Bee and Wasp stings

Introduction

New Zealand is fortunate to have very few stinging insects. These are members of the hymenoptera in which the ovipositor has been modified into a sting delivering venom and are known collectively as Aculeata. There are 29 native solitary hunting wasps, most of which hunt spiders as food for their offspring and are not known to be aggressive towards people. The native solitary bees amount to 18 species of Leioproctus, seven Hylaeus species and four species of Lasioglossum. All these solitary insects, evolved to use their venom in small amounts for subduing other insects, (not mammals) or in a limited defensive effort. It is the introduced social species from the Aculeata that are mainly responsible for stings to humans. These insects manage a communal defensive effort directed specifically at mammalian predators (like people) and so employ toxins and strategies that are effective against mammals, sometimes fatally so. These introduced animals include four species of wasp, a similar variety of bumblebees, and the honeybee. The honeybee is unique in that an individual can only sting once, and then dies. A wasp or a bumblebee is able to sting repeatedly. All of them defend their nest sites by deploying many individuals to attack the aggressor. Insect repellants (like DEET) are not effective on hymenoptera.

The incidence of stings varies with your location and the season. Wasps' stings are the most numerous, particularly in the late autumn when they actively hunt at picnics and barbeques, dive into soft drink tins, rubbish, and consume the sweet saps from garden plants and trees. Honeybee stings are less numerous and more common in the spring, but it depends on the setting (urban, rural, orchards etc). Bumblebee stings are infrequent, often in mid to late summer when the nests are disturbed as a result of being bigger and more obvious, or because it's a 'tidy-up' time for people and their gardens. The reporting of incidents leaves a little to be desired. Fortunately wingless wasps that look like ants don't figure in the statistics. Most people are unable to tell a 'wasp' from a 'bee'. A few can identify a bumblebee (there are several kinds), and only the most studious could distinguish a 'paper wasp' (either of them) from one of the vespulae. Many claim not to have seen what 'bit' them in any case.

In some respects the venoms from the three are very similar, and how an individual will react, or needs to be treated, can also very similar. An allergic response to one can mean the individual will be allergic to the others. However, it's not a rule; there are also significant differences between them. Honeybee (Apidae: Apis) venom has been collected for centuries and is consequently the most studied. Mellitin, Apamin, and a peptide that degranulates mast cells are unique to honeybee venom. Wasp (Vespidae/Polistinae) venom contains different phospholipases, and a unique antigen. Bumblebee (Apidae: Bombus) venom is different from both of these, but has some similarity. Consequently there are separate preparations available for testing hypersensitivity or desensitizing. Almost all reactions to stings are allergic responses, even though we don't commonly use the phrase.

Venom biochemistry

Bee venom is a blend of components including two peptides, several acids, histamine, dopamine, noradrenaline, tryptophan, sulphur, some minerals,oils, and enzymes. Fifty percent of the dry weight of honey bee venom is mellitin. Mellitin is a chemical that is unique to bee venom and is cytolytic, which means that it bursts cells (the little red 'dot' at the sting site is burst red blood cells). Mellitin also dilates blood vessels, leading to low blood pressure. Twelve percent of honey bee venom is Phospholipase A_2 (the most potent allergen). Phospholipases are enzymes that help mellitin destroy cell membranes. Apamin is also unique to bee venom (3%) and is a neurotoxin. Hyaluronidase (2%) is an enzyme that breaks down hyaluronic acid, which is one of the components of the tissue in between your cells that hold them together. Hyaluronidase contributes to the "spread" of the reaction. Mast cell degranulating peptides cause the special 'mast' cells in your body (part of your immune response system) to release the many biochemicals (including more histamine) in their granules. Histamine causes 'leaky' capillaries and contributes to the slightly raised red area that itches in sensitive individuals. In wasp venom the major unique components are phospholipase A_1 and B, $antigen_5$, acetylcholine, and serotonin.

