

Imported Fire Ants: The Ants from Hell!

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ABSTRACT

Imported fire ants may certainly be considered the ANTS FROM HELL! This review focuses on both the interesting entomology of fire ants and the important medical characteristics of fire ant stings. They sting and they kill; they destroy; they mate in mid-air; and we may not be able to stop them. However, although they inject extremely potent venom, individuals can prevent secondary infections by leaving the so-called pustules alone and not opening them. Individuals who suffer systemic reactions may receive adequate treatment with the whole body extract immunotherapy. (Allergy Proc 15: 11-15, 1994)

Imagine, if you will, a black poster with red letters that say "They sting; They kill; They destroy; They mate in mid-air; Nothing can stop . . ."

THE ANTS FROM HELL!

In July 1990, the *Smithsonian Magazine* cover story was fire ants. At that time they had a picture of a rather large ant spurting fire from its mouth and burning a diminutive Uncle Sam with the caption "Invader called, 'The Ant From Hell turns up the heat on Uncle Sam.'" *Texas Monthly* magazine of August 1988 also featured fire ants. In this case the cover showed a picture of an ant in a tank top looking tough and mean saying, "Public enemy #1, the fire ant: ruthless, dangerous, unstoppable, and it's after you!" In fact, *Texas Monthly*, inadvertently, may have found the best way to control fire ants because in their picture the fire ant is smoking a cigarette, and that may be the best way to control these pests.

Today we are going to discuss a little bit about the

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fire ants and get to know them a little better, both from an entomological perspective and from a medical perspective. There are, in the United States, both imported as well as native fire ant species. The native species include *Solenopsis xyloni* and *Solenopsis geminata*. The imported species include *Solenopsis richteri* and *Solenopsis invicta*. These latter species were imported from South America. Thus, the origin of their name imported. They were native to the Platte River region of Argentina, and probably were imported through the port of Mobile, Alabama on agricultural products during the early 1900s.¹² *Solenopsis richteri* was imported first followed by *Solenopsis invicta*. However, because *Solenopsis invicta* is a much more aggressive species than *Solenopsis richteri*, *Solenopsis invicta* now is the predominant imported fire ant species throughout most of the Southeastern United States.¹² *Solenopsis richteri*, is limited, pretty much, to a small area in the northern parts of Mississippi and Alabama.¹²

The map, Figure 1, clearly shows the current location of the imported fire ants in the Southeastern United States. The map also shows the 10° isobar below which the average temperature is less than 10°F in the winter. This isobar has been reported to be important as fire ants have difficulty wintering when the average temperature is below 10°F.⁴ It was thought they were not able to survive this cold. However, fire ants are, if nothing else, industrious. Fire ants are interbreeding with other species in order to improve their cold intolerance.⁵ Also, they are doing innovative things, such as wintering under interstate highways.⁵ Because the highways are kept free of snow and absorb whatever heat is available, the ants are surviving. This allows them to come out in the springtime in areas where we might not normally expect to find them. In addition to developing more cold tolerance, I fully expect the fire ants to be able to cross the deserts to the west, where they

Fire Ants in USA

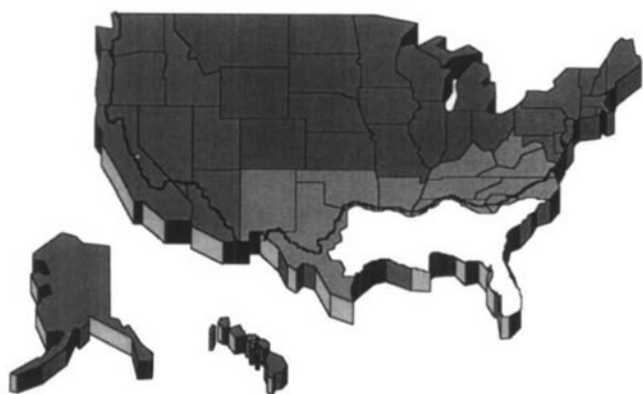


Figure 1.

do not tolerate the dryness very well, and eventually reach the California coast. This is very similar to the original trip they made from South America to the U.S. Consequently, it is expected that fire ants will eventually infest not only the Southeastern United States, but also the west coast, and perhaps reach as far north as Washington, D.C. on the east coast.

