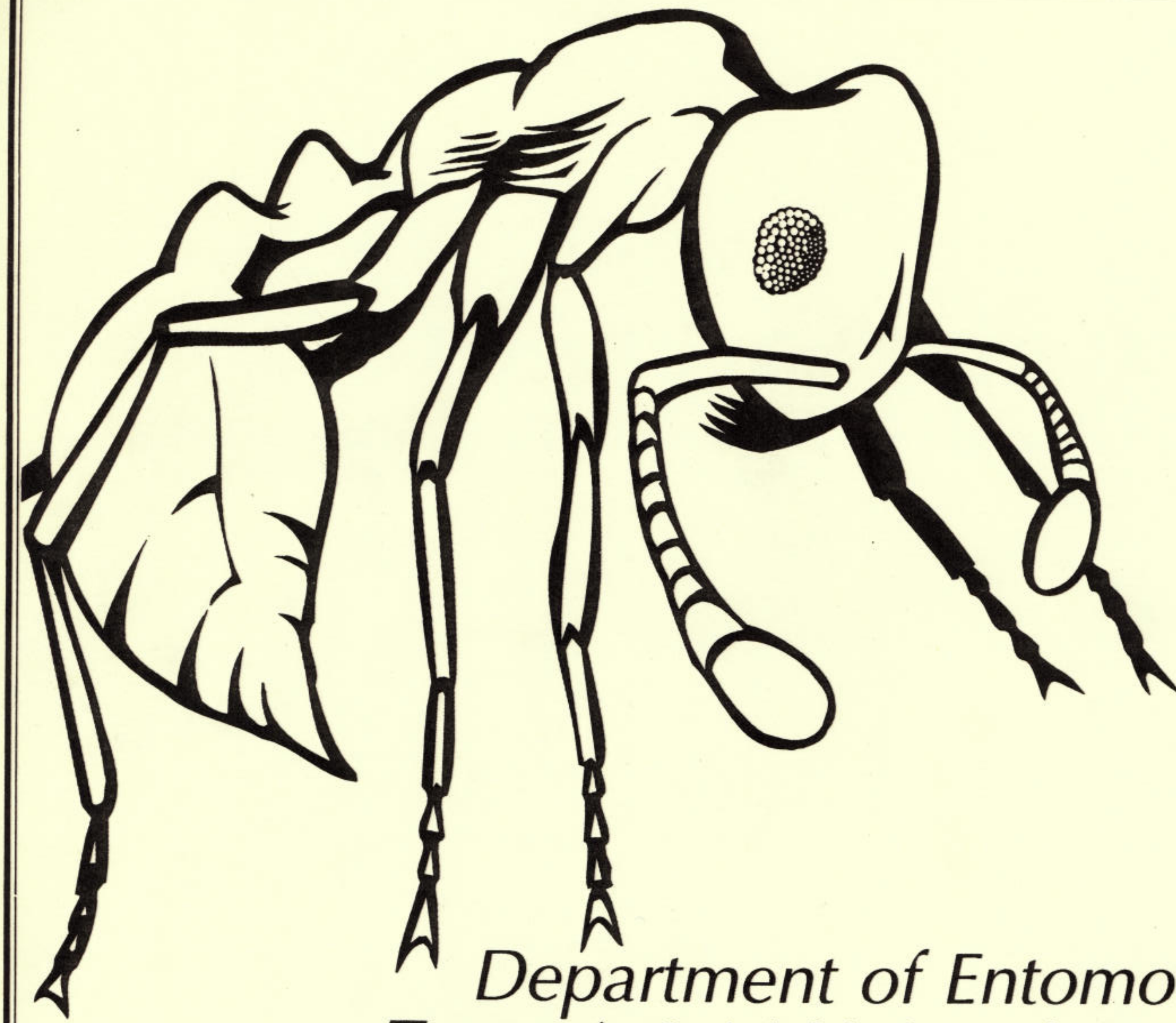
Proceedings of the 1990 Imported Fire Ant Conference



Department of Entomology
Texas A & M University
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April 2 - 3, 1990

Compiled & Edited by: Michael E. Mispagel, Ph. D.

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Michael E. Mispagel, Ph.D.
College of Veterinary Medicine
The University of Georgia
Athens, Georgia 30602

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Texas A&M University
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CRITICAL THERMAL LIMITS AND LOCOMOTOR ACTIVITY OF THE RED IMPORTED FIRE ANT (HYMENOPTERA: FORMICIDAE)

SHERMAN A. PHILLIPS, Jr. and JAMES C. COKENDOLPHER

Department of Agronomy, Horticulture, and Entomology
Texas Tech University
Lubbock, Texas 79409-2134

Critical thermal maxima (CTMAX) and critical thermal minima (CTMIN) were determined for minor caste workers of the red imported fire ant, Solenopsis invicta Buren. Ants were tested from polygynous colonies collected from northwestern Texas. Mean CTMAX is lower than that reported for the upper lethal temperature for short exposures and higher than that reported for the upper foraging limit. Mean CTMIN was, likewise, lower than the reported lower foraging limit. The CT values obtained at weekly intervals as colony maintenance temperatures were reduced from 29 to 9°C showed significant reductions in both CTMAX and CTMIN. The CT values averaged 40.7 (MAX) and 3.6°C (MIN). Differences between critical thermal (CT) values and those reported in previous studies of lethal and foraging temperatures were discussed.

The unabridged article is in press with Environmental Entomology volume 19, number 4.

Modification of the Temporal Foraging Activity of Two Texas Native Ants in Response to the Red Imported Fire Ant

Rafael Jusino-Atresino[1], Sherman A. Phillips, Jr.[1], and Michael R. Willig[2]
Texas Tech University, Lubbock, Texas

Abstract

The red imported fire ant (RIFA), Solenopsis invicta Buren, alters the ant community structure in which it is found. The niche characteristics of ant species that remain within the RIFA territory are still unknown. Our objective was to determine if foraging activity of ant species inside the infested localities differ from uninfested localities. Pitfall traps were used to define the S. invicta infested and uninfested localities and bait traps were used to determine the foraging activity of the ant species within each locality. A goodness of fit test (G-test) was used to test for independence of foraging activity between localities. Forelius pruinosus (Roger) and Monomorium minimum (Buckley) showed highly significant differences in foraging activity depending on locality ($P << 0.001$). Modifications of the foraging activity patterns for the ant species tested will be discused.

1- Department of Agronomy, Horticulture, and Entomology; Texas Tech University; Lubbock, Texas 79409
2- Ecology Program, Department of Biological Sciences, Texas Tech University, Lubbock, Texas 79409

Introduction

Ants are present in almost all terrestrial habitats, occupying a great diversity of niches within ecological communities. Interspecific interactions are important in determining species distribution, abundance, and behavior within habitats and are proportional to the number of ant colonies present within a community. In undisturbed communities different foraging strategies may evolve among species to avoid interspecific competition. Marsh (1988) studied the activity patterns of eight species of ants in the Namib desert in South-western Africa during the summer and winter seasons and before and after rain fall. Seven of the species studied showed a change of their activity pattern between seasons and greater differences among activity patterns were found during summer when the activity of all species was greater.

When an intruder ant species enters the community, the activity patterns already established within the ant community may be disrupted. This disruption may develop into new interspecific relationships within the community. The amount of change in activity patterns will be directly related to the competitive ability of the new intruder, and can become evident in several ways. First, the weaker species could become extinct. Savolainen and Vepsalainen (1988) studied the social organization and behavior of the boreal ants in Finland. They divided the ant fauna into three different categories: territorials, encounterers, and submissives, and found that encounterers and territorials are very competitive and can not coexist; hence, following Gause's principle, the encounterers become extinct when in presence of territorials. Second, displacement from the habitat rather than extinction of weaker species can occur. Ward (1987) showed the displacement of native ants from the Sacramento Valley by the Argentine ant, Iridomyrmex humilis (Mayr), and Tschinkel (1988) showed the displacement of Solenopsis geminata (Fabricius) from highly disturbed habitats in Florida by the red imported fire ant, Solenopsis invicta Buren. Third, ant species that remain within the habitat can modify their foraging activity to avoid interspecific competition. Savolainen and Vepsalainen (1988) also found that submissives can coexist, but only with a decrease in nest densities and number of foragers. In addition, submissives shifted their diet from a protein to a carbohydrate base.

The red imported fire ant has been shown to be a good competitor. Camilo and Phillips (in press) studied the influence of S. invicta on the ant community structure in central Texas. Their data showed that three species: Conomyrma insana (Buckley), Monomorium minimum (Buckley), and Forelius pruinosus (Roger) decreased their numbers at a slower rate than the other ants present in the community. However, whether these species maintain or modify their foraging activity is unknown. Based on that, our objective was to determine if significant differences exist in the foraging activity (number of ants actively foraging) of the ant species that remain within the red imported fire ant territory.

Materials and Methods

The study was conducted in Taylor County, Texas, during the months of July, August, and September of 1989. The study site is a flooded, disturbed range land habitat bordered on two sides by mesquite trees, at the southeastern edge of Lake Kirby in Abilene.

The study consisted of two stages. First, a survey was made using pitfall traps to determine the distribution of S. invicta. Each pitfall trap consisted of two 16 oz plastic cups containing ethyl glycol (one third of the volume) as a preservative. The pitfall traps were arranged in 23 rows of 4 pitfall traps each. The distance between rows was 20 meters and the distance between pitfall traps within rows was 10 meters. Based on the data obtained, the site was divided into two localities: infested area (presence of S. invicta) and uninfested area (absence of S. invicta), of approximately 6,000 square meters each. Second, a bait trap study was conducted to determine the foraging activity of ant species within the S. invicta infested and uninfested areas. The bait was a gel that consisted of a mixture of grape jelly (carbohydrate source) and albacore fish preserved in oil (protein and oil source) with agar. The gel was cut into cubes of approximately 1 cu cm and placed within a transparent, 1 oz, plastic cup (4.0 cm diameter x 4.5 cm height).

Data were collected twice each month with a week interval between collections. Each collection day consisted of 600 samples collected in groups of 25 bait cups randomly placed in each locality every two hours for a 24 hour period. The cups were left on their side for 15 minutes before collection to record foraging activity and not recruitment. Each collection day began at 1100 hours and ended at 0900 hours of the next day. After collection each sample was placed inside a sandwich plastic bag to maintain the sample integrity. Samples were placed in ice chests, taken to the laboratory, and maintained in a freezer. Ants were identified and counted to determine the frequency of individuals per species at each collection.

A goodness of fit test (G-test) was used to analyze the foraging activity for each species. This test is a test for independence which compares the frequency of foragers for each time between both localities (infested and uninfested areas) with a null hypothesis that foraging activity of each species is independent of locality and an alternate hypothesis that foraging activity of each species is dependent on locality. The data were analyzed in three steps. The first consisted of testing for independence among localities of foraging activity within each collection day. Second, we tested for independence among localities within each month. The data used for the G-test in the second step was new foraging activity frequencies obtained from adding the number of foragers within each month from each locality. For the third step, in which we tested for independence among localities for the whole study period, we used new foraging activity frequencies obtained from adding all the number of foragers from each locality.

Results

A total of 18 ant species was collected from the bait traps. These species were divided into four groups depending on locality and consistency of occurrence. The first group consisted of species that only occurred within the infested area. These species were: Formica gnava Buckley, Camponotus festinatus (Buckley), and Pheidole lamia Wheeler. These species were collected in very low numbers (13, 2, and 14 individuals, respectively). The second group, consisted of three species collected exclusively from the uninfested area. They were Pogonomyrmex barbatus (F. Smith), Pheidole metallescens Emery, and Prenolepis imparis (Say). From this group only P. metallescens and P. imparis were collected in low numbers (41 and 1 individuals, respectively), and for P. barbatus a total of 355 individuals were collected. The third group consisted of nine species obtained from both localities (infested and uninfested areas), but were collected inconsistently throughout the study (Table 1). This inconsistency was defined as absence of species individuals in one or more of the collection days or in one of the localities within one or more of the collection days. This inconsistency is important because the G-test requires data from each locality for every collection day. Of the nine species of this group, three were collected in greater numbers from the infested area: Conomyrma flava (McCook), Conomyrma insana (Buckley), and Crematogaster laeviuscula Emery. The fourth group, consisted of the two ant species collected consistently throughout the study and were used for the statistical analysis. They were Monomorium minimum (Buckley) and Forelius pruinosus (Roger).

Solenopsis invicta was also collected in both localities, but only within the edge of the uninfested area (91 individuals) nearest to the infested area and at night when the other species were not foraging compared to the 86,268 individuals collected from the infested area. This situation might be due to the capability of S. invicta to further expand its foraging at night until it reaches the boundaries of the uninfested area due to the lack of interference from foragers of the other ant species.

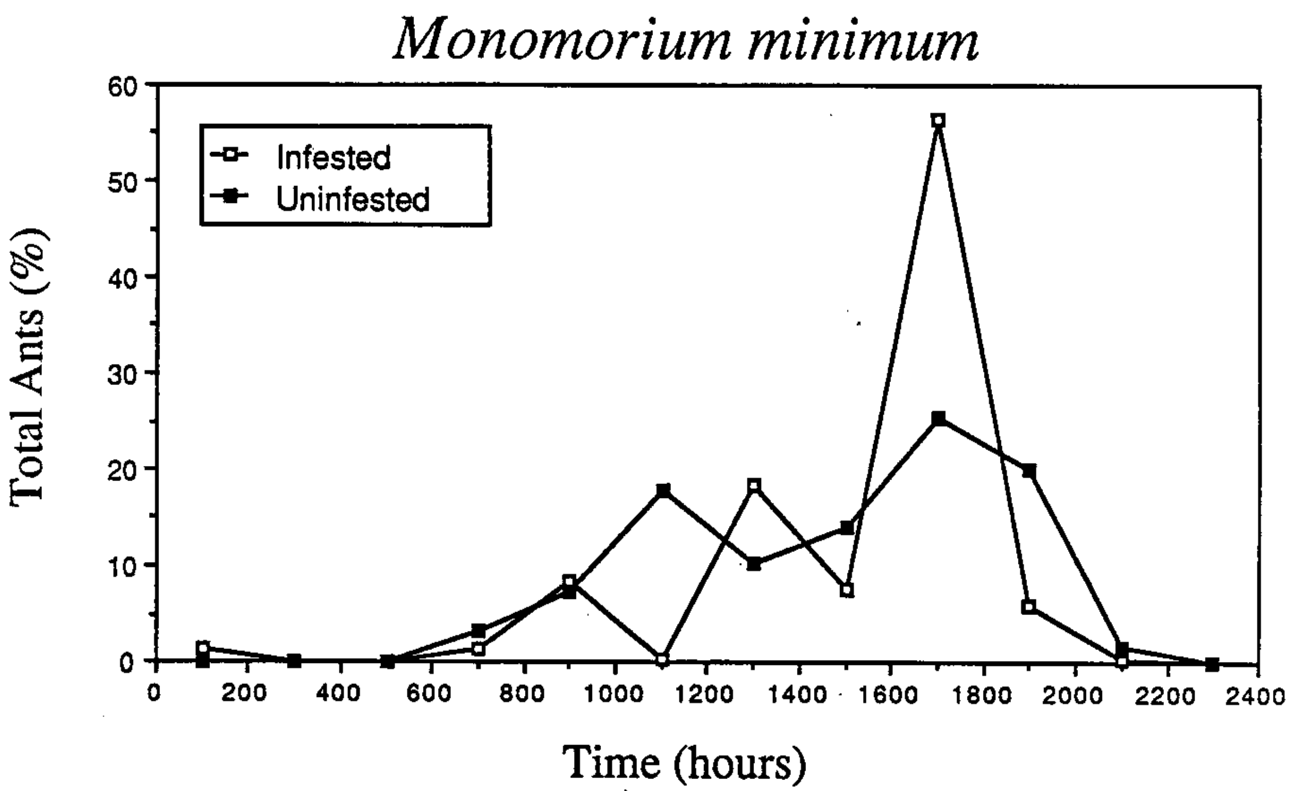
Both localities were significantly difference (d.f. = 11; $P << 0.001$) for foraging activity of the species tested. This difference indicates that the foraging activity for the species is dependent on locality. For M. minimum the value of G_{adj} was 2108.747 compared to a table value of $X^2 = 31.264$. The foraging activity for M. minimum began at 0500 hrs for both localities (Figure 1). Within the uninfested area the number of foragers was relatively constant during the whole period of foraging with two foraging activity peaks at 1100 hrs and 1700 hrs. For the infested area the number of foragers was erratic throughout the period of foraging with three distinct activity

Table 1. Species collected from both sites but not used for the G-test.

Species	Number of Ants	
	Infested	Uninfested
Forelius foetidus (Buckley)	1,244	1,402
Conomyrma flava (McCook)	918	195
Conomyrma insana (Buckley)	451	13
Formica schaufussi Mayr	71	39
Paratrechina terricola (Buckley)	1,593	3,469
Crematogaster laeviuscula Emery	7,730	4,918
Crematogaster punctulata Emery	25	35
Leptothorax pergandei Emery	1	2
Pheidole dentata Mayr	75	1,289

peaks at 0700 hrs, 1100 hrs, and 1700 hrs. The number of foragers increased and decreased very rapidly before and after each activity peak. Within the uninfested area the foraging activity ended at 2300 hrs whereas the foraging activity in the uninfested area ended at 0300 hrs. This difference of four hours indicate that to obtain the same kind of resources M. minimum needs to expand their temporal foraging activity within the infested area. For F. pruinosus the value of G_{adj} was 349.899 compared to a table value of X^2 = 31.264 (d.f. =11; P << 0.001). The foraging activity for F. pruinosus began at the same time (0700 hrs) for both localities (Figure 1). Within the uninfested area the species showed more foraging activity in the morning and reached a peak at 1300 hrs. In the infested area the species showed more foraging activity during the afternoon with a foraging activity peak at 1500 hrs. For both localities the foraging activity ended at 2300 hrs.

In conclusion, the foraging activity differences found between both sites suggest an adaptation that enables these species to survive within the red imported fire ant territory. Perhaps this difference in foraging patterns together with the slower decrease in forager numbers, demostrates that some ant species that remain within the red imported fire ant territory are rapidly adapting to it presence and are thus avoiding interspecific competition.



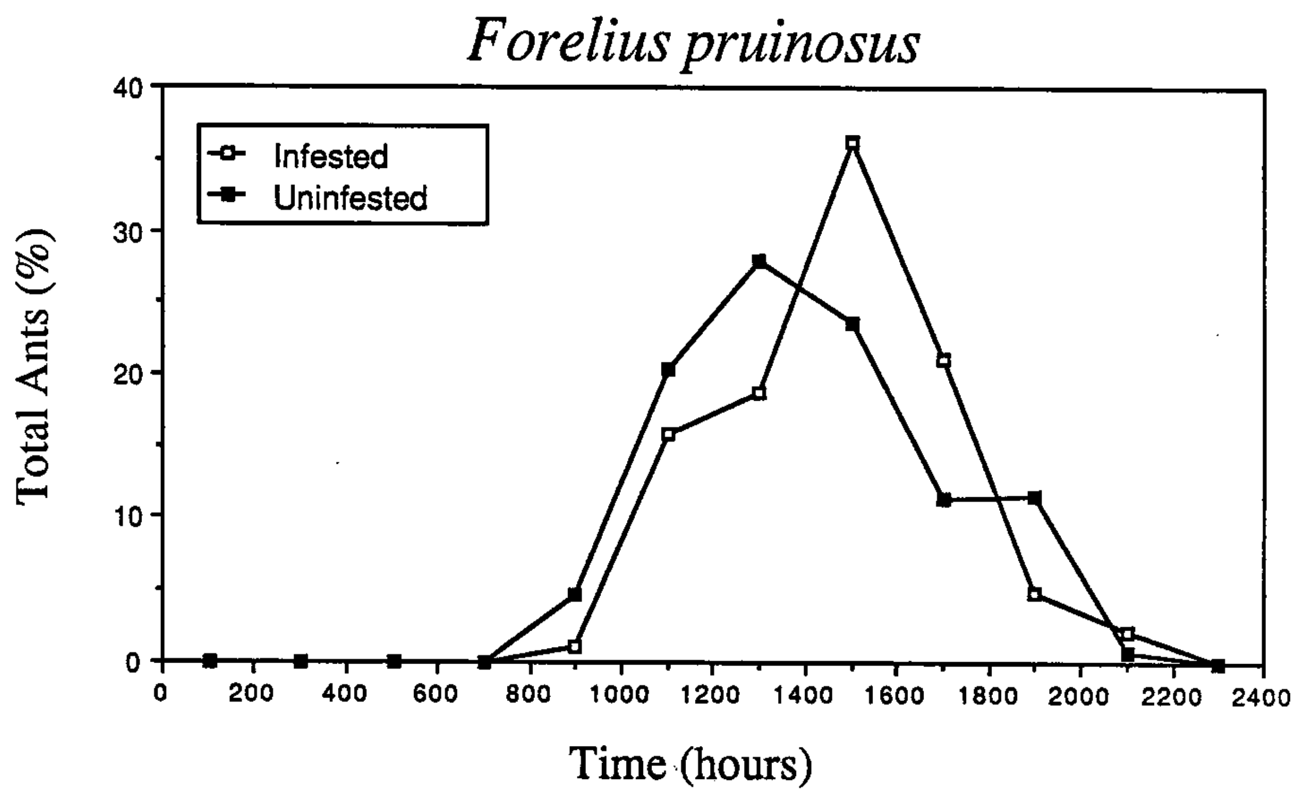


Fig. 1 Temporal foraging frequencies based on total number of ants collected.

