Articles

What Physicians Should Know About Africanized Honeybees

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The Africanized honeybee, popularly known as the "killer bee," is already well established in Texas and has recently entered California and Arizona. As the Africanized honeybee spreads in North America, the medical community must become aware of the problems associated with this insect and ensure that sting emergencies can be handled quickly and appropriately. The major differences between Africanized and European honeybees are that the former are more irritable, they swarm more readily and frequently, they defend their hives more vehemently, and they sting more collectively. It is not the composition nor the volume of an individual bee's venom, but rather the cumulative dose of multiple stings that accounts for the morbidity and mortality associated with Africanized honeybee-sting incidents. Even nonallergic persons are susceptible to the toxic effects of these large combined venom loads. Africanized honeybee-sting victims are treated the same as victims of European honeybee stings. Authorities will prepare for the bees' arrival by expanding public awareness, teaching risk-avoidance behavior, providing for the removal of troublesome hives, and developing sting treatment protocols that can be initiated rapidly in the field or emergency departments. Health care professionals should participate in the educational efforts and in the development of needed emergency response protocols so that the effects of the Africanized honeybee will be merely a nuisance rather than a plague.

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In many areas of the country, policy makers and the agriculture community are preparing for the arrival of the Africanized honeybee. Popularly (and inappropriately) known as the "killer bee," this insect entered Texas in 1990,[1] and it has now been identified in California and Arizona.[2,3] The limits of its northward expansion are thought by some experts to be the southern third of the United States,[4] but its ultimate limitations will depend on its ability over time to develop a tolerance to cold.

The medical community, too, should prepare for the continued spread of this insect, not because of some impending health crisis that will result from the influx of this aggressive bee, but because of the many questions, concerns, and fears that the public may have. Experience in South and Central America has shown the importance of public education, readily accessible emergency treatment, and a coordinated bee tracking and hive control program.[5] In adopting these principles in the United States, we may find that fatal stings resulting from this bee are relatively infrequent. Health care professionals can best prepare for the arrival of Africanized honeybees by understanding the nature of this bee, by ensuring that we can handle sting emergencies quickly and appropriately, and by participating in community education. To this end, it is hoped that an understanding of the material in this review will allow readers to answer the questions, and allay the fears, of their patients.

'Africanization' of Honeybees

Many races of honeybees exist today. Honeybees were brought to the New World by the European settlers.[6,7] European honeybees (*Apis mellifera mellifera*, *Apis mellifera ligustica*, *Apis mellifera carnica*, and *Apis mellifera iberica*) eventually established themselves throughout much of North and South America, with the exception of largely tropical regions. Reports of substantial honey production by the African honeybee (*Apis mellifera scutellata*) prompted several attempts to introduce this race into the Americas, but the bees never before survived as a distinct race.

In 1957, during studies of the African honeybee in Brazil, the queens and workers of 26 hives escaped into the countryside, establishing wild, or feral, African colonies.[8] The descendants of these bees are considered Africanized honeybees because they are actually a hybrid between these African honeybees and the local European honeybees. Many African traits have persisted despite the genetic mixing of races: excitability,

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aggressive defense of their hive, and frequent swarming. The Africanization process has spread north and south at a rate of 320 km (200 mi) per year, as these bees have continued to breed with, and often outcompete, the more docile European honeybees.[4]

The specific mechanisms of this hybridization, or Africanization, had long been unknown. Africanization could theoretically occur by the interbreeding of African drones with European queens or European drones with African queens. Recent findings of mostly African mitochondrial DNA (maternally inherited) imply that the territorial spread of the Africanized honeybee has occurred primarily as a consequence of female migration.[9,10] The accidental transportation of bees by humans, however, and parasitism of European honeybee hives by Africanized honeybees also play roles in the Africanization process.[6] The important issue is that the Africanized honeybee is a hybrid that has, for the most part, retained many of the aggressive behavioral traits of *A m scutellata.*