Let's examine some of the entomological features of imported fire ants. Fire ants are members of the class of invertebrates called insecta and have three body segments—a head, a thorax, and an abdomen—six legs, and paired wings. Normally, the only winged members of this species are the mating pairs of drones and princesses. Usually, shortly after a rain in the spring and early summer, mating pairs will be released from the mound.¹² They do, in fact, then mate in mid-air. After mating, the new queen will fly to the ground and there begin a new mound. The first brood requires about 4 weeks to develop.¹² During this time, the new queen survives by absorbing the muscle mass of her flight wings.¹² Her wings consequently drop off as they are no longer needed. After the first 4 weeks, workers are produced in abundance. They range in size from about 2 mm to 7 or 8 mm, and the queen is often a centimeter in size. A mature colony after about 3 years of growth will contain up to 1/4 million workers.¹²

Fire ants build mounds. Unlike several other ant species, they do not denude the area around their mound, so the mounds can be seen with grass and other vegetation growing through them. The characteristics of the mound depend upon the soil characteristics and the amount of moisture. In moist clay soil, fire ants may build mounds up to a meter high.¹² In sandy dry soil, the mounds may be almost flat. This has medical significance as many times people do not realize that they are standing upon a fire ant mound. It is in defense of their mounds that fire ants are most ferocious. Another interesting point about their mounds is that when the mounds or the ants themselves are irritated, they

will often move the openings of their mounds up to 30 m away.¹² This is often enough distance to remove them from the yard. Eradication of fire ants or of any particular mound is made more difficult by this behavior. In addition, fire ants have been shown to have more than 30 queens per colony in some cases. Because eradication of the mound requires destruction of the queen, this improves the chance of the mound surviving and makes it more difficult for us to eradicate them as well.⁷

Turning to the venom components of the imported fire ant, the amount of venom that is found in an imported fire ant approaches 40 nl per ant. Ninety-five percent of this venom volume is composed of piperidine alkaloids.² Only 0.1% of the venom is composed of protein.² This amounts to approximately 10–100 ng of protein per sting.⁹ When you consider that the average protein found in other hymenoptera stings, such as a honey bee, is about 50 µg, one can clearly see that fire ant venom is several orders of magnitude more potent than other hymenoptera venom. Doctor Hoffman of East Carolina University has examined the protein components of the venom. Table I shows the four protein components that have been described so far.⁹ By international convention, these are called Soli I, Soli II, Soli III, Soli IV. These have various molecular weights. Soli II composes the majority of venom protein component. Soli I and Soli III show some homology with other hymenoptera venoms, such as the yellow jacket and the wasp antigen 5 family.⁹ Most importantly, when people are given maintenance immunotherapy (IT) at 1:10 concentration of the whole body extract [WBE], the amount of protein that is found in that concentration and volume of WBE for Soli II and Soli III have been determined by Dr. Hoffman (see last column in Table I).⁹ Clearly, individuals receiving micrograms of protein of either Soli II or Soli III are receiving more protein than they receive in a single sting by imported fire ant (10–100 ng).

Before going on to the medical importance of imported fire ants, we should spend a moment to recognize how important these hymenoptera are in the agricultural world. Fire ants are omnivorous; that is, they eat both plants and animals.¹² They frequently build their mounds in cultivated areas because it's easier for them to build them there than in uncultivated areas.¹² Not only have they been found to eat a variety of crops, ranging from soy to cotton, but when farmers attempt to harvest their crop, if they set their harvest high enough to avoid the fire ant mounds they often have a significant impact on their harvest yield; and if they set them low enough to get their whole crop, they often destroy their farm equipment.¹¹ Fire ants have been known to attack and kill young and injured animals.¹¹ They have decimated populations of lizards and birds, mostly by preying upon their eggs in several locales in

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TABLE I

Imported Fire Ant Venom (40 nL/ant)

		% of venom protein	(Baer, 1979)	Protein in WBE
Transpiperidine alkaloids		95%		
Proteins (10–100 ng/sting)		0.1%		
Soli I	37 kD	2.5%	Cross reaction with Yellow Jacket	—
Soli II	28 kD	67%	—	7–25 µg/mL
Soli III	26 kD	20%	Antigen 5 family of neurotoxins	10–16 µg/mL
Soli IV	15 kD	9%	—	—

Hoffman et al., 1991.

