POTENTIAL OF THREE BIOLOGICAL CONTROL AGENTS FOR SUPPRESSION OF *SOLENOPSIS INVICTA*, THE RED IMPORTED FIRE ANT

RICHARD S. PATTERSON AND JUAN A. BRIANO
Medical and Veterinary Entomology Research Laboratory Agricultural Research Service, U.S. Department of Agriculture, P.O. Box 14565, Gainesville, Florida USA 32604

Abstract—Three potential biological control organisms, a fungus *Beauveria bassiana*, a protozoan *Thelohania solenopsis* and a parasite, *Solenopsis daguerrei* are being evaluated in the field to suppress fire ant populations. All of these organisms have some detrimental effect on fire ants in the laboratory but little is known what effect they have on field populations. Although *B. bassiana* gave complete mortality of ants in the laboratory, no mortality was observed when it was mixed with the potting soil and fire ants were exposed. This fungus did seem to stimulate colony movement. If the soil was sterilized, then this fungus was more lethal to the ants, especially the brood and queens. The fungus was effective against ants in media with little or no organic matter such as vermiculite or sand. However, for practical control of fire ants in potting media, *B. bassiana* does not work. In the laboratory colonies infected protozoan with this disease *Thelohania solenopsis* quickly died and it was very effective in the field in reducing the size and number of fire ant colonies. However, much more research needs to be done before this disease can be introduced into the United States. Still this organism appears to have great promise as a potential biological control organism of fire ants. It has been reported in the literature that the parasite *Solenopsis daguerrei* will kill the queen, and is very specific for fire ants. However, it is cyclic and does not seem to be very lethal to the fire ant colonies in Argentina. Although it probably has a draining effect on the host colony.

INTRODUCTION

Although, there are over 20,000 species of ants in over 300 genera throughout the world. Only a few dozen species of exotic and native ants are serious urban pests. Many of their fellow members in the same family and genus are completely innocuous in their native homeland. These urban pests become a problem when they are somehow released from their natural restraints and they interfere with man's well being. The imported fire ants, both the black *Solenopsis richteri* and the red *S. invicta* are excellent examples of species that were accidentally introduced into an environment free of any biological restraints and within a few decades have become a major economic pests (Wilson, 1986).

In their native homeland of South America in undisturbed areas fire ants are not a serious pest, but in the southeastern U.S., they are considered to be a major urban pest and millions of dollars are spent annually to control them (Lofgren, 1986). In Florida, the red imported fire ant invades homes, hospitals and restaurants and is very difficult to control according to a survey of Pest Control Operators (Bieman and Wojcik, 1990). Although the black imported fire ant, *S. richteri*, which came from Argentina was first introduced into Mobile, Alabama in the 1920's, ironically its rapid spread may have been initially hampered by another South American ant accidentally introduced into the U.S.A., the Argentine ant, *Linepithema humile*. The black imported fire ant was, however, able to outcompete the Argentine ant and most of our native ants, and was able to establish itself in several thousand acres within two decades after introduction (Lofgren *et al.*, 1975). Attempts to control this species using various pesticides met with limited success. Then in the late 1930's a more virulent form or species of fire ant, the red imported fire ant, from Brazil, later named *S. invicta*, was imported into Mobile, Alabama. Within twenty years it was the dominant ant in the region (Lofgren, 1986). Wojcik (1993) reported on a twenty year study in central Florida which showed that *S. invicta* had replaced the tropical fire ant, *S. geminata* and *Pheidole dentata* as the dominant ants found along roadsides in open areas. According to Porter (1992), it now represents 97% of the ants collected along roadsides in the region, whereas, in Brazil fire ants represent only 23% of the ants collected and *S. invicta* is not necessarily the dominant fire ant species collected. There are numerous *Solenopsis* species (Trager, 1991) in South America. The impressive and rapid spread of *S. invicta* in the U.S.A. has been aided by several factors such as favorable climate, the ant's biology, ecology, and the lack of competitors. Climatic conditions in the southeast United

