Rostrum

Expanding habitat of the imported fire ant *(Solenopsis invicta)*: A public health concern

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Residents in the southeastern United States would hardly describe life with the aggressive imported fire ant as peaceful coexistence. The continued spread of these insects has produced agricultural problems, changes in the ecosystem, and increasing numbers of subjects with sting sequelae, including hypersensitivity reactions, secondary infections, and rare neurologic sequelae. Evolutionary changes have facilitated their expansion northward into Virginia and westward into California, and increasing urbanization will likely permit further expansion. Recent reports of building invasion with sting attacks inside occupied dwellings, including health care facilities, heighten public health concerns. This article reviews the medically important entomology, clinical aspects of stings, and the current approaches to chemical control of fire ants. We also propose directions for future research and treatment. (J Allergy Clin Immunol 2000;105:683-91.)

Key words: *Imported fire ant,* Solenopsis invicta, Solenopsis richteri, *whole-body vaccine, venom vaccine, immunotherapy, anaphylaxis, hypersensitivity reactions, chemical control measures*

The black imported fire ant (IFA), *Solenopsis richteri* (a native of Argentina and Uruguay), and the red IFA, *Solenopsis invicta* (a native of Argentina, Paraguay, and Brazil), appear to have entered the United States through Mobile, Ala, in the early 20th century.[1] Shipments of infested nursery stock and other agricultural products, natural mating flights, and floating on flood waters have contributed to their outward spread.[1-3] *S invicta,* the predominant species, infests more than 310 million acres in 12 states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia) and Puerto Rico. Ant populations have recently been found in Arizona, California, and New Mexico (Fig 1).

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Abbreviations used

IFA:	Imported fire ant
RAST:	Radioallergosorbent test
USDA, APHIS, PPQ:	US Department of Agriculture, Animal, Plant, Health and Inspection Service, Plant Pest and Quarantine
WBV:	whole-body vaccine

These aggressive, venomous ants have an adverse impact on agriculture and wildlife, including the decimation of some ground-nesting birds, turtles, frogs, and arthropod species.[3,4] The ultimate range of the fire ant is unknown. Previous estimates based on the ants' inability to reproduce at low temperatures predicted limitation of their habitat to areas where the average minimum temperature is greater than –12.2°C (10°F).[4] Revised estimates predict expansion to areas with average minimum yearly temperatures greater than –17.8°C (0°F) presuming the climate does not become warmer or the IFA does not become more cold tolerant.[2] If these estimates are correct, the IFA likely will ultimately inhabit at least 25% of the continental United States.

The US Department of Agriculture estimates that IFAs have expanded westward approximately 120 miles per year. Because of their mobility and their ability to establish colonies in diverse habitats, the detection of new infestations is difficult. For example, an IFA infestation in California that was discovered in 1998 was estimated to have been 3 to 4 years old before it was detected. Thus "new" infestations usually exist several years before detection, and maps illustrating the expansion of the IFA will necessarily lag behind the actual rate and degree of infestation. This presents problems for those individuals responsible for controlling the spread of this pest. Documentation of IFA expansion originally relied on surveys conducted throughout the southern United States by personnel of the US Department of Agriculture, Animal, Plant, Health and Inspection Service, Plant Pest and Quarantine (UDSA, APHIS, PPQ). These individuals previously conducted visual inspections along roadways, fields, pastures, and nurseries. Current methods of detection have expanded to include setting pitfall traps and ant traps baited with a food attractant. The USDA no longer conducts IFA surveys. State surveys depend on state