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SYSTEMATIC SURVEY OF THE THREE COASTAL COUNTIES OF MISSISSIPPI FOR INCIDENCES OF POLYGYNOUS COLONIES OF THE RED IMPORTED FIRE ANT, *Solenopsis invicta* BUREN

Timothy C. Lockley
USDA-APHIS-S&T-Imported Fire Ant Station
3505-25th Avenue
Gulfport, Mississippi 39501

ABSTRACT

In the springs of 1989 and 1990, a systematic survey of the three coastal counties of Mississippi was conducted to determine the relative populations of monogynous vs. polygynous colonies of the red imported fire ant, *Solenopsis invicta*. Of the 179 sites examined in 1989, 3.3% were completely polygynous (n=3). Of the remaining sites 86.1% (n=157) were completely monogynous and 10.6% (n=19) were found to harbor both multiple and single queen colonies. Among the monogynous sites, 17.8% (n=28) contained multiple dealate sterile females. In 1990, of the 179 sites examined, 3.3% were polygyne (n=3). One polygyne site (Jackson Co.) from 1989 had reverted completely to monogynaeity and a new site 2.0 km east had changed from mixed to totally polygyne. Of the remaining sites, 90.6 % (n=165) were completely monogynous and 6.1% (n=11) contained both multiple and single queen colonies.
Of the monogynous sites, only 14 were functionally monogynous.

INTRODUCTION

Mature colonies of *Solenopsis invicta* Buren (RIFA) have, until relatively recently, been considered monogynous (Lofgren et al. 1975). Tschinkel and Howard (1978) concluded from their study of colony founding and queen replacement that colonies often have more than one mated queen. But are, never-the-less, functionally monogynous (ie. only one of the queens will lay eggs).

The red imported fire ant entered the United States at the port of Mobile, Alabama ca. 1940 (Lofgren et al. 1975). By 1957, they had entered the state of Texas. Reports of polygyny (multiple queens) started to appear in the early 70's at two widely separate locations---Mississippi (Glancey et al. 1973) and Texas (Hung et al. 1974). These studies found that multiple queens were gravid and that, when separated, produced brood. From these observations, they concluded that these colonies were functionally polygynous. Since their first discovery, polygynous colonies have been reported from Arkansas (Banks and Collins, unpublished data), Georgia and Louisiana (Fletcher 1983) and Florida (Lofgren and Williams 1984).

The polygyne phenomena is not just limited to *S. invicta*. Several other ant species have been observed to have multiple queens (Wilson 1971). Green (1952) observed large numbers of dealate queens (+25) in colonies of the black imported fire ant, *Solenopsis richteri* Forel. Fertility, however, was not determined. Polygyny has also been reported from native American fire ants, *Solenopsis geminata* (Banks et al. 1973) and *Solenopsis xyloni* (Summerlin 1976). Glancey et al. (1989) reported the occurance of polygyny among populations of the *S. invicta* X *S. richteri* hybrid.

The mechanisms behind the independent occurences of polygyny among RIFA colonies is unknown, but the frequency of this form seems to be increasing (Glancey et al. 1987). However, a recent survey of the Mississippi site where polygynous mounds were first reported showed a significant decline in polygyny. Of the mounds examined in and around the site, only ca. 50% were polygynous.

OBJECTIVE

A number of questions concerning polygyny in *S. invicta* remain to be answered. Among these are (1) how are polygynous colonies geographically distributed locally in relation to monogynous colonies, and (2) are polygyne colonies permanent or are they merely a temporary aberation? To help answer these questions, a systematic survey was conducted in 1989 & 1990 to determine the current extent of polygyny in the three coastal counties of Mississippi.

METHODS AND MATERIALS

The survey was conducted using Mississippi State Highway Commission maps of the three Mississippi coastal counties of Hancock, Harrison and Jackson. The survey was made at the juncture of all nonurban paved roads within the boundries of all three counties. The area immediately adjacent to these junctures (6 meters from the road and 50 meters along its lengths) was surveyed. A maximum of ten mounds per site were excavated and examined at length for the presence of RIFA dealate queens. Tschinkel and Howard (1978) described the phenomena of functional monogyny in colonies of S. invicta. Because of this phenomena, when more than one dealate was observed within an excavated colony, replicate samples of the dealates were collected, placed in 80% ethanol and returned to the Imported Fire Ant Station at Gulfport, MS for dissection under magnification to determine the gravidity of each specimen. Examined sites were each given a code based upon the map coordinates indicated on the MSHC maps.

RESULTS AND DISCUSSION

Of the three counties surveyed, Jackson County had the least number of paved roads followed closely by Hancock County. Harrison County contained ca. 2.5 times the total number of roads as the two adjacent counties. In Jackson County, a total of 23 sites were examined. In 1989, eighteen of these sites proved to be monogynous. Four of the remaining sites contained both multiple and single queen mounds. Only one site was completely polygynous. Ten of the monogynous sites contained colonies in which multiple sterile dealate queens were found. In 1990, the multiple queen site had completely reverted to a mixed population. No discernable change was noted in the habitat. Approximately 2.0 km to the east, a site that had been mixed the previous year had become completely polygynous. One site remained mixed (Hwy 57/I-10) and two sites had changed from mixed to single queen (Fig. 1).

Hancock county contained 30 sites. In 1989, a single site located near Point Clear was completely polygynous. Three sites were mixed. In 1990, the multiple queen site remained unchanged. However two of the mixed sites had reverted to single queen sites. Four of the monogynous sites were found to be functionally monogynous (Fig. 1).

Harrison County contained 126 sampling sites. In 1989, 1 site was completely polygyne. Eleven of the sites were mixed and 115 were totally monogynous. Thirteen of the monogynous contained unfertilized dealates. In 1990, the polygyne site remained unchanged. Of the 11 mixed sites examined in 1989, only two remained. The other nine had reverted to monogyny. One new site was found to be mixed (Fig. 1).

CONCLUSION

Mississippi can lay claim to the dubious distinction of having been the state from which the first polygynous RIFA were reported. The site, located near Hurley, Jackson County, Mississippi was known among fire ant workers as "Queen City". Sixteen years later, the same site is ca. 50% monogynous. At the same time, in states like Florida and, most notably, Texas, multiple queen colonies are on the advance with no sign of decline. A survey carried out by the Texas Department of Agriculture in 1988 found 79 of 122 Texas counties infested with multiple queen colonies. In each of the three counties surveyed in Mississippi, only a single site in each proved to be totally polygynous. Are the polygyne colonies on the decline in southeast Mississippi? Are their numbers static? Are they growing? Data from these two surveys would seem to indicte that polygyny, at least along the Mississippi Gulf Coast, is not significantly expanding and that it may even be declinig somewhat. Future, annual surveys at these same sites over the next few years may help us in answering these questions.

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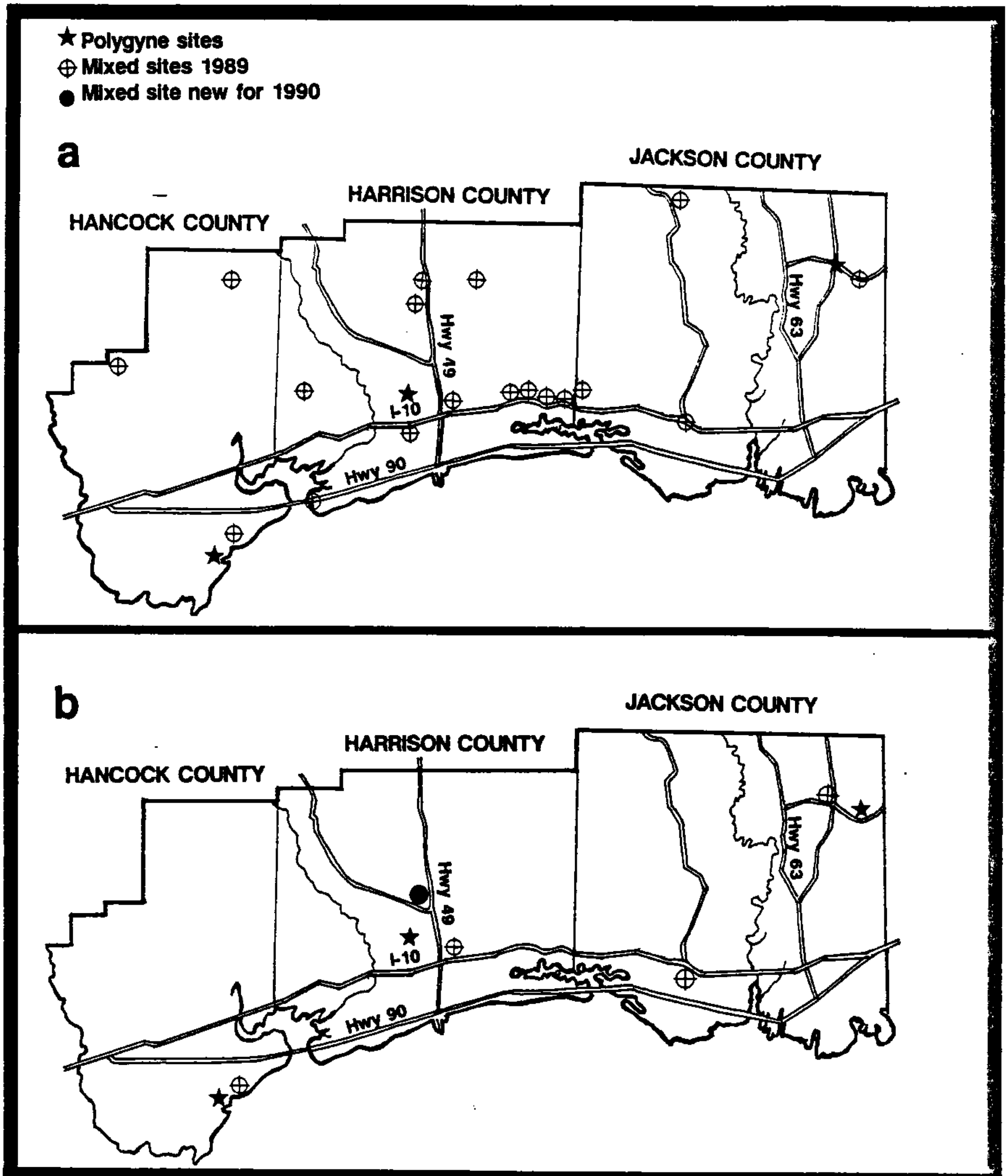

Fig. 1. Sites of polygyne and mixed polygyne/monogyne colonies of the imported fire ant *Solenopsis invicta* in the three coastal counties of Mississippi in 1989 (a) and 1990 (b).

Fire Ants in Urban Environments

Awinash P. Bhatkar

Center for Urban & Public Health Entomology
Department of Entomology
Texas A&M University
College Station, Texas 77843-2475

The impact of fire ants (Solenopsis invicta, S. richteri, S. geminata, and S. xyloni) in the urban ecosystems is felt since long but systematic research on their exact role, adaptation and management strategies has been inadequate. The most widespread and abundant of the fire ant species in urban habitats is the red imported fire ant (RIFA) S. invicta. Its status as a pest is more important in the near-environment of humans than in agricultural habitats where it is a notable but indiscriminate predator (Whitcomb et al. 1972, Sterling et al. 1984, Reagon 1986) as well as a crop pest (Adams 1986). The fire ant problems have been compounded through the sympatric occurrence of monogynous and polygynous populations of S. invicta in Texas, and also in Mississippi, Florida, Georgia, Alabama and Louisiana.

In the urban biosystems RIFA is not only a nuisance, due to its sheer abundance, but also a medically and economically important insect pest. It has imposed a change in human behavior upon urban populations in the infested states. Attempts to control RIFA in the fragile urban ecosystems has been difficult due to the fear of accumulation of pesticide residues on one hand and ever increasing indoor and outdoor forays of the stinging fire ants on the other. The fire ant infestations are a common sight in family houses, residential complexes, parking lots, lawns, golf courses, utility easements, home gardens, hospitals, laboratories, laundromats, parks and recreational areas, schoolyards, backyards, playgrounds, grocery stores, restaurants, hotels, motels, nurseries, greenhouses, pet stores, kennels, animal shelters, zoos, construction and development sites, vehicles, cemeteries, etc. Fire ants plague various types of electrical and electronic equipment resulting in short-circuits and malfunctions (MacKay 1988). In fact, the 'omnipresence' of RIFA has often become a political campaign issue in the infested states. Urban populations seem to be convinced that the advent of African bee from Mexico to Texas will not overshadow the ever increasing fire ant problem.

Fire ants are not the only social insects that threaten urban environments: termites, social wasps and bees, subsocial cockroaches and aggregations of fleas, mites, psocids and aphids are just the few to be noted. Yet, paradoxically, sociobiologists are among the last to engage in applied urban ecology. Other ant species that are a nuisance, cause medical problems, and inflict damage to man and his property including, pharaoh ant (Monomorium pharaonis), carpenter ants [Camponotus (Myrmentoma) decipiens, C. (Camponotus) pennsylvanics, herculeanus, C.

(Myrmothrix) abdominalis floridanus, etc.], pavement ants [Tetramorium guineense and caespitum], crazy ants [Paratrechina longicornis, Paratrechina spp.], Argentine ant [Iridomyrmex humilis], little black ant [Monomorium minimum], harvester ants [Pogonomyrmex barbatus, P. badius, etc.], Texas leaf-cutting ant [Atta texana], corn field ants [Lasius neoniger and alienus], odorous ants [Tapinoma sessile, melanocephalum], and other tramp ants, that are being introduced every year.

Fire ants dispersed in the urban habitats is generally with man's activities. For example, the early 1960's infestation of RIFA was first in the urban east Texas, Dallas-Fort Worth and San Antonio areas. Houston was infested during the late sixties, and in the mid-1980's, Lubbock became infested. Basic biosystematic and ecological information on the fire ant species is required in making effective population management decisions but this information is pitiably anecdotal in the urban habitats. Comparative studies on the nesting, foraging, and reproductive strategies of S. invicta are essential to understand its adaptation in urban as against the natural habitats. In urban environments, fire ants seem to be adapted to: 1) limited nesting sites, in disturbed habitats; 2) unusual foods (hamburger, baby foods, chicken, soft drinks, candy etc.), in addition to arthropods, honeydew, plant nectar, and protein- and lipid-ladened tissues; 3) artificial climates created through concrete structures and asphalted areas, hot water systems, sprinkler irrigation, air-conditioning, landscaping, etc.; 4) intraspecific competition with the replenished RIFA populations from nuptial flights and human transport; 5) adversities due to the toxicants used (pesticides, herbicides, fungicides, repellents, etc.), land movement, landscaping and other habitat alterations, and 6) interspecific competition with other species of ants. The modes of their adaptation are largely unknown. Predation of the landed queens (Nickerson, et al. 1975) and competition with other species (Bhatkar 1988a, b), are important components of the natural RIFA population regulation.

In controlling the fire ant populations in urban environments, several public relations issues can also be involved: bureaucratic assessment of research priorities, medical and legal implications of the fire ant stings (including those of the alleged fatalities), control techniques (due to colony displacement to untreated properties), wide-spread control decisions and quarantine measures, and last but not the least, unsafe usage of pesticides in homes and gardens. At present, a home-owner must accommodate the pest control operator's best judgment as to whether a product works. Efficacy data on insecticides is greatly hampered due to the lack of effective statistical tests applicable to shifting colonies of the monogynous form and proliferated supercolonies of the polygynous form. Analysis of the data in the experimental areas often does not give a correct population estimate since the very assumptions underlying F or Chi-square tests are violated [Bhatkar 1990, 3rd Nat. Urban Ent. Conf. (present.), College Park, Maryland]. The effect of underground foraging by the fire ant on other organisms is virtually unknown.

To facilitate research with some of these pest ant issues, a laboratory has been established to study the urban pest ants [Urban Pest Ant Laboratory, UPAL] at the newly established Center for Urban and Public Health Entomology of Texas A&M University. According to Dr. Roger E. Gold, Director of the Center and Endowed Urban Pest Management Chair, research at the Center emphasizes a balance of basic and applied investigations to achieve pest management goals. The basic research needs are in the following areas: pest diagnostics (species identification and determination of pest status); biological and nutritional requirements; foraging, nesting and reproductive strategies in eurytropic environments; colony composition and population structure; species diversity and ecosystem analysis; exploration of the biological control agents, and habitat management. The applied research needs are: evaluation of the efficacy of available pest control agents; development of their appropriate delivery systems; operational safety; residue analysis, and integration of environmentally safe management approaches to reduce the fire ant populations in urban environments.

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Impact of Imported Fire Ants on Georgia Homeowners

Stan Diffie and Craig Sheppard
Entomology Department
University of Georgia
Coastal Plain Experiment Station
Tifton, Georgia 31793

A two part survey was conducted in October and November 1989 to help determine the cost of the imported fire ant to Georgia homeowners. 159 people were asked to complete a twelve question survey form at the Sunbelt Agricultural Exposition in Moultrie, GA. Employees at the Coastal Plain Experimental Station were mailed survey forms and asked to complete and return the forms. 161 people responded. The costs of medications, professional medical service, and control were specifically sought in the survey. A broad category asking for costs of miscellaneous damage such as replacing plants, mower damage, and replacing electrical wires was included. We recognize that a valid economic estimate is difficult to determine because of the emotional factor associated with the fire ant.

The survey began be asking if someone in the immediate family was stung last year and if so, what age those persons were. 91% of the respondents reported stings. Also, how many times did this person get stung during the past spring and summer. These ages were compared with he age distribution of Georgia's population. Table 1 shows children 6 years and less comprise 9% of the state's population. As can be expected, this age group accounted for almost 23% of the people stung.

The primary objective of the survey was to determine how much money is being spent each year because of fire ants in the state of Georgia. The largest amount of money was expected to be spent on control. 85% of the people questioned attempted to control fire ants last year. Table 2 indicates all monies spent for all purposes related to the imported fire ant by the households surveyed. South Georgia represents all counties south of Macon, GA and all respondents from Macon to the Tennessee border are represented in the North Georgia column. According to the people surveyed almost $21.00 per household was spent on control. An additional ten dollars was spent by each household on miscellaneous damages. This included replacing dead flowers, girdled trees, damage to mower blades, repairing well pumps, and any other money spent as a result of fire ants. Medical costs averaged five dollars per household. This low estimate was probably the result of the small number of people who actually went to a doctor or hospital because of stings. The average total dollar amount for all expenses related to fire ants came to $36.21 per household.

Estimates for previous years for the state of Georgia had established the cost of imported fire ants at about $7,000,000. Actually, if we assume 1,000,000 households in the infested area (1,800,000 in the entire state) and 85% of them paid for fire ant control, we see 850,000 households spending a total of $21,000,000. Add medical costs (850,000 x $5,00 = $4,250,000) and misc. expenses for south Georgia only (425,000 x $10.36 = $4,600,000) or about $9,000,000. These total to an expenditure of $30,000,000 caused by the imported fire ant. Extrapolating is risky but this survey, with 320 respondents, gives much higher values than our previous unsupported estimates. We are attempting to verify some of these figures.

Since most of our research involves control, it was especially interesting to determine what people were using for control and if they were satisfied with it. In this question neither methods nor products were listed. If a respondent could not remember a product, trade names were not offered.

While compiling the data we did take the liberty of changing spellings and grouping like products together. For instance "Floriden" was assumed to be "Furadan".

61.5% of the respondents used a labeled drench, granule, or powder. Baits were used by 19.6% of the people. Unlabeled pesticides were used by 6.6% of the respondents. Pest control operators performed 1% of the treatments. The miscellaneous category accounted for 11.3%.

Diazinon drenches and granules comprised almost 29% of all controls, generic or tradenamed, used. Drenches and granules using chlorpyrifos accounted for another 6.7%. If the respondent did not list an active ingredient or trade name the response was placed under 'drench-granule'. Orthene was a significant product being listed by almost 12% of the responses.

Bait usage was at 19.6%. Amdro was the most used bait at 15.7%. A little over 1% bought and used Affirm last year. Logic was not reported in our survey but it could have been a portion of the 2.6% in the unnamed bait category.

Unlabeled pesticides accounted for 6.6% of fire ant control in the survey. Chlordane and soil insecticides/nematicides each comprised 2%. A few people still reported using Mirex.

Gasoline/diesel fuel made up 7% of the material used. and it was the most used treatment in the miscellaneous category. Grits and hot water finished second and third respectively in this category.

Another question in the survey asked "Did you obtain satisfactory control?" 104 respondents reported satisfactory control and 173 answered "no". 43 people did not answer this question. The next question asked "Do fire ants cause any other problems?" 178 people said fire ants cause additional problems and 101 said they do not and 41 people chose not to answer. The 101 was in good agreement with the 104 who reported satisfactory control. If the person killed the fire ants, obviously they did not cause any other problems.

The last area of concern in the survey was the effectiveness of the respondents control efforts. The responses were fairly evenly distributed. Only 6% of the people reported no control. Table 4 shows the distribution of the responses.

Table 5 shows the six products that provided the best control according to the respondents. Only treatments used by at least 10 people were included. This omitted materials like chlordane which performed well when used. The people who used gasoline/diesel fuel reported the highest percentage control. Orthene finished second with about 60% control. Diazinon and Amdro provided what the respondents felt was a little over 50% control. Sevin and chlorpyrifos came in just under 50% The other products were not used by at least ten people.

In summary most people still have strong feelings about imported fire ants. People reported spending over $20 per household last year on control. They also reported fire ants were costing them another $5 and $10 on medical and miscellaneous expenses respectively. Over 30 products/treatments were reported by the 85% of the respondents who treated. Less than 40% of the respondents were satisfied with the level of control they obtained. This may have been partially due to improper use of treatments and not necessarily product failure.

Table 1.