Many of these proteins are also recognized as foreign by the human immune system (antigens) and lead to a response from the body's immune system. The 'first responders' are the lymphocytes. Lymphocytes come in different types. Their surfaces recognize things that belong and things that don't and they respond in two ways to things that don't. They will release antibodies which 'label' the foreign matter so that some action can be taken against it, and they will produce more lymphocytes which are there as a form of 'memory' of the event. A ‘normal’ response produces immunoglobulinG (IgG); an allergic response produces ImmunoglobulinE (IgE).The mast cells too play an early role. Mast cells are covered in immunoglobulinE antibodies and come ‘pre-loaded’ with histamine, serotonin, protein-destroying enzymes, the anticoagulant heparin, and slow acting leukotrienes, prostoglandins, and cytokines. In response to IgE mask cells disintegrate, liberating their contents. People all produce different amounts of IgG or IgE in response to different ‘invaders’, and what the antibodies ‘recruite’ to aid their effort varies between individuals, so the range of response is very different and depends on the venom, the dose, the site, the individual’s physiology, and even their psychological state.

The venom from a sting therefore has a direct physical effect on surrounding tissue, but also causes a response in the body that may or may not magnify that effect. For example, the venom itself will destroy mast cells and release their contents to have a local effect, but the body’s immune system can also start to produce immunoglobulins that will degranulate mast cells remote from the venom site and create a system-wide (systemic) effect. The table below shows the range of possible reactions to a sting.

Reactions	Reacting Immunoglobulins	Onset Times	Clinical Manifestations
Local	IgG	4-48 hours	Painful, pruritic, & oedematous sting lesions, 2.5-10cm in diameter.
Systemic	IgE	12-24 hours	Headache, fever, nausea, vomiting, diarrhea.
Toxic	IgE	½-1 hour	Systemic symptoms, syncope, seizures, hemolysis, rhabdomyolysis, acute tubular necrosis with renal failure.
Allergic	IgG	12-24 hours	Initial wheal & flare response at sting sites, followed by painful, pruritic indurated lesions.
Anaphylactic	IgE	10-20 min up to 72 hours	Generalized urticaria, angioedema, dysnpea, bronchospasm, inspiratory stridor, wheezing, chills, fever, apnea, respiratory failure, hypotension, cardiovascular collapse, rarely disseminated intravascular coagulation.
Delayed (Apis only)	IgG	2-14 days	Headache, malaise, low-grade fever, generalized lymphadenopathy, polyarthralgias, serum sickness & thrombotic hrombocytopenic purpura possible, rarely peripheral neuropathy.

(After Diaz, 2007.)

Minimising the dose

There is a basic difference between honeybee stings and the others in terms of the construction of the ‘apparatus’. A wasp or bumblebee’s stinger has no barbs. This means that the insect can withdraw her stinger, and is able to sting again. In contrast, a honeybee can not withdraw her sting. The sting consists of two barbed lancets and a stylet, and the venom gland discharges into a space in between the lancets and stylet, and venom can only travel down this shaft as movement in the opposite direction is prevented by valves. The venom sac has no musculature; the muscle associated with the sting is attached to plates which drive each lancet in turn forward with respect to the stylet, the stylet supporting each using a sort of 'monorail' connection. Once the sting has become caught in the skin the bee can't escape without it becoming dislodged from her body, and as that happens, the Dufour and Koschevnikov glands are torn out and remain with the trapped sting. The later gland produces isopentyl acetate, the 'banana' scented pheromone beekeepers are familiar with. This marks the site and stimulates other bees to sting. The lancets meanwhile, are driving themselves, one by one, deeper into the skin and continue to dispense venom.