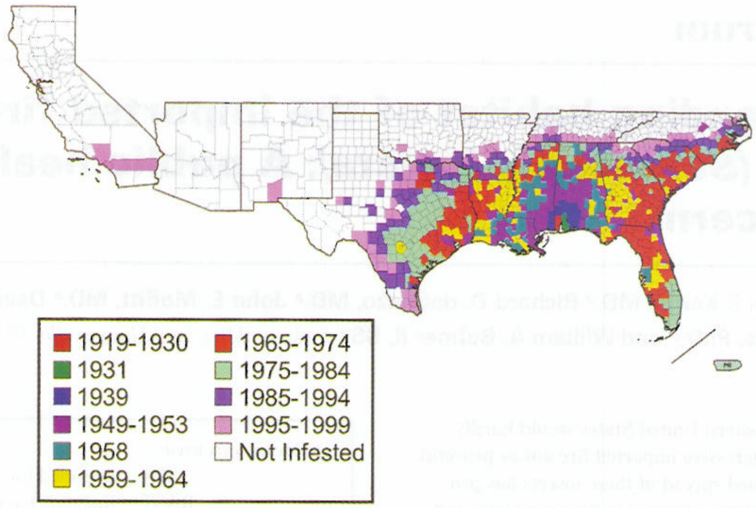

FIG 1. US range expansion of imported fire ant *(S invicta)*, 1918-1999. (The assistance of Anne-Marie Collcutt, US Department of Agriculture, Gulfport, Miss, is appreciated.)

plant protection inspectors, and each state determines when IFA inspections will be conducted. Once state inspectors locate a new colony, they record the location on a map, obtain ant specimens for verification, and report the infestation to the USDA, APHIS, PPQ, which maintains records and produces a map of the Imported Fire Ant Quarantine Area, which is available to the general public. States that are completely infested with IFA no longer conduct surveys.

HUMANS AND ANTS

Problems arise when humans come into contact with IFAs (Fig 2).[5] Because IFAs favor disturbed habitats, the progressive urbanization of the United States, especially in the Sun Belt, has accelerated their expansion.[2,6,7] Polygyne (multiple queen) organization, in which numerous egg-laying queens reside in a single colony (Fig 3, *A*),[8] permits more than 500 fire ant mounds per acre in some areas.[2,9] In rural areas, fire ants attack both humans and animals. They also damage farm equipment, electrical systems (Fig 3, *B*), irrigation systems, and crops.[10,11] In urban areas, fire ants build mounds in sunny, open areas, such as lawns, playgrounds, ball fields, parks, golf courses, and along road shoulders and median strips. In addition, they move their colonies underneath pavement and alongside buildings to overwinter. Concentrations in some areas now exceed 200 mounds per acre.[5,10] When a mound is disturbed, thousands of ants swarm to the surface and sting anything with which they come in contact.

IFAs seek sites necessary for colony survival during periods of environmental stress, such as food shortages, hot and dry summer periods, or heavy rainfall.[9] Inhabited dwellings can be ideal environments for fire ants because of the availability of food, moisture, and weather protection. Thus, food requirements as fire ant populations increase may force them to enter dwellings in search of additional food, moisture, and shelter. The result is that humans may come into contact with ants not only outdoors but indoors as well.

Typically, 30% to 60% of subjects in endemic or infested urban areas are stung each year by IFAs.[5,9,12] However, one survey reported stings in 89% of subjects or immediate family members per year.[2] Furthermore, 55 (51%) of 107 previously unexposed subjects were stung within 3 weeks of arrival in an endemic area, and 8 (16%) developed fire ant venom–specific IgE antibody.[13] Stings occur most frequently during the summer, most commonly in children and typically on the lower extremities. When stinging, the ant uses its powerful mandibles to attach itself to the skin, arches its body, and injects venom through the stinger located in its abdomen. The ant will sting repeatedly if it is not quickly removed. Any subject that is stung characteristically experiences an immediate and intense burning (the "fire" inspiring the name of the ant) and itching at the site of a sting.[5,14] However, stings occurring during the off-season (eg, winter months) may go unnoticed until the local reaction develops. This may reflect the seasonal differences in IFA venom protein concentration.