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States are ideal for these two species of fire ants introduced from Brazil and Argentina. *Solenopsis invicta* has a tremendous reproductive potential more than any of our native ants. Individual or monogyne colonies may have up to several hundred thousand workers and the polygyne colonies have as many as a million workers or more (Williams, 1990). Just obtaining enough food to sustain these large colonies require a tremendous amount of energy and aggressiveness. Fire ants because of their need to support large colonies are omniferous feeders and very competitive with our native ants. Probably one of the biggest facts influencing the rapid spread of fire ants in the southeastern U.S.A. is the vast changes in the ecology of the region. Following World War II, there was a rapid population movement in the U. S. from the industrial areas of the North to the warm region of the South and West, "the Sunbelt". Forests and farms were eliminated to make room for new homes, recreational areas and industries. Since fire ants are a "Weed Species" (Tschinkel, 1986) which thrives in recently opened disturbed areas, this newly disturbed environment was an ideal situation. In South America there are numerous closely related species of fire ants which may be equal or more competitive than the red imported fire ant (Trager, 1991), plus in the tropics there are many other species of ants of different genera and families which are competing for the same space and food with the red imported fire ant. Thus the general conception that the red imported fire ant is not a problem in its home land is true to some degree. However, in some areas in South America, such as Brazil and Argentina, where climate, agricultural practices and land use are similar to the U.S.A. the red and/or black fire ant populations can be as high as in the U.S.A. often exceeding 200 colonies per acre (Banks *et al.*, 1985). In one area of Argentina covering several thousand hectares where *S. richteri* is the dominant species, the number of colonies per hectare exceeds 400; yet the farmers there do not consider fire ants a serious pest. Still the overall population density of fire ants in South America is much less than in the U.S.A (Porter *et al.*, 1990). The reason for this is more complicated than just a single pathogen, parasite or predator limiting the ants distribution.

If one looks at fire ants they would seem to be an ideal candidate for biological control agents (Jouvenaz, 1986). They are very concentrated, feed one another, they usually live in a colony which has a fairly high humidity, the immature stages are immobile in a concentrated mass, and only the queens are able to reproduce. However, over the years, fire ants have developed techniques to prevent the invasion of any pathogen, parasite, or predator into their colony that would be detrimental to it. Fire ants are excellent housekeepers and personal groomers. They seem to be able to quickly recognize any invader through chemical clues and they then attack it. They will attempt to sting any foreign object and if possible remove it from the colony. Some organisms called myrmecophiles (Table 1), have adapted and assumed the chemical clues of a particular fire ant colony and are able to survive quite well (Wojcik, 1990). The effect of these myrmecophiles on colony survival is not well known, but it is assumed that they have some draining effect (Jouvenaz 1990). Glancey *et al.*, (1981) reported that fire ants do filter out particles as small as 0.88 um thus eliminating most of the bacterial and fungus spores before they can infect the ants. Fire ants are also capable of secreting a number of chemicals from their metapleural glands and other exocrine organs which have antibiotic and antifungal properties. These secretions are spread throughout the colony and from one ant to another through grooming (Hölldobler and Wilson, 1990; Obin and Vander Meer, 1985; Jouvenaz *et al.*, 1972). Since most soils harbor many organisms that are pathogenetic to ants, these secretions aid in the survival of the colony.

Table 1. Arthropod groups (myrmecophiles associated with fire ants) (Wojcik 1990)

Diplopoda	
Acarina	
Insecta	
Thansannia	Strepstera
Orthoptera	Coloeptera
Blattarea	Diptera
Homoptera	Hymenoptera
Hemiptera	Lepidoptera

Table 2. Potential biological control of organisms for red imported fire ant, *S. invicta*[1]