Southeastern United States.¹¹ In 1981 alone the estimated loss of soybean crops due to fire ants was \$125,000,000.¹¹ So far, attempts to control fire ants have failed for the reasons that I have mentioned before. In addition, the EPA will not allow the most effective insecticides to be used in area treatment of fire ant infested locales.¹¹ Chances of eradication are therefore very slim.

Moving on to the medical importance of imported fire ants, please look at Table II. Clearly, in the Southeastern United States, fire ants are the most important cause of stings and bites. When examining everyone that has visited an emergency room at Ft. Stewart, Georgia, or has visited the physician's office for a sting or a bite, in 1979 Adams and Lofgren found that fire ants accounted for 48% of the total visits.¹ In fact, when all other identified agents were combined, including spiders, ticks, chiggers, mosquitoes, wasps, bees, and

fleas, fire ants were still the number one cause of known stings and bites in the Southeastern United States.¹

What happens to individuals who receive fire ant stings? Typically, when a fire ant stings an individual, the fire ant will grasp with its jaws, so in fact they do bite as well. The fire ant will then insert its stinger. The stinger is a modified ova-poser as all the workers are female. In nature, the venom that the fire ants injects may be used, because it is both bactericidal and fungicidal, to keep the nest area free of microorganisms.¹² In defense of the nest, the fire ant will bite and then insert its stinger, injecting its venom. If left alone, the fire ant will withdraw its stinger, pivot upon its head, and reinsert the stinger and inject again. By anchoring with its jaws, it becomes more difficult to remove the fire ant while it is carrying out this process. In fact, many people receive several stings from a single ant in a semi-circular area on an extremity. What happens after the sting? Take a look at Table III. To start with, the chances of being stung by an imported fire ant, in an endemic area, are high. Many retrospective studies have reported sting attack rates ranging from 28%–58%.¹⁷ A prospective study was done at Wilford Hall where individuals who were visiting the Southeast U.S. were asked to participate in a study. They received instructions on what fire ants were and what to look for, and they had skin testing to verify that they were previously unexposed to imported fire ants. Individuals that were willing to participate were reexamined 3 weeks later when they were ready to leave the San Antonio area. Of the 112 individuals who were eligible to participate in this study, 56 of them received a sting during their 3-week stay in San Antonio for a sting attack rate of 50%.¹⁴ Nearly all of these individuals developed an immediate wheal and flare after the sting. Ninety-six percent developed what's been called a pustule.¹⁴ In fact, what appears to be a pustule is really only necrotic tissue.⁵ This is probably caused by the piperidine alka-

TABLE II

Stings/Bites Requiring Medical Consultation at Fort Stewart, Georgia, 1979

IFA	161 patients	177 visits	(48%)
Spider	13	21	(6%)
Tick	17	18	(5%)
Chigger	14	18	(5%)
Mosquito	13	13	(4%)
Wasp	12	12	(3%)
Bee	10	13	(3%)
Flea	2	2	(<1%)
Other	85	96	(26%)
Total	329	370	

Adams and Lofgren, 1982.

TABLE III

Reactions Associated with IFA Stings		
Chance of being stung	50%	(Quinn et al., 1993)
Reactions		
Wheal & Flare	100%	
Pustule	96%	(Quinn et al., 1993)
Large local reaction	3.6–56%	(Quinn et al., 1993; DeShazo et al., 1990)
Secondary infection	54%	(Triplett, 1976)
Systemic	16%	(Triplett, 1976)
Cutaneous		
Life-threatening	0.6–2%	(Triplett, 1976; Stafford et al., 1989)
Deaths	32	(Rhoades et al., 1989)

loids contained in the venom.⁵ There is very little inflammation around imported fire ant stings if they are left to mature without being scratched. Large local reactions occur in 3.6¹⁴-56%⁴ of imported fire ant stings and are typical of large local reactions seen with other hymenoptera stings. Morbidity due to infections associated with imported fire ants may be fairly high, up to 54%.²¹ There are two reasons for this. The first is that the fire ant sting is often intensely pruritic. Individuals will unconsciously scratch until they open the pustule. The second reason is that people think they are pustules and open them on purpose. In either case, once the pustule that contains bacteriocidal and fungicidal venom is opened, the chance for infection goes up. Severe systemic reactions will occur just as they do with other hymenoptera. They may occur from 0.6²¹-2.0%¹⁸ of the time, after a fire ant sting. Deaths have occurred from fire ant stings, as reported by Rhodes et al., 1989.¹⁶