LOCAL REACTIONS TO FIRE ANT STINGS

Reactions may be classified as local (Fig 2), systemic (including anaphylaxis), or "other." Three types of local reactions are generally recognized: the wheal-and-flare reaction, the sterile pustule, and the large local reaction. We have previously characterized these reactions by histopathologic studies.[12] All individuals stung experience a wheal-and-flare response at the site of the sting within 20 minutes, followed within 24 hours by a necrotic lesion known as the sterile pustule. This pustule may last for several days and is pathognomonic for fire ant stings.[12] The epidermis overlying this pustule erodes over 48 to 72 hours and healing occurs as new epidermis

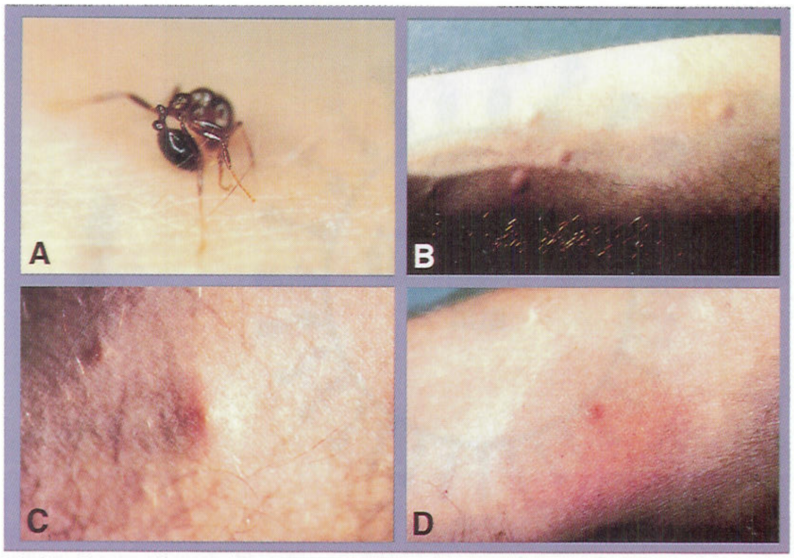

FIG 2. A, Stinging fire ant *(S invicta)*. **B,** Wheal-and-flare reactions 5 minutes after multiple fire ant stings. **C,** Sterile pustule 24 hours after fire ant sting. **D,** Cutaneous late-phase allergic reaction 24 hours after fire ant sting. Excoriated sterile pustule in center of lesion.

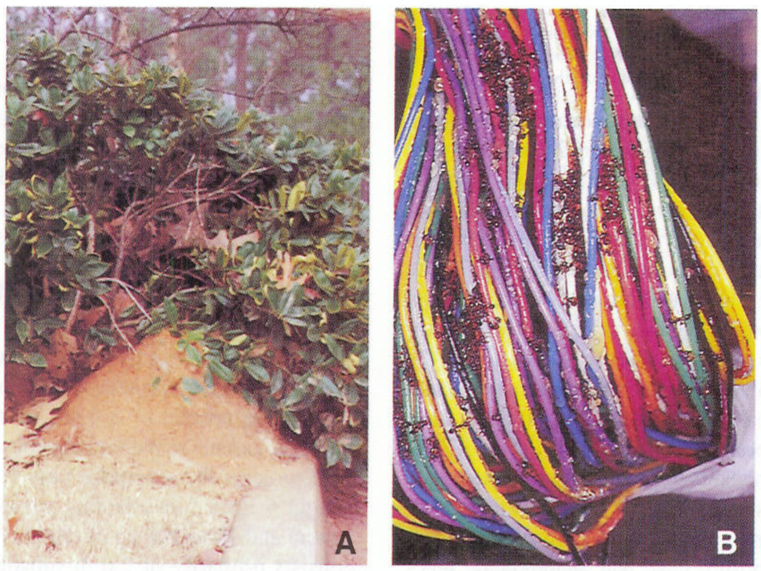

FIG 3. A, Single-queen (monogynous) fire ant mound at street curb. **B,** Fire ant infestation of electrical wiring. (Vinson SB, photographer. *New York Times Magazine*, Jan 8, 1995.) (Reproduced with permission from S. Bradleigh Vinson, Texas A&M University, College Station, Tex.)

covers the lesion base. No known therapy effectively prevents pustules or hastens their resolution. The excoriation of pustules risks superinfection with possible pyoderma or even sepsis, especially in diabetic individuals.[5]

Large local reactions to fire ant stings appear to be similar to those that are experienced after envenomation by other stinging insects. From 17% to 56% of stung subjects initially have venom-specific IgE-mediated wheal-and-flare responses that evolve over several hours into a second phase of pruritic edema, induration, and erythema that may persist 24 to 72 hours.[12,14] These reactions may involve an entire extremity. Histologically, these lesions resemble late-phase mast cell–dependent reactions and are characterized by a cellular infiltrate of eosinophils, neutrophils, and fibrin deposition.[12] Large local reactions rarely may cause vascular compromise in an extremity as a result of edematous tissue compression. Cold compresses and elevation of the affected extremity may be helpful and high-potency topical steroids and antihistamines mollify pruritus.

