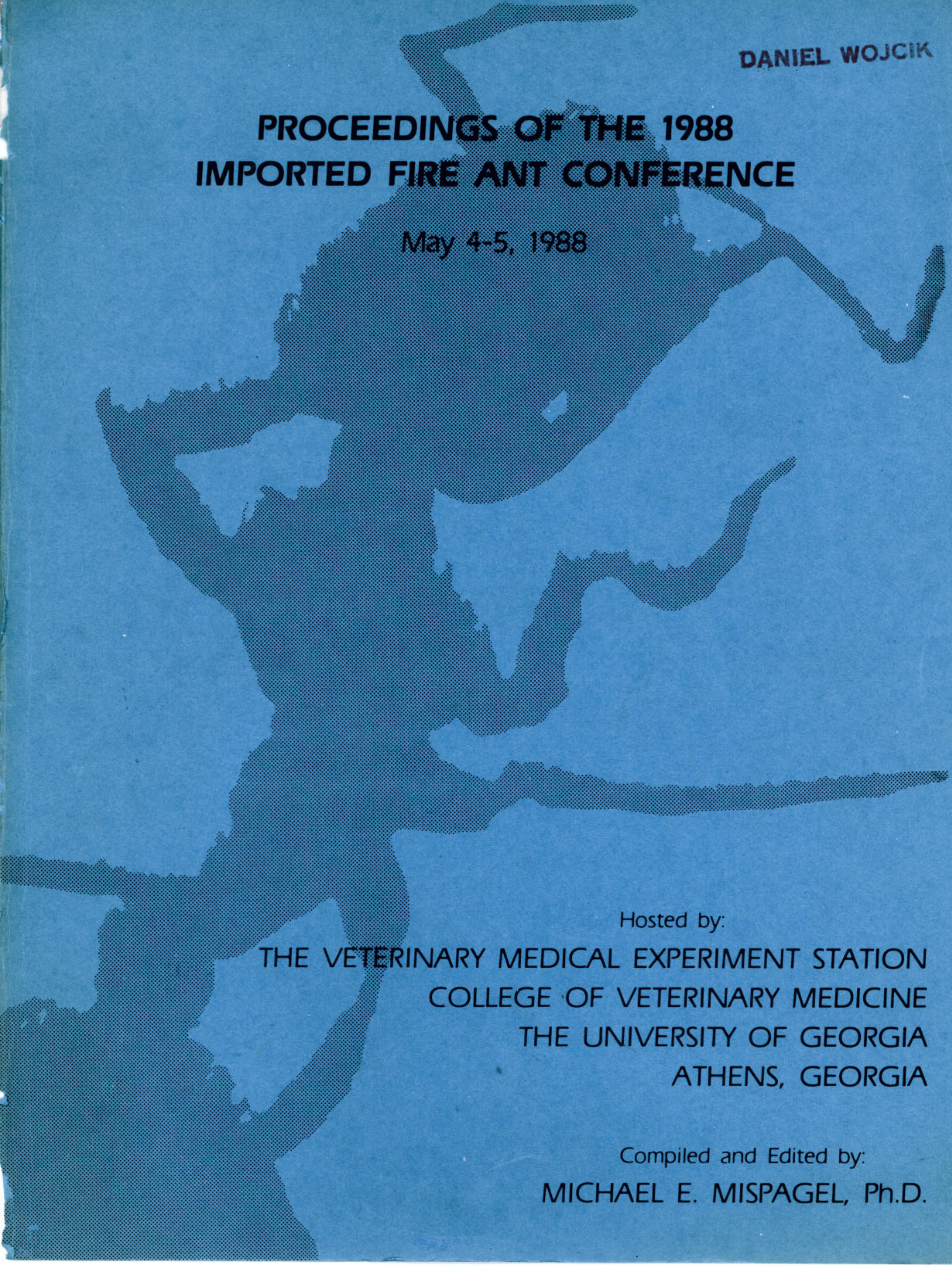
PROCEEDINGS OF THE 1988 IMPORTED FIRE ANT CONFERENCE

May 4-5, 1988



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THE UNIVERSITY OF GEORGIA
ATHENS, GEORGIA

Compiled and Edited by:

MICHAEL E. MISPAGEL, Ph.D.

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College of Veterinary Medicine
The University of Georgia
Athens, Georgia 30602

The Georgia Center for Continuing Education
The University of Georgia
Athens, Georgia 30602

Sponsored By:

The Fire Ant and Environmental Toxicology Program
The Veterinary Medical Experiment Station
College of Veterinary Medicine
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1988 IMPORTED FIRE ANT CONFERENCE

INTRODUCTORY REMARKS *

The Honorable Henry L. Reaves
Georgia State Representative

I feel honored to be asked to make a few remarks in the opening address. I would like to welcome you to the great state of Georgia and to the city of Athens.

I was first introduced to the fire ant business in the late 1950's when they first came in to south Georgia. And then in 1963 in the state legislature I was further introduced to them and worked with them with the honorable Phil Campbell, who is sitting in the back of the room now, and who was Commissioner of Agriculture then. That was one of his pet projects. It was quite a fight back then for us south Georgia boys to get money for fire ants. But when they got up here to North Georgia it was a different story. They were wondering why we had quit doing anything in south Georgia because they were really pushing it. I can say now that it's no problem to get up a good discussion about the problem. If there is any money available in Georgia, and if you need it, you can get money for the fire ant program. During the eradication program we had with Mirex we had money waiting to use. But, of course, that fell by the way.

I commend you for working with the fire ants. I have been to some of the meetings in the past several years which I am sure you attended. I'm beginning to wonder if we will ever have an eradication program. I don't think it's in the near future. Now down my way, we have more or less accepted them, work with them, kill a few, and get stung. No later than yesterday afternoon I got into some. But it is so expensive to get pastures treated. You can buy this Spectracide and something new advertised just the past few months. My wife keeps hollering for me to get some of it. She thinks it is better than the rest. We can get rid of them in the yards but when you get out into the pastures, it is just too expensive. I hope you fellas will get up something so that we can get some relief on that.

In the Southern Legislative Conference, I have been Chairman of the Agricultural Committee of that association which includes the seventeen southeastern states. We worked with this a year or two ago in a meeting in New Orleans. The people in South Carolina were pushing for that since they had just gotten over-populated up there, I think. We had meetings there, in Atlanta, and Washington, D.C. But, of course, they were just meetings as usual.

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* Transcibed from an oral presentation and edited by Dr. Michael E. Mispagel.

I'm just hoping that you can come up with something in the near future that will give us some relief to get rid of the fire ants. Of course, we have other pests too, but it seems that fire ants are on the top burner right now. In the state of Georgia, we are spending some money in two different areas. In the College of Agriculture, the Extension Entomology Department is doing a very good job under the direction of Dr. Canerday. They are getting around $50,000 a year. Also the Veterinary Medical Experiment Station is getting about $200,000 a year. I hope that we can continue to show results because we are getting a lot of questions about what we can do about the fire ants.

Again, I appreciate you people being here in Athens and I commend you on what you are doing. Thank you.

Studies on Alates and Newly-Mated Queens from Single and Multiple Queens Areas and the Loss of the Maternal Instinct Via Logic.

B.Michael Glancey, ARS,USDA, IFA Project,Gainesville,FL.

EFFECT OF LOGIC. Over the past few years we have reported to you on the effects of Logic (fenoxycarb) on the colony queen and the alates produced by the shift in caste production. We have seen that the compound causes the queen and alates to lose the ability to inhibit dealation by virgin queens. However, neither of the two types of females lose their ability to induce queen recognition.

We have subsequently found that Logic also affects the maternal instinct in virgin queens. Here are slides of the ovaries of the normally eclosed virgin female and the ovary of an alate from a colony treated with fenoxycarb. Notice that there is very little ovarian tissue left in this alate, just a remnant of what use to be.

We took both normal and fenoxycarb-treated virgin alates and aged them for 10 days. The females were allowed to dealate and both types were found to histolyze their alary muscles, produce an esophageal crop and the queen recognition pheromone. We wondered if any other effects had been produced via the treatment with fenoxycarb so we isolated 30 of each type of queen and placed them in 1 oz cups with castone bottoms. The queens were then supplied with eggs taken from one of our laboratory colonies. The normal virgin queens immediately gathered the eggs up and began tending them. The fenoxycarb-treated queens ignored the eggs or began eating them. During the week of observation, the normal virgin queens tended the cluster of eggs, licked them, and carried them around. After one week, microlarvae could be seen in these small colonies. On the other hand, no fenoxycarb-treated queen was ever seen to tend the eggs. All the eggs provided to them were eaten in a matter of days.

In light of this response, we believe that the presence of ovaries can be correlated with the maternal instinct via a material produced by the ovaries, or by the CA with a related release by the ovaries. The treatment of the colony with fenoxycarb produced females lacking ovaries, and with these glands missing, so was the maternal instinct to found a colony.

LACK OF OVARIES. Recent quarantine regulations by the states of California and Arizona require that any produce, equipment, etc. shipped into the states be free of fire ants. If a single ant is found, the truck is stopped and turned back. The two states have taken the position that nowhere in the literature can a study be found that shows that workers lack ovaries. All of us working with the fire ants know that the workers do indeed lack ovaries, but attempts to provide literature citations stating this explicitly are lacking. We therefore did a study of the 3rd and 4th worker larval instar and pupal forms of S.invicta, S.richteri, the hybrid form of richteri-invicta, S.geminata and S.xyloni. The immature forms were fixed in Kahle's solution, embedded in paraffin (mp=57^{o} C), sectioned at 5u, stained with hematoxylin and eosin and examined with phase microscopy. At least 10 individuals of each form of each species was examined. In no case was any type of ovarian tissue found.

COMPARATIVE STUDY OF SINGLE AND MULTIPLE QUEENS. We have initiated comparative studies with single and multiple queen populations. Our first study involved the collection of newly mated queens of both types and their nuptial weights. We have found a shopping center area in Ocala, Fl that is located in the heart of a multiple queen area. Each day after a rain, we visited the shopping area and made collections. In all, there were only two mating flights from which we were able to collect newly mated queens. Here is a summation of the weights of the queens we collected from both flights, and from the data one could see that there is an apparent bimodal curve with one peak at about 11.5mg and one at 15mg.

When we separate the data out by months, we can see that the May flight produced the greater number of smaller females along with the bimodal curve. The June flight produced a much more uniform weighted alate.

The single queen flights which are shown here occurred over a period of 10 months with captures in May through September, and one in February. The queens were collected from 5 different areas in Florida and the weights of the newly mated queens over all collections are summed in this slide. There is a single peak with a mean of about 15.5mg. When you examine the individual months data, you will see that the initial weights in May are heavy and that as the year progresses, the weights of the queens become lighter until in February, the peak weight is about 11mg.

This slide shows some of the data parameters for both types of queens.

Now in addition to making collections of mated queens, we also collected, by means of the Banks trap, alates leaving the mound for a nuptial flight. Traps were placed over single queen and multiple queen mounds, and after a flight, the alates both male and female were collected, returned to the laboratory, and a sample taken for weighing and for head width measurements in the case of the female alates.

The weights recorded for both types of females are presented in this slide. As you can see, the female alates from the single queen mound appear to be from a different population than the female alates from the multiple queen mound. This difference can also be seen in the head width measurements in the next slide.

And the next slide gives a total of the parameters measured. It thus appears that we might be dealing with two kinds of female alates.

The weights of the males parallels that of the females in that the males from single queen mounds tend to be somewhat heavier than the males from multiple queen mounds. In both cases, there is a tremendous range of sizes.

Two other points that may be noted here. None of the female alates trapped from either the mono- or polygynous type mound were found to be inseminated. Thus, no indication of internidal mating can be seen. The other point is that both types of males were highly fertile. Males collected were dissected to determine if sperm were present and if it was viable. There was no correlation of fertility with size of male. The high fertility figure obtained for the males from polygynous colonies is in opposition to the value obtained for such males from the place called "queen city" in Hurley,MS. Here, we obtained only a 4% fertility from the males. Many questions thus arise as to what changes are going on in the various polygynous populations around the southeast.

Population studies with polygynous colonies. We have initiated studies to determine what constitutes a polygynous colony. The study area, shown here, is a pasture located near the fire ant buildings in Gainesville, and is just about 33m X 60m. We have gridded off the pasture into 3 X 4m rectangles using permanent markers of pvc pipe (slide). An initial count of mounds was made in April, 1987. This slide shows the position of the various mounds. There were 103 mounds identified as multiple queen mounds.

We tried to determine if there was some sort of interaction between mounds by feeding a fluorescent dyed sugar water solution to one colony for four days. Seven days after the last feeding, we sampled the mounds by collecting worker ants in a talced vial and crushing 100 of the ants. The results showed positive dye in a number of mounds ranging from 1 to 30%. This slide shows the mounds with the dye (green dots on red dots.). The maximum distance we recorded was 35m.

We repeated the experiment again with a smaller area as shown in this slide. And again, we found dyed workers in mounds other than the core mound. Awanish Bhaktar has found by painting workers from polygynous colonies that they will move between colonies. So we have not only confirmed his findings, but confirmed some observations we made back in 1972 using a similar technique. It begins to look like there is no such thing as a polygynous mound, but simply a polygynous population with many tumuli.

We managed to continue our counts of the mounds in the pasture and I'd like to show you the fluctuation over a years time in the same pasture. This is the pasture count in April of 1987, this is November of 1987, notice the increase , and this is February of 1988. Incidentally, the two bare spots are tree lines and no mounds are there. As you can see, the pasture is becoming saturated with mounds and as yet we don't what the final density will be.

Another aspect of our study was to begin to collect the queens from polygynous colonies and keep a count of them. In these next slides you can see the counts of queens collected from each of these mounds. In this particular case, not all the queens were inseminated. The counts were as follows:

Mound #	#Queens	#inseminated
1	28	0
2	1	1
3	2	2
4	4	4
5	13	14
6	3	3
7	8	11
8	3	3

Another aspect of our study was to try to determine how the polygynous colonies grow. It has been postulated by the Georgia group that budding takes place. But we would like to know where are all the queens coming from. We have seen polygynous mounds in Ocala and found that 1 shovelful of soil from each mound contained over 200 mated queens. Now these mounds are built around the base of some foliage which decorates a parking lot. And there are many of these trees, about 6' apart, and each with a mound at the base of it. It is our belief that these colonies are adopting these queens from the mating flights.

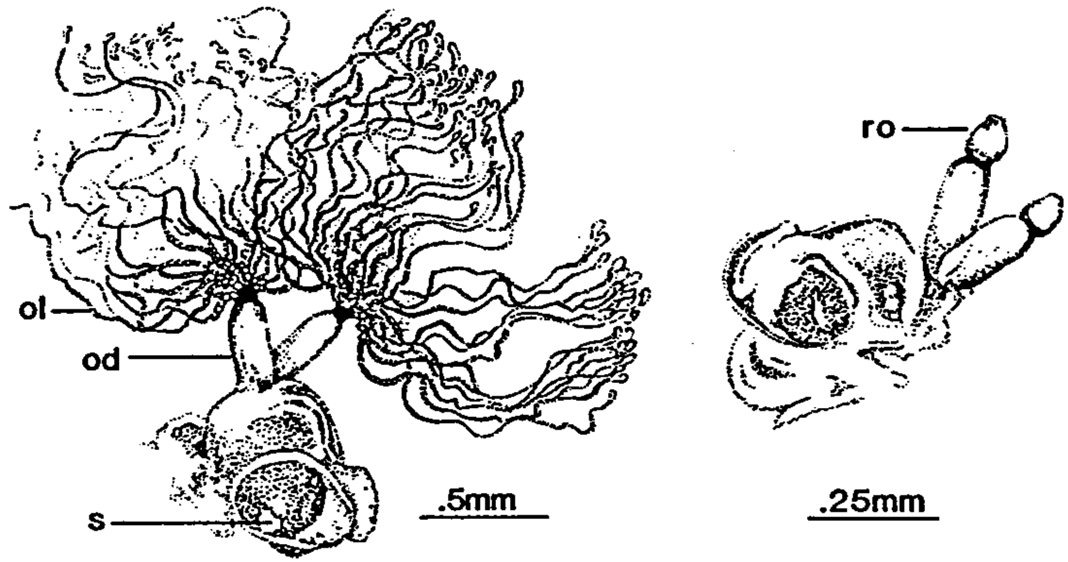
We therefore collected a number of newly mated queens and painted 100 of them orange, 100 yellow, 100 white and released them in areas around the laboratory as shown in this slide. A week later, we dug the mounds, collected all the queens and came up empty. Not a single marked queen did we find.