Do not overlook the fact that the most important response to stings from wasps or bees defending their nests should be to get away from the vicinity of the nest. Getting to safety is more important than removing stings immediately, but stings should removed as soon as possible once a person is away from the area. The method of removal does not affect the quantity of venom received by the subject. Much of the advice commonly given regarding the immediate treatment of bee stings derives from a misunderstanding of the structure of honey bee stings. Conventional wisdom says to scrape bee stingers away from the skin because pinching the venom sack could push extra venom into the victim. In fact, how fast you get the stinger out is much more important than how, and in a small number of cases, the scrape treatment results in breaking the sting lancets from the rest of the sting, with the lancets remaining in the subject's flesh. The method of removal is irrelevant, but even slight delays in removal caused by concerns over performing it correctly (or getting out a knife blade or credit card) are likely to increase the dose of venom received. The advice is to simply emphasize that the sting should be removed, and as quickly as possible, within a couple of seconds. A fingernail is the most convenient tool; just scrape or flick the sting away. If you think you can get your credit card out that quickly, 'lets do lunch'. The exception to this advice is in the case of a sting to the eyeball or eyelids. A sting to the eyeball should only be removed using microscopy, by an expert; and sting to the eyelid can be removed but must be examined in the same way to ensure remnants do not damage the eye's surface.

If the sting is followed by severe symptoms, or if it occurs on the neck or mouth, seek medical attention immediately because swelling in these areas of the body can cause suffocation. Stings directly into blood vessels can cause a very rapid cardiopulmonary escalation and systemic response. Occasionally, someone can be stung many times before being able to get away. Depending on the number of stings, the person may just hurt a lot, feel a little sick, or feel very sick. Humans can be killed if stung enough times in a single incident. With honey bees the toxic dose (LD50) of the venom is estimated to be 19 stings per kilo of body weight. Obviously, children are at a greater risk than are adults. In fact, an otherwise healthy adult would have to be stung over 1,000 times to be in risk of death, but half that can make you very sick. Most deaths caused by multiple stings have occurred in victims who were known to have poor cardiopulmonary function. A second, potentially life-threatening result of multiple stings occurs days after the incident. Proteins in the venom act as enzymes: one dissolves the 'cement' that holds body cells together, while another perforates the walls of cells. This damage liberates tiny tissue debris that would normally be eliminated through the kidneys. If too much debris accumulates too quickly, the kidneys become 'clogged' and the patient is in danger of dying from kidney failure. It is important for people who have received many stings in one event to discuss this secondary effect with their doctors. (Wasp stings are as potent in this respect as bee stings.) Patients should be monitored for a week or two following an incident involving multiple stings to be certain that no secondary health problems arise.

Treating the sting

Most reactions are local and confined to the general area of the sting with pain and a swollen itch, but over 24 – 48 hours they can develop into a much larger area (sometimes the entire extremity. A few hours after the sting more redness, oedema (swelling), and itching develop. Over 12 – 48 hours, the area can become quite swollen, painful, and may also have some associated bruising. The swelling generally begins to resolve after two days, but the site may remain tender (and continue to itch) for a few more days. The total reaction lasts 4 – 7 days. Large locals around the face and mouth or on the hands may cause temporary disability. The large local is IgE-mediated, and therefore is an allergic response. Treatment of local reactions includes ice and elevation with non-aspirin containing analgesics (Ibuprofen), both H1 and H2-receptor blocking antihistamines (diphenhydramine, (Benadryl), famotidine, ranitidine, and non-sedating ones, such as fexofenadine (Allegra), loratidine (Claritin), and ceterizine (Zyrtec), and, occasionally, systemic corticosteroids, such as methylprednisolone, or prednisone, in doses tapered over 2-3 days. Aspirin-containing analgesics should be avoided because both bee and wasp stings may be complicated by local subcutaneous hemorrhage. Taking anti-histamine or a leukotriene-receptor antagonist very soon after the sting may decrease the late phase reaction. Leukotriene-receptor antagonists' montelukast (Singulair) and zafirlukast (Accolate) block the leukotriene receptors on mast cells and eosinophils and both have peak activity 3 – 4 hours after taking them. In one study of six allergic beekeepers, the skin within their large local reaction and their blood and urine were analyzed 2 hours after a bee sting. Three of them had high histamine levels and the other three had high leukotriene levels, suggesting that allergic beekeepers *either* have high histamine release *or* increased leukotriene production, but not both. This implies that about half of beekeepers who have large local reactions might benefit from the immediate administration of a leukotriene inhibitor, whereas the other half would benefit from anti-histamines before or very soon after the sting Oral steroids are useful in treating large locals to stings around the face and hands. The small blisters sometimes formed on the sting wound should be left alone. It is possible to infect the wound if bits of the sting shaft remain or if adequate cleanliness is not observed.