SYSTEMIC AND OTHER REACTIONS

Systemic reactions may range from cutaneous manifestations (generalized urticaria, angioedema, pruritus, erythema) to potentially life-threatening manifestations of

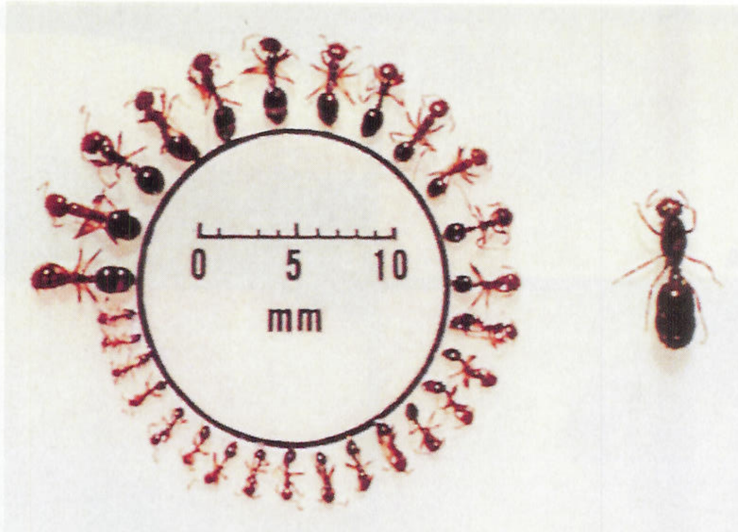

FIG 4. *S invicta* worker ants and queen. Arranged in a circle are majors (the largest workers), media (medium-sized workers), and minors (the smallest workers). Minors comprise the majority of worker ants in a colony. A queen is displayed to the right. (From Vinson SB, Sorensen AA. Imported fire ants: life history and impact. Austin: Texas Department of Agriculture, 1986.) (Reproduced with permission from the Texas Department of Agriculture and from S. Bradleigh Vinson, Texas A&M University, College Station, Tex.)

bronchospasm, laryngeal edema, or hypotension. The exact incidence of fire ant anaphylaxis is unknown because anaphylaxis is not a reportable disease. Surveys have reported that 0.6% to 16% of individuals who are stung have anaphylactic reactions.[15-17] More than 80 fatalities have been attributed to fire ant–induced anaphylaxis.[18,19] Anaphylaxis may occur hours after a sting. These systemic reactions are similar to those that are experienced with other Hymenoptera venoms, except the pathognomonic pustule almost always enables identification of the fire ant as the culprit insect. Acute management of fire ant anaphylaxis is identical to treatment of anaphylaxis from other causes. Appropriate use of epinephrine injections and other treatment modalities is reviewed elsewhere.[20]

Systemic reactions usually occur in individuals previously sensitized to fire ant stings.[14,16] However, subjects with no previous exposure have had anaphylactic reactions after their first stings.[14] Most of these subjects appear to have been sensitized previously to *Vespula* (yellow jacket) venom, a conclusion supported by clinical and laboratory studies.[14] *Vespula* venom cross-reacts in vitro with *Solenopsis* venom.

