

Mass Envenomations by Honey Bees and Wasps

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Stinging events involving honey bees and wasps are rare; most deaths or clinically important incidents involve very few stings (<10) and anaphylactic shock. However, mass stinging events can prove life-threatening via the toxic action of the venom when injected in large amounts. With the advent of the Africanized honey bee in the southwestern United States and its potential for further spread, mass envenomation incidents will increase. Here we review the literature on mass stinging events involving honey bees and wasps (ie, yellowjackets, wasps, and hornets). Despite different venom composition in the two insect groups, both may cause systemic damage and involve hemolysis, rhabdomyolysis, and acute renal failure. Victim death may occur due to renal failure or cardiac complications. With supportive care, however, most victims should be able to survive attacks from hundreds of wasps or approximately 1000 honey bees.

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Death from honey bee or wasp envenomation is a rare event. Most often it is caused by IgE-mediated Type I anaphylaxis, and the fatal incident involves a single sting. Fatal stings usually occur in the head or neck; death typically occurs from hypotension, laryngeal edema, or bronchial constriction within 1 hour, and the typical victim is over 40 years of age, with arteriosclerosis playing a contributing role.¹ Less commonly, death occurs from the toxic effects of massive envenomation involving hundreds to thousands of stings. Here we review incidents of massive envenomations and discuss the differences between bees and wasps, their venoms, and potential for danger. With the recent arrival of the Africanized honey bee in the United States (the states bordering Mexico² and, recently, Nevada) as well as the potential for their spread in the southeastern United States, there is concern that the incidence of stinging deaths will increase.

Bee vs. Wasp

Both bees and wasps inflict painful stings, but it is useful to distinguish one from the other. In the medical literature one repeatedly encounters confusion over the insect responsible for stinging. We clarify the distinction, which may be important for proper treatment.

Most bees and wasps (both of the insect order Hymenoptera) live solitary lives and are not predisposed to sting humans. The greatest threat to humans is posed by a few species of social bees—mainly honey and bumble bees (Family Apidae); and social wasps—hornets, yellowjackets, and paper wasps (Family Vespidae);

which produce large colonies of sterile workers. Nests of paper wasps (*Polistes*) and bumble bees typically contain only 100–200 insects and are not often involved in mass stinging events, so they are not discussed in this review.

The typical hymenopteran stinging event occurs when a single insect, usually a yellowjacket wasp, is disturbed while searching for food. This usually occurs in the late summer and early fall, when large numbers of hungry yellowjackets are attracted to the food of humans eating outdoors.³ Any wasp or bee will sting in defense if it is accidentally stepped on, swatted, or otherwise disturbed.

In contrast, mass envenomations occur when stinging insects respond to a human intruder as a threat to their colony. Typically, this happens when someone inadvertently stumbles into a colony or otherwise disturbs the structure in which they live (eg, by throwing rocks at, shooting at, or chopping a tree containing the colony), whereupon hundreds or thousands of stinging insects may issue forth in defense.

Originally a European and African species, the honey bee, *Apis mellifera*, is used throughout the world by beekeepers; therefore, it is the bee species most commonly involved in stinging incidents. Additional envenomations have been recorded from other honey bee (*Apis*) species in Asia, including the Asian honey bee (*A. cerana*) and the giant honey bee (*A. dorsata*). All honey bee species live in colonies of several thousand workers. Managed honey bee colonies consist of about 40,000 workers, with Africanized honey bees having slightly smaller colonies.

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Yellowjackets (*Vespula* and *Dolichovespula*, 10–15 mm in length) and hornets (*Vespa*, 15–40 mm) maintain colonies of several hundred to a few thousand individuals.⁴ In comparison to yellowjackets, which maintain comparatively larger colonies, *Vespa* hornets are more dangerous because of their greater venom injection capability and greater venom toxicity. *Vespa* wasps are distributed mostly in Europe and Asia,⁴ with one species (*Vespa crabro*) established in the northeastern United States.⁵ Yellowjackets are originally holarctic in distribution, but have become established in tropical and subtropical regions such as Australia, New Zealand, Hawaii, South America, and South Africa, where they have become serious economic pests.⁶

Sting versus Bite

A sting is delivered by a posterior, tapered, needle-like structure designed to inject venom. In contrast, a bite is delivered with mouthparts. Scorpions, ants, bees, and wasps have stings. The stings of bees and wasps are painful and potentially dangerous, whereas their bites cause minor irritation. Ants may cause damage with both a venomous sting and a noxious bite.⁷ Spiders and centipedes have venomous bites that inject venom through specialized oral structures such as fangs.

