
Allergy to Biting Insects

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Allergic reactions to biting insects mediated by IgE antibodies are generally considered to be relatively uncommon. There are only a handful of convincing reports in the literature of reactions to bites of mosquitoes and fleas. A small number of cases of allergy to bites of other flies have been reported as well as 2 cases of bedbug allergy. The biting insect that was most commonly cited as causing the allergic reactions reported in the literature and in the Registry of Reactions to Insect Bites run by the Committee on Insect Allergy of the American Academy of Allergy and Immunology was the kissing bug (*Triatoma* spp, also called reduviid bug and cone-nose bug).¹ Two recent studies performed in a community that contained prime habitat for *Triatoma* demonstrated a prevalence of IgE antibodies against *Triatoma protracta* in 6.7% of the population studied.² In the same population 3.3% demonstrated IgE antibodies to honeybee and/or yellow jacket venom.³

Most of the literature on biting insect allergy consists of case reports or summaries of uncontrolled clinical experiences, so that it is very difficult to evaluate critically. There are, however, classic studies of bite reactions in animals by Feinberg et al,⁴ and modern scientific investigation of true allergy to flea bites in dogs is now being initiated.⁵

In this review we will examine the following: how saliva (oral secretion) antigens can be obtained from biting insects; the normal spectrum of reactions to insect bites; a critical evaluation of reports of allergy to bites from various types of insects; biting insect allergens, the relationship to stinging insect allergy; and the treatment and prevention of reactions.

Insect Oral Secretions (Saliva)

Early studies of insect bite reactions established that the active substances were contained in the insect oral secretions (saliva).⁴ The oral secretions of blood-feeding insects contain a number of substances, including anticoagulants, enzymes, and reactive small molecules.⁶⁻¹⁰ These substances are irritants as well as antigens. Generally, only female flies, in which a blood meal is required for fertility, are equipped for biting. However, insects closely related to the most notorious biters may not require blood meals. Of the

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common genera of mosquitoes *Anopheles*, *Aedes*, and *Culex* all require blood meals; but the giant mosquito *Toxorhynchites* is incapable of biting because of its downward curved and inflexible proboscis.

A variety of approaches have been taken by investigators in the preparation of diagnostic and therapeutic materials from biting insects. In most cases, materials resembling the commercially available extracts of whole insect bodies have been used. In these extracts, the concentration of relevant antigens is fairly low, the extract is subject to degradation by the digestive enzymes contained in the mixture, and a significant amount of spurious cross-reactivity may appear to be present due to reactivity with generic "insect" antigens. In fairness, it cannot be overemphasized how laborious it is to prepare either saliva or salivary gland extracts. Attempts have been made to prepare more potent extract from *Triatoma* by use of only the thoracic segment, which contains the salivary glands¹¹; but this extract was not as potent as that prepared from salivary glands.^{12,13}

In an interesting study reported by Scott et al¹⁴ it was found that cell culture fluid from a cell line derived from larval *Aedes albopictus* was highly anaphylactogenic in human volunteers. The reactivity in serum could be passively transferred and was destroyed by heating the serum to 56°C, which suggests IgE antibody mediation. Studies were not performed to see whether the antigenic activity was related to adult mosquito saliva.

In their classic studies of the normal response to cat flea bites, Benjamini et al¹⁵ collected oral secretion from batches of up to 50,000 fleas. The fleas were placed in a cylindrical plexiglass container with a fine mesh on one end and a thoroughly washed animal membrane (Silverlight condom, Julius Schmidt, New York) on the other end. The animal membrane was placed over a dish of distilled water at 37°C. The membrane was allowed to just touch the water surface. Fleas were allowed to feed for up to 2 hours at a time. The accumulated oral secretion extract was tested for the presence of digestive enzymes and was found to be negative. When the procedure was optimized, approximately 500 mg of dry weight material were collected per 1,000,000 flea feeding hours or approximately 1 µg per flea in 2 hours.

Mosquito saliva has been collected by the insects biting through membranes, in a manner similar to the process described above.²³ In more recent studies mosquito saliva has been collected by having the mosquito bite directly into a gel⁸ or by stimulating the mosquito with intrathoracic injections of serotonin or pilocarpine to eject saliva into mineral oil.¹⁷ In studies with unstimulated mosquitoes, Rossignol and Spielman¹⁷ found that each stroke of the mosquito salivary pump ejected about 900 µm³ and that a mosquito could eject about 3800 µm³ of fluid per second or about 3.8 pL per second. Because the average volume of the salivary glands was 4.2 pL, it was concluded that most of the fluid is transported into the salivary ducts and is not a product of the glands.