Toxic reactions may occur after 50 to 100 simultaneous stings by winged Hymenoptera species and may be clinically indistinguishable from systemic reactions.[21] Fatal toxic reactions from ant stings have been reported in small animals, such as dogs, but no human fatalities from toxic reactions to fire ant stings have been reported.[14] Although toxic reactions have been proposed as possible factors in deaths occurring in immobilized, chronically ill subjects stung by fire ants,[22] formal toxicologic studies of fire ant venom effects in humans have not been done. It appears unlikely, however, that venom-related toxicity alone explains these deaths because nonallergic subjects have sustained thousands of stings with no complications other than pustules.[23]

Seizures and mononeuritis have also been reported after fire ant stings.[24,25] Serum sickness, nephrotic syndrome, and worsening of pre-existing cardiopulmonary disease have also been described.[22,26]

THE VENOM OF THE IMPORTED FIRE ANT

IFA venom differs from bee, hornet, and wasp venoms, which are largely protein-containing aqueous solutions. Ninety-five percent of fire ant venom is water-insoluble alkaloid, and the remaining aqueous fraction contains soluble proteins that comprise only 0.1% of the venom by weight.[27] Each *S invicta* sting transfers 0.04 to 0.11 μL of venom and 10 to 100 ng of protein.[5] The alkaloid portion consists primarily of 2,6 di-substituted piperidines that have cytotoxic, hemolytic, antibacterial, and insecticidal properties. These alkaloids produce the sterile pustule but do not induce IgE responses.[14,28] Venom protein concentrations may be 100 times higher in summer than in other seasons.[16,29] The aqueous phase of *S invicta* venom contains 4 major allergenic proteins, Sol i 1-4 (molecular weights 37, 26, 24, and 13 kd, respectively), which induce specific IgE responses in allergic subjects.[14] Sol i 1 has phospholipase A and B activity and shares some immunologic cross-reactivity with phospholipase vespid venoms.[14] Sol i 2 comprises two thirds of venom protein content and is not immunologically cross-reactive with other Hymenoptera venoms. Sol i 3 is a member of the antigen 5 family of venom proteins but does not exhibit consistent immunologic cross-reactivity with vespid antigen 5.[14] Sol i 4 comprises 8% to 10% of the venom protein and is the most basic protein component (isoelectric point 10.08). It

TABLE I. Representative chemicals for control of fire ants

Treatment	Chemical name	Trade name and manufacturer
Outdoor use		
Aerosols, sprays, dusts, granules, drenches (These chemicals can also be used as barrier or spot treatments)	Acephate	Orthene, Valent U.S.A. Corp, Walnut Creek, Calif
	Bendicarb	Ficam, BFC Chemicals, Inc, Wilmington, Del
	Bifenthrin	Talstar, FMC Corp, Philadelphia, Pa
	Carbaryl	Sevin, Rhône-Poulenc Ag Company, Research Triangle Park, NC
	Chlorpyrifos	Dursban, Dow AgroSciences, Indianapolis, Ind
	Deltamethrin	DeltaGard G, AgrEvo Environmental Health, Inc, Montvale, NJ
	Diazinon	Diazinon, Novartis Crop Protection, Greensboro, NC
	Isofenphos	Oftanol, Bayer Corp, Kansas City, Mo
	Propoxur	Baygon, Bayer Corp, Kansas City, Mo
	Permethrin	Prelude, Zeneca, Inc, Wilmington, NC
	Resmethrin	Earthfire, Invicta Corp, Nokomis, Fla
Ant baits	Abamectin	PT Ascend Fire Ant Bait, Whitmire Micro-Gen, St Louis, Mo; Clinch, Novartis Crop Protection, Greensboro, NC
	Boric acid	Bushwhacker, The Bushwhacker Association, Inc, Galveston, Tex
	Fenoxycarb	Award (Logic), Novartis Crop Protection, Greensboro, NC
	Hydramethylnon	Amdro (Siege), American Cyanamid, Wayne, NJ
	Methoprene	Extinguish, Wellmark International, Bensenville, Ill
	Pyriproxyfen	Distance, Valent U.S.A. Corp, Walnut Creek, Calif
	Spinosad	Conserve, Dow AgroSciences, Indianapolis, Ind
Indoor use		
Aerosols, sprays, dusts	Chlorpyrifos	Dursban, Dow AgroSciences, Indianapolis, Ind
	Permethrin	Prelude, Zeneca, Inc, Wilmington, NC
	Resmethrin	Earthfire, Invicta Corp, Nokomis, Fla
Ant baits	Abamectin	PT Ascend Fire Ant Bait, Advance, Whitmire Micro-Gen, St Louis, Mo
	Fipronil	Maxforce, The Clorox Co, Pleasanton, Calif
	Sulfluramid	Raid Ant Bait Plus, S.C. Johnson & Son, Inc, Racine, Wis; Dual Choice, Whitmire Micro-Gen, St Louis, Mo; FluorGuard, FMC Corp, Philadelphia, Pa
	Orthoboric acid	DRAX, Waterbury Co, Inc, Independence, La