Topical treatments

Many local and traditional remedies have been recommended for initial management of <u>local</u> hymenopteran stings including the topical applications of tobacco poultices, vinegar, baking soda and salt, aluminum sulfate, and papain, or meat tenderizer. As a rule the clinical activity of all topical treatments for hymenopteran stings (other than ice) is poor, or absent. The more popular ones include;

Antihistamines. Histamine is one of the main mediators of the inflammatory response so treatment with antihistamines is indicated. Several topical products containing antihistamines are available for treating the pain, itching and inflammation caused by bites and stings. However, topical antihistamines have been criticized as not being very effective. They are also liable to cause sensitisation so should not be used more often than two or three times a day for up to three days. Oral antihistamines are more likely than topical preparations to bring sustained and effective relief.

Hydrocortisone. This has anti-inflammatory activity and hydrocortisone cream is available for treating itching caused by insect bites. However, its usefulness is limited by the directive to limit use to two applications daily, as more frequent application may be necessary to sustain relief. It is not appropriate for use in children under 10 years of age. Once again, oral administration of a corticosteroid, say, prednisone (by prescription), is a more effective treatment.

Calamine and zinc oxide. Calamine is made from zinc carbonate with ferric oxide, which is what gives it the characteristic pink colour. It is mildly astringent and its soothing anti-itching action is due to the large surface area and porous nature of its particles, which promote the evaporation of water to cool the skin. Calamine Lotion BP also contains 0.5 per cent phenol which has a local anesthetic action. Calamine has been used for generations for treating hives and itching from many causes, including insect bites. It is cheap and there are few restrictions on its use. Zinc oxide has similar properties.

Ammonium sulphate solution (Stingose). This has been claimed to have a de-naturing effect on the proteins introduced by bites and stings, but the claim dates back to one academic paper in 1980 and should be treated with considerable skepticism. There is little or no objective evidence of its effectiveness (except, perhaps, for stings in the marine environment from jelly fish nematoblasts) nor is there a credible explanation of how it would work in the case of subcutaneous terrestrial stings.

Systemic, toxic and anaphylactic responses

A systemic reaction can be mild and manifest as purely cutaneous (skin) responses like hives (but distant from the sting site) and typically involves the trunk or scalp, and/or a rapidly-developing swelling of the face. Gastrointestinal symptoms may also occur, and include a metallic taste, nausea, vomiting, diarrhea, and abdominal cramps. Attendant neurologic symptoms include light-headedness, dizziness, (which can also have a cardiovascular cause) and tremor. "Systemic and toxic reactions to stings should be managed with supportive care, including oxygen and intravenous fluid therapy, and pharmacotherapy with intravenous analgesics, H1- and H2-receptor blocking antihistamines, and corticosteroids. Anaphylactic reactions must be managed promptly with immediate airway and circulatory support, including subcutaneous and intravenous vasopressors, specifically adrenalin, and intravenous fluid resuscitation." That's another way of saying "You need to be in hospital."