The mouth parts of a female mosquito are shown and identified in Figure 1.

Saliva from blackflies has been studied in extracts of macerated salivary glands. Each pair of glands was extracted in 5 to 15 µL of saline under a

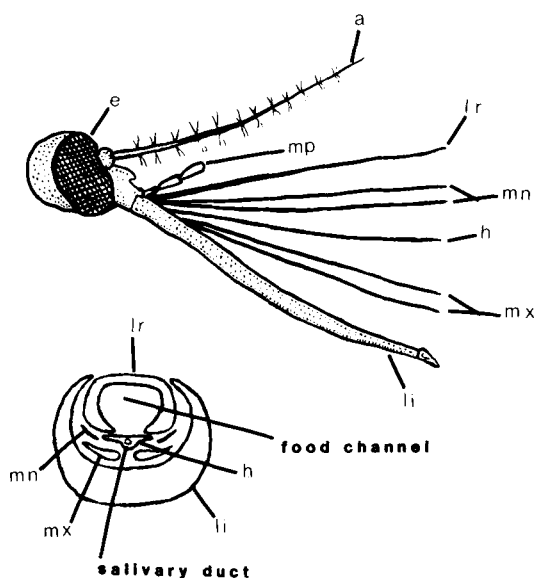


Figure 1. The head of a mosquito, showing the mouth parts. Key: a, antenna; e, compound eye; h, hypopharynx; li, labium; lr, labrum; mn, mandibles; mp, maxillary palp; and mx, maxillae. The maxillae and mandibles puncture the skin; the saliva is carried in a small duct in the hypopharynx; and the blood meal is drawn up in a duct formed by the labrum and hypopharynx. The mouth parts are also shown in cross section. (Drawings by Robert Jacobson.)

microscope.¹⁸ Both agglutinin and anticoagulant activities were found in the saliva from a number of species of *Simulium*.

The mass culture of biting insects is necessary for obtaining reliable and disease-free preparations of insect saliva. It is relatively easy to rear fleas¹⁹ and mosquitoes en masse, and methods have been developed for the rearing of blackflies.²⁰ *Triatoma* also can be reared, but with some difficulty.^{13,21} Methods have not been developed for rearing most other biting insects, including deerflies and horseflies. This means that for now these insects must be captured in the wild to procure their saliva.

The Normal Response to Insect Bites

The range of normal responses to insect bites varies as a function of both the insect and the victim. Some blood-feeding insects, especially bugs like *Triatoma*, inflict a painless bite that results in very little inflammation. Usually victims of *Triatoma* do not know that they have been bitten. Other insects, especially the biting flies and fleas, have either painful or pruritic bites and generally cause an inflammatory reaction at the site. The pain and/or pruritis at the time of the bite is a result of chemicals contained in the saliva, but thorough investigations have not been performed to characterize these substances in either fleas, mosquitoes, or biting flies.

The human response to flea and mosquito bites changes with time and exposure and has been studied in detail by a number of investigators, including Mellanby,²² McKiel,²³ Larrivee et al²⁴ and most extensively by Feingold et al.⁴ These investigators have proposed that there are 5 stages in the sequence of reactivity:

1. Induction of hypersensitivity with no observable skin reactions.
2. Delayed skin reactions.
3. Immediate skin reactions followed by delayed reactions.
4. Immediate reactions only.
5. No reactivity.

This entire sequence has been observed in studies with the cat flea, *Ctenocephalides felis felis*, by repeatedly exposing guinea pigs to natural bites for 3 months.²⁵ At the end of the 3-month period, most animals were refractory to bites. Between 60 and 90 days, most animals exhibited only immediate reactions. The transition between the stages was not sharp and there was substantial overlap within the entire group of animals.

These investigators correlated histopathology with each stage of reactivity.²⁴ During stage 1 there were no observable changes from normal skin. When the delayed reactions started to appear in stage 2, there was a diffuse mononuclear cell infiltrate of the dermis and a lesser infiltrate of the epidermis at the bite site. In the early phase, small lymphocytes predominated with occasional monocytes, while plasma cells were seen later in this stage. In the early immediate phase of stage 3, the predominant infiltrating cell was the eosinophil, with primarily mononuclear cells in the delayed phase. In stage 4, the eosinophil again dominated the immediate reaction, with only occasional monocytic infiltrates in the 24-hour biopsy specimens. During stage 5, the histology was again normal.