We figured that the paint had come off, or that workers had groomed it off so we switched to putting on wire belly bands, a la Brad Vinson. We made two releases of 100 each banded queens and again we came up empty. Now we figured that the workers were killing the queens. So we banded another 300 newly mated queens and gave 100 to each of three laboratory polygynous colonies. In a matter of a week, all the queens had been killed. At this point we rejected our hypothesis of adoption of newly mated queens.

About 10 months passed, and one day, we went to the pasture to sample some mounds for a study that Dr. Lofgren and I are doing on total ant counts in polygynous populations. We dug 15 mounds from our favorite pasture, and lo and behold, we found in one of the mounds, 4 of our orange marked queens released 10 months earlier. We measured the distance from the release point (slide of the area) and found that the ànts have covered a distance of 65 meters. We do not know it there were stops along the way or if all 4 entered at the same time. What we do know now is that adoption can be a possible mechanism for growth of polygynous colonies and that the paint is an acceptable method for marking and releasing queens. Our future plans are to sample more of the mounds in the pasture and determine if there are other queens present which we marked and released. We also plan to try and band some more newly mated queens and see if we can recapture them at later date, from areas removed from the release point. This really spectacular finding thus represents the first time that marked newly mated queens have been released and recaptured, not where we expected to find them, but recaptured at distances heretofore unthought of in the annals of fire ant research. This finding is not only exciting for what it is, but also, for what it can lead to in our approaches to solving the problem of growth rated of polygynous colonies.

300 µ

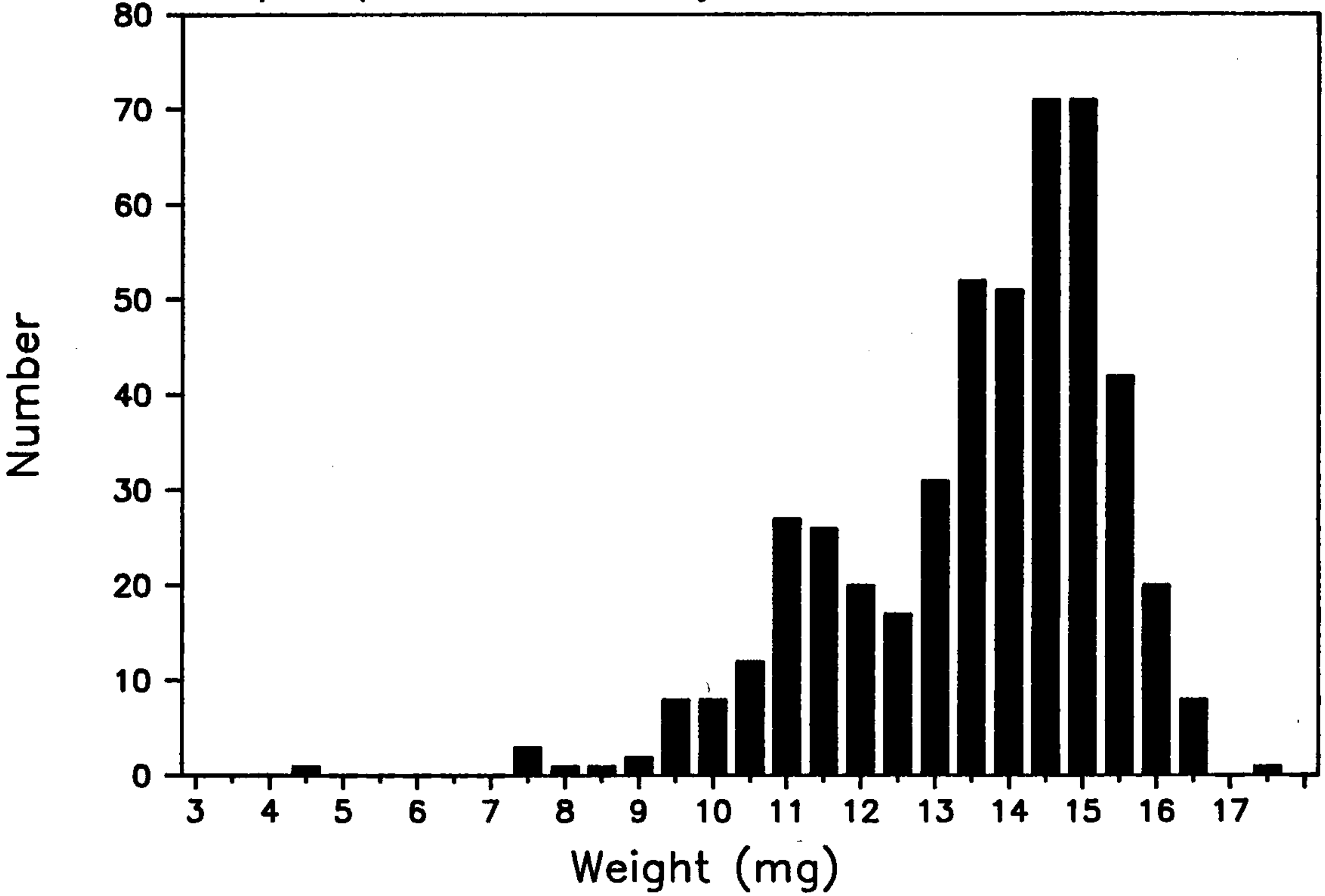
3. (a.) (b.)



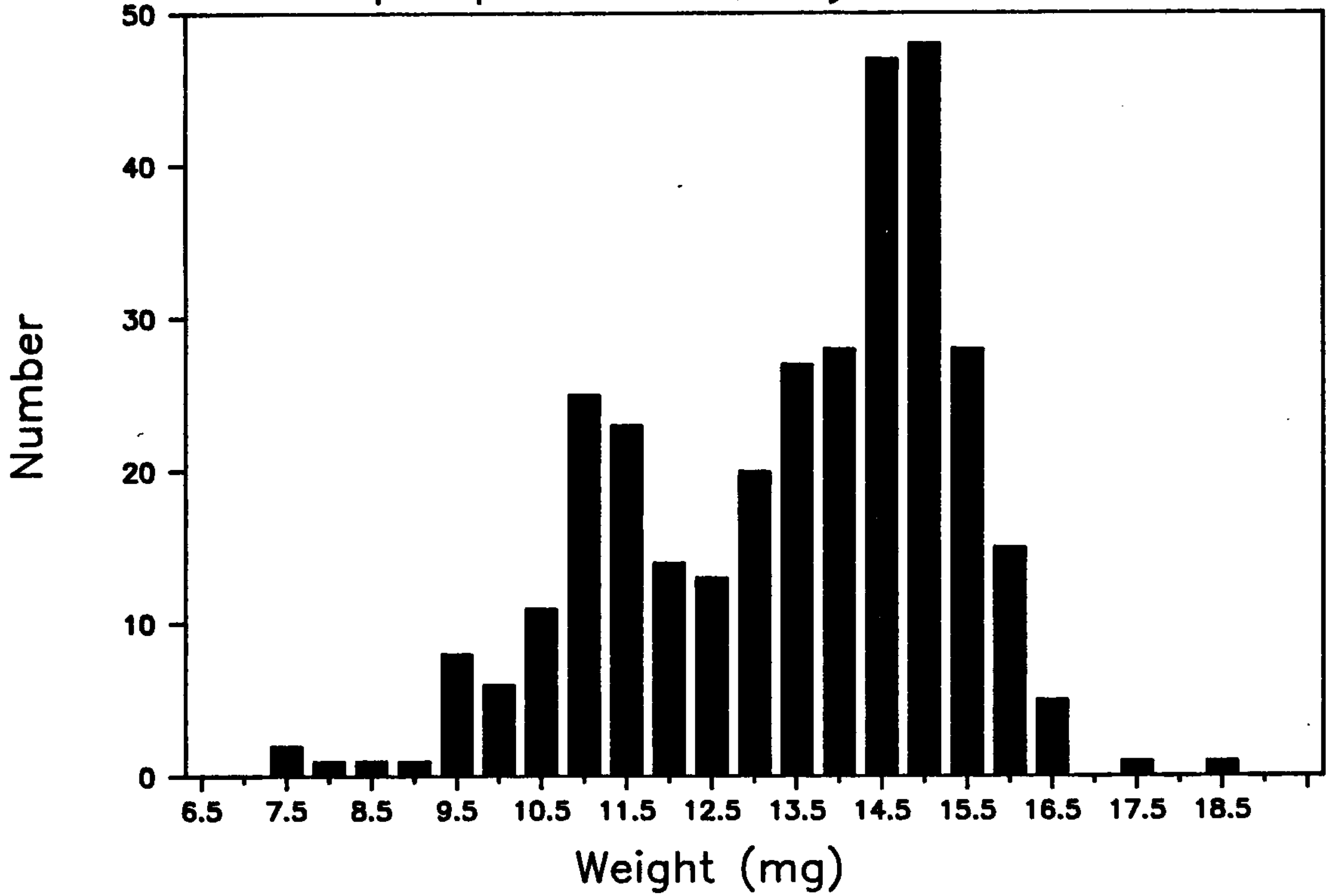
(a.) Normal ovary of newly eclosed virgin female.

(b.) Remnant of ovary of newly eclosed female from fenoxycarb treated colony.

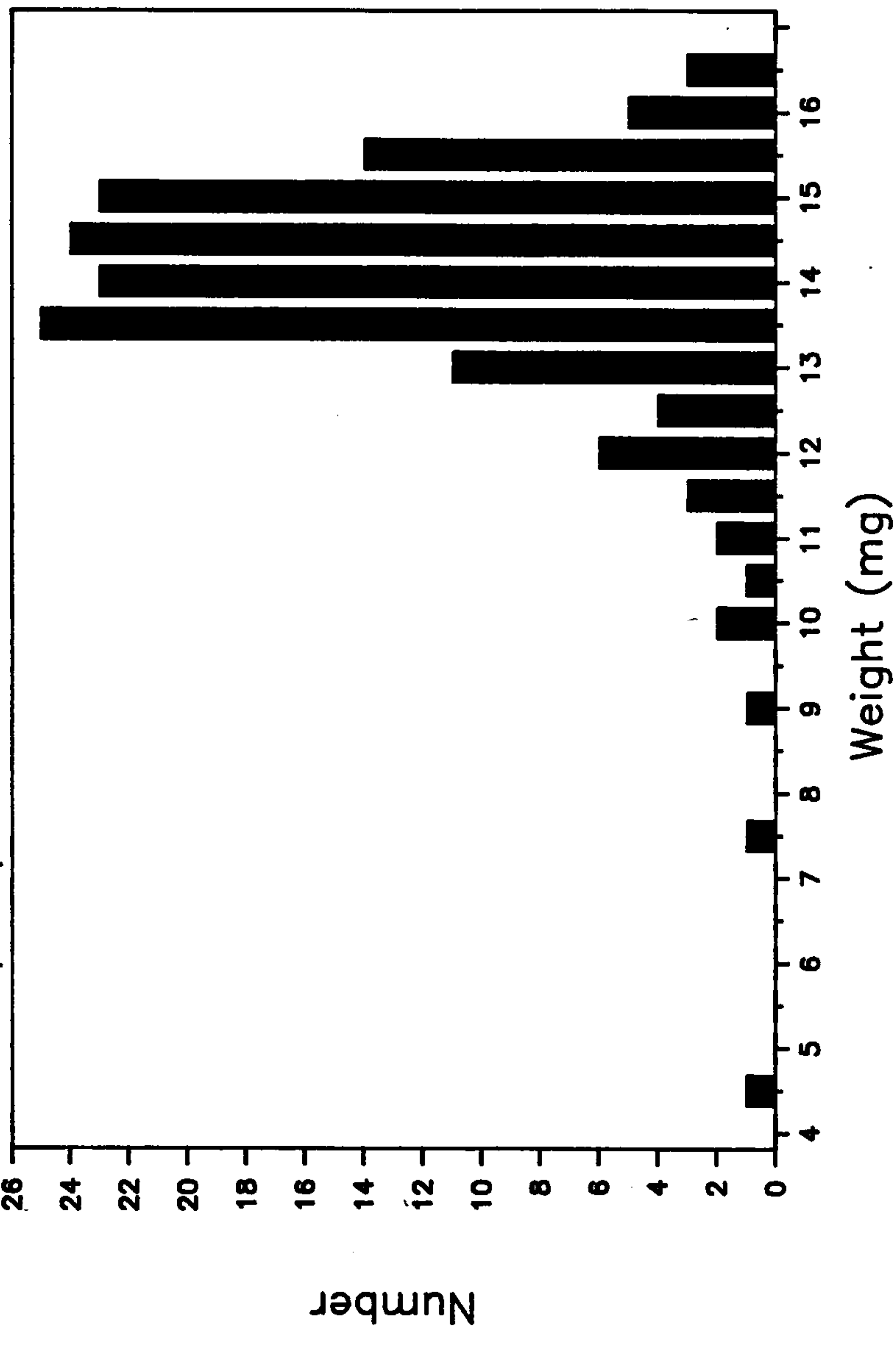
Weights of newly mated queens collected from multiple queen areas May and June, 1987. Ocala.



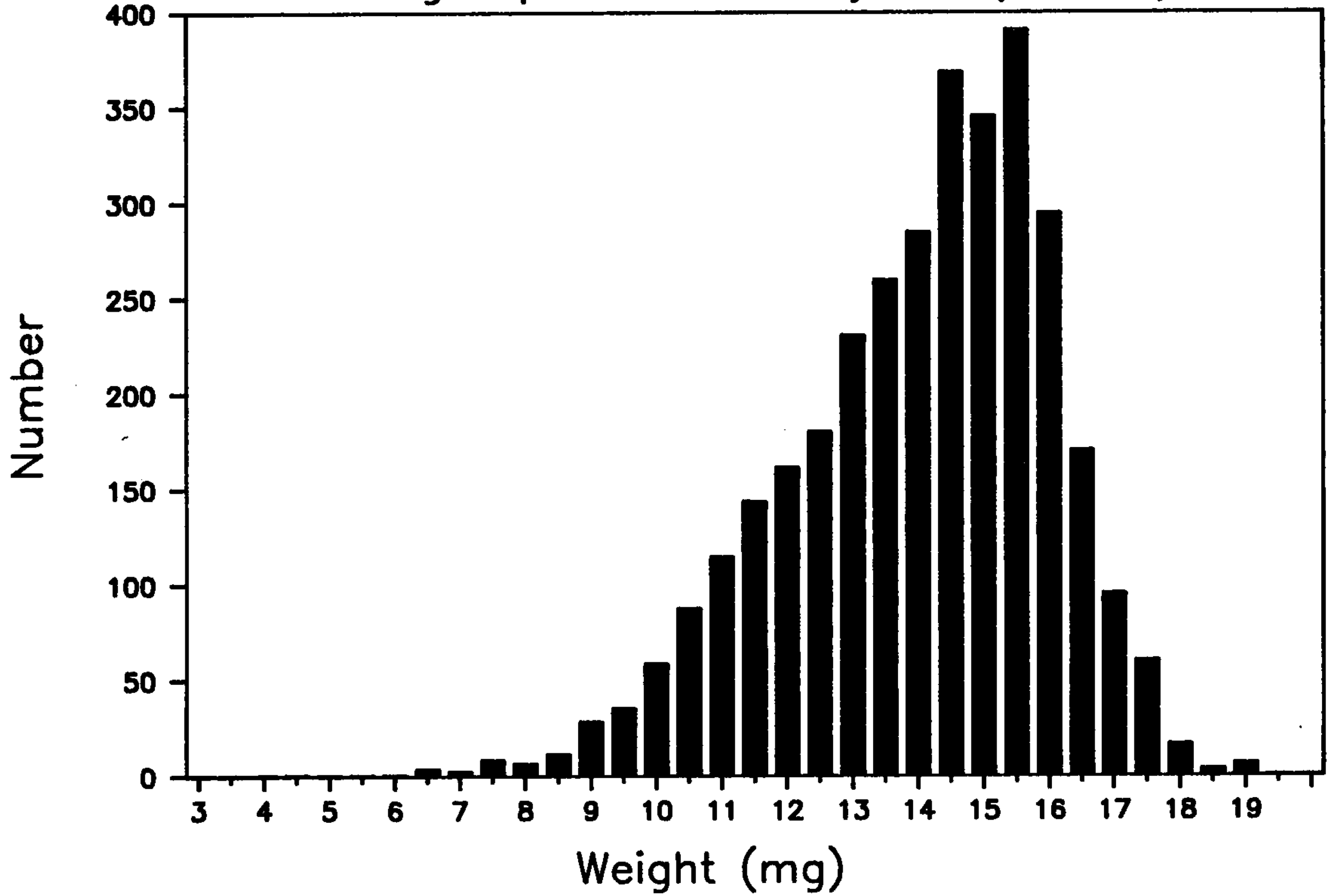
Weights of newly mated queens collected from multiple queen areas, May 1987. Ocala.