All patients at high risk of any systemic allergic reaction to hymenopteran stings, even those who have undergone successful venom immunotherapy, should carry an emergency kit containing pre-filled adrenalin syringes while outdoors and wear a medical alert identification bracelet or tag. Adrenalin must never be injected intravenously, and preferably, not subcutaneously, only intramuscularly. Patients must be cautioned against injecting adrenalin solutions into their fingers, which could result in ischemic distal digital necrosis, over superficial veins, which could result in rapid vascular up-take, or near the sciatic nerve in the upper, lateral quadrant of the buttocks. A study done in Canada showed that adrenalin for first-aid treatment of anaphylaxis in infants using the ampoules/syringe/needle method is not practical. Most parents were unable to draw up an infant adrenalin dose rapidly or accurately. Someone operating under stress is also unlikely to be able to give the correct dose, but an adult body mass will be more tolerant of small mistakes.

Fortunately anaphylaxis is a rare event. In the US about 80-90 people a year are killed by lightening (in NZ it's less than one), and around 40 people die from insect stings (less than half are honeybee stings). In the general population somewhat less than one per cent are likely to be hypersensitive. The prevalence of hypersensitivity reported is not adjusted for climatic differences between regions or countries, and doesn't account for the temporal or geographical distribution of Hymenoptera.

Ocular stings

Sting injuries have long been recognized as a significant source of eye trauma. Sting injuries can affect a variety of ocular structures, and patients typically present with an acutely painful red, watery, swollen eye. The area may be indurated (firm and nodular) around the site of sting, and the retained stinger may be visible.

In addition to the immunological and toxic effects the eye can suffer significant mechanical harm. The stinger is composed of hard chitin. As noted, the honeybee's sting is barbed and cannot be withdrawn, and while wasps and bumblebees do not possess a barbed stinger, portions of this structure may occasionally break off and remain in the tissue. Direct injuries to the lid may involve penetration of the tarsus, in which case not only will there be a reaction to the venom, but also the disembodied stinger may damage the corneal surface. Sting injuries to the ocular structures therefore often result in a puncture wound and infection from a foreign body. Ocular complications include a retained foreign body, conjunctivitis, corneal swelling or perforation, bleeding, uveitis, blistering of the conjunctiva (chemosis), painful corneal inflammation, pupil dilation, optic nerve swelling and damage, including acute and irreversible demyelination of the optic nerve, cataract formation (notably with wasp stings), and deformation of the lens iris and cornea.

Retained stingers should be removed carefully and the area should be cleaned. Removal of the stinger with a jeweler's forceps under biomicroscopy is the only sure way. Cold compresses may be helpful in limiting the secondary inflammatory response. Ice (wrapped in cloth to avoid freezing the skin) should be applied for no more than 20 minutes every hour. Oral antihistamines and anti-inflammatory agents help control associated itching and pain. In addition, more frequent administration of potent steroids for treating uveitis aggressively and proactively has been recommended to help prevent long-term effects, like cataracts, iris atrophy and glaucoma. In particular, for victims with toxic optic neuritis, early intervention with a three-day course of intravenous methyl-prednisone followed by a tapered dose of oral prednisone over seven additional days has been shown to help patients recover their sight following this type of trauma.

Beekeepers

Beekeepers have a significantly higher probability of being stung, and a far greater exposure to bee-related antigens than the general population. They have a greater risk of allergy and anaphylaxis; various studies have suggested rates of allergy between 17-43%. In a study of German beekeepers 4.4 % reported systemic reactions to bee stings (allergic reactions), 75.6 % reported mild local reactions, and 18.6 % had no reactions to bee stings. Curiously, 25.3 % of the beekeepers reported more severe reactions to bee stings in spring than in later months. There are few studies, but this one also tried to determine what factors might explain the range of values and the risk factors that appear to predict allergy. This analysis revealed that the most significant factors, in descending order of importance, were symptoms of upper respiratory allergy while working with beehives, susceptibility to allergies in general, time spent as a beekeeper, fewer than ten stings per year, and more severe non-allergic reactions to bee stings in spring. In addition, age, and body mass (but not sex), were inversely correlated with the probability of a systemic reaction, but could not be used as a predictive factor. Using the main factors identified by the study the researchers could correctly classify the allergic reactions in 85.2% of the cases. When comparing studies, much of the variance in the incidence of allergy reported could be successfully explained by the age of the beekeepers used by the different studies. To put all this another way, if you are a new beekeeper, young and skinny with a history of other allergies, and develop respiratory or skin problems when handling bee equipment and haven't been stung much, then your risk of having a systemic reaction one day is much greater compared to the big crocodile-skinned old geezer who hasn't worn gloves in years and drinks too much beer (but it should decline as you become a crocodile-skinned old …). It might be wise to make sure someone knows when and where you are working with bees

