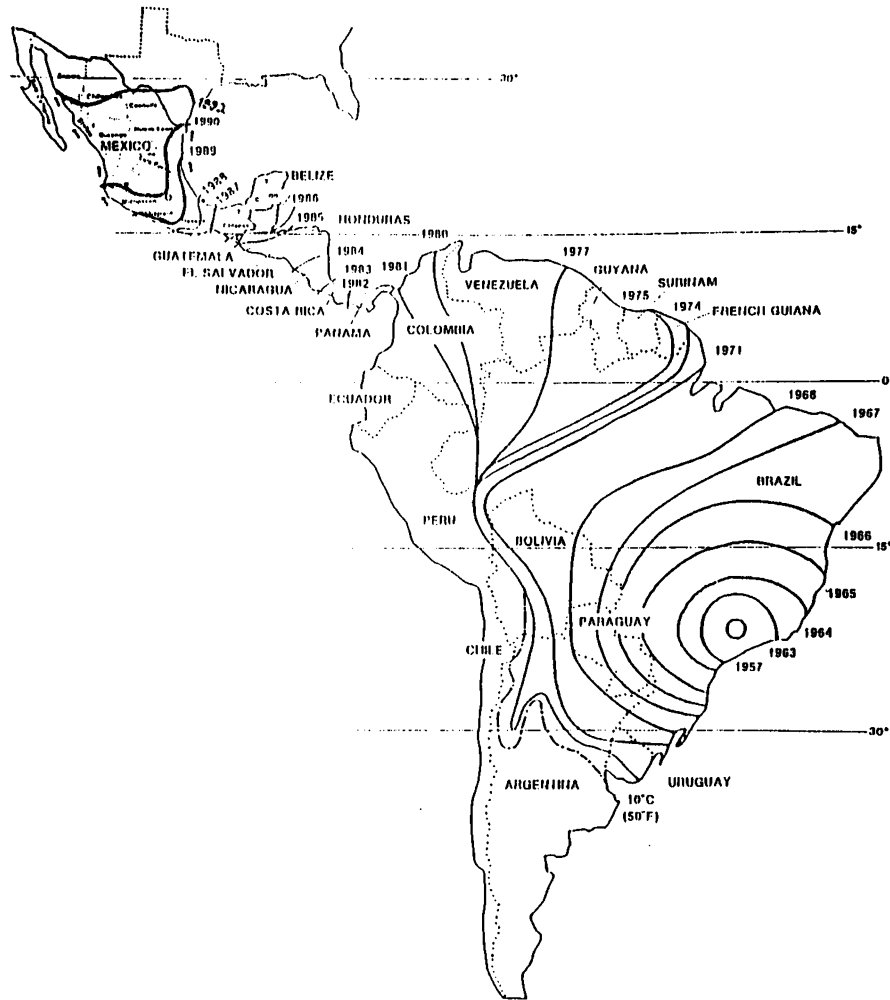


FIG. 1. Distribution of the Africanized honey bee in the Americas (through July 1992).

(mainly media derived) is highly inappropriate and negative to the beekeeping industry.^(8,10) In the United States, government and private industry plans (i.e., Texas Africanized Honey Bee Management Plan) have been formed relative to the impending arrival of this honey bee by natural northwood range expansion.⁽¹¹⁾ In the lower Rio Grande Valley area of south Texas, the first multiple stinging incident in the United States involving the AHB (via natural northward movement) was in the spring of 1991, with the first massive stinging incident (350 stings) in the fall of 1991.⁽¹²⁾ This represented the first potential fatality related to a massive stinging incident. The most extensive stinging incident in the United States occurred in July of 1992, when a 44-year-old man experienced a massive attack that resulted in approximately 800 to 1000 stings.