FIRE ANT STINGS

Age	Percent of Reported Stings	Percent of GA Population
0-6	22.6	9
7-18	19.2	23
19-40	29.3	25
41-60	25.1	35
60+	3.6	9

Table 2.

FIRE ANT COSTS

Per Household

	North GA	South GA	Statewide
Control	$28.80	$20.26	$20.90
Medicines	3.87	2.66	2.73
Doctors	7.63	1.88	2.22
Misc. Damages	0	11.01	10.36
Total	40.30	35.16	36.21

Table 3.

CONTROL TREATMENTS

Treatment	Percent Used
Affirm	1.3
Amdro	15.7
Ammo	1.3
Bait	2.6
Chlordane	2.0
Chlorpyrifos	6.7
Diazinon	28.8
Drench	4.0
Gasoline/Diesel Fuel	7.0
Granules	4.7
Grease	0.3
Grits	1.7
Hot Water	1.3
Malathion	1.3
Methyl Parathion	0.3
Mirex	1.0
Nematicide	2.0
Orthene	11.7
Pest Control Operators	1.0
Orange Peels	0.3
Sevin	4.3
Mix Mounds	0.7

Table 4.

EFFECTIVENESS OF CONTROL

Percent Control	Percent Response
0	5.8
10-30	23.6
31-45	17.1
46-70	20.0
71-90	19.3
91-100	14.2

Table 5.

SIX PRODUCTS* WITH BEST CONTROL

Treatment	Percent Control
Gasoline/Diesel Fuel[1/]	86.7
Orthene	59.4
Diazinon	53
Amdro	50
Sevin	48.8
Chlorpyrifos	48.6

* At least ten responses

[1/] Gasoline/diesel fuel may kill a fire ant colony. However, the grass around the mound is also killed. Also, it is not ecologically desirable to subject the environment to a gasoline/diesel fuel drench.

QUEEN ACCEPTANCE IN ORPHANED COLONIES OF POLYGYNE AND MONOGYNE WORKERS

S. B. Vinson and N. T. Stamps
Department of Entomology
Texas A&M University
College Station, TX 77843

Abstract - Pleometrosis does not appear to result in polygyne colony formation, but raiding between small colonies when minimums first occur did result in a small percent of the combined colonies maintaining a polygynous condition for 2.5 months. We examined queen acceptance as a means of maintaining the polygynous condition. This was examined by introducing newly mated queens into queen-right and orphaned polygyne and monogyne colonies. Queens were not accepted in either polygyne or monogyne queen-right colonies although the execution of the introduced queens in the polygyne colonies required several weeks as opposed to one or two days in the monogyne colonies.

Orphaned colonies of monogyne ants only accepted one queen within the first week and then executed additional queens within 2 days. In contrast, orphaned polygyne ants accepted most of the queens added over the first 10 days but executed additional queens added several weeks later.

Introduction - Since the discovery of polygynous colonies of the Imported Fire Ant, *Solenopsis invicta* Buren in the 1970's (Glancey et al. 1978, Hung et al. 1974) a number of differences between the polygynous and monogynous forms, has been reported. These include differences in aggressiveness, worker size, presence of sterile males, interconnected mounds and increased density (Greenberg et al. 1985, Mirenda and Vinson 1982, Bhatkar and Vinson 1987, Hung and Vinson 1974). How such colonies initially form is presently unknown. There are several possibilities and we initiated studies to examine some of these.

Materials and Methods - To examine whether co-founding queens would lead to a polygyne colony, 5, 10, 25, and 50 newly mated queens were collected, placed together in cast stone Petri dishes and maintained for 3 months. A second approach was to place two newly founded colonies that consisted of a queen and her first minimums together in a common foraging arena to determine if colonies would merge and remain polygynous if workers could make a choice. A third approach considered the adoption of queens beginning with four different initial situations. One was to examine the adoption of newly mated queens in queen right colonies and another was adoption in queen-less colonies. The last two conditions were to use monogyne colonies or polygyne colonies. For these four tests, monogyne and polygyne colonies were collected, separated from soil and placed in Fluon coated shoe boxes containing a caste stone Petri dish nest. Both queen right and orphaned monogyne colonies and multiple (10) queen right and orphaned polygyne colonies were placed in containers. Ten newly mated, marked (Bhatkar and Vinson 1990) queens were added to each colony weekly for one month and then at 56 days. Queens were observed and counted on a weekly basis for two and one half months. Ten replicates were performed.

Results and Discussion - Co-founding of 5, 10, 25, or 50 queens resulted in monogyne colonies within two months. These results were similar to those reported by Tschinkel and Howard (1983) where colony foundation by pleometrosis resulted in stronger monogyne colonies.

Newly established colonies containing a mean of 5.5 ± 3.3 minimums, 3.0 ± 2.3 larvae, 9.8 ± 3.6 pupae and a queen were paired so that colonies could selectively merge. Of the 42 pairs only four remained polygynous at 60 days suggesting that small polygyne colonies could occur through founding colony merger. Whether these queens were genetically similar or were from polygynous colonies is unknown. This study revealed that colony raiding occurs among newly founded colonies and that the victorious queen produced significantly more eggs and larvae than the defeated queen. The results also suggested that queen raiding, like pleometrosis can result in stronger monogyne colonies.

The addition of newly mated (marked) queens to established monogyne and polygyne colonies resulted in their execution within 24 hr in the monogyne colonies (leaving the unmarked nest queen) while some marked queens survived for up to 15 days in polygyne colonies (Table 1). The reduced aggressiveness of polygyne colonies (Mirenda and Vinson 1982) is documented but the results of this test suggest that the adoption of newly mated queens by queen-right colonies is not frequent. In these tests none of the newly mated queens were present at 60 days in queen-right colonies of either form.

Table 1. Adoption of newly mated queens by queen-right and orphaned monogyne and polygyne colonies of _Solenopsis invicta_. Queens (10) added at 0, 7, 14, 21, and 56 days

Treatment	Average Marked Queen Number After				
	5	10	20	30	60 days
queen-right monogyne	0.0	0.0	0.0	0.0	0.0
orphaned monogyne	2.5	1.4	1.0	1.0	1.0
queen-right polygyne	4.2	3.9	1.0	0.2	0.0
orphaned polygyne	9.8	18.3	25.6	27.8	20.3

Orphaned monogyne colonies were slow to eliminate the added marked queens for the first several days but soon adopted one marked queen and executed any added queens within 24 hr after the first ten days.

Orphaned polygyne colonies accepted most of the queens introduced during the first 10 days with many remaining for the 60 days. However, queens added after ten days were largely eliminated. After several weeks, these colonies resembled queen-right polygyne colonies described above.

The results show that workers from monogyne colonies, whether queen-right or orphaned, only accept one queen but may become temporarily polygyne if first orphaned. Similarly, queen-right polygyne colonies do not readily accept "new queens" into an already polygynous colony although their elimination may occur over a period of weeks. In contrast, orphaned multiple queen colony workers adopted a multiple number of introduced queens for several weeks but once established such colonies do not readily accept "new queens". The results suggest that workers of polygyne colonies have an elevated tolerance for a certain number of queens or the number tolerated depends on the size of the initial queen number or colony size. Whether that tolerance can be manipulated is under study.

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UTILIZATION OF A SMALL PLANT DECOMPOSING ARTHROPOD COMMUNITY BY SOLENOPSIS INVICTA BUREN

S. Bradleigh Vinson
Department of Entomology
Texas A&M University
College Station, TX 77843

Abstract - Ripe fruit (melon and peach) when placed in the field was rapidly colonized by several species of diptera (Drosophilidae and Tephritidae), coleoptera (Nitidulidae and Staphylinidae) and hymenoptera (Braconidae, Cynipidae and Formicidae) when fire ants, *Solenopsis invicta* Buren, were excluded. When fruit colonized by the above decomposer community for 3 or 6 days was exposed to fire ants, the ants consumed the decomposers and remaining fruit. Fruit initially exposed to fire ants upon field placement was primarily colonized by fire ants resulting in the exclusion of most other decomposer arthropods.

Introduction - The impact of the imported fire ant (IFA) on natural ecosystems is poorly documented and confusing (Vinson and Teer 1989). In some situations the IFA is considered beneficial and in others it is a pest (Lofgren 1986). Usually IFA impact studies have involved comparing species richness and density in IFA infested and uninfested areas (Summerlin et al. 1984), after ant removal with toxic baits (Sterling et al. 1979), or through correlating species diversity and abundance with ant density (Phillips et al. 1987). We chose to examine the impact of the fire ant on a small transient arthropod community where the fire ants could be physically excluded. Rotting fruit represents such a community. Most of the decomposer arthropods of fruit must rapidly locate and colonize the resource, and as a consequence colonization involves adults that fly (Mason 1977, Putman 1983).

Materials and Methods - Square aluminum pans (25x25x4 cm high) were filled 3 cm deep with wet sand. Ripe fruit was placed on the sand and the pan was balanced on a jar coated with Fluon® which was placed on a wooden base. The wooden base, jar, sand containing pan and fruit was enclosed in a hardware cloth cage that allowed access to the fruit by flying insects but not birds, small mammals or crawling insects such as ants. These caged fruit containers were placed in a multiple queen fire ant location near a forest that provided shade in late afternoon and evening. Access to the fruit by the IFA was provided by a wooden bridge from the pan to the ground on each side.

Pans with fruit were sprayed with water daily. Some pans were exposed to ants on either day 1, 3 or 6 and removed on day 3, 6 or 9, respectively (exposed for the last 3 days to IFA's). Additional pans were placed in the field, but were not exposed to the IFA and were collected on 3, 6, or 9 days.

The cage was removed a half hour before collection. A clear plastic bag was quickly placed over the pan and sealed, placed in a cooler and returned to the laboratory where all insects were collected. The most abundant were identified to genus and counted. For this report only the mean numbers of the adults and combined larvae and pupae (immatures) are presented.

Results and Discussion - When the IFA was excluded; large numbers of adult and immature Drosophilidae, Nitidulidae, Trephritidae; adult Staphylinidae; several families of parasitic hymenoptera, and several genera of ants other than *Solenopsis* (Table 1) were present. When the decomposing fruit was exposed to the IFA there was a reduction in both abundance and diversity of the other decomposing arthropods. When the IFA was present, the Trephritidae, parasitic hymenoptera and other ants were absent and a major reduction in both adult and larval Drosophilidae and Nitidulidae occurred. Fire ants were observed removing larvae and pupae of the Drosophilidae, Nitidulidae and Trephritidae, as well as fruit tissue. The fruit in both cases (with and without IFA's) was reduced.

Table 1. Mean number of individuals of each family collected.

Family	Stage*	Protected from IFA (days) 3	6	9	IFA Exposed (last 3 days) 3	6	9
Drosophilidae	A	53.2	7.6	0.6	0.2	0.0	0.2
	I	173.0	4809.8	912.6	0.0	816.8	80.2
Trephritidae	A	2.8	0.0	0.0	0.0	0.0	0.0
	I	0.0	3.8	10.0	0.0	0.0	0.0
Nitidulidae	A	28.4	15.2	28.6	11.8	3.2	7.8
	I	0.6	2469.6	1561.8	0.0	467.4	192.0
Staphylinidae	A	15.6	14.4	10.2	0.0	0.6	3.0
Parasitic Hymenoptera	A	2.0	7.6	2.8	0.0	0.0	0.0
Formicidae-IFA	W	5.2	8.6	2.0	0.0	0.0	0.0
S. invicta	W	0.0	1.4	0.8	1732.4	2175.8	598.0
Total Individuals		280.8	7338.0	2529.4	1744.4	3463.8	881.2

*A = Adult, I = Immature, W = Worker.

When the IFA was present, between 63 to 99 percent of the individuals were fire ants while no species comprised more than 66% of the individuals when the IFA was excluded. The results demonstrate that IFA's can severely impact certain communities reducing diversity and severely reduce the abundance of the remaining species.

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IMPACT OF IMPORTED FIRE ANTS ON WILDLIFE: THE NEED FOR RESEARCH.

R. Scott Lutz and Stephen Demarais. Department of Range and Wildlife Management, Texas Tech University, Lubbock, Texas 79409.

INTRODUCTION

The rapid expansion of red imported fire ants (*Solenopsis invicta*) (RIFA) into 250 million acres of the southeastern United States resulted in RIFA becoming a pest of Agriculture, a health hazard, and a nuisance to people in infested areas (Carter 1982). Specific impacts of RIFA on wildlife resources have received limited documentation and quantification. The spread of multiple queen colonies with their higher mound densities (Vinson and Sorensen 1986) increases the need for quantification of RIFA impacts on wildlife.

The use of wildlife resources by hunters and non-consumptive users (e.g. bird-watchers, hikers) was a billion dollar a year industry in Texas in the mid-1980's (USFWS 1988). The current distribution of multiple queen colonies in Texas coincides with some of the most economically valuable wildlife habitat in the state. Most fire ant research effort has focused on entomological questions. Entomologists have investigated methods of control (Vinson et al. 1974, Phillips and Thorvilson 1989) and impact on native ant and arthropod communities (Whitcomb et al. 1972, Stein and Thorvilson 1989, Porter and Savignano 1990). The effects of fire ants on wildlife are not well documented (Vinson and Sorensen 1986).

The objectives of this paper were to summarize existing information on the impact of fire ants on wildlife populations and to suggest a design for wildlife-related research to quantify impacts of RIFA on wildlife populations.

LITERATURE REVIEW

Field biologists have reported many isolated observations of direct fire ant and wildlife interactions. In most cases, fire ants have killed young, especially newborn animals. Fire ants invaded pipping eggs in endangered Attwater's prairie chicken

(Tympanuchus cupido attwateri) nests (N. Silvy, Pers. Commun.), and killed small rodents captured in Sherman live traps (Chabreck et al. 1986). Dr. M. Robinson reported that fire ant predation on deer fawns has increased and may be a serious mortality factor (Rollins 1989).

Fire ants have been implicated in changes in animal distribution and abundance, especially in open habitats such as prairies or shrub savannah. In a small mammal trapping project in Fort Bend Co. very few rodents were captured (<5/100 trap nights) in habitats infested with fire ants (S. Demarais, Unpubl. data). A small mammal trapping project in Brazos Co. that compared abundance of small mammals in areas with and without fire ants found more small mammals in areas of low fire ant mound density (Smith 1988). Additionally, Smith found that during seasons of high fire ant activity, both resident and transient small mammals avoided areas with high fire ant densities. The presence of imported fire ants in large numbers may contribute to the lack of birds in grassland areas (Summerlin and Green 1977). Researchers across the southeastern United States have reported fire ants in the nests of woodducks (Aix sponsa) (Ridlehuber 1982), black-bellied whistling duck (Dendrocygna autumnalis) (Delnicki and Bolen 1977), bobwhite quail (Colinus virginianus) (Travis 1938), mourning dove (Zenaida macroura) (Moore 1940), and cottontail rabbits (Hill 1972). Sikes and Arnold (1986) reported fire ant invasion of cliff (Hirundo pyrrhonota) and barn (H. rustica) swallow nests in cement culverts. These researchers reported nest success dropped from a normal of 75% (no ants) to 41% in a colony with ants.

In addition to observations by field biologists, other authors expressed concern, from an ecological perspective, that fire ants may impact wildlife communities (W. Grant, Pers. Commun.). These concerns revolve around the idea that introduction of an exotic into ecosystems may have impacts that reverberate up the food chain. The altering of the food web could have profound effects on animal abundance and diversity.

CONCLUSIONS AND RECOMMENDATIONS

Anecdotal evidence and theoretical concerns point to the need for experimental research designed to document the impact of fire ants on wildlife. We believe a cooperative research project among State and Federal resource agencies (e.g. Universities, Texas Parks & Wildlife, Texas Department of Agriculture, USDA, chemical companies) would be appropriate.

We suggest that a graduate student research project be initiated to compare population responses of game and nongame species of wildlife to RIFA. The experimental design should allow for quantification of wildlife population responses to reduced levels of RIFA infestation. Additionally, the cost-effectiveness of such treatments should be evaluated.

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THE INFLUENCE OF RED IMPORTED FIRE ANTS (*SOLENOPSIS INVICTA*) ON SMALL MAMMAL HABITAT UTILIZATION

Michael J. Killion, William E. Grant, and S. Bradleigh Vinson

Department of Wildlife and Fisheries Sciences (MJK, WEG),

and Department of Entomology (SBV),

Texas A & M University, College Station, TX 77843

ABSTRACT - The ability of invading species to alter the structure and function of native communities is widely recognized, yet little research has been done to examine the effects of *Solenopsis invicta* invasion on native North American communities. With a wide representation of life history strategies and rapid response to community perturbations, small mammals make ideal subjects for studying the effects of *S. invicta* invasion on native vertebrates. Preliminary study of habitat use by four small mammal species and polygyne red imported fire ants, conducted in Brazos County, Texas in Fall 1988 and Fall 1989, suggests hispid cotton rats (*Sigmodon hispidus*) avoid areas of high *S. invicta* foraging activity. There were no deviations from expected frequencies of occurrence in areas of high *S. invicta* foraging activity for northern pygmy mice (*Baiomys taylori*), white-footed mice (*Peromyscus leucopus*), or fulvous harvest mice (*Reithrodontomys fulvescens*). *Sigmodon* was essentially absent

from the site in 1988, when 55% of the site was classified as high *S. invicta* foraging activity, but increased substantially by 1989, when only 25% of the study site was classified as high foraging activity area. This may indicate *Sigmodon* is forced into marginal habitats when *S. invicta* are abundant and dominate a large portion of the site. When *S. invicta* are less abundant and dominate less area, *Sigmodon* may recolonize the site but remain restricted to areas of low *S. invicta* foraging activity. The mechanisms by which *S. invicta* could alter habitat use by one small mammal species, and not others, are unknown. Theoretically, mechanisms such as lowered reproductive success due to *S. invicta* predation on nestlings, decreased availability of preferred food items, or the harassment effect of *S. invicta* stings may alter patterns of habitat use by small mammals. Because *Sigmodon* has a reputation for being tolerant of nest disturbance by humans, we hypothesize *Sigmodon* may be more susceptible to *S. invicta* predation on nestlings than other small mammal species, particularly *Baiomys*, the nestlings of which remain attached to the mother's mammae for up to two weeks after birth. While our results necessarily remain tentative, we hope they will encourage greater effort to document the ecological impact of *S. invicta* on the native fauna of North America.

HOST-PATHOGEN RELATIONSHIP BETWEEN BEAUVERIA BASSIANA (BALSAMO) VUILL. AND THE RED IMPORTED FIRE ANT, SOLENOPSIS INVICTA BUREN

Stacy R. Siebeneicher, S. B. Vinson, and C. M. Kenerley

Department of Entomology, Texas A&M University

College Station, Texas 77843 (409) 845-8974

ABSTRACT

The entomophagous fungus, *Beauveria bassiana*, is an effective biological control agent of the red imported fire ant, *Solenopsis invicta*. When fed in a liquid bait, the pathogen caused high mortality among workers and brood. Light microscopy revealed spores concentrated in the crop and postpharyngeal gland of workers, although scanning electron microscopy showed spores germinating on the tarsi suggesting another route of entry. Further experimentation has shown external penetration of the exoskeleton by topical applications of the fungus.

STATUS OF USDA-ARS FIRE ANT RESEARCH PROGRAM

Richard S. Patterson

The USDA-ARS Fire Ant Research Group at the Insects Affecting Man and Animals Research Laboratory, Gainesville, Florida, has had several staff changes and redirections. We have currently five areas of fire ant research: taxonomy, ecology, impact, control, and biological control. Currently we have 7.5 scientists, 5 entomologists and 2 chemists. I make up the 0.5 scientists since I have other duties with the Household Insects Section. During this past year Dr. Clifford Lofgren retired in April, and his research area was redirected into population ecology, this position was filled by Dr. Sanford Porter formerly of the University of Texas at Austin. Dr. Porter joined the staff in the middle of December. Dr. B. Michael Glancey retired in July and his position will not be filled due to budget restraints. A senior technician, Mr. Kenneth Plumley, retired at the end of December and his position will not be refilled.

It is our aim in the taxonomy research unit to study the hybrid situation of Solenopsis invicta and Solenopsis richteri in the U.S. and South America. It is our objective to determine if these two species are true species or just a species complex created by ecological isolation. In the U.S., these two species readily intermate and create a hybrid which is fully fertile and has the characteristics of both its parents forms. It was thought that hybrids did not occur in South America due to geographical isolation. This is not true based on James Trager's book, "New Key to the Solenopsis of South America". Although no hybrids have yet been identified, there are several areas where the two species meet and have the opportunity to intermate. We contracted with Dr. Trager to finish his key the Solenopsis species of South America. There are 17 described species in this genera, Dr. Trager has synomymized many names. We hope that Dr. Wojcik's taxonomic research will build on the foundation established by Dr. Trager's key and descriptions. Most of the material that was used by Dr. Trager originally was collected by Dr. William Buren and the USDA-ARS teams who did the initial fire ant surveys in South America of Solenopsis ants. It is Dr. Wojcik's responsibility to check areas where S. invicta and S. richteri are present. Also, he will look for hybrids between other Solenopsis species. We will check this by cuticular hydrocarbons and venom alkaloids as well as morphometric means. If need be we will use isoenzyme techniques to verify any hybrids. In February 1990, Dr. Wojcik collected over 700 samples of Solenopsis ants for analysis. Hopefully within the next few months, we will know if S. invicta and S. richteri are separate species or just a species complex here and possibly in South America.

There have been and will be several changes in our ecology research program which has been very capably lead by Dr. David Williams for a number of years. He has completed some excellent studies on the effect of temperatures on colony development. He has also completed a large project in Brazil to determine the extent of fire ant populations in recently disturbed, old farming, and virgin areas. As in the U.S., the highest density of fire ants, S. invicta, present were in recently disturbed areas. In older mature farming areas the fire ants were present, but not as numerous as in newly disturbed areas also in the virgin areas the fire ants were hardly present.