Natural History of African and Africanized Honeybees

The African bees' honey production may be greater than that of the European honeybees living in the same tropical regions.[11] It is not as enormous as many people once thought, however, nor is it even greater in all situations.[12,13] African colonies, like their Africanized descendants, produce a large number of workers that quickly leave the hive to forage independently and widely. These bees are well suited to environments where flowering plants are sparsely scattered and short-lived; they do not harvest large amounts of nectar, but they are well adapted to finding the available nectar when it is rare and dispersed.[14] Nectar is a major component of honey; pollen is the primary protein source for bee larvae. Compared with European honeybee colonies, more of the African (and Africanized) foraging force is engaged in collecting both nectar and pollen, rather than nectar alone.[11,15] This is not surprising, given that large brood production is a priority with the African and Africanized colonies.[11] European honeybees, on the other hand, through their dependence on dance communication and mass recruitment, are able to collect larger quantities of nectar when it is abundant.[12]

Some of the characteristics that make African honeybees better survivors in tropical Africa—frequent swarming, absconding in the face of adversity, and aggressive defense of the hive—have made Africanized honeybees a problem for beekeepers in the New World. When their colonies became Africanized, many South American beekeepers began to neglect their hive maintenance out of fear of being attacked.[5] This led to overcrowding, which increased the irritability of the bees. Overcrowded colonies would swarm to find more room, or completely absconded, leaving the old hive vacant. Swarming bees looking for a suitable site for establishing a new colony tend to be relatively docile. But when swarms settle in areas near people or livestock, then stinging episodes are likely to follow any disturbance of their new hive.

The architecture and site selection of Africanized honeybee hives differ from those of European beehives in that the Africanized hives are often more exposed.[15] Africanized honeybees often build their hives on tree branches or in old tires and boxes. These open nests are thus more likely to be disturbed by passersby, gardeners mowing their lawns, or environmental hazards, such as rain and wind.

Africanized honeybees are difficult to distinguish morphologically from European honeybees. Africanized honeybees are typically slightly smaller than most European honeybees. They can be identified by experienced entomologists on the basis of structure—relative wing, leg, and body measurements[16,17]—by gas chromatography of cuticular hydrocarbons,[18,19] or by enzyme electrophoresis.[20-24]

Africanized Honeybee Stings

The stinging behavior of Africanized honeybees is primarily one of defense. It is not an effective defense for an individual bee because the honeybee dies in the process of stinging vertebrates; but honeybee stinging is effective for group defense. Honeybees are capable of instilling large amounts of venom into a vertebrate victim as a result of their stinging mechanism, which continues to inject venom despite the death of the bee, and also as a result of colony recruitment into the attack.

Stings generally occur in the immediate vicinity of the hive, in response to a perceived threat.[25,26] The Africanized honeybee's notoriety (as well as its common name, killer bee) results from its aggressive defense of the colony.[27-29] Hundreds of people have lost their lives as a result of killer bee-sting incidents over the past few decades in South and Central America.[30] The sting and venom of the Africanized honeybee are not substantially different from those of the European bee[31,32] and are not themselves the cause of the high mortality.[33] Fatal Africanized honeybee-sting incidents tend to involve hundreds of individual stings. The same number of European honeybee stings would be expected to lead to similarly fatal outcomes.[34] It is the cumulative dose of venom injected by numerous Africanized honeybees that explains the higher morbidity of Africanized honeybee-stinging incidents, along with a greater likelihood of stinging a hypersensitive person, of course, when several people are attacked.

In general, honeybee stinging has been shown to be induced by sudden movements, dark colors, and certain odors, including human perspiration.[35] Honeybees also sting in response to volatile chemicals such as isoamyl acetate, released from the bee's glands at the time and site of each sting.[36-38] Through this mechanism, nearby honeybees are recruited in the attack and directed toward their victim. Africanized honeybees may be more sensitive to, or release greater quantities of, these recruiting pheromones.[39] Once initiated, the sequence of stinging recruitment in an African honeybee colony can result in