CASE REPORT

R.R., a 44-year-old Latino male was mowing the grass in his yard when he was suddenly attacked by a large number of bees. Bees covered his head, and he tried to swat them away from his head and neck area. He did not go into his home because he thought he would endanger several family members. He used a water hose

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to try to remove and divert the bees, rolled on the ground, and tried to hide by sliding under his parked car. These efforts were futile, and he finally ran into the house, where family members removed the remaining bees.

EMS arrived and tried to coax him to run to their vehicle, and as he ran toward the vehicle, bees followed and the victim received more stings. EMS personnel were also stung a few times. The patient claimed to feel very dizzy and weak, and his blood pressure was 80/50. Oxygen was administered, and he was transported to a local hospital.

In the emergency room, the patient was uncomfortable and dizzy. His blood pressure was 80/50, pulse 120, and respiration rate 32. He became nauseated and vomited. Epinephrine 1:1000 0.5 ml sc, diphenhydramine 50 mg IM, and methylprednisolone 120 mg IM were administered. The blood pressure improved to 112/76 and heart rate to 96. The patient claimed to feel better. His upper airways were clear, without evidence of obstruction. The chest examination revealed clear breath sounds and a regular heart rate and rhythm. The abdomen was soft and nontender. Approximately 600–700 stingers were removed. His jeans were covered with stingers that did not envenomate the patient. The skin revealed multiple maculopapular lesions.

Laboratory results

The CBC was within normal limits, except for the WBC count of 19,800. The differential count showed neutrophils 81%, bands 12%, and lymphocytes 4%. No anemia or thrombocytopenia was observed. CPK was 1702 U/liter. The ECG revealed sinus tachycardia without evidence of ischemic changes. The BUN was 23 mg/dl, and the creatinine level was 1.4 mg/dl.

Hospital course

The patient was admitted to the medical intensive care unit, and diphenhydramine 50 mg PO q6h, ranitidine 50 mg IV q8h, methylprednisolone 80 mg IV q6h, and IV fluids were administered. The next day, the CPK increased to greater than 7000 U/liter, and IV fluid support was continued. On the third hospital day, the CPK decreased to 3400 U/liter. The BUN never exceeded 25 mg/dl, and the creatinine remained within normal limits. Examinations revealed a maculopapular eruption over the trunk and upper extremities especially. He had a complaint of left eye irritation, with mild left conjunctivitis on examination. The patient was discharged to home on the fourth hospital day. His discharge medicines included ranitidine 150 mg bid, diphenhydramine 25 mg q6h, and prednisone 40 mg a day in a tapering pattern for a total of 8 days. Following discharge, visit to an ophthalmologist revealed a foreign body (probable stinger), which was removed from the upper eyelid area.

Follow-up laboratory results 9 days after the stinging incident were normal, including a CPK of 42 U/liter. Skin test and RAST to honey bee venom was positive. One and two weeks later, the patient continued to complain of itching and burning sensation of the skin and general mild fatigue.

HONEY BEE CHARACTERISTICS

Appearance and size

There are more similarities than dissimilarities between AHB and EHB (Fig. 2). AHB are slightly smaller and weigh less (dry weight 14.8 mg vs 16.6 mg)⁽²⁾ than EHB. Three techniques are available to determine whether bees collected from a colony are AHB or EHB. These include morphologic measurements performed microscopically,⁽¹³⁾ gas chromatography of hydrocarbons,⁽¹⁴⁾ and electrophoretic techniques.⁽⁹⁾

Behavior

The behavior of AHB and EHB is the same about 99% of the time. There is no difference when encountering individual foraging bees. The difference in behavior occurs when AHB perceive that their hives