Honey bee stings have an unusual specialization: their stings are strongly barbed and are designed to remain imbedded in mammalian flesh, whereas wasp stings are not. This presence or absence of a detached sting can aid in determining whether envenomation is caused by bees or wasps. This can be critical in allergic individuals, since the venom allergens differ between the two insect groups. However, in mass envenomations involving a nonallergic victim, there is less of a need to make this distinction; although the venom dose lethal to 50% of victims (LD_{50}) differs amongst the insects, clinical care can be guided by symptomatic treatment based upon the degree of systemic toxicity.

Venom

As reviewed by Banks and Shipolini,⁸ honey bee venom is similar among the different *Apis* species, with minor variations in component quantities. Melittin (50% by dry weight) is the main pain-inducing compound, which functions by altering membrane integrity. The larger molecular-weight enzyme, phospholipase A_2 (11%), works in concert with melittin; it has no cytolytic effect by itself.^{9,10} These two components are responsible for red-cell hemolysis. Once melittin has disrupted the membrane, phospholipase A_2 cleaves bonds in the fatty acid portion of the bilipid membrane layer; it also is the major allergen in bee venom. Mast-cell degranulating protein (2%), as its name implies, causes mast cells to break down, releasing histamine. Hyaluronidase (1%–2%) is a secondary allergen; it also disrupts the hyaluronic acid connective-tissue matrix, making it a “spreading factor” that allows the other venom components to infiltrate tissues. Hyaluronidase is a component found in the venoms of a variety of evolutionarily

diverse animals (eg, snakes and spiders).¹¹ Additional enzymes include acid phosphatase (1%) and lysophospholipase (1%). Bee venom also contains a neurotoxic peptide, apamin (3%). Histamine is only a minor portion of bee venom (0.7%–1.6%); histamine reaction from honey bee envenomation is due to endogenous release initiated in the victim by other venom factors.

Because of the greater taxonomic diversity of wasps, wasp venoms are more variable in their composition among species. In general, they contain active amines (serotonin, histamine, tyramine, catecholamines); wasp kinins (similar in composition to bradykinins), which are mostly responsible for pain; and histamine-releasing peptides (mastoparans), which are responsible for the inflammatory response. Of the allergens, “Antigen 5” is the most active. Of the lesser active allergens, phospholipase A and B cleave the fatty acids of the bilipid layer at the 1 position, and hyaluronidase is a spreading factor.^{12,13} Some wasp venoms have neurotoxins (eg, mandaratoxin in *Vespa mandarinia*), and the venom of a few species contains acetylcholine.¹²

Mass Stinging Incidents

Most of the mass envenomation cases reported in the medical and entomological literature involve hundreds of stings, many resulting in toxic systemic reactions and renal failure.^{14–55} Often, the sting totals reported in the literature are estimates or are counts of the *minimum* number of stings removed from the victim. Some case histories were excluded from this study because sting totals were listed ambiguously (eg, “numerous”, or “dozens”) although one case history²³ reported as “multiple” involved 150–250 stings (B. Ariue, MD, Department of Pediatrics, Kaiser Permanente, Lancaster, CA, written communication, 1997). We also omitted a few mass stinging incidents in which death occurred within 1–2 hours, because death in these cases was probably due to anaphylaxis rather than venom toxicity.

Massive wasp attacks range from tens to hundreds of stings whereas honey bee attacks can reach several thousand stings, reflecting differences in colony size (Fig. 1). Stings in the head and neck predominate because these insects preferentially attack these areas. Renal failure or death may occur in the range of 20–200 wasp stings and 150–1000+ honey bee stings (Fig. 1). In cases where it was not reported whether acute renal failure (ARF) developed, death may have quickly occurred before systemic damage was evident. The human LD_{50} for honey bee stings has been estimated to be between 500–1200 stings.^{56,57} With medical treatment, many victims with 1000+ honey bee stings have survived.^{14–22}

Only a weak relationship exists between age and the outcome of mass sting attacks (Fig. 2). Both older and very young victims appear to succumb more easily to bee stings but not wasp stings—but the scant and variable data cannot resolve this. Surprisingly, despite children’s small body mass, several stinging incidents of 200–1000+ honey bee stings with subsequent hospitalization resulted in recovery.^{22–24}

