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Potential Biological Control Agents for the Red Imported Fire Ant

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The red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae), arrived in the United States from South America with few parasites or pathogens that regulate the ant's populations (Wojcik 1998), (see *Natural Enemies of Fire Ants*). This lack of natural enemies is one factor that has allowed the ant to spread and dominate resources in its non-native range (Porter 1998). Fire ant densities are many times greater in the United States than in South America where a variety of natural enemies attack this pest. Attempts are currently underway in the United States to augment natural enemies in order to reduce its impact.

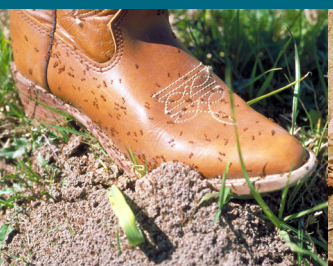
How Is Biological Control Accomplished?

Biological control of pest organisms relies on keeping native natural enemies, introducing and establishing native natural enemies into pest areas, or mass-rearing and releasing new exotic natural enemies. This last approach is known as **importation biological control.**

The first step is to search for promising natural enemies in the ant's native home, considering for importation and release in the United States only natural enemies that specifically attack the red imported fire ant. Native ant species compete with imported fire ants for food and can reduce imported fire ant populations through competition for resources. Some native ants also attack and kill young fire ant queens as they begin to establish colonies in new territories.

The importation of exotic natural enemies must be approved by the United States Department of Agriculture–Animal and Plant Health Inspection Service (USDA–APHIS). Once approved for importation and release in the United States, the exotic natural enemy is reared in large numbers and released at multiple locations over several years. The goal of importation biological control is to establish permanent and effective populations of the exotic natural enemy to eliminate the need for further mass-rearing and release, which is expensive.

Some imported natural enemies may be effective but fail to establish permanent populations. Other





native natural enemies may already be present in the United States but occur in numbers too small to provide effective control. In these cases, it may be possible to mass-rear the native natural enemy and periodically release it to increase the level of biological control. This activity is **augmentation biological control.**

This approach requires rearing procedures that maintain the genetic characteristics necessary for the natural enemy to be effective when released in the field. Some natural enemies, especially pathogens, may be formulated and applied much like an insecticide and are sometimes called biopesticides.

How Does Biological Control Work?

Parasites, pathogens, and predators can impact fire ant populations directly by killing ants or indirectly by making them less competitive with native ants for available resources. Native ants compete with red imported fire ants for food. Also, some native ants feed on fire ant queens and can eliminate colonies before they are established or while they are still small. Most of our native ant species cannot compete effectively with fire ants. If imported natural enemies reduce the fire ant's ability to compete for food, disperse, or reproduce, then native ant species may gain a competitive edge and begin to suppress fire ant densities.

It takes **a combination of several natural enemies** to shift the competitive and ecological balance in favor of the native ants. Establishing new exotic enemies and developing methods for augmenting native natural enemies of the red imported fire ant require long-term commitments to research and development. Even then, natural enemies alone will not control fire ants. Rather, biological control will be one part of an **integrated pest management** program that includes selective insecticides, cultural practices, and other control methods (see *What is IPM?* and USDA Agricultural Research *Areawide Fire Ant Suppression*).

Natural Enemies of the Red Imported Fire Ant

The following is a list of parasites, pathogens, and predators under study for potential use as biological control agents. Most are in the early stages of research. A few species have been released in limited numbers under controlled conditions and some have established and spread.

Microsporidia

***Kneallhazia solenopsae* (Formerly *Thelohania solenopsae*).** *K. solenopsae* is a microscopic protozoan that infects immature and adult fire ants. Infected ants, including queens, have shorter life spans, and, over a period of several months to a year, the colony declines in size and vigor. Presumably, diseased ants moving between multiple-queen colonies transmit the pathogen. *K. solenopsae* attacks only the exotic red and the black imported fire ant although there is an unconfirmed report of a similar strain detected in *Solenopsis geminata,* the tropical fire ant.

In Argentina, about 20 percent of the red imported fire ant colonies are infected. Surveys in the Unites States did not detect this disease organism until 1996, when it was discovered in Florida. Since then, *K. solenopsae* has also been found and/or released in most fire ant **infested southeastern states** (Milks et al. 2008). Research is underway to discover ways to increase the impact of this pathogen and culture it in the laboratory and the field (Williams et al. 1999). There is also evidence that in areas where insecticides were used to clear fire ants, infected fire ant populations will not re-infest areas as quickly as uninfected populations will (Vander Meer et al. 2007, Oi et al. 2008).

Fungi

Beauveria. *Beauveria bassiana,* a common fungus, attacks many insect species. A strain of *Beauveria* that attacks the imported fire ant was reported from Brazil in 1987. This fungus pro-

duces microscopic spores that attach to the ant's body, germinate, and grow inside the ant, feeding on its internal organs. When the ant dies, its body becomes filled with fungal growth. The fungus sometimes grows outside the dead ant, covering it with a white, fuzzy growth. Studies have shown that when *B. bassiana* is applied to the soil, it is much less effective than if the spores are applied directly to the ants. The application of *B. bassiana* to fire ant baits has been investigated, but a commercially formulated product has yet to be introduced to the market (Bextine & Thorvilson 2002).