About 25 % of beekeepers have high anti-bee venom IgE levels, and all beekeepers have increased anti-bee venom IgG. Despite this, anaphylaxis to bee stings only occurs in a minority of these individuals and we don't know why. Repeated exposure to the venom leads to a change in the way the lymphocytes in the immune system react to the particular offending antigen. The cells switch antibody production from allergic IgE to non-allergic IgG which cannot cause mast cell activation, and there is no subsequent anaphylaxis. Controlled venom immunotherapy is very successful at 'de-sensitising' individuals who have become hypersensitive.

Even without considering immunology, being stung is, at best, irritating. In the case of stings to the face they can be debilitating, and especially around or on the eyes, permanently disabling. Mass stinging events can be life threatening. Beekeepers use several methods to mitigate the risk, avoidance (by good technique), evasion (planning an escape route), and physical protection (Personal Protective Equipment - PPE). Beekeepers are able to breed strains that show a considerable difference in their propensity to sting and generally select calm, peaceable populations to work with.

The most essential of these strategies is to use a well designed veil; we have seen how dangerous a sting to the eye can be. Consider that dark glasses will make the face and eyes a target. Bees that get in under the veil, or get tangled in hair, are best dispatched between finger and thumb. If a lot of bees get in (not just one or two), walk away, if possible cover your eyes and face with your hands and remove the veil to let the bees out. Clothing fulfills various needs (not just protection), and should be practical, comfortable, washable, and light-coloured, and should not trap bees in the fabric or on the inside! Knowledge of bee behaviour allows a beekeeper to anticipate how bees react to visual cues and scents so that, for example, movements are conducted with finesse, and colours, perfumes and smells that disturb the bees are not used or masked. Gentle techniques, and the act of timing hive manipulations favourably, develop with experience. Stings and any squashed bees are best removed and the site smoked so that guarding bees are not encouraged to sting. Hive design and construction, and position, the weather, bee-forage, and the seasonal life-cycle of the colony and its neighbours all contribute to the need for a colony to heighten or lower its defensive response to a beekeeper's attentions. It is unwise try to 'work though' a situation where stinging or robbing is getting out of hand.

Caring for others

Plan and prepare your response in advance. Communication, transport, supervision, etc.

After a sting…

Get you and the victim away to a safe area

Remove the sting as quickly as possible

Relieve the local symptoms with ice, calamine, ibuprofen and liquid/tablet antihistamine as required/available.

Observe, and take action if you see

- Stings to the eye, mouth or throat
- Swelling of lips, neck, face, or eyes when they have not been stung
- Hives or welts
- Abdominal pain, vomiting

ACTION

- Stay with patient and call for Ambulance
- Give medications if prescribed (eg. Antihistamines)
- Locate EpiPen® or EpiPen® Jr if prescribed
- Contact emergency contact/parent/carer
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WATCH FOR SIGNS OF ANAPHYLAXIS (severe allergic reaction)

- Difficulty / noisy breathing
- Swelling of tongue
- Swelling / tightness in throat
- Difficulty talking and / or hoarse voice
- Wheeze or persistent cough
- Loss of consciousness and / or collapse
- Pale and floppy (young children)

DO NOT GIVE YOUR PRESCRIPTION MEDICINES TO SOMEONE ELSE

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