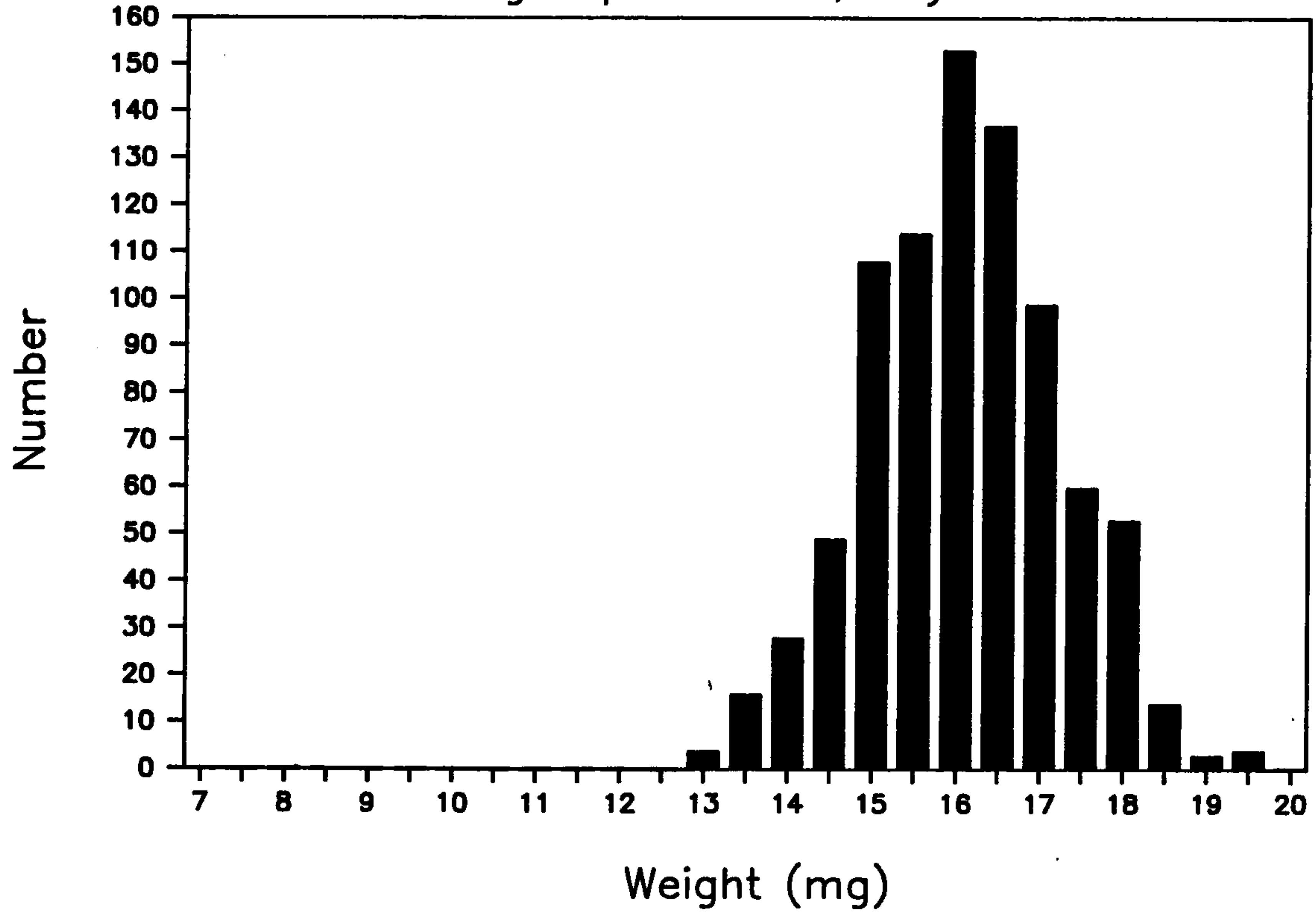
Weights of newly mated queens collected from multiple queen areas, June 1987. Ocala.



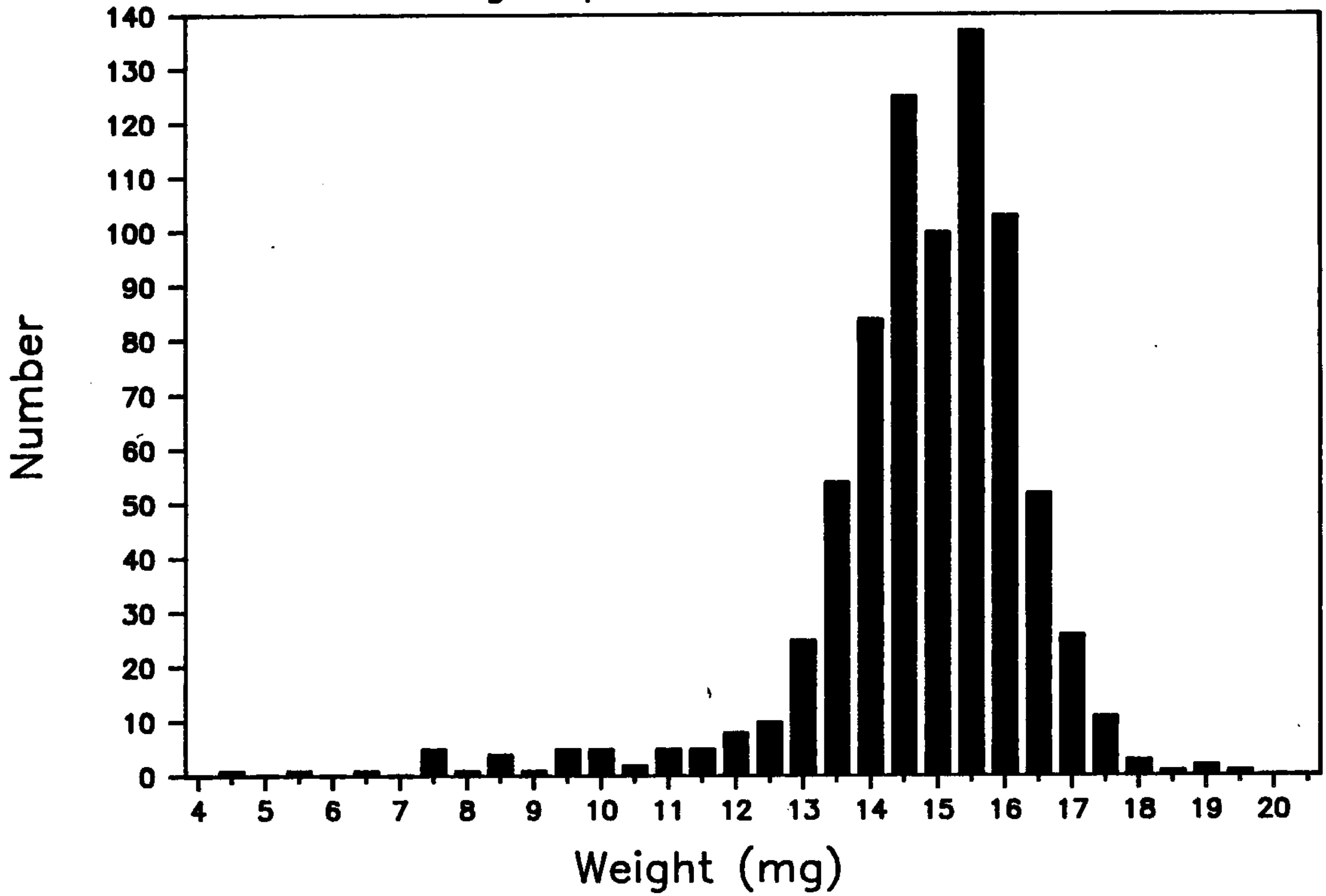
Weights of newly mated queens collected from single queen areas,May–Feb(87–88).

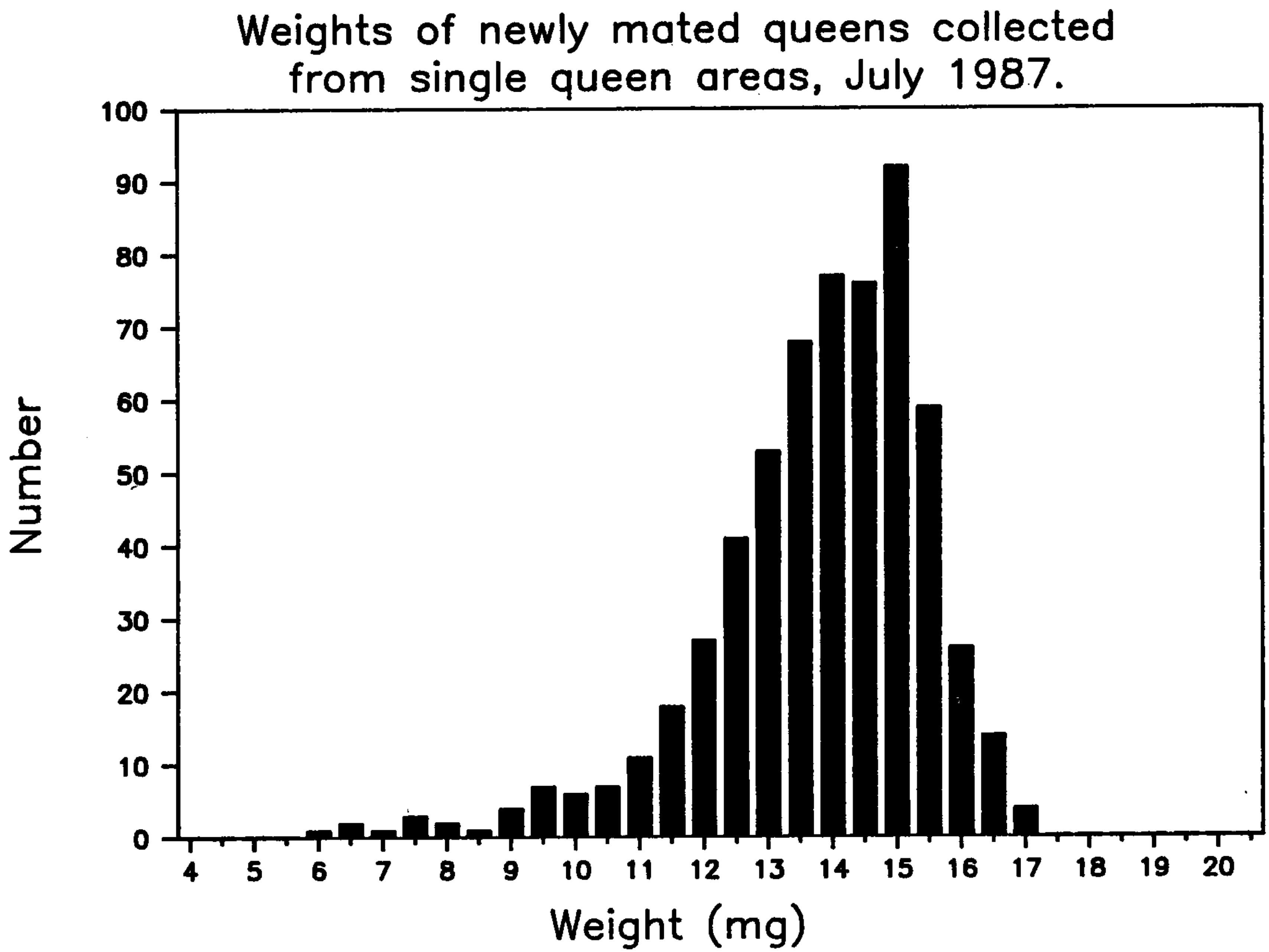


Weights of newly mated queens collected from single queen area, May 1987.

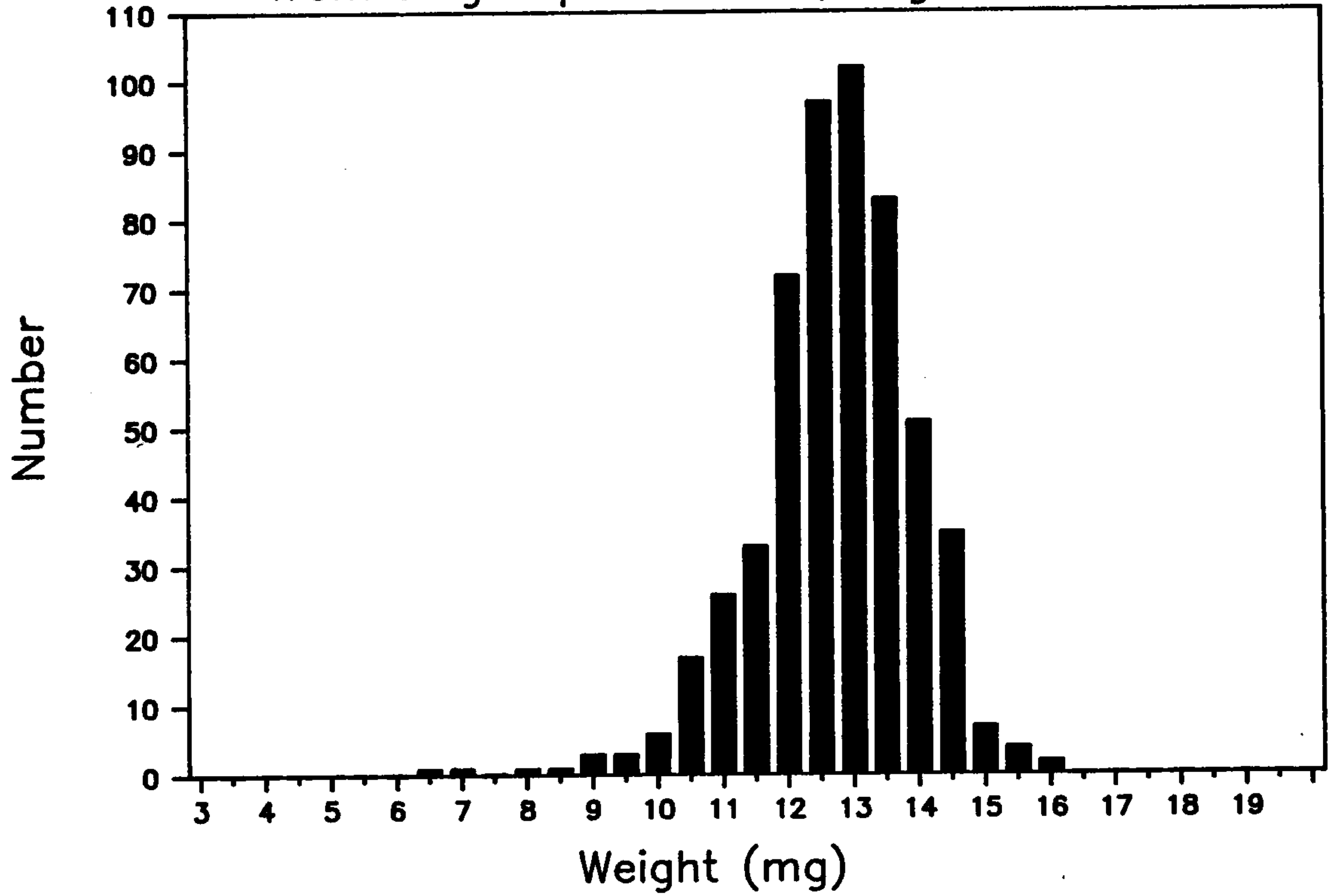


Weights of newly mated queens collected from single queen areas, June 1987.