Organisms	Pathogen	Type
Pseudomonas aeruginosa	Bacteria	non-specific
Serratia marcescens	Bacteria	non-specific
Bacillus thuringiensis	Bacteria	non-specific
Bacillus spheracus	Bacteria	non-specific
**Beauveria bassiana*	Fungus	non-specific
Metarrhizium anesopliae	Fungus	non-specific
Aspergillus flavus	Fungus	non-specific
**Thelohania solenopsae*	*Protozoa*	*specific*
**Vairimorpha invicta*	Protozoa	specific
Mattesia geminata	Protozoa	specific
Burenella dimorpha	Protozoa	specific
	Parasites	
**Steinernema carpocapsae*	Nematode	non-specific
Heterorhabditis heliothidis	Nematode	non-specific
**Tetradonema solenopsis*	Nematode	specific
Pyemotes tritici	Mite	non-specific
**Pseudacteon* spp.	Diptera (Phorid fly)	specific
**Apodicrania* spp.	Diptera (Phorid fly)	specific
Orasema spp.	Hymenoptera (wasp)	specific
**Solenopsis daguerrei*	Hymenoptera (ant)	specific
Martinezia dutertrei	Coleoptera (beetle)	specific
Myrmecosaurus ferrugineus	Coleoptera	

[1]Pathogens and parasites which have been investigated as potential fire ant biological control agents.
*Currently being investigated

Very few pathogens and parasites have been described in the literature for any species of ants. During the past several decades numerous surveys have been made in South America and throughout the United States looking for potential biological control organisms of fire ants (Jouvenaz *et al.*, 1977, 1986). A limited number of organisms have been identified (Table 2) and many of these are nonspecific for fire ants such as the fungi of the genera *Beauveria* and *Metarrhizum* (Stimac et al. 1987). The literature on pathogens and parasites of fire ants consists mainly of descriptions and how the organisms affects the individual ant. Limited research has been published on the impact of these organisms on the entire colony. Jouvenaz did an excellent study of the pathogen *Burenella dimorpha* which affects only the tropical fire ant *S. geminata.* Although usually less than 5% of colonies are infected, at times all the colonies at a single location will be infected (Jouvenaz, 1986). Unfortunately, now that *S. geminata* populations have declined because of the dominancy of *S. invicta*, this disease is very scarce (Jouvenaz personal communications), and this disease was never tested in the field as to its potential as a biological control agent.

In an attempt to rectify this deficiency, a limited number of field studies with biological organisms have been conducted on field populations of fire ants. Reported here are three studies which have been conducted with wild fire ant populations. The object of the first study was to determine the impact of a nonspecific pathogen, *Beauveria bassiana* on fire ant populations found infesting potting soil housing nursery plants. The object of the second study was to determine the impact of a natural occurring pathogen, *Thelohania solenopsae* on an indigenous population of fire ants in South America and to determine its potential as a biological control organism for possible importation into the United States to suppress *S. invicta.* The third study was on the impact of the parasite *Solenopsis daguerrei* was having on indigenous populations of *S. richteri* in Argentina.

Beauveria bassiana

Beauveria bassiana is a nonspecific pathogen that is capable of attacking many arthropods. Its potential as a biological control organism has been explored by numerous scientists for various insect pests over the years (Ferron 1978, 1981). Recently there has been a renewed interest in this organism for fire ant control. Stimac *et al.* (1989, 1990) reported on a high colony mortality (80%) when a strain of this fungus from Brazil was applied to individual fire ant mounds. They also found that it was present in the soil 150 days after treatment. They treated the soils with 200 g of the fungal formulation, using the conidia in a 5% formulation on rice. There was an increase in fire ant colony movement (forming of satellite colonies) following treatment with the fungal formulation. Because of these and other promising reports (Broome *et al.*, 1976) a series of studies were designed to determine if *B. bassiana* could be used to prevent fire ant infestations in the potting soil used for nursery plants prior to shipment.

METHODS AND MATERIALS

The strain of *B. bassiana* used in these studies originated from leafcutting ants collected in Mexico. A number of concentrations of a dry mycelium formulation was mixed with the soil were tested in the laboratory and it was found that a 0.5% formulation mixed in the soil gave the best results. A large field study using treated (0.5% dry mycelium/soil mixtures) and untreated soil in pots with and without plants was set up. The pots were infested with polygyne colonies of fire ants, a set of 5 queens, 1 gram of brood and 3–4 thousand workers were added to each pot. To check, if the fungus had any repellent effect, all pots were checked for colony movement. At set intervals for 30 days, the ant colonies in the soil from the pots were examined for any mortality. The test was run outside under ambient conditions. There was no significant mortality of the ant colonies from the fungus, but there was a repellency effect. A second large study was run using various types of media (potting soil, sand, vermiculite, and various mixtures of these, both sterilized and unsterilized). The set up was basically the same as before, except no plants was used and the pots containing the soil were held at a constant temperature (80°F) and high humidity (80–90% R.H.). A check was made of the mortality of the queens, brood and workers exposed to the fungi in the various media.