The evaluation of fire ants, then, should be carried out just as they are carried out for other hymenoptera. Individuals who have suffered a life-threatening reaction need to be evaluated. Skin testing can be done. Doctor Stafford and his group have clearly shown that WBE has testing sensitivities and specificities that are nearly equivalent to using venom when using the prick method.¹⁹ Individuals who have a positive skin test and a positive history of anaphylaxis should be placed on IT.

The great dilemma in fire ant sensitive individuals is that due to the small size of fire ants and the limited amount of venom carried per fire ant, there is no commercially available venom extract to use for imported fire ant hypersensitivity immunotherapy. Consequently, the whole body extract has been used. The dilemma is that Hunt and his colleagues at Johns Hopkins clearly demonstrated that WBE was no better than placebo in preventing subsequent reactions in individuals who were sensitive to honey bees and yellow

jackets.¹⁰ Until recently, because it was the only available therapy, WBE was used despite its lack of proven efficacy. Recently, it was reported by us that there is some reason to believe that WBE may be effective.⁶ Seventy-six individuals who suffered a systemic reaction to fire ants were offered IT with WBE.⁶ Sixty-five of those patients accepted this recommendation and 11 refused.⁶ Please see Table IV. Of the sixty-five individuals who were on IT, 47 had received subsequent accidental field stings when they were re-evaluated by our clinic several years later.⁶ Of those 47 individuals who were stung, only 1 underwent a systemic reaction.⁶ Of the 11 patients who refused IT, 6 had suffered subsequent sting events and all 6 individuals suffered systemic reactions, $p < 0.00001$.⁶ In addition, we asked all of the 76 individuals to return to our clinic for further evaluation. Thirty-one of the patients who were on IT and 4 of those who had refused IT returned for re-evaluation.⁶ Of the 31 individuals on IT, 26 had skin tests that had become negative;⁶ the other five had decreased skin test sensitivity.⁶ The four individuals who had refused IT had skin testing that remained about the same.⁶ Thirty of the individuals who were on IT and had received follow-up skin testing agreed to participate in a sting challenge. The sting challenge was carried out under physician supervision in a room equipped with emergency materials. We were, of course, concerned about getting systemic reactions and treating them. The problem we ran into was getting the fire ants to sting. After removing them from the locale of their mound and giving them a few minutes to calm down, most of the fire ants were more interested in exploring their surroundings rather than in stinging the individuals that we wanted them to sting. Eventually, we had to force the head of the fire ant down against the skin in order to make it insert its stinger and begin to sting. Thirty of the individuals were stung and none of those individuals reacted to their sting challenge.⁶

TABLE IV

Demographics of Treated and Untreated Patients

	Immunotherapy Group	Untreated Group
No. of patients	65	11
Age range	2-76 (mean: 37)	23-61 (mean: 42)
Sex [M:F]	22:43	7:4
Initial IFA sting history		
Reaction type		
Generalized cutaneous	24 (37%)	1 (9%)
Generalized life-threatening	41 (63%)	10 (91%)
No. multiple anaphylaxis	9 (14%)	1 (9%)
Study evaluation		
No. without subsequent stings	18	5
No. with repeat stings	47 (112 events)	6 (11 events)
Reaction type*		
Generalized cutaneous	0	2
Generalized life-threatening	1 (2.1%)	4

* *P* value comparing 1/47 to 6/6 is <0.00001.

Although this study is, in part, retrospective, it does reassure us that there may be some protection. It provides us with some evidence (besides Dr. Hoffman's studies mentioned above) that there may be enough venom in the WBE to protect IFA sensitive patients.