Dr. Williams has also been doing some cooperative work with the Charles Darwin Research Station on the Galapogos Islands on two serious pest ants, Wasmannia auropunctata and Solenopsis geminata. The work involves both basic biology and control of these two ant pests. In the future, Dr. Williams will be doing more work on the impact fire of ants and other pest ants such as pharaoh ant and Argentine ants, on urban populations. This is an increasing problem in Florida and is considered by the Florida Pest Control Association to be their number one pest problem in the state. The control of ants in an urban setting is very difficult and often very poor control is achieved following chemical treatments. Since Dr. Porter will be taking over some of the ecology research, his first responsibility will be to study the single and multiple queen complex in Florida. He has already done a preliminary survey in South Florida during March. He will also do some work on the multiple queen in other areas of the U.S. and South America.

In the past, very little fire ant research had been done in South Florida in the semi-tropical region of the state to determine interaction of fire ants with the arthropod fauna of South Florida. A cooperative study with Palm Beach County Parks Department was set up by Dr. Wojcik to determine which fire ant control technologies would give the most efficient ant suppression with the least effect on other ant and arthropod species in the area. Amdro and Logic baits were applied at recommended dosages as a broadcast and single mound treatments in the parks. The data taken at monthly intervals indicated that both chemical baits were effective for fire ant control, and that the same arthropod complex was present six months after the treatment in both treatment and control areas. The single mound treatments had less initial adverse effect than the broadcast on other ant species, but broadcast treatments were less expensive due to high labor costs for single mound treatments. Within six months there was no difference in any of the treatment plots, but the fire ant populations were lower than in the check plots. These studies will be repeated this year in both South and North Florida to determine if timing of treatments is important in fire ant control within the state of Florida, since we have such a diverse ecosystem in Florida from the temperate regions of the north to the tropical regions in the southern areas of the state.

Dr. Vander Meer has concentrated mainly on pheromone research in relation to bait enhancement and species specific baits. Most of the work has concentrated on the queen recognition pheromones and the recruitment of ants to the components of these pheromones. Of the three queen pheromones isolated previously by Dr's. Tumlinson and Glancey, only one or maybe two are exhibiting attraction to worker ants (brood and queen tenders). One of the components of the trail pheromone has been synthesized in sufficient quantities for use in the baits. The second component should be synthesized within the next two months. These will be incorporated into a bait formulation along with an attractant fraction of soybean oil which should enhance the toxic bait. It is planned to have this work on the baits completed within the next year. Dr. Robert Vander Meer has been assisted by Dr. Pedro Hernandez who has synthesized the components of the trail pheromones.

Since Dr. A. Banks will be reporting on his studies with teflubenzuron, I will not repeat the data here except that this compound looks very promising for fire ant control. Recent studies investigated the effect of Amdro, Logic, and sulfluramid baits on multiple queen population of Solenopsis invicta. One pound per acre of any of the three compounds gave adequate control of fire ants in the field. Logic gave slightly better control then the other two against multiple queen colonies. Studies with a Sumitomo IGR, pyriproxyfen, look promising for fire ant control. Activity of pyriproxyfen is similar to fenoxycarb (Logic) .

In the area of biological control, Dr. Don Jouvenaz has completed his studies on the yeasts; these are not pathogenetic, but may be stressing the ants. He is currently working with the steinernematid nematode, in cooperation with Biosys for treatment of nursery stock, the exotoxin of Bacillus sphaericus was ineffective against fire ants. In the fall of 1989 a project review of the pathology unit of our laboratory suggested that we redirect some of our efforts in this area in the future. In South America, the biological control project in Argentina on the effect of Thelohania solenopsis on indigenous populations of Solenopsis richteri being conducted by Mr. Juan Briano is going very well. This microsporidian disease appears to have no overt effect on the ant colonies. Diseased colonies are still in existence 16 months later. Disease increases colony movement, but the ants take the disease with them when they move. The major workers have a heavier rate of infection than the other castes. We also have been studying the long term effect of the parasitic ant, Solenopsis (Labauchena) daguerri on fire ants. This parasite is very numerous at times in the fire ant mounds but appears to be very cyclic. We see no signs that it kills off the colony even though we often find several Labauchena adults yoked on the fire ant queens. Dr. Silveira-Guido of Uruguay did much of the classical work with this parasite and he thought it had promise as a biological control agent. He was never able to colonize this parasite or reestablish it in new locations. This past year, 14 colonies of fire ants with Labauchena were brought back to Gainesville, Florida and all died. In Argentina the Labauchena are still present in the field, but are not adversely affecting the fire ant host colonies. This work will probably be terminated in the near future when Mr. Briano comes to Gainesville for his M.S. Degree in Entomology.

In the future we will be trying to do more research with less resources. Therefore, the USDA-ARS program will be very structured and goal-oriented. One of our main emphasis will be to aid APHIS in their program as well as continue studies on the basic biology, ecology, and control of this difficult species, the imported fire ant.

FIRE ANT CONTROL IN ELECTRICAL EQUIPMENT

William P. MacKay, James Irving and S. Bradleigh Vinson
Department of Entomology
Texas A&M University, College Station, TX 77843

Abstract: *The red imported fire ant, Solenopsis invicta Buren, causes numerous problems, including the invasion of electrical equipment. The ants remove insulation from wires and bridge terminal blocks, causing shorted circuits. They enter mechanical switches and cause malfunction by interfering with the action of the switch. They can become a serious problem when they interfere with traffic signals.*

We have tested several insecticides and practices to reduce the impact of fire ants in electrical equipment. We have found that the insecticide Dursban (chlorpyrifos) is effective in reducing ant populations in electrical equipment. Additionally the sealing of electrical components to eliminate the entry of ants is important. These two practices can eliminate the problem in most cases.

INTRODUCTION

Imported fire ants, as well as numerous other ant species, are strongly attracted to electric fields (MacKay et al., unpublished). In addition, the fire ant appears to be attracted to the protection from the elements offered by electrical equipment. This attraction results in two basic problems: first the ants cause short circuits and second they interfere with the action of mechanical devices. The ants remove insulation from wires causing shorts between lines. In addition, they bridge contacts on terminal blocks, causing direct shorts through their bodies. The principal problem is the interference caused when they enter relay switches. They accumulate in such large numbers that the switch is no longer able to function or is shorted. This causes numerous problems in equipment, ranging from pump motors and air conditioners to traffic signal lights. Although this is a common and widespread problem (Messor et al. 1986; Vinson and MacKay, *in press*), it has not been studied to any extent. It has been reported previously in other ant species. The white-footed ant, *Technomyrmex albipes* enters relay switches in New Zealand and causes them to malfunction (Little 1984). *Solenopsis xyloni* causes extensive damage to electrical equipment in Texas (Engleson 1940). Termites may also attack plastic and lead- sheathed cables (Gay and Calaby 1970).

We have designed a control program consisting of the use of insecticides and the sealing of relay switches, that has been very successful in reducing the impact of the imported fire ant in electrical equipment.

METHODS AND MATERIALS

We treated a total of 15 signal control cabinets in the city of Bryan and 20 cabinets in the city of College Station, Texas. An additional five cabinets in Bryan and ten in College Station were used as controls. The assignment was made using random numbers. Cabinets are somewhat variable in size, with the bottoms ranging in area from 0.21 m^2 to 0.76 m^2, depending on the amount of equipment contained in them. The majority were a standard 0.65 m^2. Each of the cabinets is mounted on a cement pad slightly larger than the base of the cabinet. Conduits enter the cabinets through holes in the bottom of the cement pad or through PVC pipe embedded in the pad.

Two treatments, the first consisting of chlorpyrifos (0.5%) in a corncob grit, and the second consisting of a mixture of pyrethrins (0.10%), piperonyl butoxide (1.00%) and silica gel (4.00%) were begun on 13 May 1988, after the cabinets had been cleaned. Cabinets in College Station had not been previously treated with any product except the occasional use of 1,1,1 trichloroethane, which is not very effective. Those in Bryan had been treated with a mixture of pyrethrin (1.00%), piperonyl butoxide (10.00%) and silica gel (40.00%) whenever ants were causing problems, which is also not very effective. Chlorpyrifos was used at 1/3, 2/3 and at the level recommended (915 g/m^2) by the manufacturer (five cabinets/level). Additional cabinets (five) were treated with a combination of pyrethrin, piperonyl butoxide and silica gel. The material was sprayed on the bottom of the cabinet until a uniform white covering remained. The cabinets of Bryan were also treated in a similar manner with three levels of chlorpyrifos on 10 May 1988 (five cabinets / level).

The cabinets were monitored at monthly intervals throughout the summer season. Three other cabinets in College Station were treated with 1,1,1 trichloroethane whenever fire ant populations increased to the point they were causing problems in the circuitry. This is the most common response of the signal technicians in the area (MacKay, pers. obs.).

We have shown that relay switches are strongly attractive to fire ants due to the electric field generated (MacKay *et al.*, 1989). Cabinets have from one to five relay switches, depending on the complexity of the signal lights controlled by the cabinet. We designed two sets of six relays mounted on a Plexiglas frame. The relays were operated (on a 1 H_z signal or one cycle/sec) at night (18:00 of one day to 08:00 of the following day) in two laboratory nests. It was dark in the laboratory during much of this time. This schedule simulated the activity of the relays in the field, which are most active at night when traffic signals are in flash mode. Circuitry was designed which allowed us to randomly determine which relays would be active at any specific times (three controls and three active relays). All relays had power to the points (120 VAC, 1.89 Amps) in order to simulate the condition of relay switches in the field. Ants were removed at regular intervals, counted and returned to the relays to determine the rate at which ants accumulated.

We tested the effect of several sealants on relay switches. We used roofing cement, two silicon sealers (Duncan 25 year siliconized acrylic caulk and Duncan all purpose adhesive and caulk), and two types of epoxy cement (Devcon 5-minute and plastic steel). Each of the relays used in traffic cabinets was enclosed in a plastic box. We simply sealed the area around the bases of nine pins which protrude from the relay, both on the inside and outside of the switch. Sealed relays were tested in laboratory nests using relays mounted in Plexiglas and in the field under actual conditions.

Non-parametric statistical analysis were used as none of the distributions were normal (Kolmogorov-Smirnov one sample test) and the variances were heteroscedastic (Bartlett's test).

RESULTS AND DISCUSSION

Relay switches are very attractive to workers of the imported fire ant, especially when relays are active (Fig. 1). Significantly more ants enter active relays in the laboratory (Wilcoxon's signed rank test, alpha < 0.005). Field data show a similar trend to laboratory data (Fig. 2). Two cabinets were in the flash mode throughout the summer 1987 (relay switches active at all times). One of these was randomly selected to be treated with the insecticide Insect Control, the other was randomly selected to be a control cabinet. These two cabinets were the only ones which were continuously in the flash mode in the area. These two cabinets were compared with three randomly selected cabinets which were not in the flash mode throughout the summer and which were treated in the same way (one with Insect Control, the second was a control, the third was equipped with sealed relays). Each of the cabinets had three relay switches. The relays in the control cabinet in flash mode accumulated large numbers of ants (Fig. 2), significantly more than the control cabinet used for comparison (Wilcoxon's signed rank test, alpha < 0.05). The treated cabinet had statistically equal numbers of ants in the active relays as did the cabinet with sealed relays and the cabinets which were not in flash mode. Obviously active relays accumulate ants at faster rates in both laboratory experiments and under actual field conditions. Additionally the treatment of a cabinet with chlorpyrifos effectively reduced the numbers of ants which enter the relays to levels similar to those of relays which were not active. Epoxy was much more effective than any of the other sealants tested. No ants have entered any of the relays either in field experiments or lab experiments in any of the four relays we have sealed with epoxy. Relays sealed with other products and

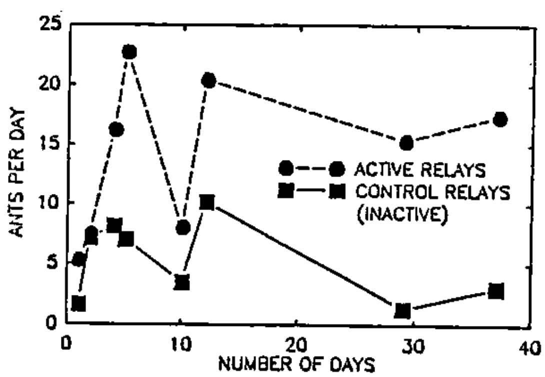

Figure 1. *Laboratory data comparing the rate at which ants enter active and inactive traffic cabinet relays.*

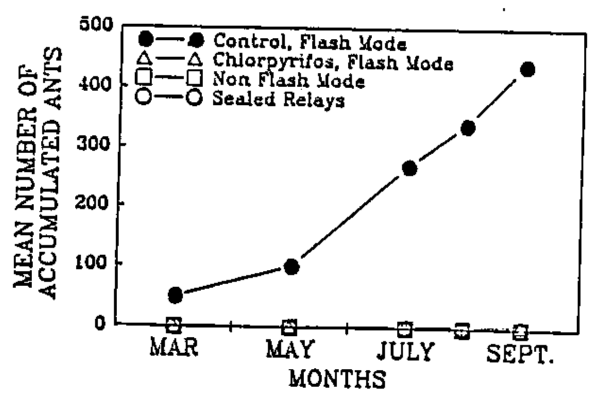

Figure 2. *Field data comparing the accumulated numbers of imported fire ants in active and inactive relays in the city of College Station, Texas.*

tested in laboratory nests accumulate hundreds or thousands of ants within a month.

We developed effective control of the imported fire ant in traffic signal cabinets (Fig. 3). Insecticidal treatment with chlorpyrifos significantly reduced the ant populations in College Station (Table 1, Figure 3a), although the populations in the treatment and control cabinets were not significantly different in the city of Bryan (Table 1, Figure 3b). This was apparently because the populations in the control cabinets were low throughout the experiment. A comparison of the population levels in the treated cabinets in Bryan before and after treatment did demonstrate a statistically significant reduction in the populations (alpha = 0.022, Wilcoxon's signed ranks test). Thus, we can conclude treatment of the cabinets with chlorpyrifos controlled ant populations

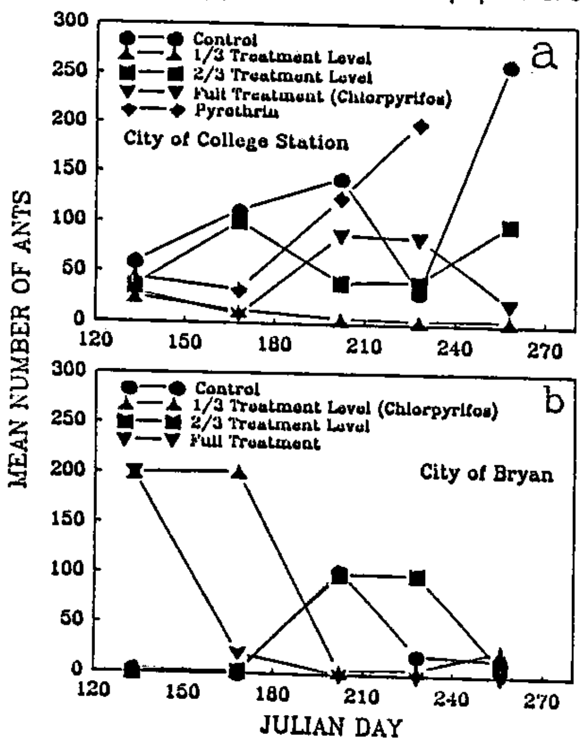

Figure 3. *Fire ant populations in signal cabinets in College Station (a) and Bryan (b) during 1988. The various treatments are indicated in the figure.*

in both cities. Orthogonal comparisons and Newman- Keuls Multiple comparisons tests showed that the treatment levels were not significantly different in controlling ant populations in the cabinets in either city, but ant populations were significantly lower in the treated cabinets when compared to the control cabinets. Pyrethrins were not very effective (Fig. 3a) and ultimately one cabinet had to be treated with chlorpyrifos due to the ineffectiveness of the product. 1,1,1 trichloroethane rapidly killed ants, but cabinets treated were reinfested the following day. Chlorpyrifos destroyed all of the ants in cabinets within three hours. These data are similar to those reported by MacKay (1988).

CONCLUSIONS

We have demonstrated that ant problems in electrical apparati can be successfully controlled using a combination of sealing any mechanical relay switches (Which are the most attractive electrical component) and treating the apparati with the insecticide chlorpyrifos. These procedures would not be applicable if relay switches were not surrounded by a protective cover which can be sealed, and under applications where the insecticide would become wet, which would result in reduced effectiveness (due to decomposition by fungi) and would result in contamination of the environment. The insecticide may be effective in some areas and not in others with different environmental conditions. Thus further experimentation may be necessary to use our procedures in other locations and with other equipment.

Table 1. *Wilcoxon's signed ranks tests of the effects of insecticidal treatment of traffic signal cabinets in the cities of Bryan and College Station, Texas, using two-sided probabilities and a normal approximation.*

	Ants	Level of Insecticide	Date
COLLEGE STATION ALPHA LEVELS			
Ants	1.000		
Level	0.002	1.000	
Date	0.001	1.000	1.000
BRYAN ALPHA LEVELS			
Ants	1.000		
Level	0.159	1.000	
Date	0.198	1.000	1.000

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EFFECTS OF TEFLUBENZURON ON LABORATORY COLONIES OF RED IMPORTED FIRE ANTS

W. A. BANKS

Insects Affecting Man And Animals Research Laboratory
Agricultural Research Service, U. S. Department of Agriculture,
Gainesville, Florida 32604

The activity of insect growth regulators against the red imported fire ant, Solenopsis invicta Buren, has been documented in a number of studies (Banks 1986, Banks et al. 1978, 1983, 1988, Phillips et al. 1985, 1989, Vinson and Robeau 1974, Vinson et al. 1974). The juvenile hormone mimics have been most effective against the fire ant and commercial baits have been developed with two of these materials.

Benzoylphenyl urea (BPU) compounds, of which diflubenzuron or dimilin is the best known, have been successfully developed as control agents for a number of insects. These materials, commonly known as chitin inhibitors, interfere with normal endocuticular deposition and molting, and in some cases act as ovicides. Although a few BPUs have been tested against the fire ant, they have generally been relatively inactive because of the virtual insolubility of these compounds in soybean oil or other foods acceptable to the fire ant.

Teflubenzuron (1-(3,5-dichloro-2,4-difluorophenyl)-3-(2,6-difluorobenzoyl)-urea) is one of the newer BPUs and is considerably more toxic to a number of agricultural pests than is diflubenzuron. It has given excellent control of some insects, such as the diamondback moth, and the red flour beetle, that are highly resistant to other insecticides (Ishaaya & Klein 1990). In early 1988, we were supplied a 5.0% oil dispersible concentrate, and a 10% emulsifiable concentrate of teflubenzuron, by EM Industries (U. S. representative for CelaMerck), for evaluation against the fire ant. We were unable to prepare any type formulation with the oil dispersible concentrate, but did manage to incorporate the emulsifiable concentrate into soybean oil reasonably well. In the initial test at 5 and 10 mg per colony (0.5 ml of 1.0 or 2.0% solution), however, the materials were so repellent to the ants that they buried the micropipets containing the oil solution with detritus within one hour. Naturally they had no effect on the ants and we advised the supplier of the results.

Late in 1988 the supplier advised us that teflubenzuron had shown excellent activity against some Lepidopterous pests at extremely low dosages and requested that we try another test with the material at low concentrations. Accordingly, 0.1% and 0.5% solutions in soybean oil were made with the emulsifiable concentrate and each concentration was tested against three laboratory-reared colonies of Solenopsis invicta. Queenright colonies with 20-25 ml brood and 20,000-40000 workers were given 0.5 ml of the 0.1% solution (0.5 mg/colony AI), and queenright colonies with 30-35 ml brood and 50,000-70,000 workers were given

0.5 ml of the 0.5% solution (2.5 mg/colony AI). Three colonies, comparable to those treated with the 0.5% solution, were each given 0.5 ml of neat soybean oil as untreated controls.

Effectiveness of the treatments was based on comparison of the before and after treatment colony indices. The colony index is derived by multiplication of assigned values for worker numbers and quantity of worker brood (see table below); e.g. a colony with a rating of 5F would have a colony index of 125 (5 x 25).

Estimated number of worker ants			Estimated quantity of worker brood		
	Rating	Value		Rating	Value
<100	1	1	0	A	1
101-5000	2	2	1-5	B	5
5001-20000	3	3	5-10	C	10
20001-35000	4	4	10-20	D	15
35001-50000	5	5	20-30	E	20
>50000	6	6	>30	F	25

Teflubenzuron was very effective against the laboratory colonies of S. invicta (Table 1). Worker brood production ceased very soon after treatment and by four weeks posttreatment two replicates at the 0.5 mg dosage were devoid of brood and only a few pupae remained in the third replicate. All replicates at the 2.5 mg rate were devoid of brood at four weeks. No further brood production occurred through one year except one replicate at the 0.5 mg rate contained about 0.5 ml at the one year posttreatment evaluation.

The workers did not exhibit any direct effect of treatment, thus, as is typical with most insect growth regulators, colony mortality was very slow and dependent on old-age attrition of the worker force. All three replicates at the 2.5 mg rate were dead by nine months, however, two replicates at the 0.5 mg rate were alive at one year, although neither contained more than 500 workers. No alate production occurred in any of the treated colonies throughout the test. The untreated controls showed no change or an increase in size through 24 weeks posttreatment but began a decline thereafter and all three were devoid of worker brood and reduced in size by one year.