Metarhizuim anisopliae Aspergillis spp. (see *Fungi as Biocontrol Agents*)

Virus (see *Viruses as Biocontrol Agents*)

Parasitiods

Phorid flies. Phorid flies (*Pseudacteon* spp.) are small flies that parasitize ants, including fire ants. The adult flies are about 1/16 inch long and fly rapidly. They hover above disturbed fire ant mounds or along foraging trails, waiting for an opportunity to swoop down and parasitize workers by depositing an egg into them. Once in the ant, the egg quickly hatches into a tiny maggot. The maggot feeds inside the ant for about 3 weeks before the parasitized ant dies. The ant's head falls from its body as enzymes produced by the parasite dissolve the connective tissue that attaches the head to the body. During the final stage of attack, the maggot consumes all of the head's contents. Pupariation, the onset to the larval-pupal transition, occurs in the severed head capsule and the adult fly emerges from the ant's head about 3 weeks later.

Typically, parasitism rates in infested colonies only reach 1 to 3 percent of workers, and this alone has little impact on fire ant numbers. The flies' effect on ant behavior is more important. Fire ant workers quickly recognize when phorid flies are present and either attempt to escape underground or assume a defensive posture. The presence of only 3 to 4 flies is sufficient to disrupt ant activity.

As a result, ants attacked by phorid flies spend less time searching for food. Native ant species, which are not attacked by the phorid flies, benefit by the greater food resources available to them. Thus, the reduction in food collection and increased competition from native ants has a much greater negative impact on a fire ant colony than does the death of a small percentage of worker ants from parasitism. Red imported fire ants respond similarly to introduced phorid flies, whether in the United States or their native South America.

About 20 species of *Pseudacteon* in Brazil and Argentina attack the red imported fire ant and several of these species have been evaluated, mass-reared, and released in the United States (Callcott et al. 2011). It is expected that those phorid species that attack ants foraging for food will be more effective than those fly species that attack ants only at disturbed mounds. Six *Solenopsis*-attacking phorid fly species have been released and established in the United States: *Pseudacteon tricuspis, P. curvatus, P. obtusus, P. litoralis, P. nocens,* and *P. cultellatus* (Gilbert et al. 2008, Plowes et al. 2011, Porter et al. 2011).

Parasitic ant. *Solenopsis daguerri* is an unusual ant species that takes control of the fire ant colony by parasitizing the fire ant queen or queens (see *Parasitic Ants as Biocontrol Agents*). The parasitic ant enters the fire ant colony and

is not killed because it produces the same pheromone (chemical signals) that fire ants use to recognize their fellow nest mates. The parasitic ant seeks out a fire ant queen, crawls on top of her, and grasps her tightly with its legs and jaws, thereby "yoking" the imported fire ant queen. A fire ant queen can become "yoked" by two or three parasitic queen ants. Each parasite produces queen pheromones that allow it to masquerade as a fire ant queen. Thus deceived, the worker fire ants proceed to feed the parasite and tend the eggs it produces. The fire ant queen, left untended by the workers, gradually stops laying eggs and starves to death. Fire ant workers rear the parasitic ant eggs and soon the fire ant colony becomes a colony of parasitic ants. Emerging parasitic ants, which are all queens (no worker ants are needed) leave the colony in search of new fire ant colonies to parasitize. In South America, the parasitic ant is present in about 1 to 4 percent of fire ant colonies. The parasitic ant is not currently in quarantine in the United States and researchers are developing methods to rear sufficient numbers of the parasite for eventual release across the North American fire ant range.

Strepsiptera. Strepsiptera are minute insects that parasitize other insects. One species, *Caenocholax fenyesi,* attacks the red imported fire ant in the United States (Cook et al. 1997, 1998). Like other Strepsiptera, *C. fenyesi* has a complex and unusual life cycle. The female parasitizes a species of bush cricket, *Hapithus agitator.* Once the immature parasite has consumed the cricket, she develops into the adult stage. However, the adult female never leaves the dead cricket. Rather, she produces thousands of eggs that hatch into larvae called triungulins. The tiny, flattened triungulins leave the female and search for new hosts. While female triungulins must find another bush cricket, male triungulins develop in fire ant adults. Once a male triungulin attaches to a passing fire ant, it burrows into the ant to feed and develop. Parasitized fire ants typically climb to a high perch where they soon die. The adult male Strepsiptera then emerges from the dead fire ant. In Texas, only about 1 to 2 percent of the fire ants in a colony are parasitized by *C. fenyesi.*

Orasema. Species of *Orasema* (Eucharididae) are tiny wasps that parasitize immature ants, including fire ants (see *Distribution, abundance and persistence of species of Orasema (Hymenoptera: Eucharitidae) parasitic on fire ants in South America*). Female *Orasema* wasps lay large numbers of eggs on plant leaves and buds. The eggs hatch into tiny flattened larvae called planidia. They lie in wait and attach to passing ants. Once in the ant colony, the planidia leave the worker ant, attach to ant larvae, and consume their hosts after pupation begins. Typically, *Orasema* kills a small percent of fire ants. Several species of *Orasema* parasitize the imported fire ant in South America, and several other species of *Orasema* occur in the United States. Research is underway to learn more about these ant parasites and to develop mass-rearing techniques.