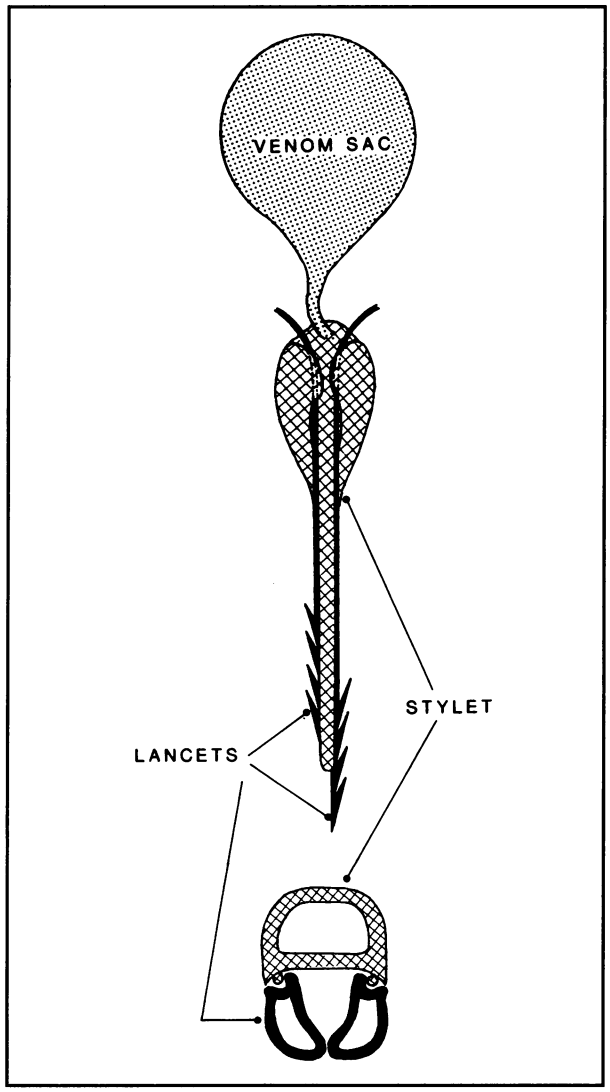

Figure 1.—The schematic drawing shows the honeybee-sting mechanism. The ventral view shows the alternating motion of lancets. The lower portion of the drawing shows a cross-section (based on Snodgrass[41] and Mulfinger et al[42]).

hundreds or thousands of individual stings.[28] These bees may pursue a victim as far as 1 km (0.6 mi) and may remain aggressive for hours or even days.[40]

The Sting

As for all honeybees, the sting mechanism (Figure 1) is composed of two barbed lancets tracking along a central stylet.[41,42] The alternating thrusts of the two lancets transport the sting farther into mammalian skin as each barbed lancet becomes firmly entrapped in the fibrous tissue, able only to advance and not retreat. As the lancets alternately advance, the venom is simultaneously pumped into the victim. When the honeybee attempts to escape, its barbed stinger will be left behind, still pushing forward and still pumping venom as a result of its self-contained venom sac and intrinsic musculature.

Honeybee venom comprises three categories of constituents (Table 1): enzymes, peptides, and biogenic amines.[43] The amount of venom in each Africanized honeybee venom sac may be slightly less than that of the European honeybees in the United States,[31] although the components are essentially the same.[32,44] Even within the same race, the dry weight of various venom components varies from one colony to another.[44]

Clinical Manifestations of Bee Stings

Few studies have looked specifically at the clinical manifestations of Africanized honeybee stings. Because the composition of their venom is essentially the same as that of European honeybees, the clinical manifestations are considered to be the same, adjusted for venom load (number of stings).

The reason that Africanized honeybee-sting incidents occasionally result in death is that they commonly involve hundreds of individual stings. The median lethal dose of honeybee venom has been estimated at 19 stings per kg, or 500 to 1,400 stings for humans.[45]

Although the clinical manifestations of Africanized honeybee stings have not been systematically studied, the spectrum of reactions to a single or a few European honeybee stings has been well described.[46] Honeybee-sting reactions are often classified as local, major local, or systemic; they can also be described as immediate or delayed. Local symptoms include pain, pruritus, erythema, urticaria, and angioedema. When severe but contiguous with the sting site, these symptoms are described as major local reactions. When these symptoms occur in remote locations, they are considered systemic reactions. Nausea, vomiting, diarrhea, and intestinal or uterine cramping are common systemic reactions. More severe systemic reactions include bronchospasm with wheezing, laryngeal edema with inspiratory stridor, dyspnea, hypotension, and a sense of impending doom. Hypotension or hypoxia may lead to a loss of consciousness. Bronchospasm or laryngeal edema can impede breathing, and cardiac collapse can cause shock; either one can be fatal.