In summary, fire ants may certainly be considered the ANTS FROM HELL! They certainly sting and they kill; they destroy; they mate in mid-air; and we may not be able to stop them. However, although they inject extremely potent venom, individuals can prevent secondary infections by leaving the so-called pustules alone and not opening them. Individuals who suffer systemic reactions may receive adequate treatment with the WBE IT.

REFERENCES

- Adams CT, Lofgren CS. Incidence of stings or bites of the red imported fire ant and other arthropods among patients at Ft Stewart, Georgia, U.S.A. *J Med Entomol* 19:366-370, 1982.
- Baer H, Liu TY, Anderson MC, Blum M, Schmid WH, James FD. Protein components of fire ant venom (*Solenopsis invicta*). *Toxicons* 17:397-405, 1979.
- Blum MS, Callahan PS. Chemical and biological properties of the venom of imported fire ant and the isolation of the insecticidal component. *Trans 11th Internal Congress Entology [symp 3/4]:290-293*, 1960.
- deShazo RD, Butcher BT, Banks WA. Reaction to the stings of the imported fire ant. *N Engl J Med* 323:462-466, 1990.
- deShazo RD and Soto-Aguilar M. Reactions of the imported fire ant. *Allergy Proc* 14:13-16, 1993.
- Freeman TM, Hylander R, Ortis A, Martin ME. Imported fire ant immunotherapy: Effectiveness of whole body extract. *JACI* 90:210-215, 1992.
- Glancey BM, Craig CH, Stringer CE, Bishop PM. Multiple fertile queens in colonies of the imported fire ant, *Solenopsis invicta*. *J Georgia Entomol Soc* 8:237-238, 1973.
- Hoffman DR, Dove DE, Moffitt JE, Stafford CT. Allergens in hymenoptera venom XXI cross reactivity and multiple reactivity between fire ant venom and bee and wasp venoms. *JACI* 82:828-834, 1988.
- Hoffman DR, Jacobson RS, Schmidt M, Smith AM. Allergens in hymenoptera venoms XXIII. Venom content of imported fire ant whole body extracts. *Ann Allergy* 66:29-31, 1991.
- Hunt KJ, Valentine MD, Sobatka AK, Benton AW, Amodio FT, Lichtenstein CM. A controlled trial of immunotherapy in insect hypersensitivity. *NEJM* 299:157, 1978.
- Lofgren CS. The economic importance and control of the imported fire ant in the United States, In: *The Economic Impact and Control of Social Insects*. Vinson BS (Ed.) New York Pregor Press, 1986, pp. 227-256.
- Lofgren CS, Banks WA, Glancey BM. Biology and control of imported fire ants. *Ann Rev Entomol*, 20:1-30, 1975.
- Motta P, Hylander RD, Martin ME, Freeman TM. Discontinuing fire ant immunotherapy (abstract) *JACI* 87:238, 1991.
- Quinn JM, Tracy JM, Demain JG, Hoffman DR, Freeman TM. A natural history of exposure to imported fire ants (*Solenopsis invicta*) (abstract). *JACI* 91:189, 1993.
- Rhoades RB, Schafer WL, Neuman M, et al. Hypersensitivity to the imported fire ant in Florida. A report of 104 cases. *J Florida Med Assoc*, 64:247-254, 1977.
- Rhoades RB, Stafford CT, James FK. Survey of fatal anaphylactic reactions to imported fire ant stings. *JACI* 84:159-162, 1989.
- Stafford CT, Hutto LS, Rhoades RB, Thompson WO, Impson LK. Imported fire ant as a health hazard. *Southern Med J* 82:1515-1519, 1989.
- Stafford CT, Hoffman DR, Rhoades RB. Allergy to imported fire ants. *Southern Med J* 82:1520-1527, 1989.
- Stafford CT, Moffitt JE, Bunker-Soler A, Hoffman DR, and Thompson WO. Comparison of *in vivo* and *in vitro* tests in the diagnosis of imported fire ant allergy. *Ann Allergy* 64:368-372, 1990.
- Triplett RF. Sensitivity to imported fire ant: Successful treatment with immunotherapy. *Southern Med J* 66:477-480, 1973.
- Triplett RF. The imported fire ant: Health hazard or nuisance? *Southern Med J* 66:477-480, 1976. □

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