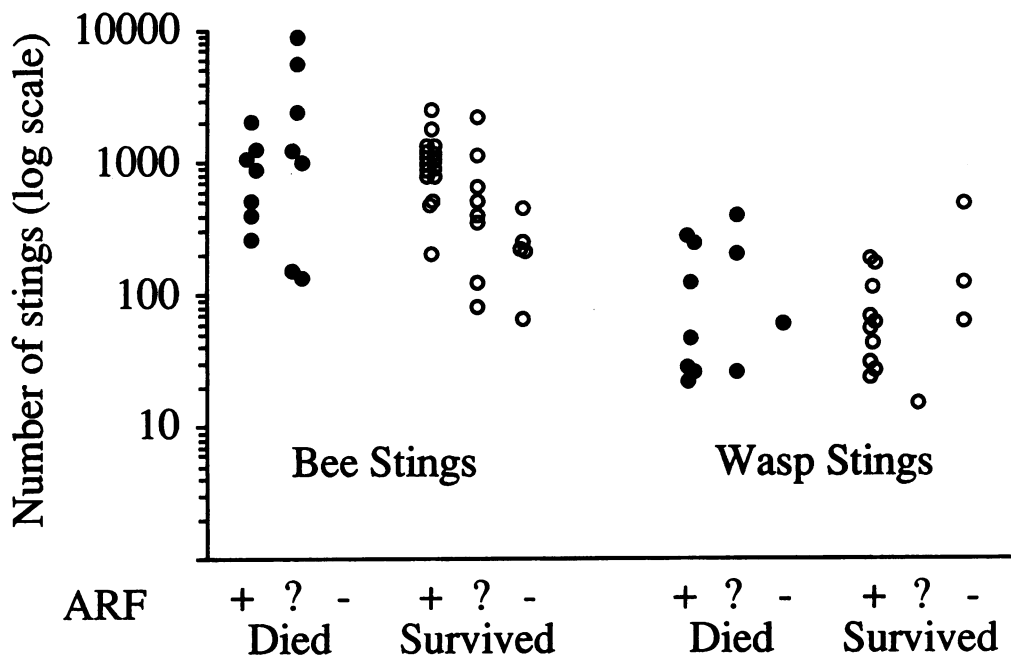


Figure 1.—The number of bee or wasp stings is plotted against the outcome of the stinging incident (died ●, survived ○). Under categories of “died” or “survived”, the data are separated into categories of whether acute renal failure (ARF) was observed (+), did not occur (–), or was not evident from the case history (?). Sting estimates were scored as 110% of the reported numerical value for ease of graphing (eg, “1000+” is displayed as “1100” on the graph); in cases of multiple overlapping values, the data points are clustered around the value as best possible).

Children still are at high risk because they are more likely to be stung due to carelessness, and are less able to escape when stung.

Clinical stinging attacks from wasps involve fewer insects, but there were more deleterious effects from their stings than from a similar number of honey bee stings (Fig. 1). Deaths from massive wasp attack^{25–32} are most often the result of attacks by *Vespa orientalis* and *Vespa affinis*. These large eastern hemisphere wasps have killed, via acute venom toxicity, with less than 300 stings. Mammalian toxicity tests on mice show that honey bee venom LD₅₀ (3 mg/kg) is about equivalent to that of the larger hornets (*Vespa* spp), and yellowjacket wasp (*Vespula* [= *Paravespula*] spp) venom is about 3-fold less toxic.⁵⁷

Pharmacological Effects of the Venom

In individuals who are not allergic to venom, small numbers of stings cause little systemic damage, and the response is limited to a localized wheal at the sting site, with edema, erythema, and pruritis. Symptomatic treatment is all that is required.

Despite differences between bee and wasp venoms, their pharmacological effects are somewhat similar. In massive envenomations, initial symptoms include edema, fatigue, dizziness, nausea, vomiting, fever, and unconsciousness. Endogenous histamine response can cause quick onset of diarrhea and incontinence;^{19,33,34} in

one case the victim defecated bees he had swallowed while still under attack.¹⁹ Systemic damage may develop within 24 hours, although there are instances of delayed onset (2–6 days).^{35,36} Systemic effects include hemolysis with its associated hematuria and hemoglobinemia. Rhabdomyolysis may occur, leading to serum elevations of creatinine phosphatase (CPK) and lactate dehydrogenase; CPK levels of 91,000 IU/liter have been reached within 24 hours of mass stinging by bees (normal <160 IU/liter).¹⁶ The venom does not appear to affect the smooth or cardiac muscle.³² Hepatic serum enzyme levels may be elevated. Thrombocytopenia can occur without evidence of disseminated intravascular coagulation.³⁶ Oliguria and ARF due to acute tubular necrosis are common (Fig 1). Damage is usually reversible, responding well to dialysis; complete recovery may require 3–6 weeks. Although typically indirect renal damage is thought to result from the breakdown of blood cells or muscle tissues, there may be a direct nephrotoxic effect since ARF can occur without rhabdomyolysis or hemolysis.^{14,37} Other symptoms include muscular aches, cramps, hyperkalemia, hyperglycemia, and hypertension. In contrast, a pediatric case of 120 German yellowjacket (*Vespula germanica*) stings in a 3 1/2-year-old child showed no serum abnormalities but instead showed central nervous system aberrations (eg, hallucinations).³⁸