The onset of some serious reactions can be delayed for 8 to 24 hours. Delayed renal failure has been described following Africanized and European honeybee stings.[47-51] Delayed hematologic[34,52] and neurolog-

TABLE 1.—*Major Constituents of Honeybee Venom*

Enzymes	Mast cell-degranulating peptide
Phospholipase*	Secapin
Hyaluronidase*	Tertiapin
Acid phosphatase *	Protease inhibitor
α-D-Glucosidase	Biogenic amines
Lysophospholipase	Histamine
Peptides	Dopamine
Melittin*	Norepinephrine
Apamin	

*Allergens.

ic[47,49,52] complications have also been documented. The mechanisms of these complications are not yet completely understood.

Most of the deaths occurring in the United States are currently the result of anaphylaxis; these deaths often are associated with only one or two stings. More than 40 deaths are reported each year in the United States due to hymenopteran (ant, bee, and wasp) stings.[52] The true number of deaths is probably greater, given that some deaths that are attributed to cardiac arrests or to unknown causes may actually be the result of bee-sting anaphylaxis.[53,54] The prevalence of bee-sting allergy is estimated to be from 0.5% to 5%.[55-59] Most sting-related deaths in the United States now occur in older persons and in those with coronary artery disease.

Even a single bee sting to the neck, face, or mouth can cause substantial swelling and obstruct breathing.[60-62] Hundreds of stings, even in nonallergic persons, may lead to many of the manifestations seen in hypersensitive victims. Children are particularly susceptible to the effects of multiple stings because they receive a larger dose of venom per kilogram of body weight for any given number of stings. The proportion of children seriously injured in bee-sting incidents will probably increase as Africanized honeybee-stinging incidents become more common.

Psychological Aspects of Bee Stings

The tremendous psychological effects of the killer bee influx cannot be overemphasized. An uncontrollable fear of stinging insects is common.[63-65] Sensationalized reports of the Africanized honeybee, combined with myths about its lethal venom, enormous size, and ability to sting repeatedly, have created unwarranted anxiety.[65,66]

Most bee stings, at least for the next several years, will continue to result from European bees. Even when Africanized honeybee stings outnumber those of European honeybees, public fear must not be allowed to further complicate this already troublesome situation. If public fear escalates, the panic that ensues following a bee sting—Africanized or not—could well increase the consequent morbidity by way of added cardiovascular stress, associated traffic accidents, or irrational behavior such as attempting to destroy beehives without adequate personal protection or experience.

Bee-Sting Treatment and Prevention

Because Africanized bee-sting incidents tend to involve hundreds or thousands of bees recruited in the attack, the first response of a victim should be to escape. Most healthy children and adults can outrun a swarm of bees long enough to find shelter or to reach a relatively safe distance from the hive. The very young and old, physically disabled, and persons with cardiopulmonary disease, however, may not be able to reach a safe distance before collapsing.

Treatment principles of major sting reactions are essentially the same (Table 2), whether the offending bees are of European or African descent; these have been reviewed elsewhere.[34,47,55,67] Patients who have had hypersensitivity reactions, multiple stings, or single stings in the mouth or neck should receive immediate medical attention and close observation. Most people who die of bee-sting hypersensitivity reactions are those who do not receive medical attention within the first hour.[51]

When available, the offending bee should be submitted for precise identification. Victims of insect bites and stings notoriously incriminate the wrong insect.[68] Proper identification becomes paramount when considering immunotherapy or when investigating the possible arrival of Africanized bees into a new region.

Prevention and Education

The best approach to Africanized honeybee stings is prevention. Because sting incidents generally occur near a hive, avoidance is key. Children must be taught not to play with or near hives. Untrained persons should not attempt to move or destroy beehives on their own. Instead, the discovery of a wild hive should be reported to the appropriate authorities.