These observations led Feingold et al⁴ to propose that the normal bite reaction is immunologically mediated. They cited the following four lines of evidence: 1) A history of previous exposure to the specific insect bite is required—the sensitizing dose; 2) There is an initial nonreactive period, which suggests that sensitivity evolves over time. A toxic reaction should not have a nonreactive period; 3) The type of reaction depends on the number of bites and the time interval between initial exposure and challenge; and 4) The eventual development of nonreactivity after repeated exposure suggests the development of protective immunity. This would not be typical of an irritative phenomenon.

Further evidence has been reported that strongly supports the hypothesis that there is an immunologic basis to normal reactions to flea and mosquito bites. Allen²⁶ has reported the passive transfer of delayed reactivity to *Aedes aegypti* bites in guinea pigs by transfer of leukocytes from sensitized animals. Scott et al¹⁴ have demonstrated that human volunteers had IgE antibodies against mosquito antigens found in tissue culture supernatant. The presence of both IgG and IgE antibodies to flea saliva antigens have been demonstrated in dogs allergic to flea bites as well as IgG antibodies in nonallergic dogs.⁵ Recently IgG antibodies against *Aedes* mosquitoes and tissue culture fluid were demonstrated in several groups of Finnish people.²⁷

This evidence all suggests that human reactions to bites of mosquitoes and possibly fleas have 2 immunologic components: 1) an immediate phase, probably mediated by IgE antibodies; and 2) a delayed phase, which may involve both IgE-antibody mediation and cell-mediated immunity. Although many

studies of mosquito reactivity have been carried out in humans, studies of flea reactivity have been performed mainly in guinea pigs and dogs.

Biting Insects That Cause Allergic Reactions

Order Hemiptera, Family Reduviidae, Genus Triatoma

The most commonly reported and best studied anaphylactic reactions to insect bites are those from kissing or conenose bugs of the genus *Triatoma*. Various species are found over much of the milder temperate regions of the world. *Triatoma* are found in the southern half of the United States, the 2 most important species for allergy, *T. protracta* and *T. rubida*, being found in the desert Southwest and California foothills. *Triatoma* are also important medically as the vector of the trypanosome that causes Chagas disease. The bite of *Triatoma* is generally painless and usually occurs at night and, unless there is an allergic reaction, the victim may never know he was bitten. A blood meal generally takes from 3 to 30 minutes and multiple individuals may feed simultaneously. Each insect inflicts multiple bites.

Allergic reactions to *Triatoma* bites have been reported from many locations and were first described in 1894.²³⁻³⁸ A single series reported over 110 cases.^{31,32}

Contemporary investigators have used saliva and salivary gland extracts in skin test and radioallergosorbent test (RAST) to verify histories of *Triatoma* induced anaphylaxis.^{2,11-13,21,39-41} The American Academy of Allergy and Immunology Biting Insect Registry reported 50 cases of *Triatoma* allergy; Pinnas et al⁴² reported 38 cases, and Chapman et al⁴³ reported on 28 cases. All of these cases were RAST positive to salivary antigens from the appropriate species. Studies using various body parts have shown the allergenic activity to be associated with saliva and the salivary glands.^{11,12}

Recently investigators have grown *T. protracta* and *T. rubida* in captivity and prepared salivary extracts for biochemical and antigenic analysis. The most striking finding, in contradistinction to allergens of other biting insects and venoms from stinging hymenoptera, is an almost absolute species specificity.^{12,39-44} Cross-reactivity between the 2 species was only observed in 2 of 38 patients in 1 study⁴² and in 1 of 30 cases in a second study.⁴⁴ No evidence of cross-reactivity could be found by RAST inhibition using saliva from 3 additional species.⁴⁴

Chapman et al⁴³ separated *T. protracta* salivary gland extract by gel infiltration, and found 2 peaks, 1 of about 70,000 molecular weight (MW) and the other of 17,000 to 25,000 MW. The allergenic activity was found in the lower MW peak, which was found to contain 6 proteins by isoelectric focusing (IEF). Two of the IEF fractions, pI 6.7 to 7.3 and pI 8.2 contained most of the allergenic activity. Each of these fractions gave a single arc in immunoelectrophoresis and 2 closely spaced bands of MW 18,000 and 20,000 on sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE). In RAST inhibition, each of these fractions completely inhibited binding of the other, leading the authors to suggest that they were isoallergens.