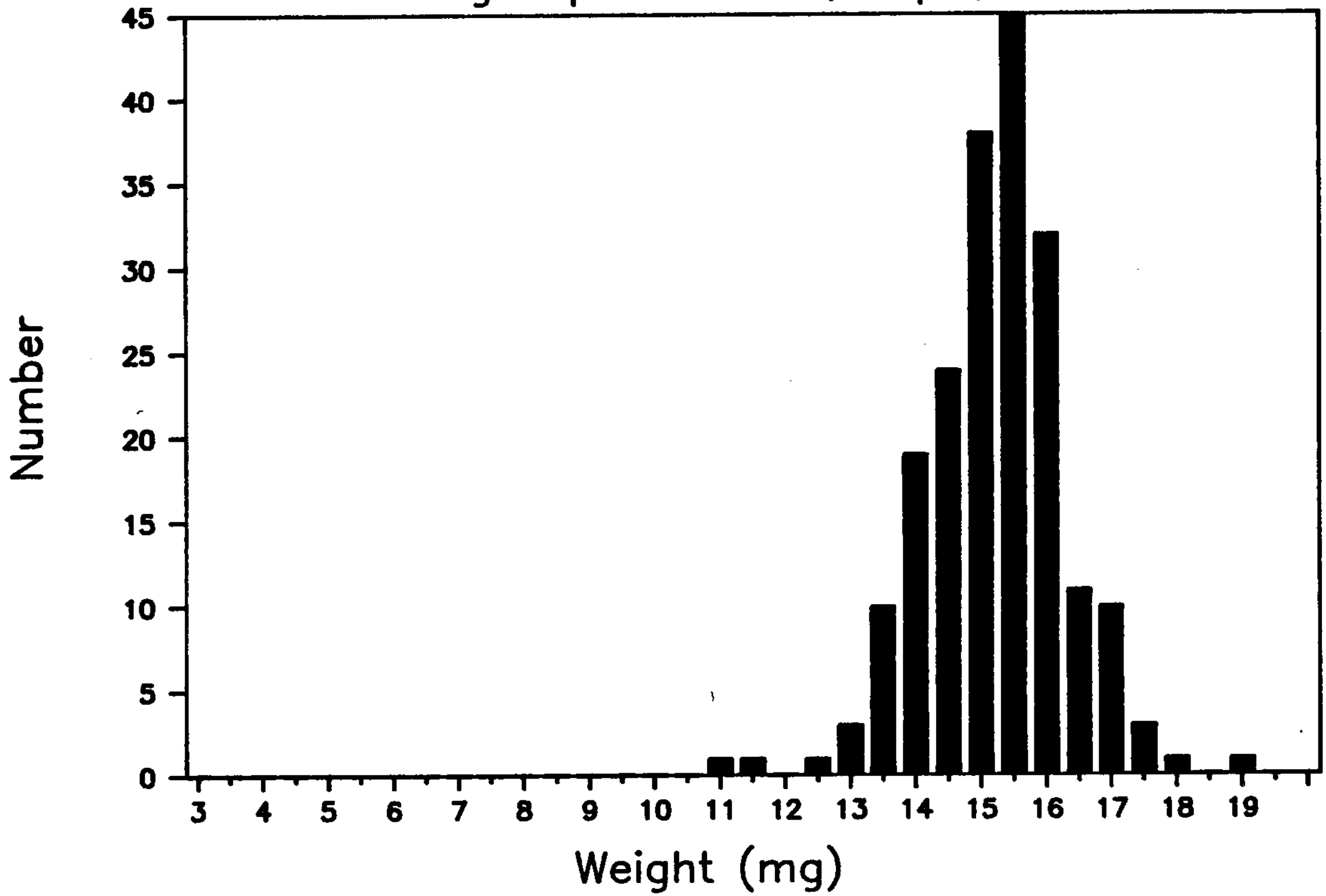


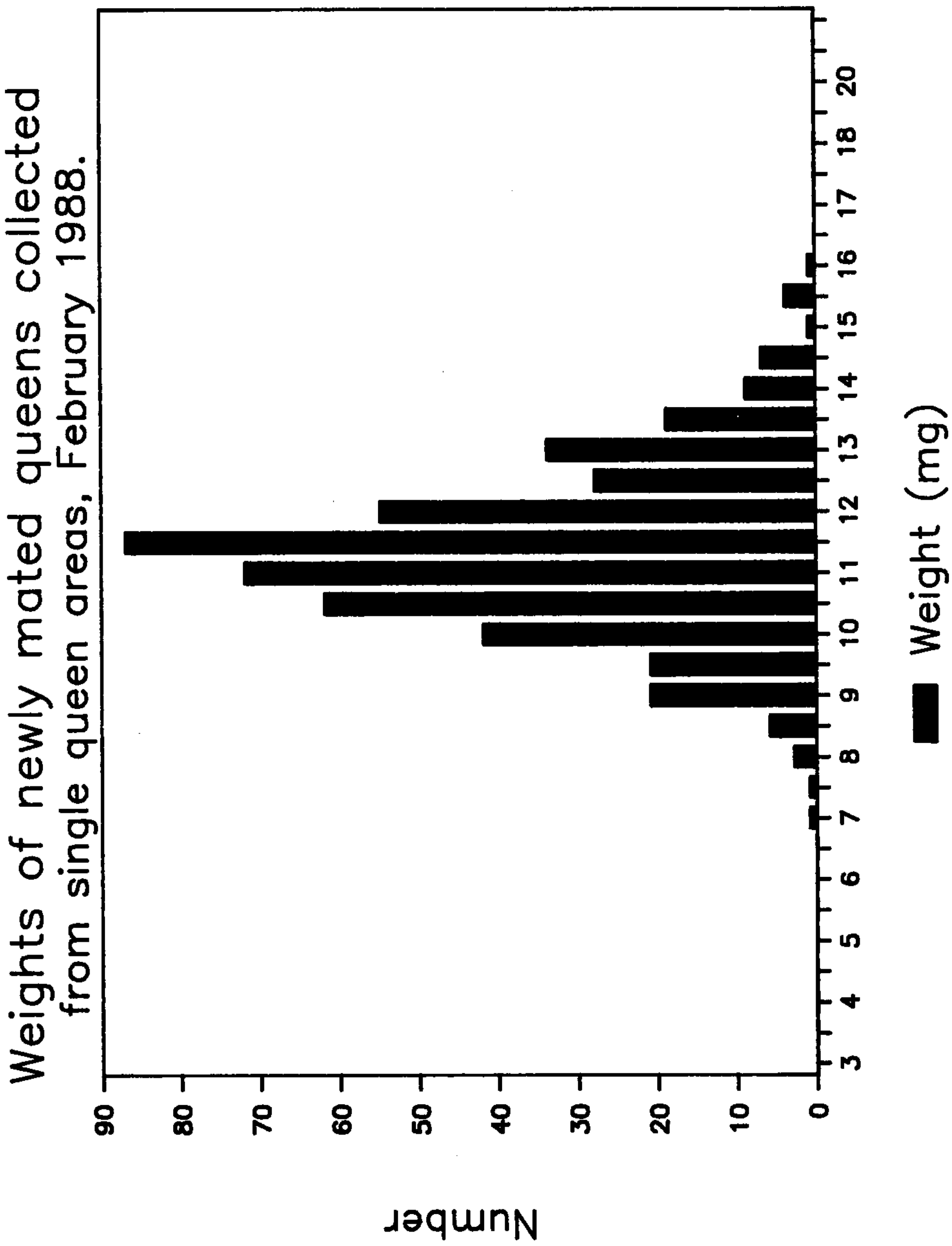

Weights of newly mated queens collected
from single queen areas, July 1987.
Number
100
90
80
70
60
50
40
30
20
10
0
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Weight (mg)

Weights of newly mated queens collected from single queen areas, August 1987.



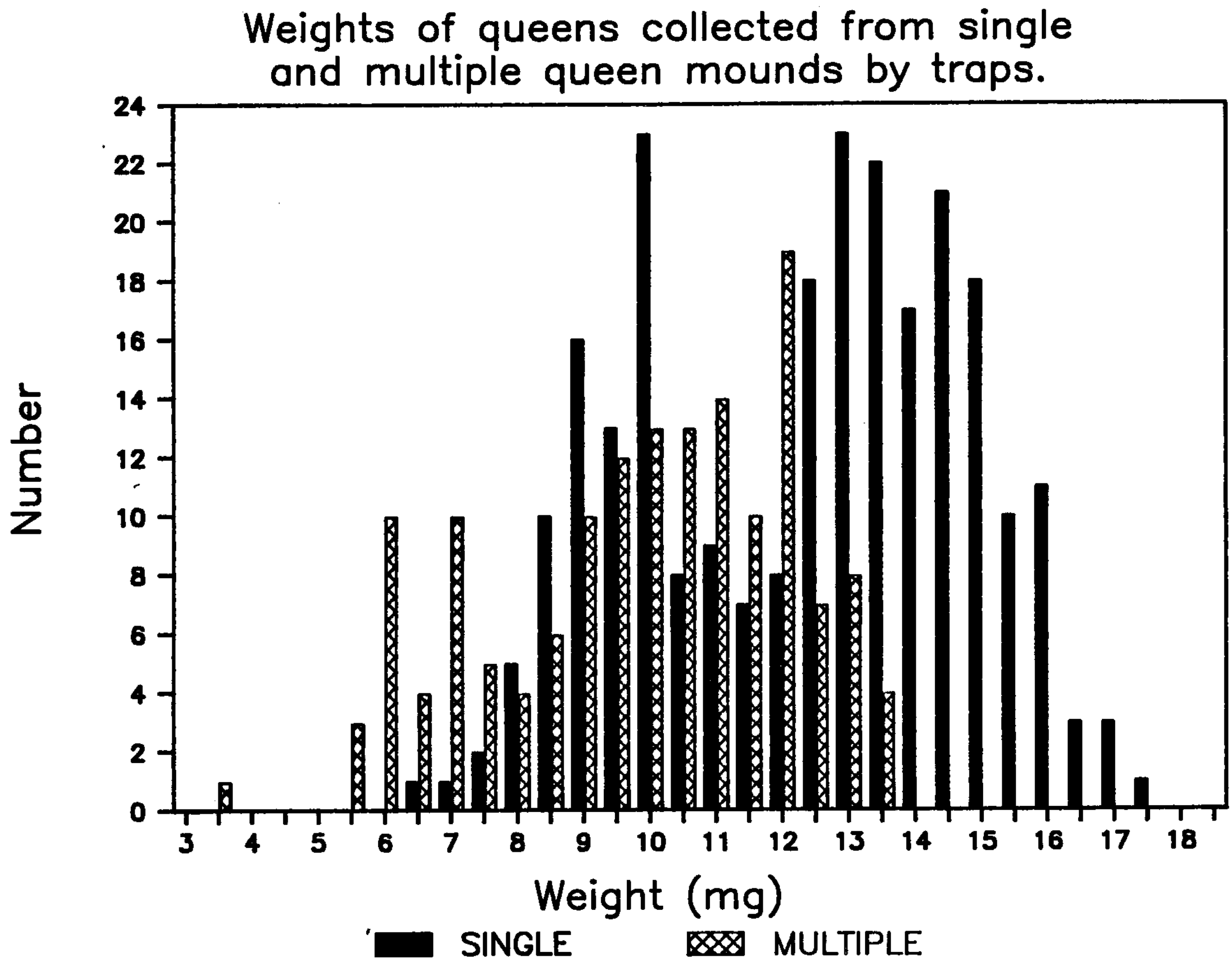
Weights of newly mated queens collected from single queen areas, Sept., 1987.

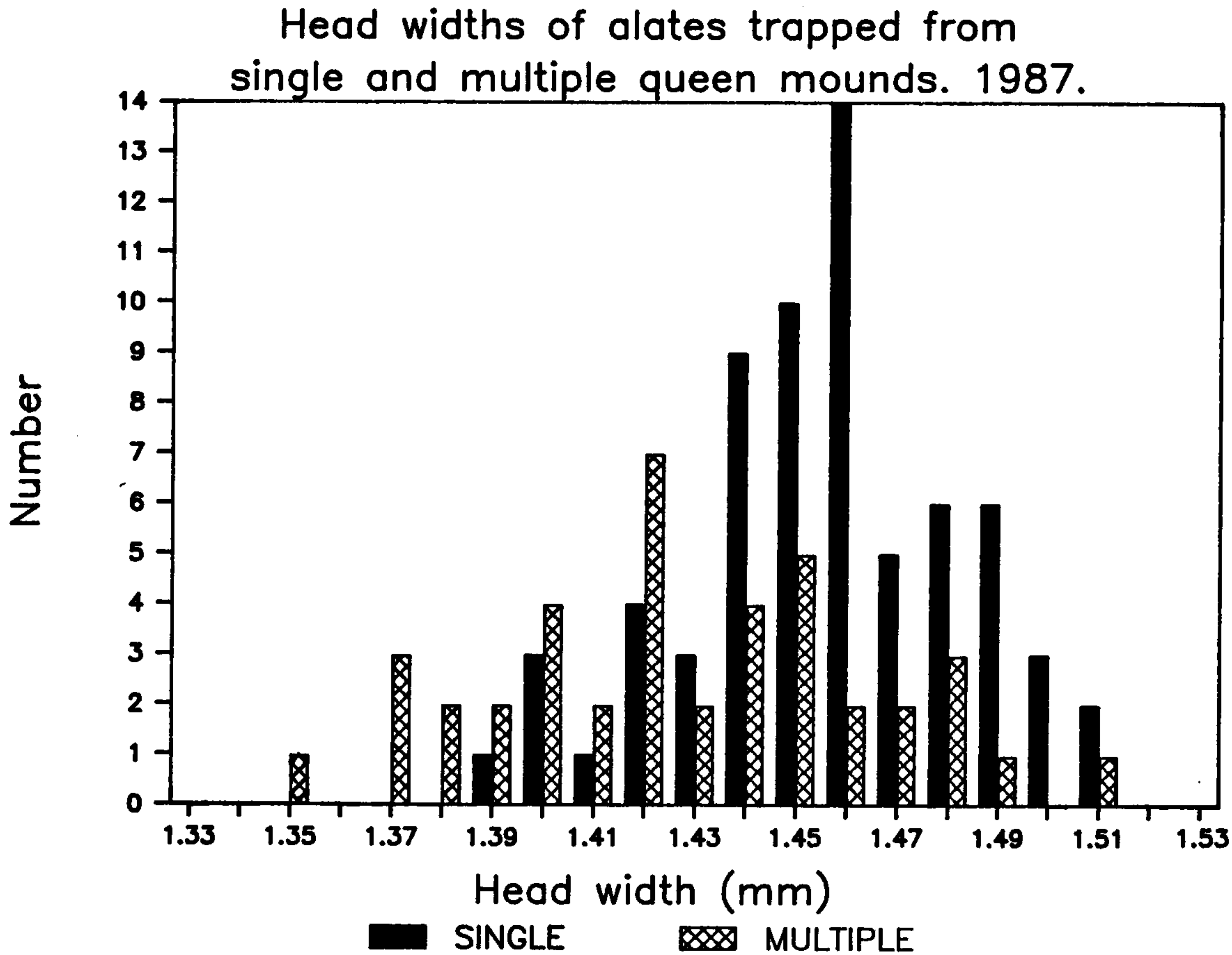



Weights of newly mated queens collected
from single queen areas, February 1988.
Number
0
10
20
30
40
50
60
70
80
90
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
20
Weight (mg)