Hypersensitive persons have long been counseled to reduce their chances of being stung by avoiding the use of perfumes or hairsprays and not wearing brightly colored clothes. Food and garbage may occasionally attract honeybees, so care should be taken to conceal these items. When outdoors, shoes, long pants, and long sleeves should be worn. In high-risk bee-sting areas (such as areas with established Africanized honeybee colonies), nonallergic persons should also follow these guidelines. Occupations most associated with honeybee stings are those with extensive outdoor exposure: landscapers, park rangers, utility workers, and construction

TABLE 2.—*Emergency Treatment of Honeybee Stings*

Reaction Type	*Treatment*
Local reactions	Remove remaining stingers Wash open wounds Cold compresses; elevate extremity Anesthetics/analgesics—topical, enteral
Major local reactions*	Antihistamines Close observation Epinephrine, if cardiopulmonary compromise is suspected Oral corticosteroids
Systemic reactions*	Epinephrine Antihistamines Aminophylline Parenteral corticosteroids Cardiovascular mor itoring and support, including intravenous fluids, vasopressors, dialysis Airway protection

*In addition to treatment measures given for local reactions.

personnel.[34] Bees are sensitive to vibrations, and many attacks have occurred after lawn mowers or tractors have gotten too close to a hive.

Successful honeybee-management programs in South and Central America have targeted three public health priorities: widespread education, readily accessible first aid (which has occasionally included the distribution of emergency bee-sting kits), and the creation of honeybee-control squads to remove or destroy troublesome hives.[5] Honeybee-control programs in Venezuela decreased the annual number of deaths in that country from almost 100 in 1978 to only 20 in 1985.[30]

Learning from our southern neighbors, communities in Texas are successfully instituting public awareness campaigns and are developing emergency protocols for responding to bee-sting incidents.[1] Reports of major stinging attacks trigger an immediate and integrated response by fire and emergency medical departments. Citizens are being informed about Africanized honeybees and about bee stings through public service announcements, mailings, and school projects.

Immunotherapy

Bee-sting immunoprophylaxis can be useful in many circumstances, and much has been written elsewhere about the appropriate patient selection, performance, efficacy, and shortcomings of immunotherapy.[55,69-75] Because the composition of Africanized honeybee venom is essentially the same as that of European honeybee venom, patients having hypersensitivity reactions to Africanized honeybee stings should be skin tested or provided immunoprophylaxis according to the same guidelines. Any person displaying bee-sting anaphylaxis should be referred to an allergist who can then determine whether or not that person would benefit from immunotherapy. The decision to initiate immunoprophylaxis for Africanized honeybee stings must be individualized because the clinical manifestations resulting from multiple Africanized honeybee stings are often the result of venom toxicity rather than allergy, and the benefit of immunoprophylaxis under these circumstances is therefore questionable. The efficacy of immunoprophylaxis with derivatives of European honeybee venom in preventing hypersensitivity reactions to Africanized honeybee stings may be equivalent; however, this has not yet been demonstrated.

Looking Toward the Future

As we look ahead to the Africanization of honeybees in North America, our anxiety should be tempered with the knowledge that African societies have lived peacefully with the African honeybee for thousands of years while managing its hives and harvesting its honey.

As more North American honeybee colonies become Africanized, it is probable that major bee-sting incidents will occur with increasing frequency. We will be facing the following public health problems:

- Getting emergency medical care to bee-sting victims quickly enough so that life-saving treatment can be instituted; and
- Preventing citizens from doing themselves more harm as a result of ignorance, misunderstanding, or overreacting to the Africanized honeybees.

The solutions to these problems will require integrated, well-prepared emergency medical services and public education. Health care professionals can help decrease the threat of this Africanized honeybee by being well informed, providing factual information to their patients, and participating in local and regional policy development before the bees arrive.