Five patients who had suffered life-threatening anaphylactic reactions from *T protracta* bites were given immunotherapy with salivary gland extract.¹³ Treated patients showed a significant rise in IgG-blocking antibodies to salivary antigens and were able to tolerate a bite challenge with no reaction. These patients had all experienced multiple episodes of life-threatening reactions before beginning therapy, so no pretherapy challenges were performed, nor were control patients treated with placebo.

Order Hemiptera, Family Cimicidae

There are 2 reports in the literature of allergic reactions to bedbug bites.^{45,46} Both are case reports without any attempt at evaluation.

Order Siphonaptera

Fleas are commonly cited as a cause of allergic reactions in man. However, there is little convincing evidence that IgE-mediated systemic reactions are very common in humans. There are a number of unconvincing reports of IgE-mediated reactions and their treatment by various types of immunotherapy in the literature.⁴⁷⁻⁵⁰ The normal response to flea bites in guinea pigs and rabbits has been well investigated and was discussed in the section on normal reactions to insect bites. The most common form of systemic reaction in man to flea bites is papular urticaria.^{51,52} This rash does not have a physical appearance similar to IgE-mediated urticaria, and no investigators have presented any convincing evidence that IgE antibodies are involved in its pathogenesis.

One interesting case was submitted to the Academy of Allergy and Immunology Registry. A house painter developed intense pruritis and erythema at the sites of flea bites. Over a period of a few days the lesions became hyperpigmented. The patient was positive to an intradermal skin test with flea whole body extract (WBE) at 1:500,000 and highly positive to flea by RAST. His lesions did respond to topical steroids, but an experimental course of flea WBE immunotherapy gave no improvement.

IgE-mediated flea allergy does, however, appear to be common in dogs and cats.^{5,53-59} The symptoms consist of a generalized dermatitis that is highly pruritic. Gross and Halliwell⁵³ challenged flea-naive dogs and induced hypersensitivity. The lesions had 2 phases as had been described in guinea pigs.⁴ The immediate phase showed edema and primarily an eosinophilic infiltrate, and in the delayed phase a perivascular lymphocytic infiltrate with occasional histiocytes. Halliwell and Longino⁵ developed a radioimmunoassay (RIA) for dog IgE antibodies against flea antigens and showed that flea allergic dogs had higher specific IgE levels than either flea-exposed but nonallergic dogs or flea-naive dogs.

Feingold et al⁴ collected a large amount of cat flea oral secretion and studied its antigenicity and allergenicity in guinea pigs. Skin reactivity was the result of a relatively low molecular weight fraction, which was not sensitizing by itself, but did sensitize when administered as whole oral secretion or in Freund's complete adjuvant.^{6,15,60} Further studies showed that there was an irreversible

association of this substance with fibrous proteins¹⁵; that sensitivity could be induced in a naive animal by immunization with a biopsy from a reaction in another animal⁶¹; and that "flea hapten" reacted with collagen to form the antigen.^{62,63} In their review of responses to insect bites Feingold et al⁴ used these experiments to explain the common observation that when one receives a flea or mosquito bite, it is not unusual for old reaction sites to flare up along with the new site. They also postulated that this may be the mechanism of papular urticaria from flea bites.

Order Diptera, Family Culicidae

Mosquitoes are probably the most well known and most common biters of man. There are about 150 species found in the United States and Canada, belonging to 13 genera. Not surprisingly, there are many reports in the literature of reactions to mosquito bites.^{22,64-75} Most of these reports are anecdotal and describe what are most probably severe local reactions. Frazier⁶⁴ reported 38 cases, but did not give any details. Three cases have been reported in some detail and have had immunologic evaluations performed. In the first case,⁷³ an 8 year old girl presented with a reaction that began as a normal bite response. It was accompanied in a few hours by generalized fatigue, nausea, anorexia and elevation of temperature. Each bite site then developed remarkable erythema and edematous swelling with intense pruritus. At 48 hours the sites had become bullous; they then crusted and scarred after persisting for 1 month. The patient was challenged with *Aedes* WBE and developed systemic shock and generalized urticaria. She was positive in skin testing and RAST and also reacted strongly to a single gel filtration peak prepared from the extract.

The second case⁷⁴ was a 14 year old girl who developed local skin reactions, fever, and hepatosplenomegaly from bites. The reactions became purulent in appearance and left deep ulcerations as they resolved. The patient was positive by skin test, RAST, and passive transfer test to extracts of *Aedes*, *Anopheles*, and *Culex* mosquitoes. A third case recently reported from Japan⁷⁵ is particularly interesting in that the subject had agammaglobulinemia without detectable total or specific IgE. This patient developed delayed reactions beginning 10 to 20 hours after the bite, but not immediate reactions. When the reactions began to develop, local swelling and intense itching appeared, followed by formation of a vesicle at the center of each site. At 48 hours the reactions became purpuric and then crusted over. Many times the local reactions were accompanied by fever beginning 48 to 72 hours after the bite and persisting for about 2 days. Over a period of years the patient's response to mosquito bites has lessened without intervention.