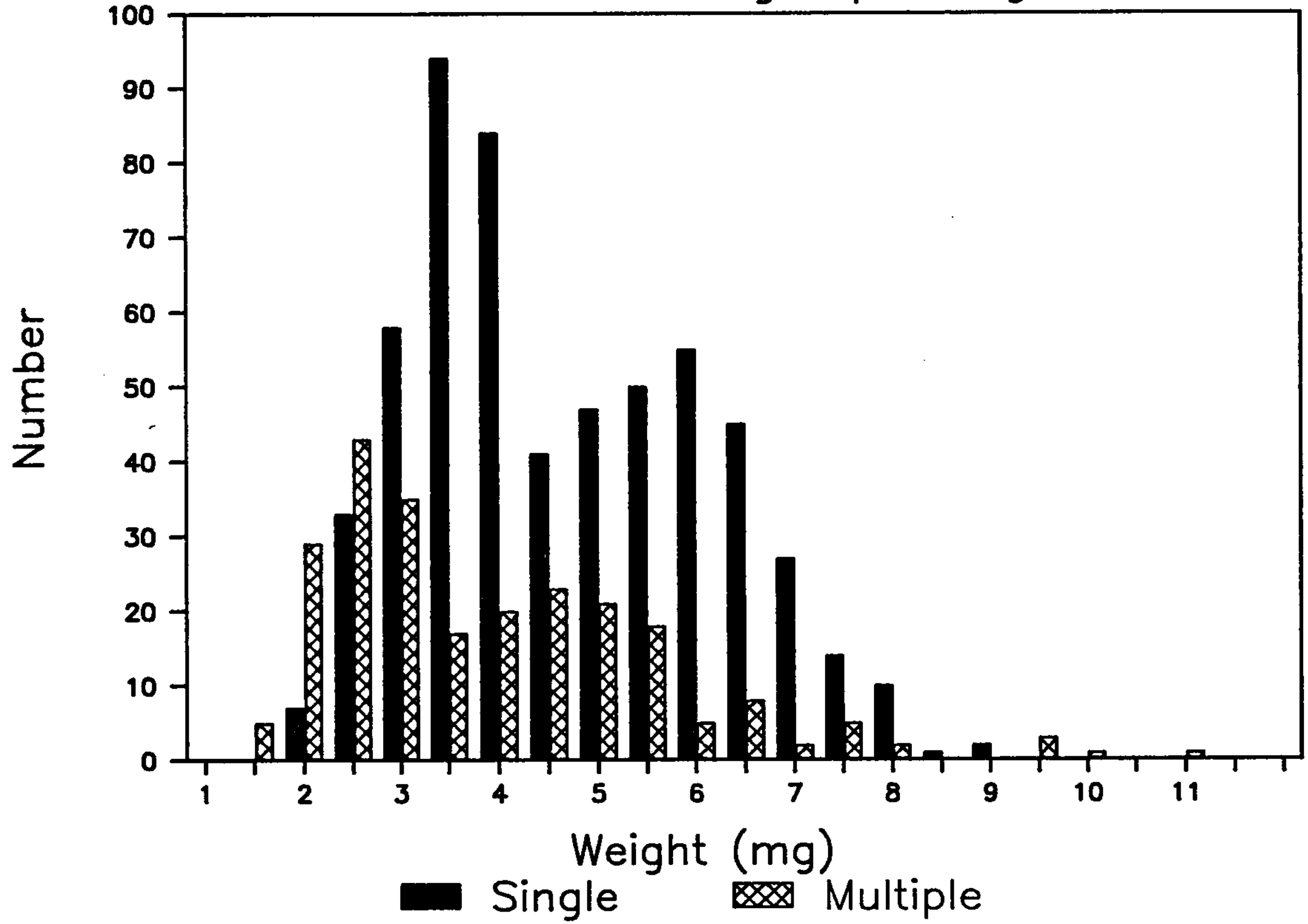
Weights of newly mated queens collected in the field.

QUEEN TYPE	MONTH	N	MAXIMUM	MINIMUM	MEAN WT. (mg)
Multiple	May	324	18.5	7.1	13.2
Multiple	June	148	16.1	4.4	13.7
Single	May	842	18.9	12.2	15.4
Single	June	777	19.5	4.4	14.5
Single	July	599	16.6	5.9	13.5
Single	August	544	15.7	6.3	12.5
Single	Sept.	199	18.6	10.6	15.0
Single	Feb('88)	473	15.66.	6.6	11.1


Weights of queens collected from single
and multiple queen mounds by traps.
Number
24
22
20
18
16
14
12
10
8
6
4
2
0
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Weight (mg)
SINGLE
MULTIPLE

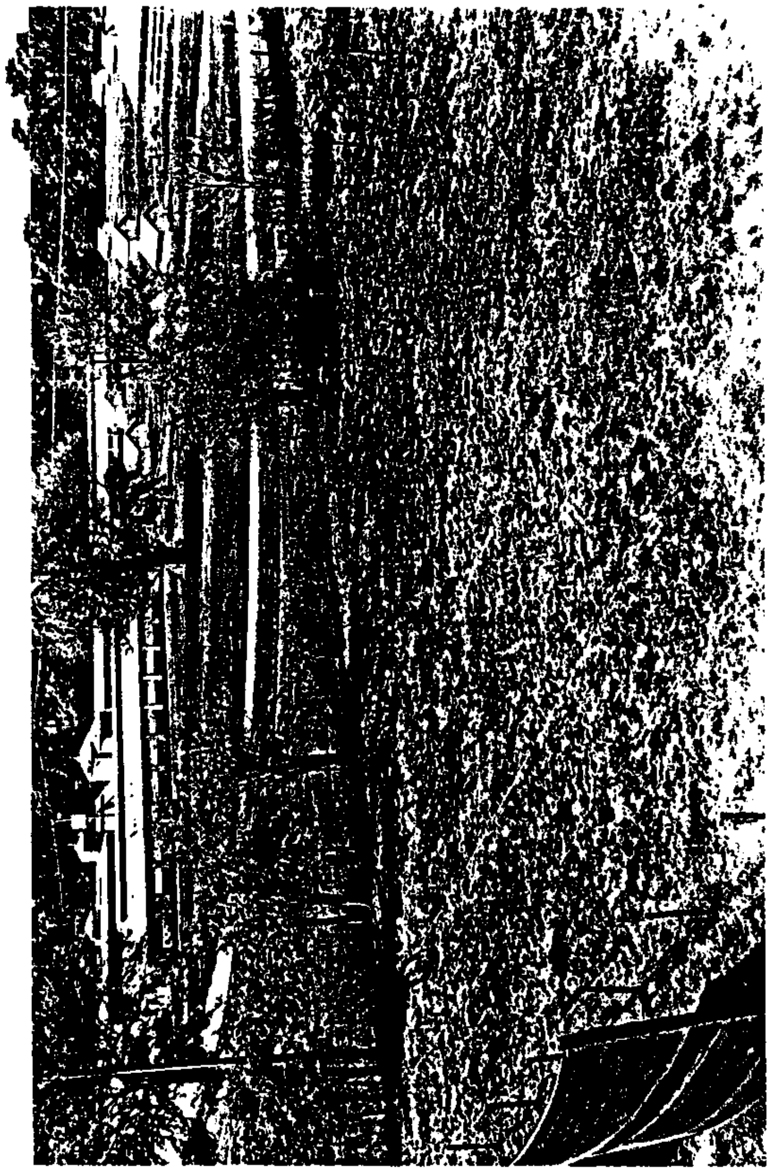

Head widths of alates trapped from
single and multiple queen mounds. 1987.
Number
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1.33
1.35
1.37
1.39
1.41
1.43
1.45
1.47
1.49
1.51
1.53
Head width (mm)
SINGLE
MULTIPLE

Weight of male alates collected by trap over a mound during nuptial flight.



HEAD WIDTHS AND WEIGHTS OF ALATES COLLECTED BY TRAPS FROM MOUNDS

ALATE TYPE	N	MAXIMUM	MINIMUM	MEAN WT.	MEAN HW.
			FEMALE		
Single	67	1.51	1.39		1.46
Multiple	40	1.51	1.35		1.43
Single	252	17.1	6.45	12.15	
Multiple	152	13.35	3.1	9.63	
			MALE		%Fertile
Single	567	8.75	1.66	4.47	94.4
Multiple	237	11.5	1.45	3.7	87.8



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HYBRIDIZATION PROBLEM (UNITED STATES)

The hybrid between S. invicta and S. richteri is reproductively viable and morphologically indistinguishable from S. richteri. We discovered the hybrid several years ago through species-specific venom alkaloids and hydrocarbons. The distinctions between the two species and their hybrid is clear.

Collections made in conjunction with other projects indicated that the hybrid population was much more extensive than originally thought. Consequently, in collaboration with APHIS we undertook an extensive survey whereby APHIS personnel collected samples from the intersecting points of a 20 km grid laid over the northern 2/3 of MS, AL, and GA. Most of the samples have been collected and about 1/2 of those analyzed. All the results will be in by our next meeting.

Interestingly, based on what we know about the S. richteri distribution from 1964 and 1984, it appears as though S. richteri is being out competed by its own hybrid and may have to be put on the endangered species list.

In conjunction with the hybrid problem we have a Graduate student, Sandra Toniolo, working on genetic aspects of the problem. We anticipate that her work will add significantly to some of the studies already done. For example, Sandra will report later on her interesting isozyme studies using workers rather then the more restrictive female sexuals.

Her work on mitochondrial DNA will provide information on the lineages of hybrid populations, introgression patterns in hybrid zones, and systematics.

Isozymes and nuclear DNA can provide information on taxonomic identification, systematics, and evolution.

We have used the knowledge we have accummulated in the areas of nestmate recognition and recruitment to get a better understanding of the interactions of the hybrid and the two parental forms.

In a recent review article Holldobler and Carlin (1987) state that successful competition in the foraging arena is largely dependent on recognition and an ant species recruitment stategy.

Nestmate recognitiopn studies between S. invicta, S. richteri and their hybrid showed no significant difference between the three groups. However, in intra group tests, the two species showed significantly less aggression than in the inter-specific tests. However, the hybrid was equally aggressive in both series of tests. This is good evidence of the greater variability in heritable nestmate recognition cues in the hybrid.

We also used the recruitment pheromone to provide behavioral evidence for hybridization. In one out of four types of bioassays the two species responded only to their own recruitment pheromone; however, the hybrid responded equally to its parents and its own recruitment pheromone. This represents behavioral evidence for hybridization.

As mentioned, we have used 4 bioassays to get at the workings of the recruitment pheromone. In terms of attraction, and orientation induction, S. invicta responds to both species pheromones, whereas, S. richteri responds weakly or not at all. It is not too difficult to see that S. invicta would have an advantage in the foraging arena because of this asymmetry. You might say that S. invicta is transparent to S, richteri but not vice versa.

This has some interesting implications in the early interactions of the two introduced species. Consider the following observations made over 30 years apart:

1) Wilson found that S. richteri was being out competed in the incipient colony stage.

2) Tschinkel reported that incipient colonies of S. invicta compete with each other via brood raiding, which is accomplished through trails. The incipient colony that succeeds in getting additional brood will develop faster then those that do not or those that suffer from deficiencies. This adoption of brood is intra-specific slavery that lasts only one generation.

If the asymmetry of the recruitment pheromone responses observed in mature colonies is also true for incipient colonies, then it is not unreasonable to hypothesize that S. invicta was capable of outcompeting S, richteri at the incipient colony stage due to the asymmetry of their recruitment pheromone responses. The resulting inter-specific slavery would also serve to increase the growth rate of the colony. Again the S. richteri slaves would exist only for the one worker generation.

We realize that there are many factors involved in the current distribution of the two species. This is only one possibility.

HYBRIDIZATION PROBLEM (SOUTH AMERICA)

The biochemical characters that we developed have been very useful in a wide variety of projects with S. invicta here in the United States. We applied these techniques to South American fire ants for several reasons. 1) We wanted to define the distribution of S. invicta and S. richteri in South America and where the two were sympatric look fo hybridization and 2) we wanted to use the biochemical characters as additional tools to be used in the taxonomic revision of S. saevissima. So far we have analyzed over 1000 samples. I would like to discuss just one of the interesting discoveries we have made, because it has a direct impact on our current thinking regarding the imported fire ants and their hybrid in the United States. S. richteri in the USA may be different from the specimens found around the type location of Buenos Aires.

A) Two chromatotypes have been found in the Argentina collections that are morphologically identified as S. richteri. B) The type location for S. richteri is Buenos Aires. C) The chromatotype from the Buenos Aires area does not match the United States S. richteri chromatotype. D) Although the two types occur within 20 km of each other, we find either one type or the other. There is no evidence for introgression (gene flow). Therefore, if this relationship holds up with further collections the S. richteri in the United States would need another name!

The U.S. chromatotype is found in a very restricted habitat and appears to be surrounded by other Solenopsis species with which it does not compete. This places it a great distance from the nearest S. invicta population. Since the two do hybridize in the United States, there are no mating or postmating isolation mechanisms. Based on our results thus far, the simplest pre-mating isolation mechanism is geographic isolation. We were just unlucky enough to have imported two geographically separated Solenopsis species that have not evolved mating or post mating isolation mechanisms--they didn't have to.

The real S. richteri chromatotype is distinctive because of the predominant cis and trans C11 alkaloids that were previously associated with the geminata and xyloni complexes. Although the trans alkaloids appeared in the past to correspond well to the Saevissima complex, it is now known to be not always the case. In view of this the complex scheme should be re-evaluated.

PHEROMONES

We have critically reviewed the brood pheromone literature and found the following: A) no reported research adequately proves the existence of ant brood pheromones; B) inter-specific adoption of brood occurs; C) the morphology of brood and their individual stages is distinctive; D) brood contribute in a positive way to colony nutrition; E) brood do not display agonistic behavior (aggressive action requires agonistic display by both parties). We propose an alternative to brood pheromones. Our hypothesis is that associative learning of a brood characteristic, such as morphology, behavior, or nestmate recognition cues coupled with a 'reward' obtained by the workers from the brood (queen specific food) is sufficient to explain the preferential treatment of brood by workers. We hope that this stimulates renewed interest in brood pheromones.

We have finally, unambiguously determined that the queen deposits material on eggs laid, by removing the eggs directly from the queen as they were laid. I will not go into details now, but this work has implications in several areas: A) benefits to the eggs; B) caste determination; C) evolution of Hymenoptera; and D) disemination of semiochemicals (i.e. for nestmate recognition cues, control of reproductives).