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REFERENCES

1. Texas Africanized Honey Bee Advisory Committee: Texas Africanized Honey Bee Management Plan. College Station, Texas, Dept of Entomology, Texas A & M University, 1992

2. Levy C: Africanized honey bees enter Arizona. Vector Ecol Newslett 1993 Sep; 25:6

3. Beams F: Africanized honey bees arrive in California. Vector Ecol Newslett 1994 Dec; 25:11

4. Taylor OR: African bees: Potential impact in the United States. Bull Entomol Soc Am 1985; 31:15-24

5. Winston ML: The Latin American experience, chap 7, Killer Bees—The Africanized Honey Bee in the Americas. Cambridge, Mass, Harvard University Press, 1992, pp 87-101

6. Rinderer TE, Hellmich RL II: The process of Africanization, chap 5, *In* Spivak M, Fletcher DJC, Breed MD (Eds): The 'African' Honey Bee. Boulder, Colo, Westview Press, 1991, pp 95-117

7. Oertel E: History of beekeeping in the United States, *In* Beekeeping in the United States. US Department of Agriculture, Agricultural Handbook, No. 335, 1980, pp 2-9

8. Kerr WE: The history of the introduction of African bees to Brazil. Afr Bee J 1967; 39:3-5

9. Hall HG, Muralidharan K: Evidence from mitochondrial DNA that African honey bees spread as continuous maternal lineages. Nature 1989; 339:211-213

10. Smith DR, Taylor OR, Brown WM: Neotropical Africanized honey bees have African mitochondrial DNA. Nature 1989; 339:213-215

11. Pesante DG, Rinderer TE, Collins AM: Differential pollen collection by Africanized and European honeybees in Venezuela. J Apicultural Res 1987; 26:24-29

12. Rinderer TE, Collins AM: Foraging behavior and honey production, chap 12, *In* Spivak M, Fletcher DJC, Breed MD (Eds): The 'African' Honey Bee. Boulder, Colo, Westview Press, 1991, pp 235-257

13. Rinderer TE, Collins AM, Tucker KW: Honey production and underlying nectar harvesting activities of Africanized and European honeybees. J Apicultural Res 1985; 23:161-167

14. Pesante DG, Rinderer TE, Collins AM: Differential nectar foraging by Africanized and European honeybees in the neotropics. J Apicultural Res 1987; 26:210-216

15. Winston ML: The biology and management of Africanized honey bees. Annu Rev Entomol 1992; 37:173-193

16. Daly HV, Balling SS: Identification of Africanized honeybees in the western hemisphere by discriminant analysis. J Kansas Entomol Soc 1978; 51:857-869

17. Sylvester HA, Rinderer TE: Fast Africanized bee identification system (FABIS) manual. Am Bee J 1987; 127:511-516

18. Carlson DA, Bolten AB: Identification of Africanized and European honey bees, using extracted hydrocarbons. Bull Entomol Soc Am 1984; 30:32-35

19. Carlson DA: Africanized and European honeybee drones and comb waxes: Analysis of hydrocarbon components for identification, chap 33, *In* Needham GR, Page RE, Delfinado-Baker M (Eds): Africanized Honey Bees and Bee Mites. Chichester, West Sussex, England, Ellis Horwood, 1988, pp 264-274

20. Daly H: Systematics and identification of Africanized honey bees, chap 2, *In* Spivak M, Fletcher DJC, Breed MD (Eds): The 'African' Honey Bee. Boulder, Colo, Westview Press, 1991, pp 13-44

21. Sylvester HA: Electrophoretic identification of Africanized honey bees. J Apicultural Res 1982; 21:93-97

22. Nunamaker RA, Wilson WT, Haley BE: Electrophoretic detection of Africanized honey bees (*Apis mellifera scutellata*) in Guatemala and Mexico based on malate dehydrogenase alloenzyme patterns. J Kansas Entomol Soc 1984; 57:622-631

23. Page RE, Erickson EH: Identification and certification of Africanized honey bees. Ann Entomol Soc Am 1985; 78:149-158

24. Lavine B, Carlson DA: European bee or Africanized bee? Species identification through chemical analysis. J Anal Chem 1987; 59:468A-470A

25. Wilson EO: Communication: Alarm and assembly, chap 12, The Insect Societies. Cambridge, Mass, Belknas Press of Harvard University Press, 1971, pp 233-246

26. Breed MD: Defensive behavior, chap 15, *In* Spivak M, Fletcher DJC, Breed MD (Eds): The 'African' Honey Bee. Boulder, Colo, Westview Press, 1991, pp 299-308