A second test begun in November 1989 to verify results of the previous test is producing the same results (Table 1). Effects of the treatment were not exhibited as quickly. All three replicates at 0.5 mg and two at 2.5 mg still contained some worker brood at four weeks, however, by eight weeks all treated colonies were devoid of worker brood and remain so after 16 weeks. Although only a few (<25) were produced, female alates were present in two replicates at the 2.5 mg rate at 12 weeks posttreatment in this test.

These tests with teflubenzuron have been encouraging and field evaluations are planned for 1990.

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TABLE 1. EFFECTIVENESS OF TEFLUBENZURON AGAINST LABORATORY COLONIES OF RED IMPORTED FIRE ANTS (AVG. OF 3 REPLICATIONS).

DOSAGE MG/COLONY	PRETREATMENT COLONY INDEX	% REDUCTION IN COLONY INDEX AFTER WEEK[a]							
		4	8	12	16	20	24	32	52
				TEST 1					
0.5	101.7	90.8	96.7	97.0	97.7	97.7	98.0	98.0	96.4
2.5	150.0	90.7	96.7	97.3	98.2	98.4	98.7	98.9	100
CK	131.7	- 7.6	0.0	-13.9	-13.9	-13.9	-13.9	22.5	97.0
				TEST 2					
0.5	133.3	83.5	97.2	98.2	98.3				
2.5	150.0	88.7	96.4	98.0	98.0				
CK	140.0	- 6.7	- 6.7	33.1	25.5				

[a] Numbers preceded by minus represent increase rather than reduction.

EVALUATION OF PROGRAM APPROACHES TO RED IMPORTED FIRE ANT MANAGEMENT

Bastiaan M. Drees, Extension Entomologist
and S. Bradleigh Vinson, Professor
Department of Entomology, Texas A&M University System

Until recently (Trostle 1984), the approach to the control of the red imported fire ant (RIFA), Solenopsis invicta Buren, was area-wide treatment. The hope for eradication, or at least wide-spread suppression, was still viable. With the realization that eradication was not technically, economically and/or environmentally feasible, a shift occurred in the philosophy of RIFA control. The principals of integrated pest management (IPM) were applied to fire ant management (Hamman et. al 1986, Drees and Vinson, 1988 and 1989). Programs are now being developed to manage problems caused by the ants without necessarily removing the species from the ecosystem. These site-specific programs use a combination of available suppression tactics (management system adjustments, mechanical methods, habitat modification techniques, biological methods and chemical controls) to attain management objectives in a way that is 1) most effective, 2) least expensive and 3) least disruptive or detrimental to the environment and non-target organisms. Most importantly, programs implemented must be justified, both economically in commercial agricultural situations and environmentally.

Although RIFA management programs have been proposed for certain sites (ornamental planting and turf; pastures, rangegrass and non-agricultural lands; homes, structures and greenhouses; home vegetable gardens and orchards; poultry houses; field crops; and, apiaries), they are largely based on theoretical approaches. Research is now being conducted to provide data to support these programs and document their success. MacKay (1989) has provided an excellent example of the development of a RIFA management program for electrical equipment.

Ornamental pastures

RIFA management in cattle production (rangeland and pastureland) has received a lot of attention recently. One method of suppressing ant populations in pastures is by using a bait-formulated insecticide such as Amdro® (hydramethylnon), currently registered for use in this site. Another product, Logic® (fenoxycarb) may soon be fully registered for this site. Logic was issued an Experimental Use Permit (EUP) for pastures in 1988.

Logic was applied at a rate of 1.38 lbs per acre to an improved 65 acre pasture on the Mitchell Farm, Brazos County, by aerial application, 19 April 1988. Adjacent areas (40 acres) to the treated pasture were used as an untreated check. Before treatment and periodically after the application, RIFA mound densities were monitored by counting the number of active mounds within 0.25-acre circular subplots (anon. 1980) at approximately the same location within treatment areas throughout the monitoring period. A total of 16 subplots were sampled in the treated area and 8 in the untreated area. Statistical differences between mean subplot mound densities of treated and untreated areas occurred 2, 5 and 12 months post-treatment (Table 1). Percent reduction in mound densities, calculated using Henderson's formula (Henderson and Tilton 1955), were 30, 56 and 25 percent, respectively. Perhaps due to the hilly terrain comprising treatment plots, much variation in mound densities and response from the Logic treatment was observed between subplot sites. Lower densities of mounds occurred in higher and drier areas of the treated pasture, and control resulting from treatment appeared to be better. In low, flood-proned areas (where more favorable conditions for fire ant survival exist), higher densities of mounds were consistent throughout the monitoring period.

Although significant reductions in active RIFA mound densities can be achieved using annual or semi-annual applications of a bait-formulated insecticide, a more important consideration for the agribusiness of cattle production is: Will the investment into fire ant suppression provide an economic return? The cost of a program based exclusively on bait applications requires an annual investment (the Government Program rate of Amdro in 1989 was $2.90 per lb./acre while the market value varies from $6 to $12 per lb./acre, not including cost of application). If a return on the investment is not realized, these treatments may result in the production and maintenance of what may be termed an aesthetically pleasing "ornamental pasture" in which the ants and their mounds are merely less visible and noticeable.

Alternative programs for cattle producers

In pastures, RIFA reportedly attack calves, causing temporary blindness (Joyce 1983) and occasionally death (Lofgren 1986). However, they may also help suppress ticks and tick related problems (disease and related insecticide applications to cattle)(Harris and Burns 1972, Fleetwoood et al. 1984) and immature stages of horse flies (Johnson and Hays 1973, Drees 1987). Alternatives to a periodic area-wide bait-application program might include 1) establishment and maintenance of a calving pasture where fire ants are managed (chemically) to prevent ant attacks during calving (a method to reduce the need for area-wide chemical treatments), or 2) adjusting the fertility program to schedule shortened calving period during periods of the year when RIFA foraging activities are minimal (when soil temperatures are lower than 65-70^{o} F)(a management system approach). These alternatives, where feasible, allow cattle producers to avoid the RIFA problem of foragers attacking calves, while utilizing the beneficial aspects of RIFA presence as natural enemies to help suppress tick problems. As an extra bonus, maintaining populations of the single queen (monogynous) RIFA form may delay or prevent the invasion of the multiple queen (polygynous) form.

In hay production, RIFA presence has not been documented to affect yield or quality of forage produced (Blust 1977). RIFA reportedly cause problems because the tall, hardened mounds may destroy harvesting machinery and the ants invade hay bales (Lofgren, 1986). These aspects of the RIFA may be overcome by 1) using disc-type cutters designed to cut through mounds (a mechanical method of managing this RIFA problem) and/or by periodically "dragging" pastures (Blust 1977), and 2) scheduling labor to remove bales from the field immediately following harvest and particularly before rains, before the ants move into bales (a management system approach to overcoming this fire ant problem). Maintaining RIFA populations may also help suppress armyworm outbreaks and prevent characteristic resurgence of ant populations if and when chemical treatments are discontinued.

These suggestions have yet to be packaged into a management program and scientifically evaluated, but offer alternatives that may be economically and environmentally more acceptable than routine large-scale chemical treatments.

Ornamental turf

Most insecticide applications for RIFA occur in urban environments on ornamental turf. A number of alternative methods of control exist, but most consumers rely on some type of chemical treatment program (Drees and Vinson 1989). The C&D Grass Farm in Jackson County, Texas was used in 1989 to conduct a series of tests to evaluate various RIFA control methods: broadcast application of a bait (Logic, containing fenoxycarb), 2) broadcast application of a contact insecticide (Dursban®, containing chlorpyrifos); 3) individual mound treatments (Whitmire PT® 270 and Cessco Accudose®, containing chlorpyrifos); and 4) programs based on the combination of these methods.

The first test was initiated, 11 May 1989. A portion of the farm was divided into 24 quarter-acre square plots (3 rows of 8 plots). Plots were separated on all sides by a 13.44 ft. buffer zone. Eight treatment regimes listed in Table 2, replicated 3 times in a randomized block design, were applied. Plots were evaluated for the presence of active RIFA mounds before initial treatment and through the year. Within each 1/4-acre plot, a 1/5-acre subplot was monitored. The number of active mounds per subplot was statistically analyzed for each evaluation date. Percent reductions were calculated using Henderson's formula (Henderson and Tilton 1955).

Comparison of the three individually-applied RIFA control methods in trial 1 (Table 3) illustrate the following points:

1) Chlorpyrifos mound injection alone produced no significant reduction of RIFA mound numbers. However, since individually-treated mounds were not specifically monitored, the lack of suppression within plots may or may not have resulted from treatment failure.
2) The single application of a broadcast Dursban application produced significant percent reductions in active mound densities within 62 days after the monitoring period began. This was somewhat slower than expected. However, the effects of this treatment lasted for 83 days.
3) The single Logic application produced statistically similar results to those from the single broadcast Dursban treatment, although Logic produced numerically greater percent reductions. Furthermore, Logic continued to suppress mound activity for 186 days.
4) The effects of the broadcast Logic treatment were evident, even in small (1/4-acre) treatment plots within an area where most neighboring plots were also treated.
5) The spring Logic application combined with broadcast Dursban or mound injection treatments did not produce statistically better results than was produced by the single Logic application in this trial.
6) Numerically, the best program was the Logic + Dursban broadcast + Logic program (treatment No. 8, Table 2). However, this treatment was rarely statistically different from other treatments involving a combination of treatments that included a Logic application, except after 186 days when both double Logic-treated plots had significantly lower active RIFA mound densities than other treatments.

In a second trial established 2 July 1989, adjacent to the trial described above, four 1-acre square plots were established and treated as follows: 1) untreated check; 2) Logic (1.5 lbs. per acre) applied using an electronic seeder (2 July); 3) Dursban 4E broadcast spray (2 lbs. active ingredients in 30 gal. water per acre (20 July) applied using a boom-type applicator; and, 4)

Logic (2 July) followed by Dursban broadcast spray (20 July). Before and after establishment of this test, the number of active mounds per quadrant of a 1/2-acre circular subplot within each plot was monitored. The resulting values for active mounds within 1/16-acre quadrants were subjected statistical analysis.

In this second trial, the July application of Logic produced results similar to those produced by a broadcast Dursban application within 22 days and was statistically better for a longer period of time (57 and 124 days) when applied with or without a broadcast Dursban application (Table 4). From this trial, we made the observation that the effects of the mid summer Logic application appeared to be more rapid and dramatic than the spring application made in the first trial, although this observation could not be statistically tested. Perhaps, environmental conditions during mid-summer increase the rate of natural worker ant mortality, resulting in a more rapid colony decline. In addition, summer treatments, whether applied in combination with a spring application (first trial) or alone, for the most part, provided suppression longer into the calendar year than did spring treatments alone.

This type of comparative data allows pest control operators and homeowners to justify the implementation of the RIFA management program approach that best suits their management goals, economic and labor constraints and environmental concerns. However, additional long-term program evaluations are necessary to substantiate findings of these trials.

Pecan Orchard Fire Ant Management

The impact of the RIFA in pecan orchards has not been conclusively documented. Pestiferous aspects of RIFA include 1) interference of production operations such as grafting, mowing and harvesting operations, 2) predation by the ants on natural enemies of certain pests such as vulnerable stages of the green lacewing (*Chrysopa* spp.), which naturally suppresses population of the pecan aphid (*Monelliopsis pecanis* Bissell - yellow pecan aphid and *Monellia carvella* (Fitch) - blackmargined aphid) complex (Tedders et al. 1989), and 3) damaging drip or sprinkler irrigation systems by chewing into pipes, clogging nozzles or burying system components. Beneficial aspects of the ants include predation on primary pecan pests such as pecan weevil (*Curculio caryae* (Horn))(Dutcher and Sheppard 1981), hickory shuckworm (*Cydia caryana* (Fitch)) and perhaps others.

RIFA management options in pecan orchards include cultural and chemical methods. Dragging heavy objects (such as railroad ties) can reduce mound height temporarily so that hardened mounds will not interfere with mowing or ground harvesting machinery operations. Insecticides registered for RIFA in pecan include 1) bendiocarb (Rotate® 2 1/2G) registered for non-producing citrus and pecan orchards, and 2) chlorpyrifos (Lorsban® 4E). Alternative methods, such as the use of very hot water are available (Drees and Vinson 1989), although the practicality of using these methods on a large scale is doubtful.

Applied research/result demonstrations were conducted to document the effectiveness of available insecticidal methods for RIFA control in the pecan orchard. With this information, one could begin contemplating the economic justification of including these approaches in a pecan production system. Two tests were conducted at Royalty Pecans in Burleson County, Texas: 1) use of chlorpyrifos trunk sprays to eliminate RIFA foraging activity in the pecan tree canopy, and 2) ground application of bendiocarb, chlorpyrifos and an experimental compound, isazofos (Triumph®), to eliminate RIFA foraging and mound activity in an abandoned portion of the orchard.

Trunk sprays: All of the trees in the treatment site were of a size where their canopies were not touching, leaving only the individual trunks as a means of access for the ants into the tree canopies. On 23 June 1989, chlorpyrifos (Dursban® 4E) was applied to runnoff at a rate of 1 fl oz per gal (peach tree borer rate) to the trunks with a hand pressure sprayer up to a height of about 4 feet to three of three trees. These sets of treated trees were positioned between an equal number of tree sets designated as untreated (control) trees. A second application was made on 13 July. Evaluation was conducted weekly by attaching a 1.0 x 0.5 inch olive oil-soaked index card to each middle tree of the three-tree sets. Treated trees were sampled both above and below the treatment area. Untreated trees were sampled with one strip 3 feet above ground level. The number of RIFA in contact with these cards after 1 hour was documented and analyzed using the Student's t test ($P \leq 0.05$).

Olive-oil card monitoring efforts produced erratic results as indicated by the "check" (C) column in Table 5. However, foraging activity in trees above the trunk-treatment zones areas was virtually eliminated for more than 16 weeks (112 days). Thus, trunk treatment appears to be an effective method for maintaining ant-free trees. This method could be used to eliminate the nuisance of ant presence during grafting, pruning and (shaker) harvesting operations and/or to preserve aphid predators during portions of the growing season. If insecticide treatments required for aphid species could be reduced or eliminated as a result of the suppression of RIFA, such trunk treatments could be justified economically within a pecan production system.

Broadcast applications: This test was initiated on 22 September 1989. Five non-replicated 1-acre square plots were established. Treatments were applied 25 Sept. 1989: 1) bendiocarb (Rotate® 2 1/2G), at a rate of 12.5 lbs/acre (0.31 lb active ingredients (AI)/acre) was applied using a Herd Seeder, 2.25 setting, 5-7 mph double-treated pattern; 2) chlorpyrifos (Lorsban® 4E), 1 qt/acre (1 lb AI/acre) + 30 gal water; 3) isazofos (Triumph® 4E, FL-840876), 1 qt/acre (1 lb AI/acre) + 30 gal water (H. Ray Smith, Senior Field Research & Development Representative, Ciba-Geigy). Treatments 2 and 3 were applied using Yamaha PS-50 Spray Equipment with a 24 ft boom and 20 inch nozzle spacing; and 4) untreated (check).

The number of active RIFA mounds were determined (Francke 1883) in 6 permanently-established contiguous 0.03-acre square subplot areas (36 x 36 ft.) within treatment plots before and weekly following treatment. In addition, the number of RIFA foraging on 0.5 x 0.5 inch olive-oil soaked index cards affixed to 6 tree trunks within treatment plots during an approximate 1 hour exposure period were documented. Results of monitoring procedures were analyzed using subplot analysis of variance with the Duncan's Multiple Range test ($P < 0.05$) (Ecosoft 1981). Percent reductions were calculated using Henderson's formula (Henderson and Tilton 1955).

Broadcast applications of chlorpyrifos, bendiocarb and isazofos all produced significant reductions in the number of active RIFA mounds relative to the untreated plot within the course of this study (Table 7). Statistically, chlorpyrifos performed overall better than the other materials, providing maximum suppression 27-35 days following treatment. Isazofos performed in a similar trend. Bendiocarb produced significant levels of suppression erratically (5, 27, 35 and 56 days following treatment). All insecticides tested gave virtually 100% control of foraging ants within 2 days (Table 8). After this time, though, the elimination of RIFA foraging in trees became statistically less consistent. Some trees had no ants for up to six weeks while others had ants after two and these numbers remained consistent. Because the liquid pesticides were applied with a long boom, it is probable that the mounds at the base of the trees were left untreated.

These results document the feasibility of using broadcast orchard floor treatments to suppress ant activity prior to harvesting operations. Significant levels of suppression extend beyond the 28-day preharvest interval specified on the Lorsban 4E (chlorpyrifos) label. Thus, an application made a month before anticipated harvest date should 1) provide RIFA suppression and 2) provide for the treatment to harvest interval to elapse, satisfying both requirements. This type of treatment may be particularly suitable when using ground harvesting equipment. However, the suppression of RIFA canopy foraging appears to be more effectively achieved using trunk treatments rather than with broadcast applications of sprays or granules to the orchard floor. Since the only direct effects of RIFA suppression using a broadcast application on pecan production appears to be worker safety and elimination of ants during periods of specific field activity such as harvesting operations, the monetary benefit resulting from an investment in this pesticide application to control RIFA remains to be justified.

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Table 1. Mean mounds per quarter acre circle subplot in a fenoxycarb (Logic®, 1.25 lbs. per acre) treated (19 April 1989) versus untreated pasture on the Mitchell Farm, Brazos County, Texas, 1988.

Date	---Mounds/0.25 acre subplot--- Untreated	Fenoxycarb	T value	P	Percent reduction
Pretreatment					
15 April 1988	25.63 ± 17.88	14.63 ± 18.63	-1.3811	0.0906	--
Posttreatment					
7 June 1988 (2 months)	32.38 ± 26.40	13.00 ± 15.59	-2.2726	0.0166*	20**
12 Sept.1988 (5 months)	15.13 ± 10.08	3.81 ± 5.09	-3.6958	0.0006*	56**
9 May 1989 (12 months)	23.88 ± 20.20	10.19 ± 8.02	-2.3984	0.0127*	25**
12 Sept. 1989 (17 months)	26.25 ± 9.95	22.50 ± 19.72	-0.5026	0.3101	--

* Indicates statistically significant difference between means according to the Student's t test ($P \leq 0.05$).
** Percent reduction calculated using Henderson's Formula (Henderson and Tilton, 1955)

Table 2. Treatment regimes evaluated on the C&D Grass Farm, Jackson County, Texas, 1989.

1. Untreated
2. Chlorpyrifos (Whitmire PT® 270 or Cessco Accudose®) individual mound injection (25 May, 21 June) in accordance with label directions
3. Chlorpyrifos (Dursban® 4E) broadcast spray (23 May) using 2 lbs. active ingredient in 30 gal. water per acre using a boom-type applicator
4. Broadcast fenoxycarb (Logic®) (11 May) using 1.5 lbs. Logic per acre applied using an electronic Cyclone® seeder
5. Broadcast Logic (11 May) + chlorpyrifos individual mound injection (25 May and 21 June)
6. Broadcast Logic (11 May) + chlorpyrifos (Dursban 4E) broadcast spray (23 May)
7. As in no. 3, followed by a second application of Logic (3 August)
8. As in no. 4, followed by a second application of Logic (3 August)

Table 3. Number of active red imported fire ants per 1/5-acre under various treatment regimes, C&D Sod Farm, Jackson County, Texas, 1989.

Treatment	Pre-treatment 11 May day 0	Red imported fire ant mounds per 1/5-acre[1/] and percent reduction in parentheses — Post-treatment: 7 June day 27	21 June 41	12 July 62	3 Aug. 83	7 Sept. 119	11 Nov. 186
Untreated	4.0b	3.6abc	2.6a	5.3a	7.6a	9.0ab	9.0ab
Chlorpyrifos mound injections (25 May, 21 June)	5.3ab	4.6ab (4)	2.0a (42)	6.0a (15)	9.0a (11)	10.7a (10)	11.0a (8)
Dursban® 4E broadcast spray (chlorpyrifos)(23 May)	3.0b	1.0cd (63)	0.3a (85)	0.3b (92)	2.0b (50)	4.3bc (36)	6.3abcd (7)
Logic® (fenoxycarb) (11 May)	10.0a	1.6cd (82)	0.6a (91)	1.0b (92)	1.3b (93)	4.0bc (82)	3.0cde (87)
Logic + chlorpirofos mound injections	6.3ab	1.3cd (60)	1.0a (76)	1.0b (88)	3.0b (75)	5.0abc (65)	5.3bcde (63)
Logic + Dursban broadcast spray	6.5ab	0.3d (95)	0.0a (100)	1.0b (88)	1.6b (87)	4.3bc (71)	7.0abc (52)
Logic + chlorpyrifos mound injections + Logic (3 Aug.)	3.0b	5.0a (0)	2.0a (0)	0.6b (85)	3.0b (47)	3.3bc (51)	0.7e (90)
Logic + Dursban broadcast spray + Logic (3 Aug.)	5.0ab	0.3d (93)	0.0a (100)	0.0b (100)	0.6b (94)	0.3c (97)	0.7e (94)
LSD	5.423	2.923	2.872	2.872	4.465	5.894	5.663

[1/] Means followed by different letters are significantly different according to the LSD test ($P \leq 0.05$). Numbers in parentheses indicate percent control using Henderson's formula (Henderson and Tilton, 1955).

Table 4. Number of active red imported fire ant mounds prior to and following initiation of suppression programs, C&D Turf Farms, Jackson Co., Texas 1989.