Modified from deShazo RD, Williams DF, Moak ES. Fire ant attacks on residents in health care facilities: a report of two cases. Ann Intern Med 1999;131:424-9.

has 35% identity to Sol i 2 but does not cross-react immunologically.[14] *S richteri* venom has very similar proteins corresponding to Sol i 1, Sol i 2, and Sol i 3 but does not have a protein corresponding to Sol i 4.[14]

WHOLE BODY VACCINES

Commercial IFA vaccines are all whole body vaccines (WBV). IFA venom vaccines are not commercially available. Crossed immunoelectrophoresis, skin tests, and in vitro IgE tests generally have demonstrated that IFA WBV, unlike WBV of the winged Hymenoptera, contain significant and stable quantities of venom allergens.[14,30] Butcher and Reed,[30] however, evaluated 3 commercial vaccines and demonstrated significant variability in antigenic content and potency. Different strategies have developed to enhance quality control. US allergenic vaccine manufacturers have a voluntary program to verify Sol i 2 and Sol i 3 content of WBVs.[14] We have recommended skin testing and therapeutic administration of vaccines prepared from proportional mixtures of *S invicta* vaccines obtained from 2 or more manufacturers after assessing venom content by skin testing known IgE-positive subjects.[31]

VENOM VERSUS WBV

Both skin testing and in vitro tests, such as ELISA and radioallergosorbent testing (RAST), can be used to confirm a clinical history of IFA hypersensitivity. Proper diagnosis and treatment of IFA hypersensitivity requires reagents containing venom proteins. Variable IFA venom concentrations in WBV vaccines likely account for divergent results in reports of diagnostic skin testing. However, sensitivity, specificity, and positive predictive value are comparable to intracutaneous testing with pure venom if WBVs with verified venom content are used.[14] Subjects without a clinical history of allergic reactions to IFA should not be tested because of the high degree of asymptomatic IgE production in an exposed population. Skin test reactivity among control subjects with no history of IFA hypersensitivity ranges from 8% to 42% with WBV and 8% to 29% with venom.[32-35] These findings are similar to epidemiologic reports on the prevalence of skin test reactivity to other Hymenoptera venoms.[36] Venom RAST has proved superior to WBV RAST in several studies because its active material is not diluted by allergenically inactive body substances.[14] A venom ELISA assay has demonstrated equivalent sensitivity to venom RAST and is less expensive.[16] In contrast to most WBV RASTs, the Pharmacia CAP solid phase binds 3 times more protein than cellulose disk systems and yields WBV-specific IgE results similar to venom RAST and ELISA.[16] Venom CAP assays outperform whole-body CAP assays.[37]

IMMUNOTHERAPY FOR THE PREVENTION OF ANAPHYLAXIS

The indications for immunotherapy to prevent the recurrence of sting-related anaphylaxis are not clearly established because the natural history of fire ant allergy is poorly defined. In allergy to winged Hymenoptera, children with exclusively cutaneous (isolated urticaria and angioedema) reactions have a very low risk for future systemic reactions. However, no similar data are available for children with cutaneous reactions to fire ant stings.

Immunotherapy has been used to treat IFA allergy for almost 30 years. Fire ant venom is unavailable commercially and has not been studied for immunotherapy. Treatment consists of weekly subcutaneous injections of gradually increasing doses of WBV until an empirically predetermined maintenance dose, usually 0.5 mL of a 1:10 dilution of the 1:10 weight/volume stock WBV solution, is reached. Maintenance doses are typically administered every 4 to 6 weeks.[38] Uncontrolled studies suggest a high degree of efficacy, but treatment failures have been reported.