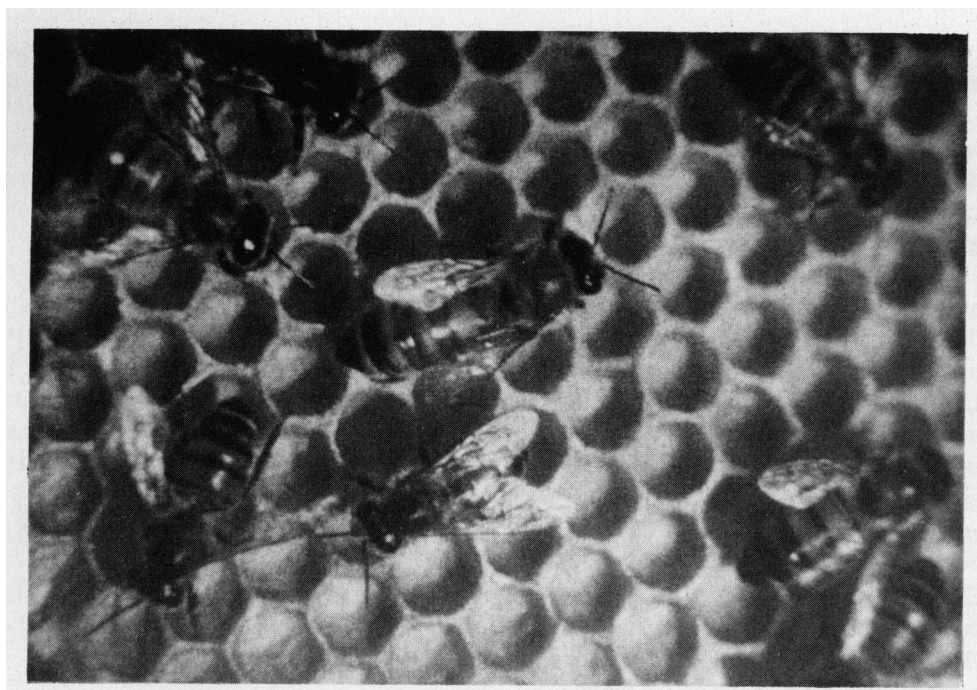


FIG. 2. European honey bee in center, surrounded by Africanized honey bees.

are threatened and, therefore, their food and brood. Disturbances that create the perception of threat by AHB often cause an aggressive–defensive response. Human or animal disturbance of AHB is usually unintentional, and the result is a dramatic surprise attack.⁽¹⁵⁾ The operation of machinery (tractors, lawn mowers, and weed eaters) in the general area of an AHB hive is the most common source of unintentional disturbance. Interestingly, a swarm (ball) of bees on a tree limb is not in a significantly increased defensive mode. To compare the stinging characteristics of AHB with EHB, an experiment was designed that included agitating the bees by spraying synthetic alarm pheromone (which is similar to that produced by bees and released by bees during perceived threats) on the entrance to hives and by shooting a large marble at the hive and waving a dark suede target in front of the entrance. The suede target was attacked by the bees. These experiments showed that AHB had a more rapid response time, an increased proportion of bees in the colony responded, and there were eight times more stings delivered to the target by AHB than by EHB.⁽³⁾ Hundreds of stings can occur within 1–2 minutes.⁽¹⁵⁾

AHB are much less selective in nesting sites. The typical EHB hive is in a tree or in a hole of a tree. AHB frequently select holes in walls and in the ground or under mobile homes, in old tires, and so on. Unfortunately, these unexpected nesting sites lead to more unexpected encounters. AHB swarm several times a year, whereas EHB swarm only once or twice a year. Swarming occurs when new queens are produced in a colony and part of the colony leaves with a queen, thereby increasing the number of colonies in an area. Sometimes, an entire swarm leaves a site, making them less predictable and, unfortunately, less useful from the standpoint of the honey bee industry. In areas established with AHB, there are approximately 12 times more colonies of AHB than of EHB. Therefore, the total number of colonies and bees in a geographic area dramatically increases.⁽¹⁵⁾

VENOM COMPONENTS AND TOXIC REACTIONS

A multiplicity of pharmacologically active components are present in bee venom, including peptides, enzymes, and biogenic amines that cause toxic reactions. The most important component is the peptide mellitin, which comprises approximately 50% of bee venom. It is a highly toxic substance that may cause