We have a good descriptive idea of the egg laying mechanism, as a result of direct egg-by-egg observations of queens over two hour time periods. For example, the rate of laying is very regular, rather then in clumps.

The weights of queens were measured in all of our studies, which allowed us to look at several other possible correlations. For example, we can estimate that it requires about 12 polygyne queens to lay an equivalent number of eggs as a physogastric monogyne queen.

Much effort is currently being expended on the application of queen and trail pheromones toward making fire ant baits more species-specific. We should have some definitive results next year.

NESTMATE RECOGNITION STUDIES

Our nestmate recognition work has complimented many of the other areas of research. I would like to spend a little time discussing how we think it works.

In general, there are two interacting facets of nestmate recognition- A) nestmate recognition cues: these are certain chemicals on the surface of every individual; and B) the template- The template is the pattern of chemical cues that are learned by an individual and associated with nestmates. This template is compared in some way with the detected cues on an encountered intruder. If the template and cues match everything is fine. If not, agonistic behavior is displayed.

I like to define colony odor as all odors associated with the colony. These can be derived from environmental or heritable sources. Some ant species use chemical cues from one or the other cue sources or from both. Unfortunately, the fire ant uses both environmental and heritable recognition cues. Heritable cues, called discriminators, can come from workers or queens. We determined that queens do not play an influencing role in fire ant nestmate recognition, and that the worker discriminators are the most important source of heritable cues. This is in sharp contrast to Camponotus species and to prevalent theory that puts the queen in the drivers seat.

We have established that heritable colony markers; i.e. hydrocarbons, change with time. Using this as a model for heritable nestmate recognition cues, we conclude that they are dynamic rather than static. Environmental cues are also dynamically changing, therefore the worker nestmate recognition cues are continuously changing! It follows that the worker template must be continuously updated. We call this an iterative learning process.

Several studies have dealt with polygynous S. invicta. We found that polygyne S. invicta workers do not recognize neighbor nest workers, or monogyne workers as different. The fact that they display a full aggressive response to S. richteri indicates that they are not generally less aggressive. These results have implications regarding the netsmate recognition mechanism. The aggression bioassay was demonstrated to be an excellent method for determining if a colony was polygyne of monogyne with a minimum disturbance to the colony. In blind tests 100 percent of the colonies were correctly assigned.

Other studies have established that in the laboratory polygyne nest workers are more aggressive toward each other and monogyne workers. This may be indicatative of the loss of interactions with the other matrilines and patrilines of the field population. We also established that as in the monogyne system, environmental factors can influence nestmate recognition in polygyne populations.

With this as background, we developed a mechanistic model that explains the results. For monogyne and polygyne populations we environmental factors can vary both qualitatively and quantitatively. In this two dimensional projection there are an infinite number of points. At any given time the environmental component of a colony's nestmate recognition cues are represented by a point. The heritable cues, however, are variable only in a quantitative sense. There are an infinite number of points on this one dimensional line. At a given point in time the heritable nestmate recognition cues of a worker are represented by a point on the line. In terms of nestmate recognition cues, polygyne and monogyne workers are not different, they will always be represented by discrete nestmate recognition cues. We propose then that the templates of the two forms are different. An emerging polygyne worker comes in contact with multiple matrilines and patrilines as well as more numerous envirnmental cues due to social interactions on a population level rather then at the nest level. The template of the polygyne worker has a broader window of acceptable variation when compared to the template of monogyne workers.

PROGRESS IN FIRE ANT SEMIOCHEMICALS- 1987/1988

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HYBRIDIZATION PROBLEM (UNITED STATES)

Lofgren, C. S. et al. **A Population Survey of S. invicta, S. richteri and Their Hybrid.**

Toniolo, S. et al. **Comparison of Electrophoretic Patterns in Workers of Solenopsis invicta, S. richteri, and their Hybrid.**

Toniolo, S. et al. **Mitochondrial DNA and Differentiation of Hybrid Fire Ant Populations.**

Toniolo, S. et al. **Nuclear DNA and the Differentiation of Hybrid Fire Ant Populations.**

Obin, M. S. and Vander Meer R. K. **Between and Within Species Recognition Among Imported Fire Ants and their Hybrid: Application to hybrid Zone Dynamics.** J. Chemical Ecology - SUBMITTED.

Vander Meer, R. K.; Lofgren, C. S.; and Alvarez, F. M. **Behavioral Evidence for Hybridization between the Fire Ants, Solenopsis invicta and S. richteri** - Submitted to the Journal of Insect Behavior.

Vander Meer, R. K. and Lofgren, C. S. **Separation of S. invicta and S. richteri in the foraging arena and implications on their population dynamics in the United States.**

Vander Meer, R. K.; Lofgren, C. S.; and Alvarez, F. M. **A chemical basis for the separation of S. invicta and S. richteri in the foraging arena.**

HYBRIDIZATION PROBLEM (SOUTH AMERICA)

Vander Meer, R. K.; et al. **A Biochemical and Morphological Survey of Fire Ants in South America.**

Vander Meer, R. K.; et al. **The Black Imported Fire Ant: Will the Real Solenopsis richteri Please Step Forward!**

Ross, K.; Vander Meer, R.; and Trager, J. **A Comparison of Biochemical, Genetic, and Morphological Characters in Defining Populations of Fire Ants, Solenopsis saevissima Complex, in Agentina.**

PHEROMONES

Morel, L. and Vander Meer, R. K. **Do Ant Brood Pheromones Exist?** Ann. Entomol. Soc. Am., Forum sect. - IN PRESS.

Vander Meer, R. K. and Morel, L. **The Implications of the Use of the Sting and Associated Glands in the Egg Laying Mechanism of the Ant Solenopsis invicta.**

Morel, L. and Vander Meer, R. K. **The Egg-Laying Mechanism of Solenopsis invicta.**

Morel, L. and Vander Meer, R. K. **The Role of Weight and the Number of Queens in the Egg-Laying Rate and Queen Pheromone Release in the Ant, Solenopsis invicta.**

The Solenopsis invicta Queen Attractant Pheromone: Isolation from the Queen's Poison Sac Contents.

Isolation of Additional Attractive Queen Pheromone Components from the Poison Sac of the Fire Ant Queen.

An Improved Synthesis of the Solenopsis invicta Queen Produced Attractant Pheromones.

Isolation of the Queen Attractant Pheromones of Solenopsis richteri.

Incorporation of Attractant Queen Produced Pheromones and/or Recruitment Pheromones into Fire Ant, S. invicta, Bait Formulations.

Elucidation of the Chemistry of the Orientation Inducer Pheromone of S. invicta.

Attractants and Repellents for Fire Ants.

MYRMECOPHILES

Vander Meer, R. K., Jouvenaz, D. P., and Wojcik, D. P. **Chemical mimicry in a parasitoid (Hymenoptera: Eucharitidae) of fire ants (Hymenoptera: Formicidae).** J. Chem. Ecol., submitted for publication.

NESTMATE RECOGNITION STUDIES

Obin, M. S. and Vander Meer, R. K. **Sources of nestmate recognition cues in the imported fire ant Solenopsis invicta Buren (Hymenoptera: Formicidae).** Animal Behaviour - IN PRESS.

Obin, M. S. and Vander Meer, R. K. **Template-label matching mechanism mediating fire ant nestmate recognition (Hymenoptera: Formicidae): Experimental analysis using diet-derived cues.** Annals of the ESA - IN PRESS.

Obin, M. S. and Vander Meer, R. K. **Nestmate recognition in Solenopsis invicta Buren (Hymenoptera: Formicidae): Do Queens Label Workers?** Annals of the ESA - IN PRESS.

Vander Meer, R. K., Saliwanchik, D., and Lavine, B. **Nestmate Recognition in Fire Ants: An Iterative Learning Mechanism.**

Vander Meer, R. K., Lavine, B., and Saliwanchik, D. **Intra-Colonial Differences in the Volatile Gas Chromatograph Patterns of Fire Ant Temporal Castes.**

Morel L., Vander Meer, R. K., and Lofgren, C. S. **Comparison of Nestmate Recognition Between Monogynous and Polygynous Populations of the Fire Ant, Solenopsis invicta Buren.** ESA-ANNALS - SUBMITTED.

Obin M. S., Morel, L., and Vander Meer, R. K. **Nestmate and Species Recognition in Polygynous Fire Ants, Solenopsis invicta, in Laboratory Colonies.**

Vander Meer, R. K. and Morel, L. **Comparison of Nestmate Recognition Abilities of Polygynous Solenopsis invicta Populations from Widely Separated Locations. - La Grande Experience.** The data is in!

Nuptial Flights of Monogynous and Polygynous Colonies of Red Imported Fire Ants

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More than 15 years have elapsed since Glancey et al. (1973) reported the occurrence of multiple fertile queens in colonies of the red imported fire ant (RIFA), Solenopsis invicta Buren. Multiple queen populations are now known from 8 of the 11 infested states, but unfortunately, our understanding of the multi-queen phenomenon in the fire ant is still very fragmentary.

We began a series of studies at the Gainesville laboratory in 1987 to add to the growing log of information on polygyny in S. invicta. Nuptial flight studies were included as a part of this research.

Three sites, that were at least five miles apart, where both monogynous (M) and polygynous (P) colonies were present in fairly close proximity were located in Alachua Co., Fla. Colonies were identified as M or P on the basis of mound density, size distribution of workers, and the presence or absence of numerous de-alated females.

Flight activity of both monogynous and polygynous nests of RIFA was monitored from early May through late September with alate traps, modified from the design of Morrill and Whitcomb (1972) (Fig. 1).

The traps were set in place on May 7 and 8. No-Pest strips (dichlorvos) were taped to the inner top of the plastic jars that were inverted over the top of the traps to serve as a killing agent. The traps were checked on Monday, Wednesday, and Friday of each week and any captured alates were removed, placed in small plastic cups and returned to the laboratory. Representative samples were removed for various examinations by Dr. Glancey and the remainder was frozen for later sorting as to number and sex.

The data (Table 1) shows that, with the exception of the polygynous colonies at one location, dates for beginning and ending of flights was about the same for both types of colonies. The number of intervening days on which flight occurred was much higher for the single queen colonies at all three locations than for the multiple queen colonies. At location 3, flight from multiple queen colonies occurred only once and only one nest was involved in that flight.

The number of females captured was considerably lower than the number of males except at location 1, where the number of males and females was about equal for the monogynous colonies and the females outnumbered males about 3 to 1 in the polygynous colonies.

The results from these studies are in line with the findings of Vargo and Fletcher (1987) that polygynous colonies produce fewer alates than do monogynous colonies of similar size.

The small total numbers of alates captured was rather surprising, particularly for the monogynous colonies. In a similar study in 1986, conducted only with monogynous colonies, we captured larger numbers from a single mound in one flight (12863 males, 8768 females) than was collected for all flights during the 1987 study. A total of 84031 males and 72650 females was captured in 1986 in 10 traps from May through August.

Two factors may have been involved in the smaller catches in

1987, an extended drought from late March through May reduced the number of alates produced in all colonies during the summer of 1987. Secondly, the high concentration of dichlorvos in the jar may have reduced the number of alates that flew up into it and were thus captured. A mixture of 50:50 isopropanol and ethylene glycol with a few drops of detergent was used in the traps in 1986, however, this solution made internal tissues of the alates brittle and very difficult to dissect and study, thus was not used in 1987.

Another problem that made the trap studies difficult was the tendency of colonies to move from beneath the traps. Every trap in the 1987 study was relocated at least once during the 135 days and one trap was relocated 17 times. Efforts were made to the extent possible to locate the same colony when relocating the trap , however, it was not always possible to do so.

The results of the study emphasize the need to conduct additional studies to more clearly define differences in flight activity of monogynous and polygynous RIFA colonies. Success of such studies may require modification of trap design to reduce colony movement and use of other killing agents that will not inhibit entry of the alates into the catch area.

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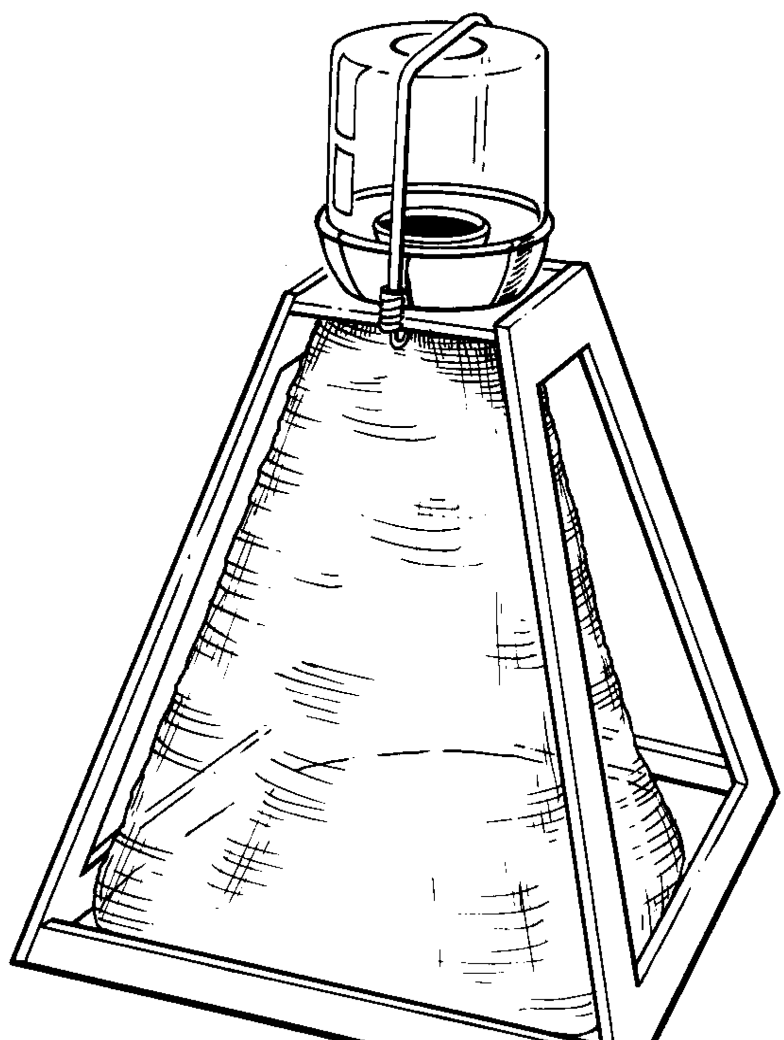
Table 1. Alate Trap Studies of Mating Flight Activity In Monogynous and Polygynous Colonies of Red Imported Fire Ants, Alachua Co., FL. 1987.

	Colony type and location					
	Monogynous			Polygynous		
	1	2	3	1	2	3
Date 1st flight	6/7	6/2	6/7	6/7	6/4	6/30
Date last flight	8/21	8/21	8/21	8/13	8/21	6/30
No. Days w/flight	12	19	15	8	4	1
Min./max No. alates/flight						
Males	0/408	0/1231	0/535	0/171	0/72	190
Females	0/437	0/64	0/37	0/341	0/6	12
Total alates for season						
Males	1812	5906	2787	356	86	190
Females	1669	276	122	1034	10	12



COMPARISON OF ELECTROPHORETIC PATTERNS IN WORKERS OF *Solenopsis invicta*, *Solenopsis richteri* AND THEIR "HYBRID".

SANDRA R. TONIOLO

Studies of enzyme systems controlled by alleles at a single locus provide information about genetic variation in natural populations. These studies make possible the measurement of the amount of genetic differentiation between populations.

Our objective was to identify diagnostic loci in workers of *Solenopsis invicta*, *Solenopsis richteri* and their "hybrid".

Colonies of the monogyne *S. invicta* were collected from areas around Gainesville, FL.; *S. richteri* and "hybrid" colonies were obtained from Columbus MS. and Pickweek TN.

Electrophoresis was conducted on horizontal starch gels and vertical system.