27. Stort AC: Genetic study of aggressiveness of two subspecies of *Apis mellifera* in Brazil—I. Some tests to measure aggressiveness. J Apicultural Res 1974; 13:33-38

28. Michner CD: The Brazilian bee problem. Annu Rev Entomol 1975; 20:399-416

29. Collins AM, Rinderer TE, Harbo JR, Bolten AB: Colony defense by Africanized and European honey bees. Science 1982; 218:72-74

30. Taylor OR: Health problems associated with Africanized bees. Ann Intern Med 1986; 104:267-268

31. Schumacher MJ, Schmidt JO, Egen NB, Lowry JE: Quantity, analysis and lethality of European and Africanized honey bee venoms. Am J Trop Med Hyg 1990; 43:79-86

32. Nelson DR, Collins AM, Hellmich RL, et al: Biochemical and immunochemical comparison of Africanized and European honeybee venoms. J Allergy Clin Immunol 1990; 85(pt 1):80-85

33. Schumacher MJ, Schmidt JO, Egen NB: Lethality of 'killer' bee stings (Letter). Nature 1989; 337:413

34. McKenna WR: Killer bees: What the allergist should know. Pediatr Asthma Allergy Immunol 1992; 6:275-285

35. Free JB: The stimuli releasing the stinging response of honey bees. Anim Behav 1961; 9:193-196

36. Boch R, Shearer DA, Stone BC: Identification of iso-amyl acetate as an active component in the sting pheromone of the honeybee. Nature 1962; 195:1018-1020

37. Ghent RL, Gary NE: A chemical alarm releaser in honey bee stings (*Apis mellifera* L). Psyche 1962; 69:1-6

38. Blum MS, Fales HM: Chemical releasers of alarm behavior in the honey bee: Informational 'plethora' of the sting apparatus signal, chap 17, *In* Needham GR, Page RE, Delfinado-Baker M (Eds): Africanized Honey Bees and Bee Mites. Chichester, West Sussex, England, Ellis Horwood, 1988, pp 141-148

39. Stort AC, Goncalves LS: Genetics of defensive behavior II, chap 17, *In* Spivak M, Fletcher DJC, Breed MD (Eds): The 'African' Honey Bee. Boulder, Colo, Westview Press, 1991, pp 329-356

40. Winston ML: Activities outside the nest, chap 5, Killer Bees—The Africanized Honey Bee in the Americas. Cambridge, Mass, Harvard University Press, 1992, pp 49-68

41. Snodgrass RE: Anatomy of the Honey Bee. London, Constable and Co, 1956

42. Mulfinger L, Yunginger J, Styer W, Guralnick M, Lintner T: Sting morphology and frequency of sting autotomy among medically important vespids (Hymenoptera: Vespidae) and the honey bee (Hymenoptera: Apidae). J Med Entomol 1992; 29:325-328

43. Banks BEC, Shipolini RA: Chemistry and pharmacology of honey-bee venom, chap 7, *In* Piek T (Ed): Venoms of the Hymenoptera. Orlando, Fla, Academic Press, 1986, pp 329-416

44. Schumacher MJ, Schmidt JO, Egen NB, Dillon KA: Biochemical variability of venoms from individual European and Africanized honeybees (*Apis mellifera*). J Allergy Clin Immunol 1992; 90:59-65

45. Schmidt JO: Allergy to venomous insects, *In* Graham JM (Ed): The Hive and the Honeybee. Hamilton, Ill, Dadant & Sons, 1992, pp 1209-1269

46. Light WC, Reisman RE, Shimizu M, Arbesman CE: Unusual reactions following insect stings. J Allergy Clin Immunol 1977; 59:391-397

47. Yunginger JW: Insect allergy, chap 59, *In* Middleton E, Reed CE, Ellis EF, Adkinson NF, Yunginger JW, Busse WW (Eds): Allergy Principles and Practice, Vol 2, 4th edition. St Louis, Mo, Mosby-Year Book, 1993, pp 1511-1524