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hemolysis,⁽¹⁶⁾ inflammatory reactions, increased capillary permeability, and smooth muscle contraction. Phospholipase A₂ (PLA₂), an enzyme that comprises approximately 12% of bee venom, causes cellular damage, smooth muscle contraction, and increased capillary permeability and appears cardiotoxic. On a weight per weight basis, PLA₂ is about twice as toxic as mellitin in mice toxicity studies (J. Schmidt, personal communication). Apamin is neurotoxic and may cause central nervous system excitation. Other significant components of bee venom (which in themselves would not be considered in high enough concentrations to cause significant toxicity) may well potentiate toxicity when combined with the venom components. These include hyaluronidase, acid phosphatase, and mast cell degranulating peptide. Minor amounts of biogenic amines include histamine and dopamine.

The amount of venom in AHB is less than that in EHB. The average weight of AHB venom is 93.5 µg/bee in comparison with EHB at 146.6 µg/bee.⁽²⁾ Biochemical and immunochemical comparisons of AHB and EHB venom are similar.^(1,2) There are no protein bands unique to AHB that would be considered as possible neoantigens.⁽¹⁾ However, two different proteins were identified in AHB by isoelectric focusing.^(17,18) There is less mellitin concentration in AHB venom vs EHB but higher concentrations of PLA₂.⁽¹⁹⁾ This is important because of the toxicity of mellitin and PLA₂. Also, since PLA₂ is the most common allergen in bee venom, an increase in allergic sensitization may occur. In a study of venom sac components, mellitin and PLA₂ varied significantly among different colonies of bees as well as among different bees of the same colony in both EHB and AHB samples.⁽¹⁹⁾

The median lethal dose (LD₅₀) of EHB and AHB venoms by IV injection in Swiss mice are similar. In venom-neutralization experiments, AHB venom was mixed with antibodies from a beekeeper exposed only to EHB and was used to challenge mice. Survival times of mice given venom plus antibodies were significantly prolonged, indicating neutralization of the lethal effects.⁽²⁾ This in vitro and in vivo evidence suggests similarity between AHB and EHB venom.

Bee venom causing toxic reactions from multiple or massive numbers of bee stings results in universal vulnerability because the reaction is dependent on the amount of venom injected. An analogy is snake envenomation, in which the amount of venom injected determines the degree of toxicity. The venom from 500 bee stings is approximately equivalent to the envenomation from one rattlesnake bite (J. Schmidt, personal communication). It is well known that one honey bee sting in an allergic patient may result in a fatal reaction. A pertinent note concerning bee venom-allergic patients is the increased risk with multiple or a massive number of bee stings and the resulting combined allergic and toxic reaction. Toxic reactions may occur rarely with few stings and certainly may occur with 50 stings.^(20,21)

Clinical problems include various cutaneous lesions, corneal ulceration, papillitis, bronchospasm, bronchopneumonia, nausea, vomiting, diarrhea, hypotension, central nervous system stimulation or psychosis, hemolysis, thrombocytopenia, rhabdomyolysis, and acute renal failure.⁽²²⁻³⁰⁾ Serum sickness-type reactions have occurred.^(10,31,32) Because of the paucity of medical literature, pathophysiologic mechanisms causing death are not well documented. However, complications of hypotension and respiratory failure have been observed.⁽²⁷⁾

Groups at increased risk

Because there are characteristically more AHB per given area and because of their more aggressive defensive behavior, both the bee venom-sensitive individual and the general population are at increased risk of coming in contact with these bees in areas where they reside. The effect of multiple stings that may occur with these bees is likely to lead to greater toxicity.^(10,29,31-33)

Children are at increased risk for exposure because they are less likely to recognize an impending dangerous situation and because a given toxic exposure is more likely to be significant in a smaller body. However, children have a better prognosis than do adults in anaphylactic reactions.⁽³⁴⁻³⁶⁾ An unresolved issue is whether the group of children with a history of bee venom cutaneous reactions only who receive multiple or massive numbers of stings is at increased risk for serious toxic effects.