RESULTS

In the first study there was no significant mortality of the ants when the soil was examined. There was significant movement of colonies from the treated soil. In the second study, as seen in table 3 there was high mortality of the queens, brood and workers in the vermiculite medium. Using a mixture of vermiculite and sterile potting soil there was less mortality of the queens, brood and workers. When potting soil was used alone, there was no effect on brood or workers and insignificant queen mortality. Therefore, there must be something in the unsterilized soil inhibiting the *B. bassiana*, because almost all the brood was infected with fungus in the sterile potting soil. A series of tests were run to determine what was causing this lack of effectiveness of the fungus in nonsterilized soil to fire ants. The results were inconclusive except that if the potting soil was sterilized, the fungus was effective. Also if a medium was used with a very low organic matter content, such as sand mixtures, the efficiency of the fungus also increased. A small field study was also conducted in which individual mounds were treated with the fungus to determine mortality and repellency. Complete colony mortality did not occur but treated colonies often moved. These results were similar to what Stimac *et al.*, 1990 had reported.

To summarize the results of these studies with this fungus we found that *B. bassiana* will kill fire ants as reported previously in the literature (Stimac *et al.*, 1990). The brood is very susceptible to the fungus, queens are less so and the workers are more resistant probably because they are more adapt at grooming themselves and one another of spores. The fungus does have a repellent effect, but is not an extremely strong one. Although it can kill ants, it was not efficient in eliminating an entire

Table 3. Effects of 0.5% B. bassiana on red imported fire ants in different substrates after 7 days.

	% Mortality		
Media	Queens	Brood	Workers
Control	9	0	0
Potting Soil	17	0	0
Sterile Potting Soil	25	95	0
Vermiculite	75	100	85
Sterile Potting Soil/vermiculite 50/50	59	95	50

colony unless the queen is infected. At this time, *B. bassiana* is not recommended for use in protecting potting soil which contains nursery stock from fire ant invasion prior to shipment.

Thelohania solenopsae

Although numerous surveys have been made of what pathogens and parasites attack fire ants, almost nothing is known of the effect these organisms have on indigenous ant populations (Jouvenaz et al. 1981). Therefore, a long term study was initiated in Argentina in 1988 to follow what happens to fire ant colonies infested with the microspordian disease, *Thelohania solenopsae*. We are working with the black imported fire ant *Solenopsis richteri*; however, some plots contained a few colonies of *S. quinquecupis*.

The objectives of this study were to determine: 1) what effect, if any, this disease had on the total colony, not individual ants; 2) what percentage of the ants and castes had the disease; 3) does the disease cause the colony to move more frequently; 4) how this disease is spread within the colony from ant to ant and from colony to colony in the field; 5) can the healthy ants perceive the infected ants in the colony and remove them, thus eliminating the disease; 6) does this disease require an intermediate host for transmission from ant to ant or colony to colony; 7) is the microspordian disease *T. solenopsae* in *S. richteri* the same as the one described in *S. invicta* from Brazil, and 8) finally does this disease have any potential as a biological control agent and should it be introduced into the U.S.A.?

Thelohania solenopsae was selected because it was the most common pathogen present in fire ant colonies surveyed in Argentina. The description of *T. Solenopsae* and the disease it caused in fire ants in Brazil was given by Knell *et al.*, 1977. Its occurrence in host ant populations had been reported by numerous earlier scientists (Allen and Buren 1974, Allen and Silvera-Guido 1974 and Jouvenaz *et al.*, 1980). All attempts to transmit the disease to healthy colonies of fire ants have failed (Jouvenaz, 1986). However, recent studies with another microspordian disease, *Amblyosporidae* in mosquitoes, have shown that an intermediate host is often required before transmission is possible back into the mosquito population, (Andreadis, 1985, 1988; Sweeney *et al.*, 1985, 1988; Becnel 1992. There are sound biological reasons to suspect that alternate hosts may be involved in intercolonial transmission of this microsporidian disease in fire ants. Since there are a limited number of arthropods which are symbiotic with fire ants (Wojcik, 1990), they were examined for the disease. Observations by Knell *et al.*, 1977 indicated that this disease did not quickly kill the colony. Often very large, apparently healthy colonies were found in the field with high infection rates of this pathogen. However, we did not know the ultimate fate of these colonies after a period of time, in fact, we do not really understand fire ant population dynamics in South America very well.