Freeman et al[39] have provided the strongest evidence supporting IFA immunotherapy. Of the 65 subjects treated with IFA WBV immunotherapy, 47 (72%) unexpectedly sustained IFA stings and only 1 had anaphylaxis. None of the 31 subjects who received a single IFA sting under direct observation had anaphylactic reactions while receiving maintenance immunotherapy. Of 11 IFA-allergic subjects in the control group who declined immunotherapy, 6 had unexpected stings and all 6 had anaphylactic reactions.[39] One report of a successful rush IFA immunotherapy protocol has been published.[40]

IFA immunotherapy for children with isolated cutaneous reactions to fire ant stings is controversial because, unlike for winged Hymenoptera stings, there are no data. Most allergists do not routinely recommend immunotherapy for this population, but 29% of survey respondents do, ostensibly because of the great risk of re-stings in an endemic area.[13,41]

MASSIVE INDOOR ATTACKS BY FIRE ANTS

Recently we have reported massive sting attacks by fire ants that have occurred in nursing homes in Mississippi and elsewhere.[9,22,42] We are now aware of many other similar attacks. The exact cause of this increasing phenomenon is unclear. Regardless, it is clear that immobilized individuals are at risk for multiple stings, when fire ants are seen in the indoor environment. Vigorous attempts are necessary under certain circumstances to identify the source of the fire ants and exterminate them.

There is no evidence that individuals who experience massive fire ant stings in the absence of systemic allergic reactions or generalized late-phase dermal reactions require parenteral corticosteroid or antibiotic therapy. Indeed, treatment with large doses of corticosteroids and intravenous fluids may complicate the management of those individuals with pre-existing cardiovascular disease. Treatment with oral antihistamines and topical corticosteroids appears to be adequate in most cases.

CHEMICAL CONTROL OF IMPORTED FIRE ANTS

Imported fire ants (Fig 4) live in colonies that contain thousands of workers (⅛ to ¼ inches long), immature ants (eggs, larvae, and pupae), winged males, and winged females (unmated queens), and one or more mated queens.[1,2] In the spring and early summer, winged males and females fly from nests and mate in flight. All males die after mating. Most newly mated queens land within a mile of the nest, but they can fly 12 or more miles.[1,2,9] After finding a suitable nesting site, mated females shed their wings and begin to lay eggs. A single queen may lay more than 2000 eggs per day and live an average of 6 to 7 years. The time from egg to adult worker is 20 to 45 days, depending on the temperature. Worker life spans are generally 2 to 6 months.[9]

Fire ants are omnivorous insects that feed on honeydew melons, plant exudates, other insects, spiders, small animals, and oils from seeds.[1,2,9,22,43] Food preferences change depending on the needs of the colony.[43] Fire ant colonies may contain a single queen (monogynous) or multiple queens (polygynous).[2,8,9] Single-queen colonies contain an egg-laying queen and as many as 100,000 to 240,000 workers. Multiple-queen colonies usually have 20 to 60 egg-laying queens and 100,000 to 500,000 workers.[2,9] Single-queen colonies aggressively protect their territories and antagonize other fire ant colonies, thus resulting in population densities of 40 to 150 mounds per acre. Multiple-queen colonies generally do not fight with each other, enabling closer proximity and population densities of 200 to 800 mounds per acre.[2,9] Multiple-queen mounds are often inconspicuous, many times consisting of small irregular-shaped soil disturbances instead of the well-defined dome-shaped mounds of single-queen colonies.[9]

Many methods attempt to control IFAs, but none permanently eradicate fire ants from an area. Chemicals are currently the only effective control measures[7] (Table I). Basic methods are broadcast applications, individual mound treatments, or both. In addition, chemical barriers and spot treatments may be helpful in certain situations. Broadcast applications use a bait that contains a slow-acting toxicant (eg, hydramethylnon) dissolved in an attractant food source (eg, soybean oil).[7,44] The attractant oil containing the toxicant is then absorbed into corn grits, a carrier that permits easy handling and application. The slow action of the toxicants allows the worker ants to feed toxic oil to the queen and other ants before they die. The queen then either dies or no longer produces eggs, leading to the eventual death of the colony. A broadcast bait application eliminates the need to locate ant mounds because it relies on foraging fire ants to feed the bait to the rest of the colony.[7] There is no colony relocation because the mound is not disturbed and most bait applications eliminate the colony queen.