Elderly individuals and those with severe diseases are at increased risk because of their bodies' relative intolerance to large toxic exposures. Certainly, those with significant cardiovascular and pulmonary diseases are at an increased risk. Medications, such as beta-blockers, may render treatment (i.e., with epinephrine) less

effective. In addition, there may be more difficulty among the elderly in physically escaping a dangerous situation. In the spring of 1992, an elderly man with known cardiovascular disease died (ruptured artery) within minutes of receiving 150 stings from EHB.

Occupations and activities that place individuals at increased risk include beekeepers, tractor drivers clearing fields and brush, yard maintenance workers (especially while operating machinery), parks department workers, and electric and telephone line employees.

Finally, the anatomic location of stings may increase risk. Multiple or massive numbers of stings in the neck area may cause upper airway obstruction. The individual who has a history of large local sting reactions could be at even greater risk. AHB have a greater tendency to sting in the head and neck area,⁽²⁾ and allergic reactions occur more commonly when stings are in the head and neck area.^(37,38)

MORBIDITY AND MORTALITY

Massive stinging incidents (greater than 100 stings) often cause toxic reactions. The predicted LD₅₀ for the number of honey bee stings per kilogram body weight is 19.⁽²²⁾ For example, more than 500 stings often would be lethal in a child, whereas 1100 stings for an average-size adult female and 1400 stings for an average adult male would represent a probable LD₅₀ (Table 1). However, as few as 100–300 stings have been fatal, and any stinging events of this number should be considered serious.^(2,22) There is one well-documented report of a 30-year-old man from Central Africa who survived 2243 stings.⁽³⁹⁾ During the initial years of AHB in Venezuela (from 1978–1981, at that time a country of 14 million people), there were at least 70 deaths attributed to AHB.⁽¹⁵⁾ There have been approximately 42 deaths in Mexico documented from 1987 to 1991 that were attributed to probable AHB (A.M. Collins, personal communication). In Texas, there is a historical average of 1 documented death per year due to honey bee stings (Texas Department of Health). It is estimated that there will be 4–5 additional deaths per year in Texas due to AHB stings (J. Schmidt, personal communication). In addition, it is estimated that there will be 1 fatal incident for every 90–200 multiple stinging incidents⁽¹⁵⁾ (J. Schmidt, personal communication). Therefore, approximately 400–800 multiple stinging events are predicted per year in Texas once AHB become fully established. It will probably be 10 years before the health impact of AHB in the United States is fully expressed. In the United States, deaths from stinging insects are predicted to increase from 40–100 per year.⁽⁸⁾ Based on this increase, several thousand multiple or massive stinging incidents per year may be predicted.

RECOMMENDATIONS AND PREVENTION

I have developed a protocol, with input from several AHB experts and researchers (Table 2), that is primarily aimed at emergency response personnel. The first of these recommendations includes running and immediately seeking shelter at the time of an attack with a large number of bees. The next important rule is not to rush in and try to rescue the victim during the attack and run the risk of becoming involved in the attack. It is better to wait and plan how to best help the victim depending on his or her ability to escape the area.

Should the victim be unstable, transport him or her immediately to an emergency facility, or contact the local emergency medical service. Initially, quick removal of stingers and attached venom sacs is very important. Ten to fifty micrograms of venom usually are injected rapidly per sting, representing 50% or less

TABLE 1. LETHALITY OF HONEY BEE STINGS BY BODY WEIGHT

<i>Body weight</i>	<i>Number of stings for LD₅₀^a</i>
Child of 30 kg (66 pounds)	570
Adult of 60 kg (132 pounds)	1140
Adult of 80 kg (176 pounds)	1520

^a Number of stings for LD₅₀/kg body weight is 19 stings/kg.