Treatment	Fire ant mounds per 0.125 acre[1/] and percent reduction in parentheses			
	Pre-treatment	Post-treatment		
	12 July	3 August	7 September	11 November
	day 0	day 22	57	124
Untreated	2.3	3.8a	4.5a	2.3a
Logic® (fenoxycarb) (2 July) 1.5 lbs./acre	3.0	1.8b (64)	0.0c (100)	0.0b (100)
Dursban® 4E (chlorpyrifos) (20 July) 2 lbs a.i./acre	4.3	1.5b (79)	1.3b (85)	1.5a (65)
Logic + Dursban	4.8	0.3b (62)	0.0c (100)	0.3b (94)
LSD		1.890	2.588	1.066

[1/] Means followed by different letters are significantly different according to the Least Significant Difference test ($P \le 0.05$). Percent control was calculated using Henderson's formula (Henderson and Tilton, 1955).

Table 5. Mean number of foraging red imported fire ants in contact with olive-oil soaked 1.0 x 0.5 inch index cards in chlorpyrifos (Dursban® 4E) treated (above and below treated area) and untreated pecan tree trunks before and weekly after treatment (28 June and repeated 13 July 1989). Royalty Pecan, Burleson County, Texas.

Day	Date	Above (A)	Below (B)	Check (C)
0	23 June	28.7±37.6	---	44.0±24.6
20	13 July	3.7±6.4	1.0±1.7	5.8±40.5
27	20 July	0±0	3.3±5.8	113.3±51.1
34	27 July	0±0	16.0±17.7	51.7±37.6
42	4 Aug.	0±0	0±0	41.3±21.8
48	10 Aug.	0±0	4.3±5.8	19.3±21.2
56	18 Aug.	0±0	3.7±3.2	26.0±22.6
62	24 Aug.	0±0	11.0±14.2	18.3±16.5
70	1 Sept.	0±0	9.7±8.7	22.3±18.0
77	8 Sept.	0±0	13.7±11.8	11.0±6.0
84	15 Sept.	0±0	14.7±10.8	32.0±16.0
91	22 Sept.	0±0	11.7±12.4	13.0±3.6
101	2 Oct.	0±0	7.7±2.1	6.3±5.7
105	6 Oct.	0.33±.58	9.0±5.3	11.3±5.0
112	13 Oct.	0.67±1.15	5.7±5.1	9.7±4.9

Table 7. Active red imported fire ant mounds per subplot within 1-acre plots on an abandoned pecan orchard floor treated, 25 September. Royalty Pecans, Burleson County, Texas. 1989.

Treatment and rate	Sept. 22 / 0	Sept. 27 / 5	Oct. 6 / 14	Oct. 13 / 21	Oct. 19 / 27	Oct. 27 / 35	Nov. 3 / 42	Nov. 10 / 49	Nov. 17 / 56
	No. active fire ant mounds per 0.03-acre subplot[1] and percent reduction[2] in parenthesis								
chlorpyrifos (Lorsban 4E) 1 lb a.i./A	10.8a	6.0b (44)	2.0c (79)	2.0c (85)	1.8d (83)	1.7d (86)	6.3c (50)	5.5b (52)	5.2c (59)
isazofos (Triumph®) 1 lb a.i./A	12.7a	8.8ab (30)	5.3b (53)	6.2b (61)	4.7c (61)	4.0c (73)	11.3ab (0)	6.0b (56	7.7c (48)
bendiocarb (Rotate® 2 1/2G) 0.3 lb a.i./A	8.8a	7.7b (11)	8.7a (0)	11.5a (0)	8.7b (0)	8.2b (19)	12.0ab (0)	10.7a (0)	10.7b (0)
untreated	11.5a	11.3a	10.3a	14.5a	11.0a	13.2a	13.5a	12.3a	13.5a

1/ Means in columns followed by different letters are significantly different using the Duncan's Multiple Range Test (P $\leq$ 0.05); Six replicated subplots.

2/ Calculated using Henderson's Formula (Henderson and Tilton 1955).

Table 8. Mean number of red imported fire ants per olive oil-soaked index card after 1 hour exposure within 1-acre treatment plots. Royalty Pecans, Burleson County, Texas. 1989.

Treatment and rate	Sept. 22 / 0	Sept. 27 / 5	Oct. 6 / 14	Oct. 13 / 21	Oct. 19 / 27	Oct. 27 / 35	Nov. 3 / 42	Nov. 10 / 49	Nov. 17 / 56
	No. foraging ants per 0.5 square inch oil-soaked card[1] and percent reduction[2] in parenthesis								
chlorpyrifos (Lorsban® 4E) 1 lb a.i./A	15.3a	0.0b (100)	7.8a (0)	6.8a (4)	4.2a (59)	1.3b (72)	11.5ab (17)	4.7ab (52)	15.8ab (0)
isazofos (Triumph®) 1 lb a.i./A	6.2a	0.0b (100)	3.2a (0)	9.5a (0)	9.8a (0)	4.0b (0)	0.5b (91)	2.7b (32)	4.3b (21)
bendiocarb (Rotate® 2 1/2G) 0.3 lb a.i./A	17.2a	0.7b (91)	5.0a (34)	10.8a (0)	6.5a (41)	13.3b (0)	8.0ab (49)	9.2ab (17)	22.8a (0)
untreated	22.2a	10.0a	9.7a	10.3a	15.0a	6.8a	20.2a	14.3a	19.5ab

1/ Means in columns followed by different letters are significantly different using the Duncan's Multiple Range Test (P $\leq$ 0.05); replicated on 6 trees.

2/ Calculated using Henderson's Formula (Henderson and Tilton 1955).

Evaluation of Drench Treatments

for Certification of Containerized

Nursery Stock

For Presentation:

1990 IFA Research Conference

College Station, Texas

April 2-3, 1990

By:

Lee R. McAnally

USDA, APHIS, S&T

IFA Laboratory

Gulfport, MS 39501

INTRODUCTION

IFA quarantine treatments are used to prevent spread of the IFA through shipment of infested nursery stock outside the IFA quarantine area (Fig. 1). Several treatment procedures including incorporation of granular Dursban into potting media, and the application of insecticidal solutions, i.e., drench treatments may be used. Drench treatments with both chlorpyrifos and diazinon are now listed in the USDA, APHIS Treatment Manual (M301.81) for certification of containerized plants. Chlorpyrifos (Dursban) is applied at a rate of 8 fl. oz. Dursban 2EC/100 gals. water. The rate of application for diazinon is 1 pint of diazinon AG 500 or 1 pound of diazinon 50 WP/100 gals. water. The Dursban treatment currently provides a 90 day certification period, but is under review, and this 90 day interval may require a reduction. Diazinon provides a 14 day certification. A study comparing alternative compounds for IFA control in containerized plants was begun in April, 1989.

METHODS & MATERIALS

In the first phase of this study, nine (9) treatments were set up, but due to renewed interest in Triumph and the receipt of several other compounds, a second trial was initiated. In both studies each treatment was applied to 18 one-gallon containers filled with Strong-lite® potting media (Strong-lite products, Pine Bluff, AR). Each pot received 750 ml or 1/5 gallon of drench solution. The pots were then weathered outdoors under natural conditions. To simulate normal agronomic practices, irrigation was added to natural rainfall as needed to maintain a minimum of 2" of water each week. Each month three pots from each treatment were composited and bioassayed with field collected alate queens using a slight modification of the procedure of Banks et al. 1964 (J. Econ. Entomol. 57:298-299). Alate queens (5/replicate with 4 replicates/ treatment) were continuously confined to treated media for a 7 day exposure period at which time average % mortality was determined.

RESULTS

Phase I

In the first study several compounds showed excellent residual activity. Empire®, a microencapsulated formulation of chlorpyrifos produced by Dow Chemical was tested at two rates. The higher rate (88.7ml/gal H_2O) is the highest labelled rate for other pests. The lower is the equivalent to the labelled rate for IFA control for Dursban 2EC. Both rates provided at least 180 days residual control and may have gone beyond 180 days but this test was predetermined to terminate at 180 days.

Several synthetic pyrethroids provided excellent results in this study. Capture 2E, a formulation of bifenthrin, (manufactured by FMC), also provided at least 180 days residual activity. Tempo 2E by Mobay is a formulation of cyfluthrin. It has also provided 180 days of residual control. Two formulations of cypermethrin, Cymbush 3E by FMC and Ammo 2.5E by ICI Americas were tested. Both maintained 100% mortality to 120 days. Cymbush fell to 95% at days 150 and 180. Ammo fell to 95% at day 180.

Oftanol, (isophenphos) failed to provide any residual activity and was not tested after 60 days. Dursban provided only 30 days residual control and was removed from the test after 120 days. As previously mentioned, Dursban is expected to provide 90 days residual activity.

Phase II

Because of renewed interest by Ciba-Geigy in the registration of Triumph as an IFA quarantine treatment, a second study was initiated in June, 1989. Three other compounds were included in this test.

Torpedo, a formulation of permethrin, registered as a termiticide by ICI was applied at its labelled rate for termites. It provided at least 180 days residual control; again, this study was designed to terminate at 180 days, so the actual length of control was not determined.

Karate, a synthetic pyrethroid also by ICI was applied at a rate equivalent to the Dursban 2EC rate. Karate also provided 180 days residual control.

Triumph 4E was tested at its labelled rate for other pests and three lower rates in order to determine its lowest effective rate. The two lower rates failed to provide 30 days residual control and were removed from the test. The two higher rates provided 90 and 120 days residual respectively (lower to higher). Both higher rates dropped to 0 by 180 days.

A unique compound, Bay NTN 33893 was tested at three rates: 1X (8 fl. oz./100 gal H_2O, equivalent to labelled for Dursban 2EC), 1/2X, and 1/4X. All rates were not active at any time and were removed from the test after 60 days.

Dursban 2EC provided 100% mortality at 24 hours, but failed to provide any control beyond that.

Those compounds that provided 180 days of control will be retested in 1990 in an expanded test designed to last longer in an effort to determine their maximum residual activity.

SUMMARY AND CONCLUSIONS

Drench treatments in general are not favored by the nursery industry due to the cost and logistics involved. However, due to the extremely long residual activity seen in several of the synthetic pyrethroid compounds, this approach to IFA certification may well fit into current management practices.

Table 1. Drench Treatments Phase I

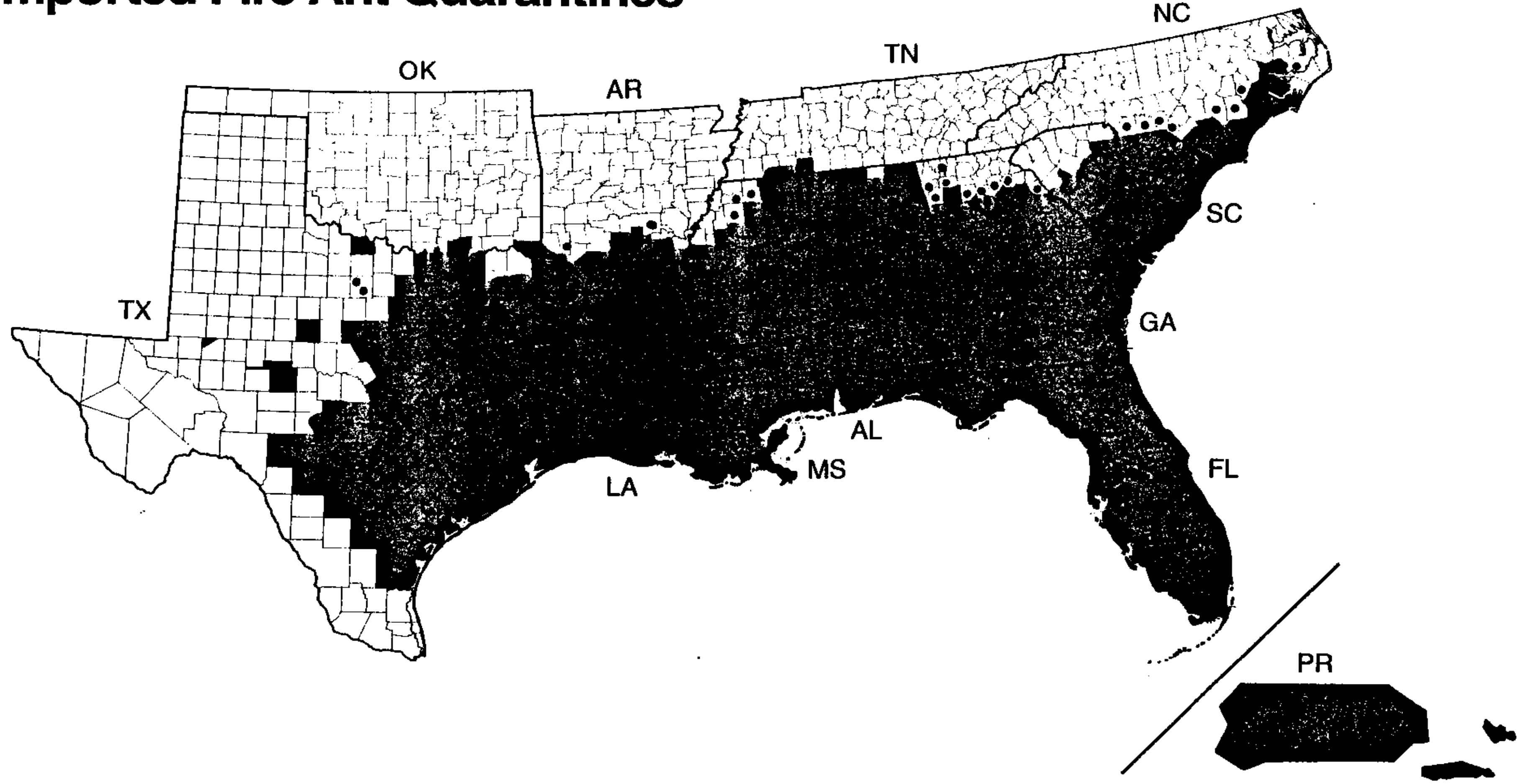
	Average % Mortality						
Insecticide	24 hrs.	30 day	60 day	90 day	120 day	150 day	180 day
Empire 88.7ml/gal	100	100	100	100	100	100	100
Empire 2.6 ml/gal	100	100	95	100	100	100	100
Capture	100	100	100	100	100	100	100
Tempo	100	100	100	100	100	100	100
Ammo	100	100	100	100	100	100	95
Cymbush	100	100	100	100	100	95	95
Dursban	100	100	50	25	10	--	--
Diazinon	100	10	30	--	--	--	--
Oftanol	100	5	50	--	--	--	--
Check	5	10	45	15	5	5	0

Table 2. Drench Treatments Phase II

	Average % Mortality						
Insecticide	24 hrs.	30 day	60 day	90 day	120 day	150 day	180 day
Torpedo	100	100	100	100	100	100	100
Karate	100	100	90	100	100	100	100
Triumph 7.4 ml/gal	100	100	100	100	100	80	0
Triumph 3.7 ml/gal	100	100	100	100	85	50	0
Triumph 1.8 ml/gal	100	10	10	--	--	--	--
Triumph 0.9 ml/gal	100	5	0	--	--	--	--
Dursban	100	5	0	--	--	--	--
NTN 0.6 ml/gal	45	5	15	--	--	--	--
NTN 2.4 ml/gal	30	5	0	--	--	--	--
NTN 1.2 ml/gal	10	0	10	--	--	--	--
Check	5	5	10	5	5	0	0

Fig. 1

Imported Fire Ant Quarantines



Conditions of Movement

Counties entirely colored are completely regulated; counties partially colored are partially regulated.

■ Areas Infested with Imported Fire Ants

Restrictions are imposed on the movement of regulated articles from: Red areas into or through white areas.

Consult your State or Federal plant protection inspector or your county agent for assistance regarding exact areas under regulation and requirements for moving regulated articles. For detailed information see 7 CFR 301.81 for quarantine and regulations.

U.S. Department of Agriculture • Animal and Plant Health Inspection Service.
Plant Protection and Quarantine Cooperating With Affected States

See reverse side for list of regulated articles.

Revised July 1989

Overview of Current USDA, APHIS, S + T Research and Development of Quarantine Treatments

by:
Homer Collins
USDA, APHIS, S+T
Gulfport, MS

For Presentation:

1990 IFA Research Conference
College Station, TX

April 2-3, 1990

INTRODUCTION

For the past several years the primary objective of the USDA, APHIS, S+T IFA Laboratory has been to conduct applied research in support of the Federal Fire Ant Quarantine. As most of you know, transport of nursery stock and other articles capable of harboring an IFA infestation is restricted (Figure 1). Movement of nursery stock outside the quarantine area is allowable after treatment of that stock with an approved pesticide. Today I would like to present an overview of research into new treatments for each category of nursery stock.

OBJECTIVE

The objective (slide) of the various studies that I will briefly summarize was to develop insecticidal treatment procedures to prevent spread of the IFA through shipment of infested nursery stock.

I. <u>Grass sod:</u> Grass sod production is a multimillion dollar industry. This high hazard commodity is often shipped long distances by tractor trailer truck (Slide). At the current time, the only approved quarantine treatment for sod involves the application of Dursban 10G at a rate of 4 to 6 lbs AI/acre. Two sets of trials were conducted in 1989 to evaluate alternate treatments. The first trial I would like to discuss was conducted in South Mississippi in an area infested with monogynous colonies. One thousand (1,000) sq. ft. test plots on a commercial sod farm were treated on August 11, 1989. Efficacy was determined by removing approximately 300 1/2" x 2" soil cores from test plots at monthly intervals and bioassaying these samples with field collected alate IFA queens (Slide). The bioassay procedure is a slight modification of the method described by Banks et al., 1964 (Jour. Econ. Ent. 57: 298-299). Results of these trials (Slide - Table 1), indicate that several synthetic pyrethroids (AMMO, CAPTURE, FORCE, FORTRESS, and KARATE) provided over 90 days residual against alate queens in a laboratory bioassay. Dursban 10G (the standard treatment), CAPTURE, and KARATE were effective at the last bioassay interval which was 150 days after treatment.

The Texas trials were conducted on a commercial turf farm with a polygynous IFA population near Bay City, Texas. When dealing with single queen colonies, we assume that the greatest risk associated with sod movement is from the thousands of newly mated queens that could be present during the cutting or harvesting operation. The chances of removing a fertile queen from a single queen colony seems remote, especially since populations of single queen colonies on sod farms are usually relatively low (10 -30 nest/acre).

However, with the large numbers of queens and nests present in a polygynous population (Slide), there is a good chance that gravid queens can be removed during the harvesting operation. This has been shown to occur experimentally.

Test plots in the Texas trials were 1 acre in size, and several combinations of baits and short term contact insecticides were evaluated (slides). Due to the larger plots and increased population densities, efficacy was based on actual colony mortality within test plots rather than laboratory bioassays as used in the Mississippi trials.

As shown in Table 2 (slide), combinations of Amdro + Dursban 10G or Amdro + Triumph 4E rapidly eliminated colonies from test plots and remained highly effective for at least 22 weeks following an August application.

II. <u>Containerized plants</u> (Slide) Containerized plants are currently certified IFA free by either:

(1.) Incorporation of Dursban 2.5G into the media prior to planting, (slides)

(2.) Drenching the plants with a Dursban or diazinon solution (Slide),

(3.) Grown under cover.

At the current time the granular incorporated treatment provides 24 months certification. However, numerous studies completed within the past 12 months have shown that the actual residual activity of granular Dursban is far less than 24 months. Therefore, we are in dire need of a treatment that can be blended or premixed into the nursery media prior to planting and provide a minimum of 24 months residual activity.

New candidate screening: A number of new candidate insecticides were screened in 1989, and some are showing a great deal of promise. Several synthetic pyrethroids have provided over 14 months residual activity after incorporation into potting media. (Slide-Table 3). Both AMMO and CAPTURE are under development by FMC. FORCE is an ICI product.

A. Triumph, an organophosphate under development by Ciba-Geigy has been in our trials for several years. Most trials have resulted in good control for 12-18 months depending upon dose rate and other factors. However, mixed results have occurred in several very recent studies.

B. Another interesting candidate is a controlled release formulation of chlorpyrifos (Slide) that is produced by Incitec International, a company that is located in Brisbane, Australia. Although we have only very preliminary data with this product, several trials are in progress. Results from other studies have shown that three years control of white grubs can be achieved with a single application of the Suscon formulation (Slide).

III. Phytotoxicity:

In addition to efficacy data, an additional requirement in the development of quarantine treatments is information on phytotoxicity. (Slide). We have an on-going project with Dr. Sam Laiche with the Mississippi Agriculture Experiment Station to evaluate all potential quarantine pesticides for phytotoxic effects.

IV. Influence of environmental factors on residual activity of quarantine pesticides:

Numerous short term studies on effect of irrigation, formulation, soil (media), pH of irrigation water, etc. were conducted in 1989.

A. A study by Anne-Marie Callcott showed that irrigation greatly increased the rate of degradation of Lorsban 15G, Triumph 1G or Dursban 2.5G relative to treatments receiving natural rainfall only. (Slide--Figure 2).

B. Several studies comparing residual activity of various chlorpyrifos formulations indicated that formulation differences were not a factor (Slides - Tables 5, 6, and 7). Table 5 summarizes results of a trial initiated by Anne-Marie Callcott in July. Table 6 is the results of a trial started in March by Avel Ladner. Table 7 presents preliminary results of a November trial.

C. Soil type (i.e., potting media) also had little influence on the residual of either Triumph 1G, or Dursban 2.5G as shown in a study done by Lee McAnally. (Slide -- Table 8).

D. A rather extensive study comparing residual activity of the Suscon controlled release chlorpyrifos formulation, Triumph 1G, Lorsban 15G, and bifenthrin at Miami, FL; Whiteville, NC and Gulfport, MS is underway. (Slide-Table 9). Preliminary results indicate that degradation of Triumph 1G and Dursban 2.5G tends to occur more rapidly under South Florida conditions.