Individual mound treatments attempt to control fire ants by chemical application to each mound.[7] The insecticides are formulated as drenches, granules, dusts, aerosols, or liquid fumigants. Locating and treating small, unseen colonies to kill the queen is difficult. If the queen is not destroyed, it will continue to lay eggs and the colony will recover.[7,44] All queens in multiple-queen colonies must be killed, thus making effective individual mound treatments extremely difficult. However, colonies treated individually may be eliminated faster if the queen is killed than are colonies treated with broadcast bait applications. Nonchemical methods of treating individual mounds include hot water application and nest excavation.[5,7,9] All individual mound treatments may prompt surviving ants to relocate.

Chemical control measures may combine the efficiency of broadcast baiting and the rapid action of individual mound treatments.[7,45,46] Baits must be broadcast first to reduce fire ant populations efficiently. Several days pass after broadcast baiting to permit fire ants to forage or distribute the bait before individual mounds are treated. Barrier and spot treatments contain active ingredients, such as acephate, that kill ants on contact.[7,45,46] These products are usually sold as sprays or dusts, and some are mixed into latex paint. They may be applied in wide bands on and around building foundations, equipment, and other areas to create ant barriers. Barrier and spot treatments do not eliminate colonies.

Only certain bait-formulated insecticides (abamectin and fipronil) and a few sprays, dusts, and aerosols are registered for use inside buildings.[22,45,46] Indoor colonies are located by following ant trails back to nesting areas. A dust or spray is applied if the entire colony, especially the queen, is accessible. If baits are used, the bait is applied first and then spot treatments are applied 3 days later. Spot treating infested areas or spraying ant trails with registered products kills foraging ants but will not eliminate fire ant colonies. If ants enter the home from outdoor colonies, residual insecticides, such as chlorpyrifos or diazinon, can be applied around the base of the structure as an outside barrier, and nearby mounds should be treated chemically.[22] IFAs are attracted to electrical fields, and equipment with wires, contact points, fuses, or switches should be inspected if infestation is suspected (Fig 3, *B*). Large quantities of ants may cause short circuits or mechanical failures.[2,47]

FUTURE DIRECTIONS

Clinical investigation of IFA hypersensitivity is in its infancy compared with that for bee and wasp venom allergy. The IFA may be the most common cause of insect sting hypersensitivity in endemic regions,[48] and its territorial expansion continues.

Determining the natural history of IFA allergy remains of paramount concern. There is abundant evidence that adults who have experienced anaphylaxis from IFA stings usually have anaphylaxis after a subsequent sting. Unfortunately, no similar data are available for children, particularly those with exclusively cutaneous reactions. Many parents and their allergists thus opt empirically for a 3-year course of immunotherapy for their child because as many as 58% of individuals living in an endemic area may be stung by fire ants each year. This preventive/therapeutic option eases the fear many parents harbor for their child's safety and also permits greater freedom in outdoor activities. IFA WBV immunotherapy generally is safe in this population and we have observed no anaphylaxis when another sting occurs after completion of such immunotherapy courses. However, IFA WBV immunotherapy may not be necessary in this population.

Numerous studies demonstrate that IFA venom is the optimal agent for diagnosis and treatment, yet it is still not a commercially viable product. This is a continuing problem. The US Food and Drug Administration should consider IFA venom vaccines for orphan drug status.

The ultimate solution to the IFA problem, eradication of the insect, seems unlikely any time soon. Continuing entomologic research may ultimately lead to control, but it requires continued financial support for research. In the interim, research to determine the most effective means of environmental control, especially for the prevention of indoor IFA attacks, cannot be overemphasized. Educational programs on the use of ant baits, removal of mounds from around houses and electrical wiring, and judicious use of pest control services may be appropriate. Research on ant repellants and on topical therapy to treat acute symptoms and to prevent late reactions would also be useful.

Finally, IFA stings in health care facilities or public buildings attract legal attention. Physicians in such cases are often asked to render an opinion concerning the quality and appropriateness of patient care. For these reasons, physicians in endemic areas should familiarize themselves with the risk management issues related to the medical consequences of IFA stings.

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