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TABLE 2. HONEY BEE MASSIVE STINGING INCIDENTS: ON SITE RECOMMENDATIONS

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1. Encourage victim to *run* away from hive to shelter (e.g., house, car)
 2. Personal safety
 - a. Instruct anyone allergic to any stinging insect to leave area
 - b. Do not attempt unprotected rescue of victim
 3. If victim is unable to move away from area
 - a. Wear beekeeper's suit to rescue victim
 - b. Train firefighters with high-pressure spray and surfactant
 - c. Heavy smoke screen
 - d. High risk: Blanket approach—one for self and one for victim
 4. Take victim to sheltered area
 5. ABCs (airway, breathing, circulation)
If stable, proceed to next step *or*, if not, CPR as indicated
 6. Scrape off remaining bees and remove stingers and attached sacs with blunt item (i.e., credit card, table knife)
 7. Estimate numbers of stings—helps to determine amount of evenomation
 8. Transport to medical facility
 9. Obtain history of
 - a. Allergy to venom of stinging insects
 - b. Other severe diseases, e.g., cardiovascular
 - c. Medications, e.g., beta-blockers
-

of venom content. Most of the remaining venom is injected more slowly over time (J. Schmidt, personal communication). Stingers and venom sacs should be removed at the skin–stinger surface by scraping with a credit card, long fingernail, or similar object. Removal of stinger sac should start with the neck area because of the potential for extensive swelling of the upper airway.

If the victim is unable to escape, it is absolutely essential to obtain assistance from emergency response personnel following appropriate precautions. The most effective is a beekeeper's suit, which completely protects the rescuer, who may then retrieve the victim. It may be important to cover the victim with a blanket, which may somewhat decrease the alarm pheromone attracting bees.

Other effective accessories in the rescue attempt include strong water pressure, especially with surfactant or wetting agents that are available on many fire trucks. Spraying vertically 20–30 feet in a fan pattern (umbrella of water) essentially intercepts bee flight activity and provides more safety to the rescue progress.^(40,41) (Fig. 3).

Prevention of attacks is of utmost importance. It is necessary to inspect an area before machinery is started because a high percentage of the attacks have been associated with some type of machinery. African honey bees are aggravated by warm, vibrating machinery as well as by the carbon monoxide from such equipment. Dark (including red) clothing should be avoided when planning outdoor activities involving the use of machinery. Never attempt to eradicate a hive with household insecticides. This is surprisingly difficult to do and is a job for trained personnel with protective gear (e.g., professional exterminator, county agricultural extension agent, fire department personnel, or others).

It is important to educate emergency response teams about rescue procedures and to distribute a list of the locations of protective gear, i.e., beekeeper's uniforms. Public education is very important. Children in the Texas school system have access to a program from the county extension agents of the Texas A&M University system. All elderly patients with underlying significant health problems should avoid working outdoors with machinery. In some Latin American countries where multiple stinging events have been reported, a fine wire caging around the tractor operator has proven helpful.

EVALUATION AND TREATMENT

Evaluation includes the immediate assessment of airway, breathing, and circulation (ABCs). The physical examination should include checking for neck swelling and upper airway obstruction. Auscultation of the



FIG. 3. Simulated victim rescue from massive honey bee attack using umbrella spray with wetting agent. (Courtesy of Mr. Kim Flottum.)

chest for pulmonary and cardiac status is essential. Important historical information includes any insect sting allergy, other complicating medical conditions (i.e., cardiovascular or pulmonary disease), and medications, such as beta-blockers. Stingers should be scraped from the patient's neck after first using a stiff, noncutting instrument (e.g., credit card). There should be no pinching or pulling of stingers, since the remaining venom in the sac could be squeezed into the patient, further intensifying the reaction. While the stingers are being removed, there should be an estimate of the number of stings to help in the prediction of severity of toxicity.