Nematodes and mites. Certain nematodes (*Steinernema carpocapsae* and *Heterorhabditis* species) attack and parasitize red imported fire ants and other insects (see *Natural, Organic, and Alternative Methods for Imported Fire Ant Management*). Ants in treated colonies often leave the nesting site or mound and move to a new location (Drees et al. 1992). However, field evaluations of commercially available species/strains of these parasites currently being marketed for fire ant control have not yet been conducted to demonstrate their effectiveness.

***Pymotes* sp.** The straw itch mite, *Pymotes tritici,* is a native external mite parasite of insects and does not normally attack fire ants. However, when applied in large numbers to fire ant colonies under laboratory conditions, straw itch mites will feed on immature ants. Published field research evaluating commercially available straw itch mites applied as directed to fire ant colonies have reported insignificant levels of control (Thorvilson et al. 1987). Moreover, the straw itch mite is widely regarded as a pest and, as its name implies, can cause skin irritation in humans.

The *Pymotes* mite and parasitic nematodes have been available for sale as individual mound treatments. Their high cost may prohibit large-scale use. Also, their effects, if any, are generally limited to the treated ant colonies and are not expected to persist in the environment or spread from colony to colony. However, additional research may improve nematode and mite strains and delivery methods to make them effective biological control agents.

Some Potential and Natural Enemies of Red Imported Fire Ants

Pathogens

Microsporidia

Kneallhazia (*Thelohania solenopsae*) (Protozoa: Microspora: Thelohaniidae). Produces large cysts in adult ants; found in adult and immature ants.

Vairimorpha invictae (Protozoa: Microspora: Burenellidae). Does not produce cysts; found in adult and immature ants.

Protozoa

Mattesia geminata (Protozoa: Neogregarinida: Lipotrophidae). Spores found in immature fire ants and infected individuals die in the pupal stage.

Fungi

Beauveria bassiana (Fungi: Deutero-mycotina). A strain of this common fungus grows internally in adult fire ants and kills them.

Metarhizium anisopliae (Fungi: Deutero-mycotina). A strain of this common fungus grows internally in adult fire ants and kills them.

Aspergillis spp. (Fungi: Deutero-mycotina). A strain of this common fungus grows internally in adult fire ants and kills them.

Virus (picorna-like virus) *Solenopsis invicta* virus (SINV-1), (see *Viruses as Biocontrol Agents*).

Parasitoids

Parasitic fly. *Pseudacteon* spp. (Diptera: Phoridae). Larvae are internal parasitoids, but few (1 to 3 percent) of the ants are parasitized. Egg-laying attempts by adult flies prevent daytime ant foraging behavior, providing time for native ants to forage.

Parasitic ant. *Solenopsis daguerri.* (Hymenoptera: Formicidae). Workerless, obligate parasitic ant (cannot complete its life cycle without a suitable host).

Strepsiptera. Tiny insect parasitoids of fire ants.

Parasitic wasp. *Orasema* spp. (Hymenoptera. Eucharitidae). Females lay eggs on plant tissue. After the eggs hatch, the planidia (first stage larvae) are phoretic on worker ants (they use fire ants as a mode of transport). In the nest, planidia feed externally on ant pupae and kill the ant in the pupal stage.

Nematodes. *Tetradonema solenopsis* (Nematoda: Mermithoidea: Tetradonematidae). Commercially available species include Steinernema caropcapsae and *Heterorhabditis heliothidis.*

Mites. *Pyemotes ventricosus* (Acarina: Pyemotidae). Common in the United States. These mites are not normally found attacking fire ants but will feed on fire ants if applied in large numbers.

Predators (also see *Predators*)

Several different kinds of insects live in fire ant colonies and feed on immature ants. These include species of beetles (Scarabaeidae, Histeridae and Chrysomelidae), true bugs (Hemiptera: Lygaeidae) and silverfish (Thysanura). None of these are being considered at this time as biological control agents.

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Broadcast Baits for Fire Ant Control
www.agrilifebookstore.org/product-p/e-628

Fire Ant Control: The Two-Step Method and Other Approaches
www.agrilifebookstore.org/product-p/ento-034

For more information regarding fire ant management, see Extension publications *Managing Red Imported Fire Ants in Urban Areas, Broadcast Baits for Fire Ant Control,* or *Fire Ant Control: The Two-Step Method and Other Approaches* posted on http://AgriLifeBookstore.org.

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