One patient with a convincing history was reported to the Biting Insect Registry. He developed persistent large local reactions beginning at the bite and progressing inward for up to 48 hours. The reactions were very similar to large local reactions seen from *Hymenoptera* stings. Serum from this patient was strongly RAST-positive to mosquito extract.

Newsome et al¹⁶ isolated a protein from *Aedes aegypti* oral secretion that was strongly skin reactive. This substance called F-1 was a protein containing

about 9% carbohydrate with a large proportion of glycine and proline. The molecular weight was not determined, but it was excluded on Sephadex G-25. The substance was homogeneous in electrophoresis and immunoelectrophoresis. Substance F-1 induced immediate skin reactions in previously sensitized guinea pigs in a dose-dependent manner. Further studies have not been reported.

To the best of the author's knowledge, there has never been a report in the literature of a classic systemic anaphylactic reaction to a natural mosquito bite.

Order Diptera, Family Simuliidae

Blackflies are common from the tropics to the Arctic. The insects require rapidly running water to breed, so they are most common along streams and rivers. Several species carry onchocerciasis or river blindness. In the northernmost areas of the United States and in Canada, they are a seasonal plague in May and June, making many outdoor activities uncomfortable. Several reports of allergic reactions to blackflies have been reported in the literature.^{64,76,77} However, none of the reported cases have convincing histories of systemic reactions. Fifteen cases of severe delayed local reactions, some of whom had fever, leukocytosis, and lymphadenitis, were described by Gaillard et al.⁷⁶ Ten of these patients were skin test-positive to blackfly WBE, and 8 were known to be sensitive to other insects.

Many cases of suspected blackfly allergy were referred to the Biting Insect Registry, but only 11 were found to be RAST-positive. One patient had a convincing history of severe life-threatening anaphylactic reactions to blackfly bites each June for a number of years. This patient was strongly skin-test and RAST-positive to blackfly WBE, and only marginally positive or negative to other biting insect extracts. This individual had previously experienced anaphylaxis from *Hymenoptera* stings and was RAST- and skin test-positive to venoms, but had not received immunotherapy.

Order Diptera, Family Tabanidae

Deerflies and horseflies of the genera *Chrysops*, *Hybomitra*, and *Tabanus* are large, very colorful flies that inflict painful bites. A significant number of cases with systemic reactions from these insects' bites have been reported.^{1,64,78,79} Wilbur and Evans⁷⁸ reported on 3 cases with systemic reaction to deerfly: 2 with generalized urticaria and wheezing and 1 with systemic anaphylactic shock. All 3 were skin test-positive to WBE skin tests at 1:100,000 and their serum could passively transfer the immediate reactivity. Two of the patients' leukocytes were positive to WBE by histamine release. Frazier⁶⁴ included 10 more cases in his survey. Fifteen cases have been referred to the Biting Insect Registry with histories of systemic reactions. Patterns of RAST cross-reactivity with biting fly extracts were variable. Some patients appeared to react to only 1 extract and others to various combinations.

Of all the biting flies, IgE-mediated reactions to bites of *Tabanidae* appear to be most common. The insects are also relatively large, so it should be

possible to obtain saliva or salivary glands. However, at present no one has been successful at rearing colonies of any insect of this family in the laboratory.

Order Diptera, Stomoxys Calcitrans

The stable fly or biting house fly usually bites before it is about to rain. This insect is unusual among flies in that both sexes bite. There are no detailed descriptions of reactions to stable fly in the literature, but at least 1 case was referred to the Biting Insect Registry. Stable fly appears to have only limited cross-reactivity with *Tabanidae*.

Order Diptera, Genus Culicoides

The *Ceratopogonidae*, variously called biting midges, punkies, sandflies, sandfleas, and no-see-ums, are vectors of several microfilarial diseases. There have been 2 reports in the literature of severe reactions to bites of *Culicoides furens*.^{80,81} In 1 case, a 13 year old developed large wheal reactions at the sites of bites. These reactions then crusted and eventually resolved to hyperpigmented scars. All 3 cases in the literature were skin test- and passive transfer test-positive to extracts of *Culicoides furens*. The passive transfer activity was lost by heating the serum to 56°C. No cross-reactivity was observed with mosquito or nonbiting insect extracts.