MATERIALS AND METHODS

Six circular plots, 40 meters in diameter, were set up in unimproved pastures containing cattle and hogs in Saladillo, (Buenos Aires Province) Argentina. Each active fire ant colony was plotted on a map by measuring from a central stake using the four compass quadrants. The plots were almost side by side in a series of pastures. The average number of active colonies per hectare was 198 in the six plots. Three of the plots had fairly high disease rates with 35% of the colonies being infected. The other three plots were relatively free of the disease with only 3% of the colonies being infected.

The plots were checked monthly. The number of colonies (mounds) in each plot was checked monthly to determine the viability of the colony. If the colony moved since the last observations, we wanted to know if the diseased ants moved with the colony? We tried to follow individual colonies. Some of this was done with dyes, but mainly it was with observations on new mounds in close proximity to old abandoned colonies or mounds. We also checked for the presence of brood, workers, and sexuals and if the colony appeared to be healthy and if the disease was present. Each colony or mound was measured for its height, width and ant activity. A small glass vial was inserted into the mound for less than 10 minutes to collect the ants. Then the vials were removed, capped and returned to the laboratory so ants could have microscopic examination for the disease. In the laboratory, the ants were ground with water in a tissue grinder, then a small drop of the ground material was placed on a glass slide, covered by a cover slip and examined by phase-contrast microscopy at 400× for the presence or absence of *Thelohania* spores. Since this sampling was a mixture of many individual ants both major and minor workers and usually the older ants, initially we could only tell the presence or absence of the disease in the colony; not the percentage or which castes were infected. Jouvenaz (1986) had reported that fire ant workers, sexuals and queens were infected with this disease in Brazil. We later check individual ants from each caste and the various age classes for the disease as well as any myrmecophiles present in the colony.

RESULTS

The number of active fire ant colonies per hectare in Argentina in a short grass pasture habitat of the Saladillo area was similar to that southeastern United States, especially in north central Florida. Adams (1986) reported 60–150 colonies/hectare as being heavy densities of *S. invicta* in Florida and Georgia. There was a 25% loss of active fire ant colonies in the plots from October to March (spring to early fall) in Argentina. This is similar to what is found with *S. invicta* in the Southern U.S.A. (Hayes *et al.,* 1982). Of the active colonies 75% left their original colony site and moved to a new location usually within a meter of the original site. This also is similar to what has been observed in the U.S. for *S. invicta* and *S. richteri* (Hayes *et al.*, 1982).

There was greater loss of colonies with *Thelohania*, (45%, versus 25%) than of non-infected colonies during the first year. Once a colony was infected it remained infected whether it moved or not. We observed no colonies losing their infection. However, this is difficult to verify because of colony movement, since we were not always sure of the origin of each new colony. We later examined whole colonies and found that if the queen was infected then all progeny in the colony were infected. In polygyne colonies, since some queens may be infected but not all and there is a mixture of infected and uninfected workers. It was speculated that the disease is vertically transmitted transovarilly by the infected queen. How it is transmitted horizontally from ant to ant within the colony or to other colonies is a mystery. Probably an intermediate host is involved but we are unsure what it is, although several myrmecophiles have been found infected with the disease. We do know that in the area where 35% of the colonies were infected; 80-90% of the colonies were infected four years later and the number of fire ant colonies had decreased to less than 30/hectare. Large fire ant colonies seem to be able to withstand the disease as noted by Knell *et al.* (1977) while small colonies appear to die off. Therefore, the size of colonies is important. It is probably dependent on when the colony becomes infected and if all the queens are infected.