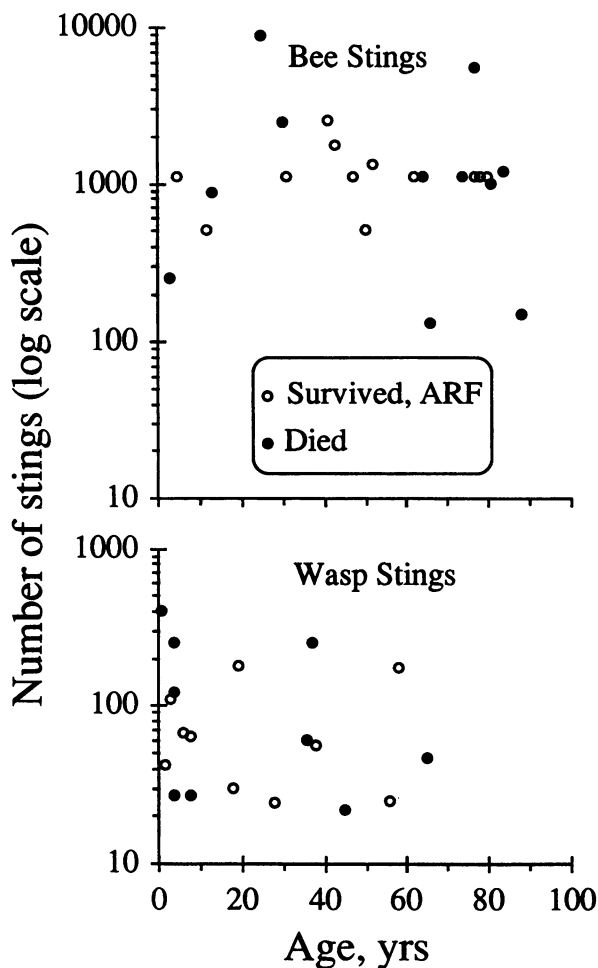


Figure 2.—The number of bee and wasp stings is plotted against age showing envenomations resulting in death (●) or survival with renal damage (○). Case reports from Figure 1 where renal failure did not occur or could not be definitively determined from the report were not included here. Sting estimates were scored as 110% of the reported numerical value for ease of graphing (eg, "1000+" is displayed as "1100" on the graph); in cases of multiple overlapping values the data points are clustered around the value as best possible.

Death has occurred within 16 hours to 12 days after the stinging incident for honey bee stings,^{18,21,39–44} (An 88-year-old female died 4 days after receiving 100–200 Arizona Africanized honey bee stings; a 66-year-old convalescing male died 12 days after receiving about 130 stings [J. O. Schmidt, PhD, US Department of Agriculture, written communication, 8 October 1997]). Death has occurred within 4 hours to 9 days for wasp stings.^{25–32,45} Fatalities are typically the result of renal failure due to breakdown products of hemolysis, myolysis, and the ensuing renal damage; or from cardiac arrest due to complications of the venom toxicity. Fatal cases include victims who

were sent home after initial examination, only to return the next day with graver symptoms.^{25,28}

Emergency Assessment and Treatment of a Mass-Envenomated Victim

Mass envenomations only occur near colonies of stinging insects. If attacked by large numbers of stinging insects, a person's best defense is to run away from the colony as quickly as possible, as the insects will not continue pursuit outside their territorial range. Honey bees will leave detached stings in the victim, and these should be removed as soon as possible by whatever method is quickest. Erroneous conventional medical advice states that the venom sac should never be squeezed, since this purportedly injects more venom into the victim; however, this was recently shown to be incorrect.⁵⁸ Removal of bee stings that have been embedded for more than one minute will have little or no effect in reducing envenomation since most of the venom empties from detached honey bee stings within 10–20 seconds.⁵⁹ Emergency personnel should be alert to living bees or wasps still entangled in the victim's clothing,^{38,46} since this could create additional problems by exposing hypersensitive attending medical personnel to stings.

Blood chemistry studies performed over a period of hours to days will reveal whether toxic venom effects have occurred. Particular attention should be paid to serum levels of hemoglobin and myoglobin. Patients should be admitted for observation, as delayed onset of serious symptoms may occur. If a victim is involved in a mass stinging incident of several hundred wasp stings or 1000+ honey bee stings, careful observation in a hospital setting and supportive care will often be sufficient to overcome the toxic effects of the venom, and most patients can be expected to recover.

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