Three cases with convincing histories of systemic reactions from insect bites that were thought to be *Culicoides* were referred to the Biting Insect Registry. None of the 3 sera reacted with an extract prepared from *Culicoides varipennis*.

Order Diptera Miscellaneous

The true sandfly, *Phlebotomus*, is reported to cause allergic reactions.⁸² These insects carry *Leishmania* in tropical areas.

There is 1 case reported⁸³ of a severe systemic reaction to the bite of a larva of a stiletto fly of the family *Therevidae*. Bites from both the adult and larval form of this insect are very rare.

Practical Considerations

Diagnosis of Insect Bite Allergy

The physician who needs to evaluate a patient with a history of a severe systemic reaction caused by an insect bite is faced with a number of serious difficulties. The commercially available reagents have generally been WBEs; however, little is known about their potency or stability. Recently, a number of these extracts have been removed from the market. The commercial extracts that have been available are generally not clearly identified by genus and species, so it is not possible to know whether or not the proper insect was used to prepare the extract. The careful studies performed on *Triatoma* allergy

have been done with salivary gland extract, which is not commercially available. In *Triatoma* allergy, it is critical to use the correct species, since this genus shows a very high degree of species specificity. It is improbable that higher quality commercial extracts prepared from biting insect oral secretions will be available in the near future, because of the high cost of production and the limited demand.

A number of studies have shown that skin testing with oral secretion or WBE of biting insects can be helpful; however, it is critical to remember that saliva of many insects, especially biting flies and fleas, may induce wheal formation as part of the normal nonallergic response. RAST has been used in a number of laboratories with both oral secretion and WBE and appears to be generally useful. A few specialized reference and research laboratories offer RAST to some of the biting insects to the allergy community. A few investigators have used other techniques, such as passive transfer testing and histamine release from patient leukocytes, but these tests are generally not recommended for routine diagnosis.

Some patients who report severe reactions from insect bites also have coexistent *Hymenoptera* venom allergy; others may have allergy caused by inhalant insects and insect parts. If WBEs are used for diagnosis, it is important to verify that the reactions are specific for the insect being tested and are not cross-reactions to these other common sensitivities.

Immunotherapy

In uncontrolled trials, immunotherapy with *T protracta* salivary gland extract produced protective immunity in patients who had previously experienced multiple life-threatening reactions from bites.¹³ Many patients have been treated with WBEs of other biting insects and investigators usually report success in at least reducing the severity of reaction, whether local or systemic. However, none of these studies have consisted of properly controlled or designed trials, so it is not possible to evaluate the reported results. At the present, immunotherapy with WBEs cannot be recommended. Immunotherapy is probably also inappropriate for severe local reactions, although there is substantial evidence that the course of these reactions can be modified by intense exposure.⁴

Treatment

Severe systemic reactions to insect bites are treated the same as any other anaphylactic reaction. For these patients, an epinephrine syringe is essential; and it cannot be overemphasized that both the patient and family should be instructed in its use. One cannot avoid most biting insects effectively, and some bites like *Triatoma* may not be apparent until the reaction develops.

Severe local reactions should be treated symptomatically. Most reports indicate that topical or systemic corticosteroids may be helpful, particularly in cases with extensive delayed reactions that might lead to scarring. Occasionally, systemic steroids have been used.

Avoidance and Control

It is very difficult to avoid insects that bite. Certain times and circumstances increase the probability of bites. Mosquitoes are most active on overcast days, in dark shady areas or near dawn and dusk; blackflies are most numerous near rapidly running water, and many horseflies and deerflies are found near the edge of bodies of water. Some commercial repellents are effective. In the morning and evening ultraviolet bug lights with high voltage screens can keep large areas almost mosquito free. The regular use of these lights also may help to reduce the local population. Other control measures are the use of yellow light bulbs and burning citronella candles or kerosene lamps. Large scale control involves many complex environmental questions and is generally the responsibility of governmental bodies.

Infestations of biting insects inside buildings can be controlled by the use of registered insecticides. Aerosols for control of fleas, mosquitoes, and flies can be purchased in hardware and grocery stores. Flea control may require repeated applications of residue type products. Control of biting insects and difficult cases with fleas may require professional exterminators. Local agricultural extension services and health departments will generally provide advice on insecticides for specific purposes. The United States Department of Agriculture also has a number of publications available with suggestions for insect control methods.

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