SUMMARY AND CONCLUSIONS

Although management practices of the nursery industry dictate the need for a long term residual treatment that can be used to certify nursery stock IFA free, we currently have no such treatment to offer. Several candidate treatments seem to offer excellent potential for this use pattern, but appear to be one to two years from registration and general use.

Table 1. Efficacy of Various Candidate Insecticides on Commercial Grass Sod in South Mississippi. 1/

Pesticide & Formulation	Rate/acre (lbs./AI)	% MORTALITY TO ALATE QUEENS AT INDICATED 2/ DAYS POST-APPLICATION (30)	(60)	(90)	(120)	(150)
Capture 0.2G	1.0	100	100	100	100	100
Capture 2EC	1.0	100	100	100	100	100
Dursban 10G	6.0	100	100	100	100	100
Karate 1EC	1.0	100	100	100	100	100
Lorsban 15G	6.0	100	100	100	55	100
Force 1.5G	1.0	100	100	100	80	80
Ammo 0.75G	1.0	100	100	100	75	--
Fortress 5G	6.0	100	100	100	5	--
Dyfonate 20G	6.0	100	75	20	--	--
Torpedo 2EC	1.0	100	0	40	--	--
Ammo 2.5EC	1.0	100	0	0	--	--
Dursban 2EC	6.0	100	5	0	--	--
Tempo 2EC	1.0	95	25	0	--	--
Cymbush 3EC	1.0	70	0	0	--	--
Pounce 3.2EC	1.0	50	0	--	--	--
XPM 4902 1G	1.0	60	0	--	--	--
Oftanol 5G	6.0	25	5	0	--	--
Triumph 1G	1.0	35	0	--	--	--
Triumph 1G	2.0	35	0	--	--	--
Triumph 1EC	2.0	30	0	--	--	--
Triumph 1EC	1.0	25	75	0	--	--
Mocap 5G	6.0	25	15	0	--	--
Check		5	0	10	--	--

1/ Trial initiated August, 1989.

2/ Standard laboratory bioassay using alate queens; 5 queens/repl. and 4 reps./sample.

Table 2. Efficacy of Various Treatments and Combinations of Treatments for Control of Multiple Queen IFA Colonies Infesting South Texas Sod Farms. 1/

TREATMENT		PRE-TREAT POPULATION 2/	% COLONY MORTALITY AT INDICATED WEEKS AFTER TREATMENT				
Insecticide & Formulation	Rate/Acre (lbs.)	No. of Colonies	(4)	(8)	(16)	(22)	(26)
Amdro + Dursban 10G	1.5 & 60	7	100	100	100	100	100
Amdro + Triumph 4E	1.5 & .75AI	10	100	90	100	100	100
Logic + Triumph 4E (2X)	1.5 & 2.5AI	13	92	85	100	92	100
Amdro	1.5	10	100	90	80	90	80
Logic + Dursban 10G	1.5 & 60	7	43	100	86	86	100
Dursban 10G	60	13	38	85	92	100	92
Logic + Triumph 4E	1.5 &.75 AI	18	33	28	61	83	78
Triumph 4E	.75 AI	8	50	37	25	62	37
Logic	1.5	8	0	0	25	25	62
Untreated Ck.	--	17	47	0	12	0	29

1/ Trails initiated August, 1989.

2/ Based on 1/4 acre subplot within 1.0 acre treatment plots.

Table 3. Residual Activity of Candidate Pesticides Blended into Nursery Potting Media. 1/

	% Mortality to Alate Queens Confined to Treated Media at Indicated Months Post-Incorporation						
Insecticide 2/	(1)	(2)	(3)	(6)	(9)	(12)	(14)
Ammo 0.75G	100	100	100	100	100	100	100
Capture 0.3G	100	100	100	100	100	100	100
Force 1.5G	100	100	100	100	100	100	100
Pounce 1.5G	100	100	100	100	0	0	—
Dursban 2.5G	100	100	100	75	0	0	—
Turcam 2.5G	100	100	15	20	0	0	—
Advantage 5G	45	100	20	0	0	—	—
Furadan 5G	25	35	0	0	—	—	—
Oftanol 5G	0	25	0	0	—	—	—
Check	5	10	5	15	0	0	10

1/ Trial initiated December 14, 1988.

2/ Initial concentration of Capture 0.3G = 72.6 ppm. All other treatments = 86.3 ppm.

Table 4. Residual Activity of Suscon 10CR and Triumph 1G in Nursery Potting Media. 1/

Treatment		% Mortality at Indicated Months Post-Treatment 1/		
Formulation	Dose Rate	(1)	(2)	(3)
Suscon 10 CR	20 ppm	40	0	75
	40 ppm	80	100	100
	60 ppm	65	100	75
	80 ppm	70	100	80
	100 ppm	100	100	90
Triumph 1G	20 ppm	100	100	40
	40 ppm	100	100	30
	60 ppm	100	100	40
	80 ppm	100	100	20
	100 ppm	100	100	15
Dursban 2.5G	11.2 g. AI/ cu. yd. (65 ppm)	100	100	35
Untreated Ck.	—	10	10	5

1/ Trial initiated November 22, 1989.

Table 5. Residual Activity of Various Granular Formulations of Dursban or Triumph Incorporated into Strong-Lite Potting Media at 11.3 g. AI/cu. yd. of Media and Aged at Gulfport, MS. 1/

Treatment Insecticide	Carrier/ Formulation	% Kill at Indicated Months Post-Treatment 2/ (1)	(2)	(3)	(4)	(5)
Dursban 2.5G	Pecan hulls (Ford's)	100	100	100	10	10
Dursban 2.5G	Corn cobs (Ford's)	100	35	100	35	0
Lorsban 15G	Clay (Dow)	100	100	45	25	10
Triumph 1G	Clay (Ciba-Geigy)	100	100	20	40	20
Check	---	10	30	0	20	10

1/ Trial initiated July 6, 1989.

2/ Standard lab bioassay using alate queens; 5 queens replicate and 4 replicates/sample.

Table 6. Residual Activity of Various Formulations of Chlorpyrifos in Two Types of Potting Media 11.3 g. AI/cu. yd. of Media. 1/

Treatment	Media	% Mortality (Months Post-Treatment) 2/				
		(1)	(2)	(3)	(4)	(5)
Ford's 1% Dust	Strong-Lite	100	100	100	0	70
Ford's 1% Dust	Baccto	100	100	100	10	60
Ford's 2.5G	Strong-Lite	100	100	45	10	10
Ford's 2.5G	Baccto	100	100	5	5	5
Dow Empire 20%	Strong-Lite	100	100	5	5	5
Dow 50% WDG	Strong-Lite	100	100	5	10	15
Check	Strong-Lite	10	5	0	0	10
Check	Baccto	0	10	0	15	25

1/ Trial initiated March, 1989.

2/ Standard laboratory bioassay using field collected alate queens; 4 replicate/treatment with 5 queens/replicate.

Table 7. Residual Activity of Various Chlorpyrifos Formulations at Application Rates of 100 ppm in Strong-Lite® Potting Media. 1/

Formulation	Formulator	% Mortality at Indicated Months Post-Treatment 2/ (1)	(2)	(3)	(4)
Empire 20% 3/	Dow	100	100	100	100
Suscon 10 CR	Incitec	100	100	25	5
10 G	Ford's	100	100	10	15
2 EC 3/	Dow	100	45	0	0
WDG 50%	Dow	100	20	10	0
1% Dust	Ford's	100	20	5	0
XRD 429	Dow	100	5	15	5
Lorsban 15G	Dow	100	5	0	0
50 WP	Dow	100	0	0	0
2.5G	Ford's	70	5	5	5
Check	—	5	20	5	5

1/ Trial initiated November 3, 1989.

2/ Standard laboratory bioassay using field collected queens; 4 replicates/treatment with 5 queens/replicate.

3/ Applied as drench rather than incorporated.

Table 8. Residual Activity of Triumph 1G and Lorsban 15G in Various Types of Potting Media 1/

Treatment: Insecticide	Treatment: Media	Dose Rate (gms. AI/yd.^{3})	Initial Theoretical Conc. (ppm)	% Mortality at indicated months post-treat 2/ (1)	(2)	(3)
Triumph 1G	Baccto	22.4	60	100	10	0
	Sunshine	22.4	200	60	30	5
	Strong-Lite	22.4	129	100	5	0
	Peat Moss	22.4	143	100	100	100
Lorsban 15G	Baccto	11.2	30	100	10	30
	Sunshine	11.2	100	100	20	10
	Strong-Lite	11.2	64	100	60	15
	Peat Moss	11.2	71	100	100	100
Check	Baccto	--	0	10	10	5
	Sunshine	--	0	10	25	5
	Strong-Lite	--	0	5	0	0
	Peat Moss	--	0	5	0	0

1/ Trial initiated October 20, 1988.

2/ Standard laboratory bioassay using alate queens; 5 queens/rep. and 4 replicates/treatment.

Table 9. Residual activity of granular formulations of chlorpyrifos, izaphos, and bifenthrin incorporated into Strong-Lite potting media at 11.3 grams AI/cu. yd. (65 ppm), and aged at Miami, FL; Gulfport, MS and Whiteville, NC. 1/

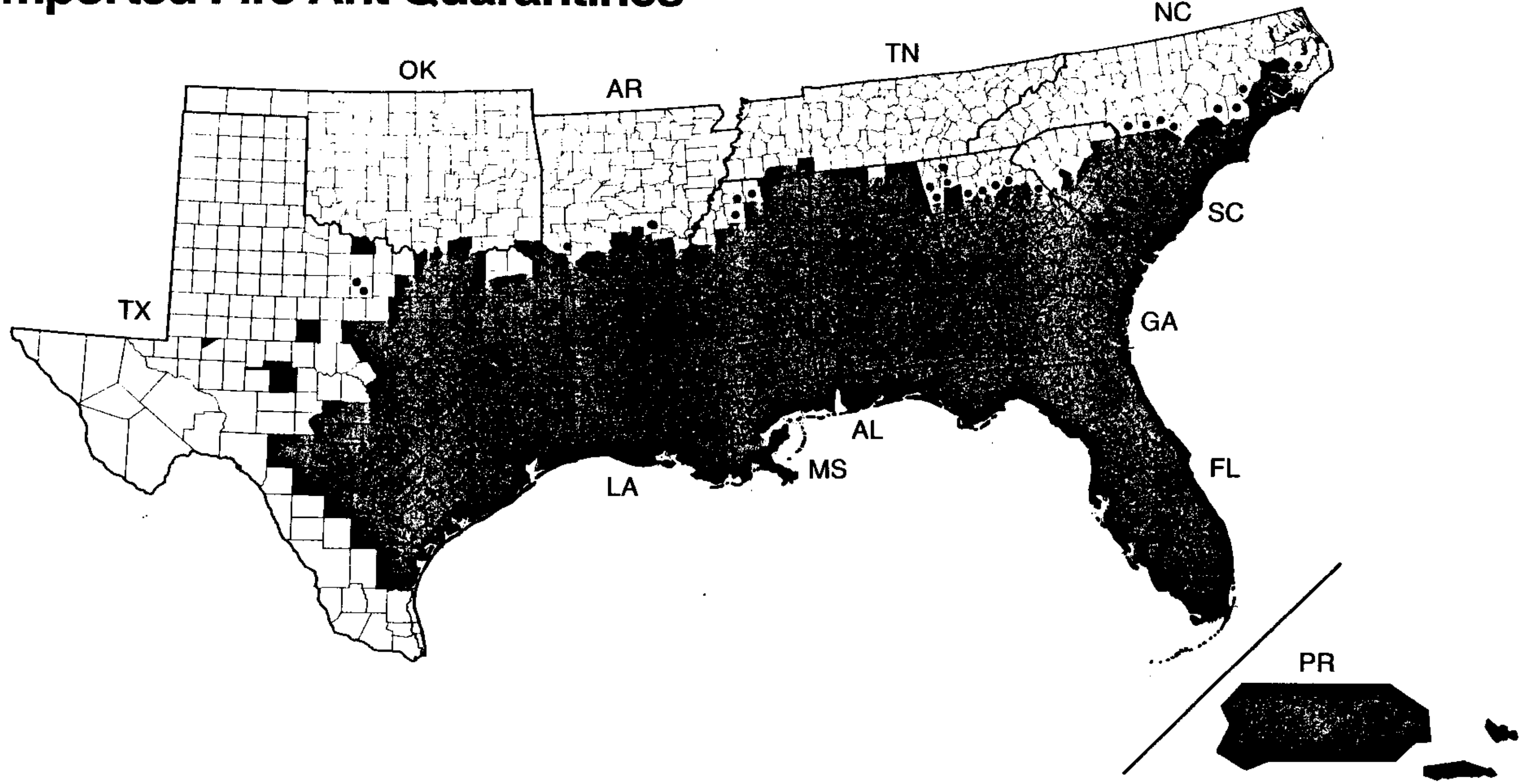
Treatment			% Kill at Indicated Months Post-treat 2/			
Insecticide	Formulation	Location	(1)	(2)	(3)	(4)
bifenthrin	Capture 0.3G	FL	100	100	100	100
		MS	100	100	100	100
		NC	100	100	100	100
chlorpyrifos	Lorsban 15G	FL	100	100	100	55
		MS	100	100	100	100
		NC	100	100	100	10
chlorpyrifos	Dursban 2.5G	FL	25	5	0	5
		MS	100	100	100	10
		NC	100	40	100	75
chlorpyrifos	Suscon 10 CR	FL	95	25	15	
		MS	100	100	50	
		NC	100	100	100	
izaphos	Triumph 1G	FL	0	5	10	20
		MS	100	100	5	5
		NC	100	100	100	0

1/ Trial initiated October, 1989.

2/ Standard lab bioassay using alate queens; 5 queens/replicates and 4 replicates/treatment.

FIG. 1

Imported Fire Ant Quarantines



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U.S. Department of Agriculture • Animal and Plant Health Inspection Service.
Plant Protection and Quarantine Cooperating With Affected States

See reverse side for list of regulated articles.

Revised July 1989

Fig. 2. Effect of irrigation on residual activity of three granular pesticides blended into potting media at 11.3 g. AI/cu. yd.

Effect of Mobay NTN 33893 on Imported Fire Ants

Anne-Marie Callcott
USDA, APHIS, S&T
3505 25th Ave.
Gulfport, MS 39501

Poster Presentation
1990 IFA Research Conference
April 2-3, 1990
College Station, Texas

INTRODUCTION:

Mobay NTN 33893 FS (flowable solution) is an experimental nitromethylene heterocyclic (NMH) compound under investigation for use against a variety of insect pests. NMH compounds affect the insects' nervous systems, apparently by competing for receptor sites at nerve synapses, thus producing both exitatory and depressant effects on nerve transmissions. NTN is highly systemic in plants by uptake through seed and soil applications, making this compound highly toxic by ingestion and, to a lesser degree, by contact. In a number of major crops, NTN has shown to be toxic to many pests, including aphids, plant bugs, leaf and plant hoppers and thrips (NTN 33893 insecticide product profile, 1990, Mobay). Mobay feel the compound may also be effective against imported fire ants (IFA) due to its activity against other social insects such as termites.

OBJECTIVES:

1) To determine efficacy of Mobay NTN 33983 (NTN) against IFA
2) To determine the most efficacious method of introducing the compound to IFA

MATERIALS AND METHODS:

Laboratory Tests

Drench Studies:

IFA colonies were collected in the field, brought to the laboratory, and allowed to rebuild their nests in 12" X 15" X 6" plastic tubs for 3-5 days.

NTN was prepared as a mound drench treatment at a variety of concentrations and applied to the colonies at a rate of one quart NTN solution per mound.

Bait Studies:

NTN was also prepared as a bait, using several different carriers and attractants such as peanut butter, honey and water, macerated mealworms (*Tenebrio* sp.), and 10% sucrose solutions.

RESULTS:

Laboratory Tests

Drench Studies:

Test I - May 17, 1989

Five colonies were drenched using 7.81 ml NTN/liter water/mound (equivalent to 2X Dursban 2EC label rate for mound drench). Approximately 95% mortality had occurred in each treated mound by two hours post treatment, and survivors were moving very slowly. By 28 hours post treatment, 100% mortality had occurred in all treated colonies.

Test II - June 22, 1989

IFA colonies were drenched with 1 quart of the following treatments (3 replicates/treatment):

Dursban 2EC standard - 15cc/gal water

NTN - 15cc/gal water

NTN - 7.5cc/gal water

NTN - 3.7cc/gal water

NTN - 1.8cc/gal water

NTN - 0.9cc/gal water

Check - plain water

Totally abnormal behavior was observed 6 - 24 hours after treatment and eventually, all rates provided 100% colony mortality in 2-14 days after application (Table 1).

Table 1. Observations of laboratory colonies drenched with various rates of NTN.

Treatment	Visual Observations at Indicated Time Post Treatment: 6 hrs.	24 hrs.	2 days	9 days	14 days
Dursban 2EC-Standard	100% mortality	-------	------	------	------
NTN 15cc/gal water	ants alive but non-responsive to stimuli very slow movements	ants unresponsive or dead ants "clustered" on soil with slight antennal movement	100% mortality	------	------
NTN 7.5cc/gal water	ants alive but non-responsive to stimuli very slow movements	ants unresponsive or dead ants "clustered" on soil with slight antennal movement	some recovery in activity	100% mortality	------
NTN 3.7cc/gal water	ants alive but non-responsive to stimuli very slow movements	ants unresponsive or dead ants "clustered" on soil with slight antennal movement	some recovery in activity	100% mortality	------
NTN 1.8cc/gal water	ants alive but non-responsive to stimuli very slow movements	ants unresponsive or dead ants "clustered" on soil with slight antennal movement	some recovery in activity	greatly reduced activity	100% mortality
NTN 0.9cc/gal water	ants alive but non-responsive to stimuli very slow movements	ants unresponsive or dead ants "clustered" on soil with slight antennal movement	100% mortality*	------	------
Check	normal activity	normal activity	normal activity	normal activity	normal activity

* possibly due to improper mixing - each dilution mixed separately, not in serial dilutions possible problem getting NTN into solution

Bait Studies:

I. Peanut butter bait

NTN was mixed with peanut butter to provide a 2% NTN bait. Ten grams of bait in a petri dish was offered to each of five field collected IFA colonies. Up to 3 hours after bait introduction, all colonies were feeding well with some foragers around the food source showing symptoms of CNS poisoning. By 24 hours post treatment, no colonies were feeding and very little bait was removed. Colonies were observed for 7 days at which time the test was terminated due to lack of mortality.

II. Honey and water bait

A 1.5% bait was prepared using equal parts honey and water. Ten grams of the bait solution was offered in petri dishes to each of three colonies. Ants actively fed for a few hours. Check colonies continued feeding for 24 hours. By 4 days post treatment, ants in the treated colonies were "clustering" on the soil and moving very slowly when agitated, despite minimal bait ingestion. Colony mortality had not occurred by 7 days post treatment and test was terminated.

III. Macerated mealworm bait

A macerated mealworm preparation (25 g. mealworms and 5 g. water blended for 3 minutes in a laboratory blender) was mixed with NTN to provide a 1% bait. Three colonies were given 10 g. of bait each in a petri dish. All colonies actively fed during the first hour. By 2 hours post treatment, feeding had ceased and foragers in the feeding dishes showed symptoms of CNS poisoning. Three days after treatment, some colonies were "clustering". At 7 days, all colonies were "clustering" on the soil surface, even after minimal bait ingestion. However, by 21 days, colonies had recovered and no significant mortality had occurred.

IV. Sucrose bait

A bait test using serial dilutions of NTN in a 10% sucrose solution was initiated. NTN rates of .0001%, .0005%, .001%, .01%, .05% and .1% were introduced to IFA colonies. Three colonies were treated with each dose rate. Colonies were fed the NTN/sucrose bait in micropipets, each colony receiving a maximum of 240 ul. of bait (Banks & Harlan, 1982, J. Ga. Entomol. Soc. 17:460-466). Three untreated check colonies received 240 ul. each of 10% sucrose.

The lower rates were readily consumed, and caused some "clustering" on the soil and sluggish movements, but had little lasting effect on the colonies. The two highest rates were repellent to the foragers (avg. - 36% of the bait consumed), but did cause "clustering" for several days and reduced responsiveness to stimuli. The .001% bait was well received by the workers with 95% of the bait consumed within 24 hours of introduction. A concentration of .01% resulted in comsumption of 60% of the available bait within 24 hours. In both of these trials, extreme reduction in response to stimuli and reduced movements were observed, but entire colony mortality was not achieved in the 21 day test period.

Residual Contact Activity in Soil

I. Drench studies:

Residual contact activity of NTN FS was tested by drenching Strong-Lite® nursery potting media contained in 1 gallon pots with NTN drenches. Activity was determined by bioassay of treated media using alate queens. Application rates were 2.4 ml/gal water (label rate of Dursban 2EC), 1.2 ml/gal water and 0.6 ml/gal water. Pots were weathered under natural conditions, and irrigation added when needed to maintain 2 inches of water per week. A composite sample of two pots from each treatment was collected at 24 hours and then monthly, and bioassayed with alate queens, using slightly modified procedures described by Banks et al. (1964, J. Econ. Entomol. 57:298-299).

None of the NTN drench solutions provided residual activity, even at 24 hours post treatment.

II. Granular incorporated studies:

A 0.5G formulation of NTN 33893 was incorporated into Strong-Lite® potting media at a rate of 11.35 g. AI/cu. yd. of media (Dursban 2.5G label rate) using a portable cement mixer. The treated media was placed in 1 gallon nursery pots and subjected to natural weather conditions. A composite sample of 2 pots of the treated soil was collected and bioassayed monthly.