Nineteen enzyme systems were studied in individual workers from 15 colonies of *S. invicta*, 10 colonies of *S. richteri* and 5 "hybrid" colonies.

As show in this slide, 17 in 19 enzyme studied with 28 loci were monomorphic in these taxa.

In the next slide the enzymes Phosphoglucose isomerase (PGI) and Esterase (EST) varied between *S. invicta* and *S. richteri*. In column one as show here PGI has two alleles 100 and 91 with I fixed for allele 91, and R fixed for allele 100 and hybrid as you see contain both alleles.

In Est-2 there are 3 alleles: the most common allele in I is equal to 100; R is fixed for 90; and H has 84 and 100 but no 90 which is hard to explain because if hybrid taxon is in fact a cross between IxR one wonder what happened to allele 90. The only that can be is that the hybrid may have lost 90 by genetic drift or sampling error.

Estera-1 has 3 alleles; its fixed in Solenopsis richteri (100), S. invicta has 84, 100 and 106 and hybrid has both parental types alleles.

As show in this slide heterozygotes of PGI have 3-band electromorph patterns typical of dimeric enzymes, and Esterase has a two-band heterozygotes which is typical of monomeric enzymes.

Table 3 shows diagnostic value of Est-2 and PGI, both can be used to discriminate S. invicta and S. richteri; these species can be distingueshed by using PGI electromorph with a probability of 100% and Est-2 with 97.75% of probability.

The advantage of the electrophoretic technique is that variation in the banding pattern can be directly equated to variation in the gene coding for the variant proteins. Also, it makes possible to estimate the degree of genetic divergence at a number of loci coding for enzymes or other proteins without having to make fertile crosses.

The results for PGI show evidence of introgression between S. invicta and S. richteri.

We will be extending these isozyme studies to more populations of I:R:H in the distribution range of these taxa to see:

1. if here are ecological/geographical differences in allelic distribution;

2. to genetically figerprint populations and analyse

introgression;

3. to study the phylogenetic relationship within I:R:H in mitoDNA.

IR-4 RESIDUE STUDIES FOR THE REGISTRATION OF LOGIC FOR CONTROL OF IMPORTED FIRE ANTS IN POTATOES AND SOYBEANS

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During the past ten years, our laboratory has led the way in the development of at least seven chemical bait toxicants. Four of these have now reached the marketing stage. However, it has been a disappointment to us that none of these baits are currently registered for agricultural use even though there is growing evidence that fire ants cause significant damage to a number of fruit and nut trees, row crops, and vegetables. At a meeting we had with our counterparts in APHIS, USDA last fall, we had some discussion about this, and finally came up with a conclusion that we would like to see if something could be done for getting some registrations through the IR-4 program. There are some reasons why these baits have not been registered for agricultural use. One of the main ones is the cost of developing residue data for registration through EPA. Also, there has been the question of economics, i.e., whether or not any one of these baits, if registered, would end up paying off the cost of getting them registered.

I would like to review some of the evidence we have for economic damage using slides. In young citrus trees, ants build mounds around their base and chew away the bark resulting in death of the tree. We have even found them feeding on the young citrus fruit itself. When our data on young citrus trees is plotted, it shows a direct correlation in the number of dead trees and the density of ants. In discussions yesterday with people from MAAG Agrochemical, they now have a registration for Logic in citrus and the bait is being accepted very well by the growers. This is good news to us, but represents only one crop.

Okra of course is a minor crop in the south. Ants feed around the flower which results in misshapen pods. Egglants are damaged dramatically in some cases from feeding on the plant crown. In one field, 50% of the plants were lost. Corn plants occasionally will be found with the roots eaten off. Soybeans can be severely affected by fire ants. We have conducted work in Gainesville investigating the growth and yield of soybeans subjected to fire ant predation and have found definite reductions in yield. Fire ants may feed on the roots and root hairs of the growing plants and reduce plant stand. Also, at harvesting time, mounds are a problem causing loss of yield, and damage and wear to harvesting equipment.

Chuck Apperson at North Carolina State also reported that fire ant activity decreased yield of soybeans during the years 1979 and 1980. Our work conducted in Gulfport and Gainesville showed that the number of plants per meter row was reduced in infested fields vs. non-infested fields resulting in about a 5 bu/acre difference. Al Banks and Claude Adams of our laboratory conducted a survey in six of the southern states in which they randomly selected two fields in each of the counties they entered and determined the average mound density of fire ants after harvest. They found a large number of fire ant mounds in the soybean fields ranging from an average of 34.5 to 52.4 mounds per acre. Even if only a small percentage of the actual soybean acreage is affected by fire ants, the losses can run into millions of dollars in the South since the average yield is reduced by about 5 bu per acre.

Work near Hastings, FL with potatoes showed definite scarring by the fire ants. This damage reduces the market quality of the potatoes and can result in major economic losses. A paper on this subject will be published in the J. Econ. Entomol. in 1988.

The IR-4 program is federally funded with its national offices at Rutgers University. It ties together researchers in pesticide development on minor crops with pesticide residue laboratories, the Environmental Protection Agency, and the various chemical companies. Dr. Paul Schwartz with the Pesticide Assessment Laboratory, ARS, USDA in Beltsville, MD, is our contact person for involvement in this program. Potatoes and soybeans were chosen as two crops with which to work. We selected the baits Amdro, Logic, and Affirm for evaluation. However, American Cyanamid and Merck, Sharpe, and Dohme were not interested in pursuing IR-4 registration of Amdro and Affirm at present. MAAG Agrochemical was willing to work with us using Logic. Our proposed treatment schedules were sent to the IR-4 committee and reviewed in early December. Our proposals were accepted and Dr. R. D. Walkup, a chemist with the ARS Water Quality Laboratory in Tifton, GA, was designated as our cooperating chemist.

In early January, Al Banks (Study Director) and I began to get acquainted with Good Laboratory Practice regulations and standard operating procedures required for the studies. With the help of Dr. Schwartz and others, some generic SOP's were adapted for our needs. About 15 different items were covered including a general section, personnel, personnel requirements, pesticide use and storage, equipment and equipment calibration, agronomic practices, pesticide application procedures, data handling, sample handling, reporting, secure archives, quality assurance, pesticide disposal, and safety and health.

Small plots, 25 ft x 25 ft, will be used in these studies. Treatment rates will be 1.5, 3, and 15 lbs/acre of Logic with two applications; one 45 days before harvest, and the second at 15 days before harvest. The trials will be conducted at four different locations: Tifton, GA, with the help of Dr. Craig Sheppard and Dr. Don Canerday; Dillon, SC, in cooperation with Bob Epley, USDA/APHIS; Angie, LA, with the help of Homer Collins; and Gainesville and Hastings, FL. Al Banks has applied the 45 day application at Hastings, FL, with another application expected this week in Gainesville. Since the work is just getting underway, we don't have any data to share with you yet. But, as some of the crackers down in Florida say, "If the good Lord is willing, and the creek don't rise," by next year at this time, we will have some residue data for Logic in soybeans and potatoes to share with you.

Survey for biocontrol agents in Brazil - a final report, with comments on preliminary research in Argentina.

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The information presented here is the result of the combined efforts of Mr. Leocadio T. Gondim de Lima, Mr. Antonio C.C. Pereira, and Mr. Aurelio C. Campos, formerly our resident entomologists in Brazil, and Dr. D.P. Jouvenaz, Mr. W.A. Banks, Dr. D.F. Williams, Dr. C.S. Lofgren, and myself. These data are complete through the end of 1986, when this phase of the project ended. The distribution of the fire ant species in South America as shown on a map by Buren et al. (1974) is still generally correct. The taxonomic studies of Dr. J.C. Trager (University of Florida, unpublished) and the finding of hybrid crosses between Solenopsis invicta and S. richteri in the United States (Vander Meer et al. 1985) will probably alter our concepts of fire ant taxonomy and distribution in South America.

In February 1984, as a result of a cooperative agreement between the USDA-ARS and EMBRAPA (Empresa Brasileira de Pesquisa Agropecuaria), we established a laboratory at the EMPA-MT

[a]This paper presents the results of preliminary research only and will be published later through established channels with appropriate editing. This paper and data should not be referred to in literature citations until they appear in press.

(Empresa de Pesquisa Agropecuaria do Estado de Mato Grosso S/A) Research Station in Cáceres, MT, Brazil. The main emphasis of the project was to survey for and evaluate the natural biological control agents of fire ants, primarily S. invicta in Brazil. The survey was conducted by examining fire ant nest samples for pathogens, parasites, and myrmecophiles. Standard size-samples of 2-1/2 liters of tumulus excavated from fire ant mounds were placed in buckets. The ants and myrmecophiles were separated from the soil by flotation with water (Jouvenaz et al. 1977). The ants were examined for pathogens by mascerating samples of mixed workers and brood in a tissue grinder and examining a sample of the liquid with a microscope (Jouvenaz et al. 1977). After the myrmecophiles were separated from the soil, they were preliminarily identified, labeled, and preserved. Properly labeled taxonomic samples of all ant colonies examined were preserved.

As of the end of December 1986, when this phase of the project ended, 1502 fire ant colonies had been processed in the natural enemies survey in Brazil. Most of the colonies were collected within 100 km of Cáceres. Some of samples were also collected around Cuiabá and along the Transpantaneira highway from Poconé to Porto Jofre in MT. About 150 colonies were collected around Campo Grande, MS. Multiple collections of pathogens and myrmecophiles were commonly collected from and a single colony. Although the data have not been analyzed statistically, we have thus far not found any evidence of a correlation between any pathogens and /or myrmecophiles. When sufficient myrmecophiles were found in a nest sample which contained pathogens, samples of the myrmecophiles were also examined for pathogens. These obligate myrmecophile - fire ant relationships would, of course, constitute an ideal mechanism for alternate host transmission of fire ant pathogens.

The totals and percent of each pathogen and myrmecophile collected during the 30 months (July 1984 through December 1986) the survey was conducted are given in Table 1. About 525 colonies did not contain any pathogens or myrmecophiles. Each pathogen and myrmecophile collected during the survey will be discussed briefly. Preliminary reports on this survey were published by Wojcik et al. (1986, 1987a, 1987b).

The microsporidia, Thelohania solenopsae (Protozoa: Microspora: Thelohaniidae) can be recognized by the large cysts in the adult ants. The biology of this dimorphic pathogen is summarized by Jouvenaz (1986). Both types of spores are found in immature and adult ants. It is not known if the same species of pathogen is present in all fire ant species in South America as was previously assumed (Jouvenaz et al. 1980) or if sibling species are present (Jouvenaz 1986). We do not know how this disease is transmitted in nature and we have had limited success in transmitting it in the laboratory. The 2.1% collection rate was lower than expected as previous work had indicated higher levels of this disease (Jouvenaz et al. 1980, Jouvenaz unpublished).

A second species of microsporidia, Vairimorpha invictae (Protozoa: Microspora: Burenellidae) (Jouvenaz and Ellis 1986), was found in 5.5% of the collections. It is dimorphic with both kinds of spores being found in immature and adult ants. It does not produce large cysts. Attempts to transmit this pathogen have not been successful.

The neogregarine, Mattesia geminata (Protozoa: Neogregarinida: Lipotrophidae), infects S. geminata in Florida and S. invicta and other Solenopsis spp. in Brazil. The biology is summarized by Jouvenaz (1986). The spores are found only in the immature stages of the ants as the infected individuals die in the pupal stage. Limited intra-colonial transmission has been achieved with this pathogen in the laboratory. The 5.4% infection rate is the highest ever recorded for this pathogen.

The nematode, Tetradonema solenopsis (Nematoda: Mermithoidea: Tetradonematidae), was found in 1.8% of the collections. Large gravid females and tiny males of this species occur in the gaster of the ants. These females appear to be almost entirely uterus. Large numbers of eggs and juvenile nematodes are usually present in the ants (these are the stages seen with the microscope). Up to 20 female nematodes have been found in one ant. They always occur in even numbers in each infected ant - implying parthenogenetic reproduction in the ant host. The known biology is summarized by Nickle and Jouvenaz (1987). Collections in August 1987 have extended the known distribution of this species into Mato Grosso do Sul (Wojcik and

Jouvenaz unpublished).

Several other pathogens including virus-like particles, 2 undescribed protozoans (probably a neogregarine and a haplosporidian), 2 fungi and a bacterium are known from fire ants in Brazil, but were not collected during this survey (Jouvenaz 1986).

Myrmecophilous beetles of the genus Martinezia (Coleoptera: Scarabaeidae) (previously placed in the genus Myrmecaphodius, Chalumeau 1983) were present in 25.8% of the collections. At least 5 species of this genus are present in Mato Grosso. One of these species, Martinezia dutertrei, is present in North America, and is known to be predacious on fire ant brood (Wojcik et al. in press). The small numbers of brood eaten and the low numbers of beetles, usually found in fire ant mounds, make the usefulness of this group in a biological control program questionable.

The myrmecophilous Histeridae (Coleoptera) collected from fire ant mounds are unidentified. Nothing is known about the biology of these beetles found in 20.2% of the collections.

Nothing is known about the myrmecophilous Chrysomelidae (Coleoptera) found in 0.1% of the collections.

The parasitic myrmecophilous wasps of the genus Orasema spp. (Hymenoptera: Eucharitidae) were very common being found in 38.7% of the collections. Although the average number of parasites collected was >20 per nest, one colony contained 634 Orasema spp. larvae, pupae, and adults. The biology of this species has not been studied, but is assumed to be similar to the other species which have been studied (Williams 1980). The females lay their eggs in plant tissue, the particular plant utilized depends on the wasp species. After the eggs hatch, the planidia (first instar larvae) are phoretic on worker ants. In the nest, the planidia leave the worker ant and bore into an ant larva. The planidia are endoparasitic probably until the host molts to the 4th instar or pupae. The parasite then becomes ectoparasitic. The ant pupae never develop into adults because of the feeding damage inflicted by the parasites. The host may or may not be entirely consumed, and the parasites may feed on more than on pupae. The partially consumed pupae, called phthisergates, may live for some time in the colonies and are diagnostic for Orasema spp. parasitism. The parasites are tended and protected by the host ants. The problem with using this parasite in a biological control program is that it lays it eggs in plant tissue and may cause cosmetic damage to commercial fruit crops, e.g. oranges (see Wojcik 1986).

The workerless obligate parasitic ant, Solenopsis (Labauchena) sp. (Hymenoptera: Formicidae), was found in 0.7% of the collections. We have collected the species only from the Campo Grande - Dourados area in MS. The host ants are probable not S. invicta (Trager and Vander Meer unpublished). Large numbers of males, alate females, and dealate females have been collected. This species has been hand-carried via USDA-APHIS permit to the Quarantine laboratory in Gainesville, but the survival rate was poor and no reproduction occurred.

Unidentified myrmecophilous bugs (Hemiptera: Lygaeidae) have been found in 1.3% of the collections.

Myrmecophilous Thysanura were collected from only 2.5% of the fire ant nests. These unidentified Thysanura are similar to species found in fire ant nests in North America, which are known to be predacious (Wojcik unpublished). They are probably under-represented in our samples because the ants are highly antagonistic towards the Thysanura and they do not survive the floating procedure well when large amounts of ants are present.

Unidentified myrmecophilous millipedes (Diplopoda) were collected from 14.1% of the fire ant nests in Brazil. A similar species is found in Florida and Georgia (Naves and Wojcik in press). The species in the United States is a scavenger.

Another group of myrmecophiles associated with fire ants in South America are flies of the family Phoridae (Diptera). Two genera, Pseudacteon and Apodicrania, are endoparasitic on fire ants (Williams 1980). One phorid puparium was dissected out of an alate S. invicta female (Wojcik et al. 1987c). This collection was not included in the data in Table 1, as we do not routinely dissect ants as part of the survey. The delicate structure of the flies and the extreme antagonism of the ants to the flies make it unlikely that these flies would be found in the floated nest samples. The flies can readily be collected hovering over worker ants attracted to baits (Williams and Banks 1987). In fact, they are the only myrmecophiles of fire ants which can be collected readily without using flotation to separate them from fire ant nests.