To summarize the results of this study to date with this microspordian disease we know that the fire ants move their colonies as frequently in Argentina as they do in the U.S.A. Over 75% of the colonies had moved from their initial site and established a new one within the first six months of this study. Some colonies moved almost monthly, while others have remained in the same site for a long time. Since the colonies were numerous and fairly close together, it does not appear that food supplies or mound disturbance caused this movement. There was a total loss in the number of colonies from the study (ca. 25%) during the first year. This occurred whether the colonies were infected or not. When the area was checked two years later, many more diseased colonies were lost. The presence of *T. solenopsae* seems to cause colony mortality especially of small colonies. However, it may take several years to show a significant decrease. The disease *T. solenopsae* as described by Knell *et al.* (1977) seems to have a wide range of hosts as spores have been observed in many of the other arthropods inhabiting the fire ant mound. Since no intermediate hosts have been identified yet; we do not know how this disease is spread from ant to ant or one colony to another in nature. Still all the data presently available makes this organism appear very promising as a potential biological control organism. We are continuing our research to determine how this disease can be possibly used in the field to suppress fire ants.

Solenopsis (Labauchena) daguerrei

The small workerless ant *Solenopsis (Labauchena) daguerrei*[1] has been reported in the literature to either kill the fire ant queen quickly (Bruck, 1930; Askew 1973) or kill it more slowly as described by Silveira-Guido *et al.* (1968, 1973). The queens either virgin or fertile, will yoke themselves on the

1 Probably a species comples.

neck of the fire ant queen sometimes as many as ten or more may be attached to a single queen. Thus making it very difficult for them to function normally. Once the fire ant queen dies because she has been executed by the "*Labauchena*" or dies because she has be deprived of food by this parasite, the entire fire ant colony will slowly die out. Silveira-Guido *et al.* (1965) found as many as 31% of all fire ant colonies were infested with this parasite in Las Flores and they appeared to be having a deleterious effect on the fire ant population. They tried to move the parasite from Argentina, to Uruguay and establish it there but were unsuccessful. Therefore, it was object of this study to observe the parasite in the field and determine what effect if any it was having and then make a decision on whether or not to bring it to the U.S.A.

METHODS AND MATERIALS

Initially a survey was made of the Las Flores area of Argentina where Silveira-Guido and co-workers had found such high densities of this parasite. The individual fire ant colonies were disturbed by taking a shovel full of soil and ants and scatting it on the ground. If adult *Labauchena* are present they are easily observed among the fire ants. None were found in Las Flores, however,a few of colonies in our *Thelohania* study were infested with this parasite. These colonies were subsequently recorded, tagged and followed. Some were in *Thelohania* infected colonies some were in disease free colonies. Less than 5% of the total colonies had the parasite. Each parasite infected fire ant colony was checked monthly for fire ant viability and presence of the parasite. A few (5–6) parasite infested colonies were brought back to the laboratory for observations.

RESULTS

In Las Flores the number of fire ant colonies per hectare in improved pasture exceeded 400. No "*Labauchena*" parasites were observed even though almost a hundred fire ant colonies were sampled. The colonies were evaluated over a two year period. When Silveira-Guido and co-workers surveyed Las Flores over 30 years ago and found as many as 31% of the fire ant colonies had this parasite, we checked the same pastures in our recent survey (1991–1992) and found none. In the Salidillo plots less than 5% of the fire ant colonies had the parasites. There was no difference in the % of parasitism if the fire ant colonies had the microspordian disease or not. In fact 14% of the *Solenopsis (Labauchena) daguerrei* were infected with the octospores of the microsporidian disease *Thelohania solenopsis*. The parasites are cyclic the adults males and females are mainly present in the fire ant colonies between March and June sometimes into August, which is the fall and winter in Argentina. The immature stages of the parasite are present in the fire ant colony and taken care of by the fire ant workers, the rest of the year. According to Silveira-Guido *et al.*, 1973 sometimes as much as 70% of the ant brood in a fire ant colony is made up of the parasite brood. We did not find it to be that high but it did make up greater than 5% of the ant brood present. When there are thousands of parasites present in the fire ant colony and numerous parasites yoked on the fire ant queen it certainly has to have a draining effect on the fire ant colony. The parasite in Argentina has probably 2 generations each year, a small adult population is present in December (late spring), and a larger one in March-June, depending on the weather. Therefore it must take ca 60–90 days to complete the immature stage and the adults live ca 30–60 days.