No residual activity was detected at one month post treatment and test terminated.

Field Test

A one acre plot was established in Harrison county, Mississippi and a 1/4 efficacy subplot marked in the center. IFA colonies in the subplot were counted and rated according to the procedure described by Lofgren and Williams (1982, J. Econ. Entomol. 75:798-803). All mounds in the plot were marked with engineering flags prior to treatment. Each mound was then drenched with 1 cc NTN FS/gal. water/mound (lowest effective rate from the lab drench studies). The plot was counted and observations made at 5 days, 14 days and 12 weeks after treatment.

NTN at the rate applied did not provide effective control of field IFA colonies (Table 2). Movement of surviving colonies was minimal, but the same abnormal behavior of "clustering" was observed, and large bone piles appeared at 5 days post treatment.

Table 2. NTN field drench test, Harrison Co., MS, August 2, 1989.

Treatment	Pretreat Population		Population Status at Days Post Treatment					
	No. Colonies	Pop. Index	% Colony Mort. (5)	(14)	(82)	% Pop. Index Chg (5)	(14)	(82)
NTN FS 1 cc/gal water/nest	17	210	18	17.6	5.9	-44	-16.6	-10.9
Check	9	120	11	11.1	0	-13	-25	+12.5

CONCLUSIONS:

1) Mobay NTN 33893 FS causes IFA to exhibit extremely abnormal behavior, i.e. "clustering" and decreased response to stimuli. This behavior is evident following a topical (drench) application or when ingested in bait form. Residual contact activity in soil was not seen.

2) Efforts to formulate a bait have not been totally successful. Repellency occurs at high rates, but extremely low rates cause totally aberrant behavior, and more testing is warranted. Based on results of trials completed this far, the optimum dose rate appears to be in the range of .001% to .01% in a 10% sucrose solution.

3) NTN has possibilities as a mound drench. Laboratory tests showed the drench to be effective at rates as low as 1cc/gal water. More field tests, using higher application rates, will be initiated to determine the optimum rate of application.

NON-POLLUTING IN SITU ELECTRICAL EXTERMINATION OF IMPORTED FIRE ANT COLONIES

The imported fire ants (IFA) have spread over 250 million acres in southern states and are still gaining ground.

Dr. Sarapuu has developed electrical systems for eradication of soilborn pests including fire ants. These systems can be adapted for treatment of large acreage of land as well as urban areas.

The eradication of pests in soil is accomplished by passing electric energy into the soil or anthills for destroying the ant colonies in few minutes. Figure 1 illustrates the conceptual layout of electrodes and an electric power unit that is drawn behind a tractor. Figure 2 shows various experiments that have been completed and some of the variables to be studied in oder to make the process workable.

Bio-Electrics has laboratory equipment (10 kva) and a transportable diesel generator (500 kva), for laboratory and field studies, Figure 3. The Company is looking for potential customers who would be interested for participating in the commercial development of in situ eradication of imported fire ants by electrical energy.

Figure 1

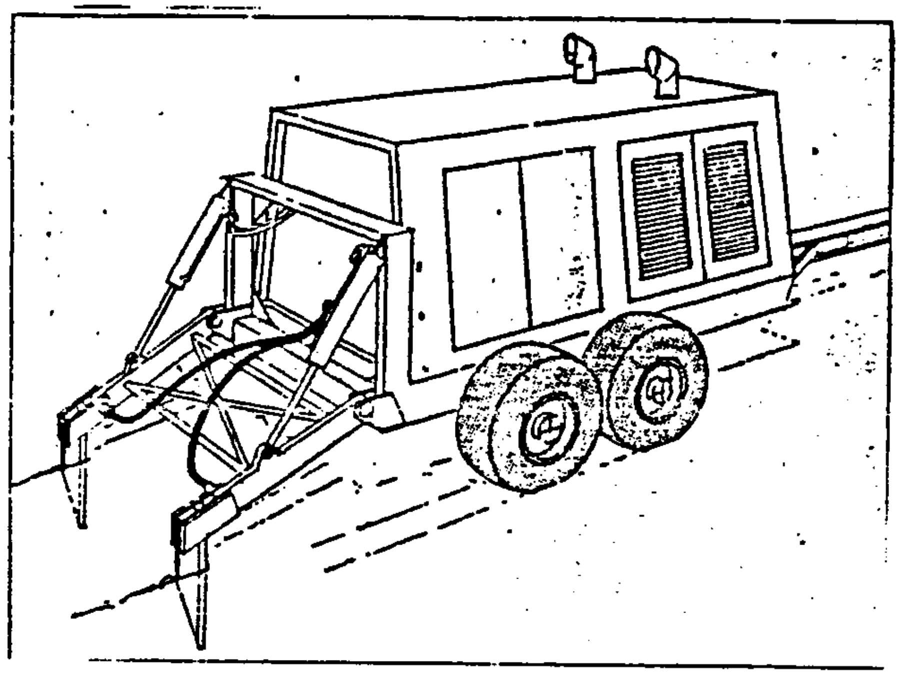
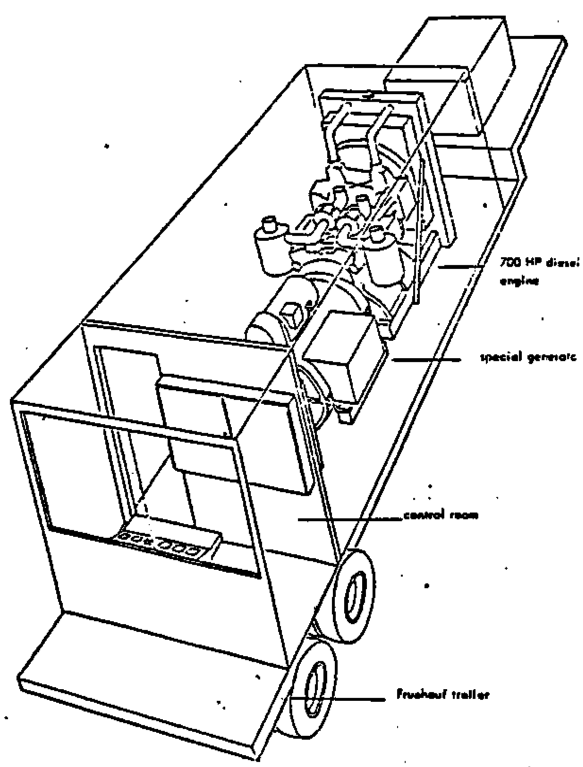


Figure 3



Schematic of 500 kva diesel-driven generator

ELECTRICAL PEST ERADICATION IN AGRICULTURE AND RELATED AREAS

Highlights of the Development Program (1985-1989)

Figure 2

I. OBJECTIVES

1. Prove the feasibility of exterminating pests (eggs, larva, insects, nematodes, viruses, bacteria, fungi, weedseeds and weeds by electrical energy:

    a. on plants
    b. in soil
    c. on postharvest products

2. Electro-enhanced tillage and electrical disintegration of clods.

3. Gathering data for designing prototype electrical machinery for field testing.

4. Gathering data for preparing the patent applications.

5. Projecting operating cost based on pilot studies.

6. Effect of various modes and quantities of electrical energy (a.c., d.c., high frequency, pulsed power, electromagnetic radiation on biological systems (agricultural pests and plants).

II. OVERVIEW OF EXPLORATORY TESTING

1. effect of electric field on seedlings.
2. electrical destruction of weedseeds by electrothermal heat
3. electrical destruction of weeds
4. killing of root aphides on lettuce roots
5. killing root aphides (Phylloxera) on roots of grapevines
6. killing viruses in soil (Rhizomania)
7. killing of nematodes in soil
8. exterminating aphides, thrips, whiteflies ,etc. on growing plants
9. measurements of electrical properties of soil
10. measuring contact resistance of electrodes in soil
11. measuring power loading of various test electrodes in field
12. evaluating various electrode types and materials used for building electrodes
13. preliminary design of prototype equipment
14. Miscellaneous:eradication of ants, termites, grasshoppers, etc.

It has been determined that using electrical energy for pest eradication is feasible. New field equipment is required for commercial scale testing.

Appendix 1

Participants in the 1990 Imported Fire Ant Conference

LIST OF ATTENDEES: 1990 IFA RESEARCH CONFERENCE

Robert S. Adamcik Attwater Prairie Chicken NWR Box 519 Eagle Lake, TX 77434	409/234-3021
Jay Adcock Griffin Corp. P.O. Box 1847 Valdosta, GA 31603-1847	912/242-8635
Lisa Alexander TDA P.O. Box 12847 Austin, TX 78711	512/463-7535
W. A. Banks USDA-ARS-IAMARL P.O. Box 14565 Gainesville, FL 32604	904/374-5913
Rodger Beckcom Bill Clark Pest Control 2975 N. 11th St. Beaumont, TX 77703	409/898-3224
Ms. Beth Bennett Evans Bio-Control Inc. 895 Interlocken Pkwy. Unit A Broomfield, CO 80020	
R. R. Bertrand Invicta Corp. Rt. 8, Box 305 Beaumont, TX 77705	409/794-1125
George Bethurum Bethurum Res. Dev. Inc. P.O. Box 3436 Galveston, TX 77552	409/744-0600
Dr. Awinash Bhatkar Texas A&M Univ. Dept. of Entomology College Station, TX 77843	409/845-5855
Jack Bixby LBJ National Historic Park P.O. Box 329 Johnson City, TX 78636	512/868-7128

Dr. Ralph Bram
National Program Leader
USDA-ARS-NPS
BARC-West, Bldg. 005, Rm. 213
Beltsville, MD 20705

Carlist Brinkley — 512/463-7535
TDA
P.O. Box 12847
Austin, TX 78711

Steven Broscious — 609/799-0400
American Cynamid
P.O. Box 400
Princeton, NJ 08540

Will Calcote
Texas Dept. of Agric.
Route 2, Box 61B
Grapeland, TX 75844

Anne-Marie Callcott — 601/864-0120
USDA-APHIS-S&T-IFA
3505 25th Ave.
Gulfport, MS 39501

R. Scott Cameron — 409/639-8170
Texas Forest Service
P.O. Box 310
Lufkin, TX 75901

James D. Carlton — 409/839-4651
Invicta Corp.
575 20th St.
Beaumont, TX 77706

D. Michael Chambers — 901/762-9806
Dow Elanco
Agric. Products Dept.
6055 Primacy Parkway, Ste. 330
Memphis, TN 38119

Mr. Dan Clair
Texas Dept. of Agriculture
P.O. Box 12847
Austin, TX 78711

Mr. Jose Guzman Collazo — 809/723-8534
Agriculture Admin. Service
P.O. Box 9200
San Juan, PR 00908

Homer Collins USDA-APHIS-S&T-IFA 3505 25th Ave. Gulfport, MS 39501	601/864-0120
Nancy Coplin Stutton Corp. 1400 A Karen Ave. Austin, TX 78757	512/452-2102
Osvaldo Cotte Agric. Extension Serv. College Station Mayaguez Campus Mayaguez, PR 00709	809/833-7007
Victor Crainich CDS, Inc. P.O. Box 292677 Kettering, OH 45429	513/434-0572
Keith Crenwelge TAEX P.O. Box 318 Hillsboro, TX 76645	807/582-3551
Stephen Demarais Texas Tech Univ. Range & Wildlife Mngmt Lubbock, TX 79409	806/742-2843
Stan Diffie University of Georgia Coastal Plains Exp. Stn. P.O. Box 748 Tifton, GA 31793	912/386-3374
Bastiaan Dress Texas Agric. Exp. Stn. P.O. Box 2150 Bryan, TX 77806	409/845-6800
Sherry Ellison Texas A&M University Dept. of Entomology College Station, TX 77843	409/845-8974
Charles Wayne Evans II Invicta Corp. 575 20th St. Beaumont, TX 77706	409/839-4651

Andy Feild 512/756-6642
TDA
Rt. 2, Box 208
Lampasas, TX 76550

Joseph Ford 601/863-8124
USDA-APHIS-S&T-NMARL
3505 25th Ave.
Gulfport, MS 39501

Mike Foerester

Octavio Garza 409/475-0440
TDA
1307 Briarwood
Pasadena, TX 77502

Theodore A. Granovsky 409/779-7251
Internat'l Inst. for Urban & Social Insects
3206 Wilderness Rd.
Bryan, TX 77801

Dr. Les Greenberg 409/845-8975
Texas A&M Univ.
Dept. of Entomology
College Station, TX 77843

Mr. Monroe Hall 217/465-5331
Illinois Cereal Co.
616 S. Jefferson
Paris, IL 61944

Herbert H. Hand 803/799-6324
Phronesis, Inc.
1517 Gregg St.
Colombia, SC 29201

Don L. Harris 904/372-3505
Florida Dept. Agric. DPI
P.O. Box 1269
Gainesville, FL 32602

Jerrold Harris 409/845-5855
Texas A&M University
Dept. of Entomology
College Station, TX 77843

Charlotte Henley 409/634-6313
Ellen Trout Zoo
P.O. Drawer 190
Lufkin, TX 75901

Gerard Hoddenbach 505/988-6870
National Park Service
P.O. Box 728
Santa Fe, NM 87501

Cliff Hoelscher 409/845-7026
Depart. of Entomology
Texas A&M University
College Station, TX 77843

Dr. Jerry Hoyt 405/924-6750
Southeastern Oklahoma State Univ.
Dept. of Biological Sciences
Durant, OK 74701

Kay Iftner
American Cyanamid Co.
VPC Dev. Group
P.O. Box 400
Princeton, NJ 08540

Glen Iley 512/463-7535
TDA
P.O. Box 12847
Austin, TX 78711

Jessee Jimmerson 512/463-7535
TDA
P.O. Box 12847
Austin, TX 78711

Pete Johnson 602/951-3654
Invicta Corp.
P.O. Box 12398
Scottsdale, AZ 85267

Dr. Spencer Johnston 409/845-8295
Texas A&M University
Dept. of Entomology
College Station, TX 77843

David W. Jones
Orkin Pest Control
Technical Service Dept.
2170 Piedmont Rd. NE
Atlanta, GA 30324

Marcus Juby 816/228-2585
Ciba-Geigy Corp
1706 Willow Cir.
Blue Springs, MO 64015

Rafael Jusino-Atresino 806/742-2828
Texas Tech University
Dept. of Entomology
Lubbock, TX 79409

Mr. M. Killion 409/845-5777
Dept. Wildlife
Texas A&M University
College Station, TX 77843

Marilyn M. Rish 512/253-5447
1221 Chisolm Valley Dr. #732
Round Rock, TX 78681

J.B. Kissam 803/656-5048
Dept. of Entomology
Clemson University
Clemson, SC 29634-0365

Allen Knutson 214/231-5362
TAMU Agric. Res. & Ext. Cntr
17360 Coit Rd.
Dallas, TX 75252

Brian Leblanc
Bengal Chemical Inc.
P.O. Box 40487
Baton Rouge, LA 70835

Tim Lockley 601/864-0120
USDA-APHIS-S&T-IFA
3505 25th Ave.
Gulfport, MS 39501

Dr. William MacKay 409/845-0344
Dept. Entomology
Texas A&M University
College Station, TX 77843

Roger Magee 512/463-7535
TDA
P.O. Box 12847
Austin, TX 78711

Floyd Mahaney 512/463-7535
TDA
P.O. Box 12847
Austin, TX 78711

Joseph Mares 912/242-8635
Griffin Corp.
P.O. Box 1847
Valdosta, GA 31603-1847

Lee McAnally	601/864-0120
USDA-APHIS-S&T-IFA
3505 25th Ave. Bldg. 16
Gulfport, MS 39501

Garland McIlveen	409/845-7026
Dept. of Entomology
Texas A&M University
College Station, TX 77843

Harry McMenemy	901/761-9711
Mobay Corp.
Agriculture Chem Div.
6077 Primacy Pkwy, Ste. 220
Memphis, TN 38119

Michael Merchant	214/231-5362
TAMU Agric. Res. & Ext. Cntr.
17360 Coit Rd.
Dallas, TX 75252

Michael Mispagel	404/542-5875
Univ. of Georgia
Dept. of Phys. & Pharm.
College of Vet. Medicine
Athens, GA 30602

Rusty Mitchell	601/956-8081
FMC Corp.
1563 East County Line Rd.
Jackson, MS 39211

Henry Mitchum

Pablo A. Rodriquez Morales	809/879-0746
Agric. Service Admin.
Box 74
Lares, PR 00669

John Morris
TDA
1801 N. Lamar #103

Roger Mulder	512/463-7535
Texas Dept. Agriculture
P.O. Box 12847
Austin, TX 78711

George Neusaenger	409/845-5369
Nat'l Park Service/CPSU
Dept. Recreation, Parks
and Tourism Science
255 Francis Hall
Texas A&M University

Dr. Ana Ortiz
United States Army
13109 Hunters Ledge
San Antonio, TX 78230

John Paige — 407/778-4660
Maag Agrochemicals
P.O. Box 6430
Vero Beach, FL 32961-6430

Richard Patterson — 904/374-5903
USDA-ARS-IAMARL
P.O. Box 14565
Gainesville, FL 32604

Dr. Sherman A. Phillips — 806/742-2828
Dept. of Entomology
Texas Tech University
Lubbock, TX 79409

Dale Pollet — 504/388-2180
Louisiana State Univ.
202B Knapp Hall
Baton Rouge, LA 70803

B. L. Porter
Invicta Corp.
P.O. Box 26088
New Orleans, LA 70126

Jay K. Porter — 713/568-5311
D.O.A. Pest Elimination Ser.
12130 Meadow Pines Dr.
Stafford, TX 77477

Sanford Porter — 904/374-5914
USDA-ARS-IAMARL
P.O. Box 14565
Gainesville, FL 32604

Gene Reagen — 504/388-1824
Louisiana State Univ.
Dept. Entomology
402 Life Sciences Bldg.
Baton Rouge, LA 70803

Bill Ree — 409/845-6800
TAEX
P.O. Box 2150
Bryan, TX 77806-2150

Rhonda Reed — 214/693-6788
TDA
Route 4, Box 654
Carthage, TX 75633

Juan Reyes-Soto — 809/752-3000
Puerto Rico Dept. Agric.
P.O. Box 8359
Humacro, PR 00661

Mr. Carlos M. Rivera — 809/721-7443
Agric. Service Admin.
P.O. Box 9200
Santurce, PR 00908

Richard Webb Robnett — 813/299-1675
3029 Lake Alfred Rd.
Winter Haven, FL 33881

Bubba Rosenkranz — 409/764-5443
City of College Station
1812 Welch
College Station, TX 77840

Sergio Sanchez-Pena — 806/742-2828
Texas Tech Univ.
Dept. of Entomology
Lubbock, TX 79409-2134

Joe B. Sandel — 409/295-8228
Walker Co. Fire Ant Committee
2205 Ave. S
Huntsville, TX 77340

Erich Sarapuu
1215 W. 12th
Kansas City, MO 64101

Deborah K. Sebesta — 409/845-3258
Dept. of Entomology
Texas A&M University
College Station, TX 778436

D. Craig Sheppard — 912/386-3374
Dept. of Entomology
Univ. of Georgia
P.O. Box 748
Tifton, GA 31793

Thomas K. Shotwell

Stacy Siebeneicher — 409/845-8974
Department of Entomology
Texas A&M University
College Station, TX 77843

Mr. Ray Smith — 409/696-8071
Ciba-Geigy
2807 S. Wilderness
College Station, TX 77840

Dr. Ann Sorenson — 312/399-5784
American Farm Bureau
400 Thames Pkwy. 2H
Park Ridge, IL 60068

Art Spector — 879-5080
D.O.A.
12130 Meadow Pines Dr.
Stafford, TX 77477

Beverly Sparks — 404/542-1765
Univ. of Georgia
200 Barrow Hall
Univ. of GA Coop Ext. Service
Athens, GA 30602

Michael B. Stefan — 301/436-8247
USDA, APHIS, PPQ
6505 Belcrest Dr.
Hyattsville, MD

Jack Swarthout — 800/637-6481
Illinois Cereal Mills — 217/465-5331
616 S. Jefferson Ave.
Paris, IL 61944

Don Taylor — 205/863-7222
CIBA-GEIGY
P.O. Box 666
Roanoke, AL 36274

Catherine Thompson — 904/372-3505
P.O. Box 1269
Gainesville, FL 32608

Dr. Harlan Thorvilson — 806/742-2828
Texas Tech University
Dept. of Entomology
Lubbock, TX 79409

Mr. James Touhey — 703/557-5182
USEPA
401 M St., SW
Washington, DC 20460

Mark Trostle — 512/863-8504
Texas Dept. Agric.
701 Ceilo Dr.
Georgetown, TX 78628

Judy Tye
TDA
2736 Lake Shore #2111
Waco, TX 76708
817/754-6954

Gerald D. Valentine
Invicta Corp.
155 Beech Dr.
Lumberton, TX 77656
409/755-0364

Edward L. Vargo
University of Texas
Dept. of Zoology
Austin, TX 78712-1064
512/472-2783

Brad Vinson
Dept. of Entomology
Texas A&M University
College Station, TX 77843
409/845-9754

Irene Wallbaum
Dow Elanco
400 W. Sam Houston Pkwy. So.
Houston, TX 77042
713/978-3741

Bernard Wendel
TDA
410 S. Padre Island Dr.
Corpus Christi, TX 78405
512/289-5551

David Williams
USDA-ARS-IAMARL
P.O. Box 14565
Gainesville, FL 32604
904/374-5982

Dr. D. Wilson
Texas Parks & Wildlife
4200 Smith School Rd.
Austin, TX 78744

Orrey P. Young
USDA, APHIS, BEEP
6505 Belcrest Rd.
Hyattsville, MD 20782
301/436-8565

Competition in nature