48. Mejia G, Arbelaez M, Henao JE, Sus AA, Arango JL: Acute renal failure due to multiple stings by Africanized bees. Ann Intern Med 1986; 104:210-211

49. Reisman RE: Unusual reactions to insect venoms. Allergy Proc 1991; 12:395-399

50. Beccari M, Castiglione A, Cavaliere G, et al: Unusual case of anuria due to African bee stings. Int J Artif Organs 1992; 15:281-283

51. Muñoz-Arizpe R, Valencia-Espinoza L, Velásquez-Jones L, Abarca-Franco C, Gamboa-Marrufo J, Valencia-Mayoral P: Africanized bee stings and pathogenesis of acute renal failure (Letter). Nephron 1992; 61:478

52. Barnard JH: Studies of 400 hymenoptera sting deaths in the United States. J Allergy Clin Immunol 1973; 52:259-264

53. Schwartz HJ, Sutheimer C, Gauerke MB, Yunginger JW: Hymenoptera venom-specific IgE antibodies in post-mortem sera from victims of sudden, unexpected death. Clin Allergy 1988; 18:461-468

54. Freye HB, Ehrlich B: Acute myocardial infarction following hymenoptera envenomation. Allergy Proc 1989; 10:119-126

55. Valentine MD: Anaphylaxis and stinging insect hypersensitivity. JAMA 1992; 268:2830-2833

56. Chafee FH: The prevalence of bee sting allergy in an allergic population. Acta Allergol (Kbh) 1970; 25:292-293

57. Settipane GA, Boyd GK: Prevalence of bee sting allergy in 4,992 Boy Scouts. Acta Allergol (Kbh) 1970; 25:286-291

58. Golden DBK, Marsh DG, Kagey-Sobotka A, et al: Epidemiology of insect venom sensitivity. JAMA 1989; 262:240-244

59. Charpin D, Birnbaum J, Lanteaume A, Vervloet D: Prevalence of allergy to hymenoptera stings in different samples of the general population. J Allergy Clin Immunol 1992; 90:331-334

60. Jensen OM: Sudden death due to stings from bees and wasps. Acta Pathol Microbiol Scand 1962; 54:9-29

61. Forthal DN, Leong C, Overturf GD: Danger on the Los Angeles freeway. N Engl J Med 1984; 311:263

62. Butterton JR, Clawson-Simons J: Hymenoptera uvulitis (Letter). N Engl J Med 1987; 317:1291

63. Crane E: The range of human attitudes to bees. Bee World 1976; 57:14-18

64. Olkowski H, Olkowski W: Entomophobia in the urban ecosystem, some observations and suggestions. Bull Entomol Soc Am 1976; 22:313-317

65. Stoner A, Wilson WT: A review of the public's reaction to Africanized honeybees. Glean Bee Cult 1977; 105:405-408

66. Nunamaker RA: Newspaper accounts of Africanized bees are designed to frighten people—Being stung by the press. Am Bee J 1979; 119:587-592, 646-647, 657

67. Müller U, Mosbech H, Blaauw P, et al: Emergency treatment of allergic reactions to Hymenoptera stings. Clin Exp Allergy 1991; 21:281-288

68. Russell FE, Gertsch WJ: Letter to the editor. Toxicon 1983; 21:337-339

69. Hunt KJ, Valentine MD, Sobotka AK, Benton AW, Amodio FJ, Lichtenstein LM: A controlled trial of immunotherapy in insect hypersensitivity. N Engl J Med 1978; 299:157-161

70. Lockey RF: Immunotherapy for allergy to insect stings. N Engl J Med 1990; 323:1627-1628

71. 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; 323:1601-1603

72. Li JTC, Yunginger JW: Management of insect sting hypersensitivity. Mayo Clin Proc 1992; 67:188-194

73. 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; 90:335-339

74. Reisman RE: Stinging insect allergy. Med Clin North Am 1992; 76:883-894

75. Van der Linden PWG, Struyvenberg A, Kraaijenhagen RJ, Hack CE, van der Zwan JK: Anaphylactic shock after insect-sting challenge in 138 persons with a previous insect-sting reaction. Ann Intern Med 1993; 118:161-168