Treatment of the patient is supportive as indicated. If the initial evaluation reveals a stable clinical situation, treatment may be directed toward cutaneous symptoms using diphenhydramine and topical treatment (e.g., calamine lotion). However, if there are clinical signs and symptoms of respiratory compromise or hypotension, epinephrine is the treatment of choice. Diphenhydramine, bronchodilators using the inhaled and IV routes, and oxygen supplement should be used. If there is swelling in the neck area and upper airway obstruction, the patient may need intubation. Volume expansion often is needed. In addition to supporting circulation, it dilutes the toxic venom components. Vasopressors and mechanical ventilation may be necessary in the most severe cases. Corticosteroids should be considered for control of the inflammatory response (Table 3). Tetanus vaccination also should be considered. The recommended medication routes, doses, and duration of treatment are dictated by clinical severity and course.

Laboratory evaluation may include arterial blood gases, ECG, and chest x-ray. In addition, since toxic components of venom may cause hemolysis, thrombocytopenia, and rhabdomyolysis, appropriate laboratory evaluation for these problems should be carried out. Acute renal failure has been documented.^(25,27,29) Unfortunately, there is scant information in the medical literature about the pathophysiologic mechanisms of the toxicity and mortality seen in AHB attacks.⁽²⁷⁾

Prehospital discharge instructions should include assessment of the need for an epinephrine kit and referral to an allergy specialist, if not already consulted, who has experience in stinging insect reactions and occupation-avocation risks (Table 4). Since biochemical and immunochemical studies of EHB and AHB

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TABLE 3. POTENTIAL TREATMENT FOR MULTIPLE OR MASSIVE STING PATIENT

For systemic reactions
Epinephrine
Diphenhydramine
O ₂
IV fluids
Bronchodilators
B ₂ agents
Aminophylline
Corticosteroids
Less frequent
Vasopressors
Intubation and mechanical ventilation
Renal dialysis
Topical treatment
Analgesics
Cold compresses
Topical soothing lotions or creams

venom demonstrate similarity,⁽¹⁾ current skin testing and immunotherapy established with EHB is also appropriate for AHB. Current clinical research with several massive sting cases (AHB) reveal that most have positive bee venom skin tests and RAST (unpublished observations).

Future therapeutic directions include the need for a specific antitoxin treatment⁽²²⁾ similar to antivenin treatment for snake bites. This could be an efficacious treatment and potentially lifesaving. Beekeepers' immunoglobulin has been used in active and passive immunization studies of honey bee-allergic patients without significant adverse reactions.⁽⁴²⁻⁴⁴⁾ It has been proposed that a human hyperimmune IgG be developed from beekeepers' serum.^(45,46) Another approach would be to develop monoclonal antibodies to specific venom components (i.e., mellitin and PLA₂).

DISCUSSION

Since AHB began to leave their hives in Brazil in 1957, these bees have continued their dramatic migration northward. No human means have stopped the migration of AHB, and, therefore, we must learn to live with them. On the bright side, after establishment of AHB is an area for 3-4 years, there seems to be a slight decrease in the number of AHB and the number of multiple or massive stinging incidents. This may be at least partially due to increased awareness and preventive measures.⁽¹⁵⁾ There has been some evidence of hybridization with EHB characteristics, although this seems to be a slow process.^(47,48) An unanswered question is whether hybridization will result in a significant change in the unpredictable aggressive-defensive behavior of AHB. Hybridization also could allow the AHB to become better adapted to colder climates.

TABLE 4. FOLLOW-UP CONSIDERATIONS FOLLOWING MULTIPLE OR MASSIVE STING

Referral to an allergist trained in stinging insect venom testing
Epinephrine kit (needed ?)
Occupation-avocation risks
Hive destroyed

There will be more allergic and toxic reactions as AHB extend their geographic realm. However, proper planning and education should help to alleviate much of the misinformation, which can result in undue anxiety and, in some cases, hysteria.

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