When colonies were examined in the laboratory any where from 1 to 4 parasites were yoked onto the queen. We never saw any signs that the "*Labauchena*" killed the fire ant queens directly. A great deal more work needs to be done on this parasite before it can be imported into the U.S.A. We must at least know if it attacks other ant species. We do know that this species will yoke either *S. richteri* or *S. invicta*. *Solenopsis* (*Labauchena*) *daguerrei* needs a close examination and it may have good potential for importation to the U.S.A. to aid in fire ant suppression, however, it won't eliminate the fire ants but it may help to suppress them.

SUMMARY

A number of potential biological control organisms of ants have been identified in the literature. A few of these have been looked at in laboratory studies. However, except for some limited personal

observations and speculations, little has been done in the field to evaluate the impact any of these have on various ant species or ant densities. We have reported here on some laboratory and field studies on two pathogens, *Beauveria bassiana* and *Thelohania solenopsae* and a parasite *Solenopsis (Labauchena) daguerrei* which infect the red imported fire ant, *Solenopsis invicta*. The fungus, *Beauveria bassiana*, a strain from Mexico and Texas was studied in the laboratory and in the field. This is a non-specific pathogen and will affect many insects. Its effectiveness is dependent on the substrate it is mixed with, in sterile soils or soils with very low organic matter, a 0.5% *B. bassiana* dry mycelium mixture gave good control of the brood, queens and workers of the fire ants. However, in high organic soils or non-sterile soils its performance was poor. The brood was most susceptible to the fungus followed by the queens, the workers were the most tolerant of the fungus. The organisms *Thelohania solenopsae* was a fairly host specific microsporidian disease. We studied *T. solenopsae* in field infected colonies for almost four years. *T. solenopsae* had a great effect on the colony structure and its survival. It has potential as a biological control agent for importing into the U.S.A. The old research by Silveira-Guido and co-workers and our recent work with the parasite *Solenopsis (Labauchena) daguerrei* indicate that it has potential as biological control agent also. However, a lot more research needs to be done on this parasite before it is imported into the U.S.A.

Although there are a number of potential biological control organisms that have been identified in South America which affect fire ants. We just do not know how each affects the entire colony of the ants. We do know that ants seem to be able to survive most infestations unless the colony is placed under stress. Once a colony is stressed, the disease seems to quickly take over the colony and the colony collapses. We will continue to work out the life history of a number of pathogens and parasites of fire ants and determine what impact each has on the entire colony. A complex of these if properly released should have an adverse effect on the red imported fire ant population in the United States.

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PROBLEMS IN THE USE OF ULV SPRAYS FOR THE CONTROL OF *AEDES AEGYPTI*, AN URBAN MOSQUITO

PAUL REITER
Centers for Disease Control and Prevention
Division of Vector-borne Infectious Diseases, Dengue Branch
2 Calle Casia, San Juan, Puerto Rico 00921-3200

Throughout most of its range, *Aedes aegypti* is an urban mosquito, intimately associated with the domestic environment. It is the principal urban vector of two important viral diseases, yellow fever and dengue. Over the past twenty years, ultra low volume (ULV) sprays applied from road vehicles or aircraft have been widely adopted for *Ae.aegypti* control, particularly during epidemics. However, although early studies in Southeast Asia indicated that ULV treatments were highly effective, recent evaluations in the Caribbean and Latin America have consistently demonstrated less than satisfactory results. The problem appears to stem from the behaviour of the mosquito, which favours heavily sheltered indoor sites when it is not feeding or ovipositing. For this reason, attempts to control it by outdoor ULV applications are essentially drift spraying operations directed from the street or the sky into the home. To understand the mechanics of this drift, we must consider airflow around and into buildings. The mechanics of such airflow are complex, but predictable. We can expect great variation in the efficacy of outdoor applications, depending on local architecture, and the efficacy of ULV in any area can only be known with certainty if careful evaluations are made *in situ*. It is likely that the method is unsuitable for use in many modern urbanizations.

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