In future work in Brazil, we intend to emphasize the collection and colonization of the nematode, Tetradonema solenopsis, and the parasitic ant, Solenopsis (Labauchena) sp., for possible introduction into the United States.

Argentina

A team of 2 imported fire ant project scientists, D.P. Jouvenaz and D.P. Wojcik, visited the USDA Biological Control of Weeds Laboratory, Hurlingham, Argentina, for the first time in March and April, 1987. As a result of their evaluation, the decision was made to concentrate biological control research efforts there. In addition to the administrative and logistical advantages of a USDA laboratory located near our Embassy and the Argentine scientific community, Argentina offers distinct biological advantages. The climate is temperate and therefore the area is more comparable to that of the United States. This fact should facilitate studies of fire ant / arthropod enemy population dynamics and epizootiology. These studies are difficult to conduct in Brazil, for the ants are cryptic during the severe extended dry season. On a second trip by Jouvenaz and Wojcik in October and November 1987, Mr. Juan Briano, an argentine national, was hired to work on fire ant natural enemies at the UDSA laboratory in Hurlingham.

On our 2 trips to Argentina, 425 fire ant colonies were processed for natural enemies using the techniques described for the Brazil project; 175 colonies did not contain any natural enemies (Table 2). Most of the colonies were collected in Buenos Aires Province, with 50 colonies collected in Santa Fe Province and 34 colonies collected in Entre Rios Province.

All of the pathogens (except the nematode *Tetradonema solenopsis*) known from Brazil were observed in Argentina on the first trip. Two organisms, a previously unknown mermithid nematode and an endozoic, dimorphic fungus previously known only from the United States, were collected in Argentina. The presence of the fungus in Argentina and the United States, but not western Brazil, suggests that our fire ants were introduced from Argentina. Polygynous colonies (12 *S. richteri* and 4 *Solenopsis quinquecuspis*) were found in 8 locations in Buenos Aires Province (Jouvenaz et al. in manuscript).

Dr. D.P. Jouvenaz is now in Argentina setting up plots to enable us to monitor the long term effects of pathogens or myrmecophiles on fire ant populations. The pathogen plots will be sampled monthly for at least the first year. The myrmecophile plots will be sampled twice a year. After the plots are established and maintained for a period of time, additional studies will be initiated, particularly on the pathogenicity of the endozoic dimorphic fungus. Special emphasis will continue to be placed on the collection and culture of the parasitic ant, *Solenopsis* (*Labauchena*) sp., as we feel that this species has a high potential for use in an integrated pest management program in the United States. The pselaphid beetle was observed to be extremely attractive to the ants and will be studied in cooperation with our chemist to elucidate the nature of the attractant chemicals.

The ultimate goal of our South American projects is to establish, in the United States, a complex of specific natural enemies as a biological control component of an integrated pest management program for fire ants. Hopefully, these introduced natural enemies will exert continuing stress on imported fire ant populations and reduce the necessity for chemical control measures in some areas.

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Table 1. Summary of collection records for pathogens and myrmecophiles found in fire ant nests from Mato Grosso and Mato Grosso do Sul, Brasil, July 1984 through December 1986.

Organism	No. of Colonies	Infested %
Pathogen		
Thelohaniidae	32	2.1
Burenellidae	82	5.5
Lipotrophidae	81	5.4
Tetradonematidae	27	1.8
Myrmecophile		
Scarabaeidae	387	25.8
Histeridae	304	20.2
Chrysomelidae	2	0.1
Formicidae	10	0.7
Eucharitidae	581	38.7
Lygaeidae	19	1.3
Thysanura	38	2.5
Diplopoda	211	14.1
Total fire ant colonies	1502	100.0

Table 3. Summary of collection records for pathogens and myrmecophiles found in fire ant nests from Argentina in 1987.

Organism	No. of Colonies	Infested %
Pathogen		
Thelohaniidae	47	11.1
Burenellidae	9	2.1
Lipotrophidae	5	1.2
Mermithidae	2	0.5
endozoic fungus	9	2.1
Myrmecophile		
Scarabaeidae	64	15.1
Staphylinidae	40	9.4
Pselaphidae	66	15.5
Histeridae	29	6.8
Tenebrionidae	7	1.7
unidentified beetles	11	2.6
Formicidae	1	0.2
Bethylidae	2	0.5
Eucharitidae	7	1.7
Phoridae	33	7.8
Lygaeidae	101	23.8
Lepidoptera	2	0.5
Diplopoda	3	0.7
Total fire ant colonies	425	100.0

RECENT STUDIES ON GROWTH OF FIRE ANT COLONIES

ABSTRACT

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We have been carrying out laboratory studies in environmental chambers for more than 8 months on growth of fire ant colonies. This is in support of our developing a dynamic life table model of the Imported Fire Ant which we feel is essential for developing long-term integrated management strategies. Today, I will present some preliminary data of these growth studies. Following my talk, Dr. Dan Haile's presentation will bring you up to date on our progress with the imported fire ant life-cycle model.

More than 1000 newly-mated fire ant queens were collected near Gainesville, in Alachua County, Florida in 1987. One hundred queens each were set up in one of 6 environmental chambers ca. 7ft long, 3ft wide and 6ft high and maintained at one of the following temperatures; 24C, 27C, 30C, 32C, 35C and a fluctuating temp 28-32C. Also, each chamber was maintained at ca. 50% r.h. and 12hrs daylight photoperiod. Each queen was originally held in a 30ml cup and then transferred to larger containers as the colony grew in size. Colonies were maintained on diet of adult house flies, egg yolk, and honey-agar.

Once a month, beginning with the 2nd month of the study, 5 colonies were selected at random and removed from each chamber, placed in a freezer to halt growth, then perserved in alcohol until counts of all stages could be made. Total counts were made for the 2nd, 3rd, and 4th months, while for the remaining months, an aliquot part of each colony was counted.

Preliminary results based on 5 months data indicate that the weights(mg) of the newly-mated queens dropped drastically during the first 90 days of the study, but returned to slightly above or below their initial weight at 120 days. A dramatic increase was noted after 151 days (Fig.1). Also, all the queens held at 35C died within 90 days. Total colony growth at the other temperatures increased dramatically between 60 and 151 days; as expected the colonies maintained at 24C grew the slowest. At 5 months, colonies held at 30C and the fluctuating temp.'s 28-32 were the largest (Fig.2). However, these temperatures may not be the optimums for growth since rough estimates of the size of colonies remaining to be counted indicate that 27C may prove to be the best temperature. This may be related to low mortality of the queens at this temperature.

FIGURE 1
DIFFERENCES IN IFA QUEEN WEIGHTS

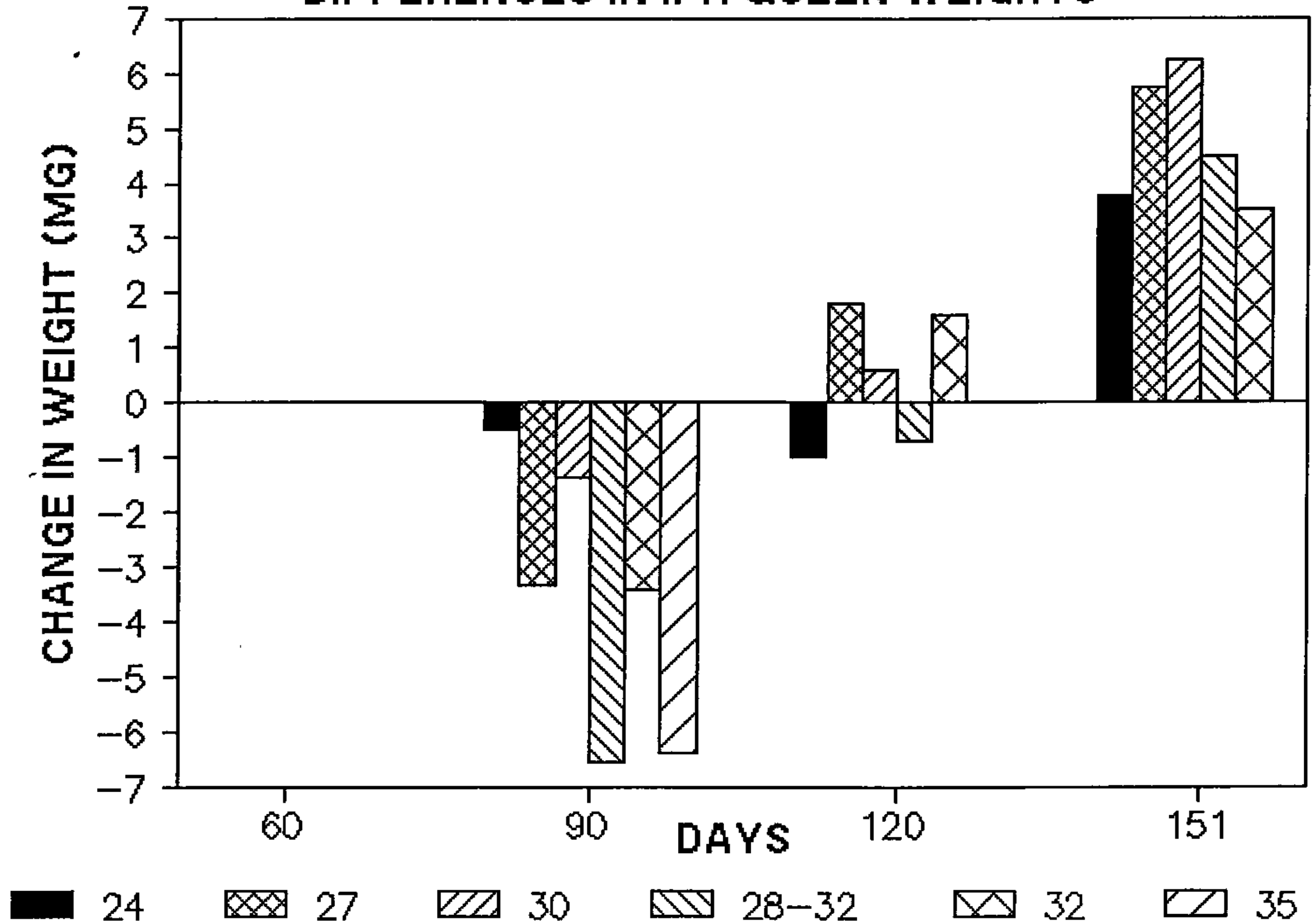
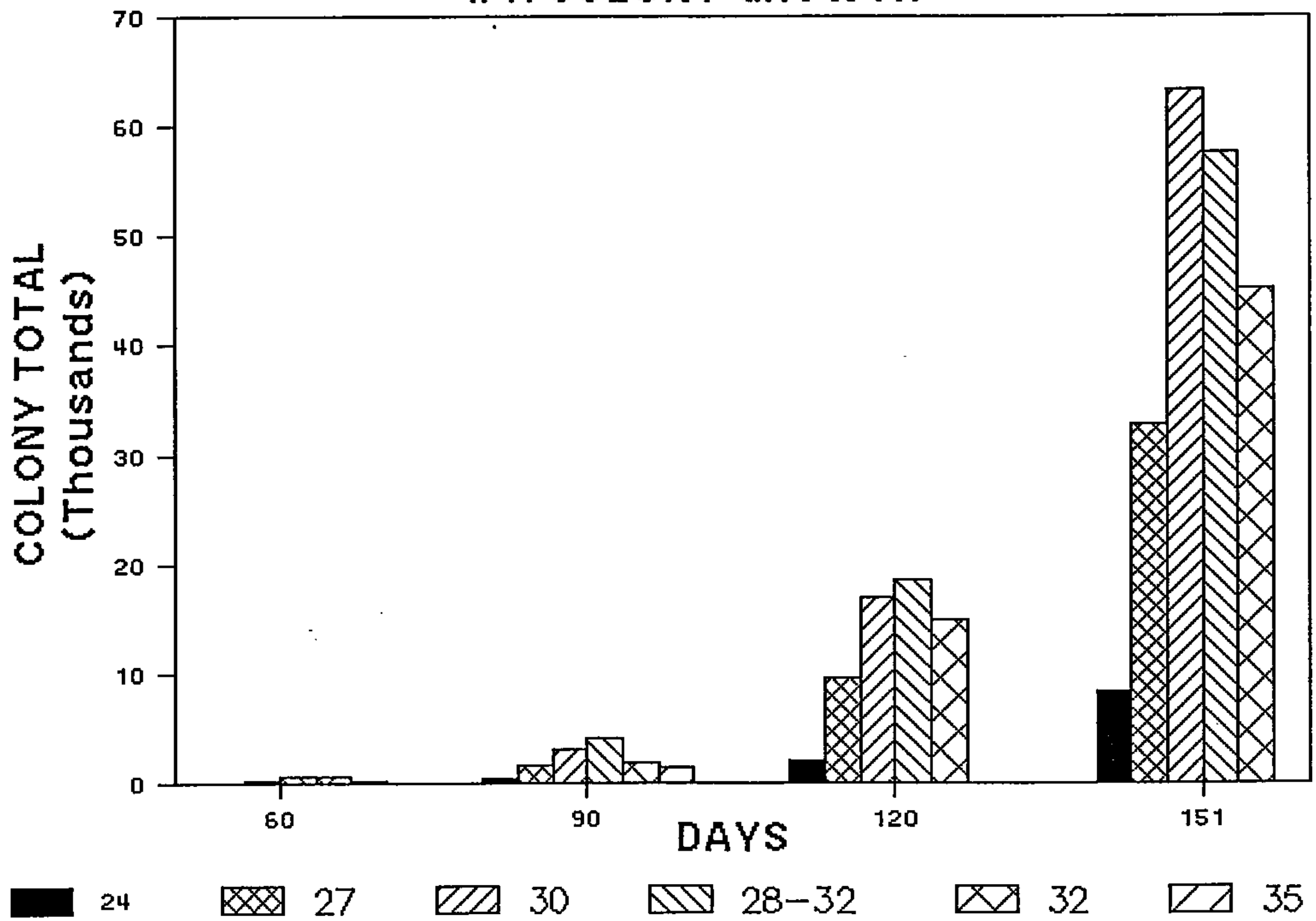


FIGURE 2
IFA COLONY GROWTH



COMPUTER SIMULATION OF THE POPULATION DYNAMICS OF THE IMPORTED FIRE ANT, SOLENOPSIS INVICTA

ABSTRACT

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A comprehensive computer model of the life cycle of the imported fire ant, (IFA), *Solenopsis invicta*, was developed to simulate the effects of major environmental variables on population dynamics of this social insect in various types of habitat. The life cycle of IFA (Fig. 1) is incremented in the model into weekly age classes and simulations are run with weekly time steps. The model incorporates (1) temperature-dependent development rates for eggs, larvae, and pupae; (2) the influence of habitat type, temperature, and precipitation on survival rates of all stages; (3) the effect of temperature and worker ant density-dependence on feeding rates; (4) density-dependent survival of colony-founding queens; (5) the effect of temperature and 4th instar larvae density on fecundity; (6) the production of alates influenced by temperature and season; and (7) the effect of temperature and precipitation on mating flights.

The model is programmed in Microsoft QuickBASIC for interactive operation on an advanced microcomputer system. Fig. 2 shows examples of the population dynamics output from the model for 3 years of simulation at Jacksonville, Florida, starting with a single cohort of new queens on week 16 of year 1. Presently refinements are being made on the model software and biological relationships. Validation studies will be conducted to compare model output with actual population dynamics at a variety of locations.

Figure 1

LIFE-CYCLE MODEL FOR THE IMPORTED FIRE ANT

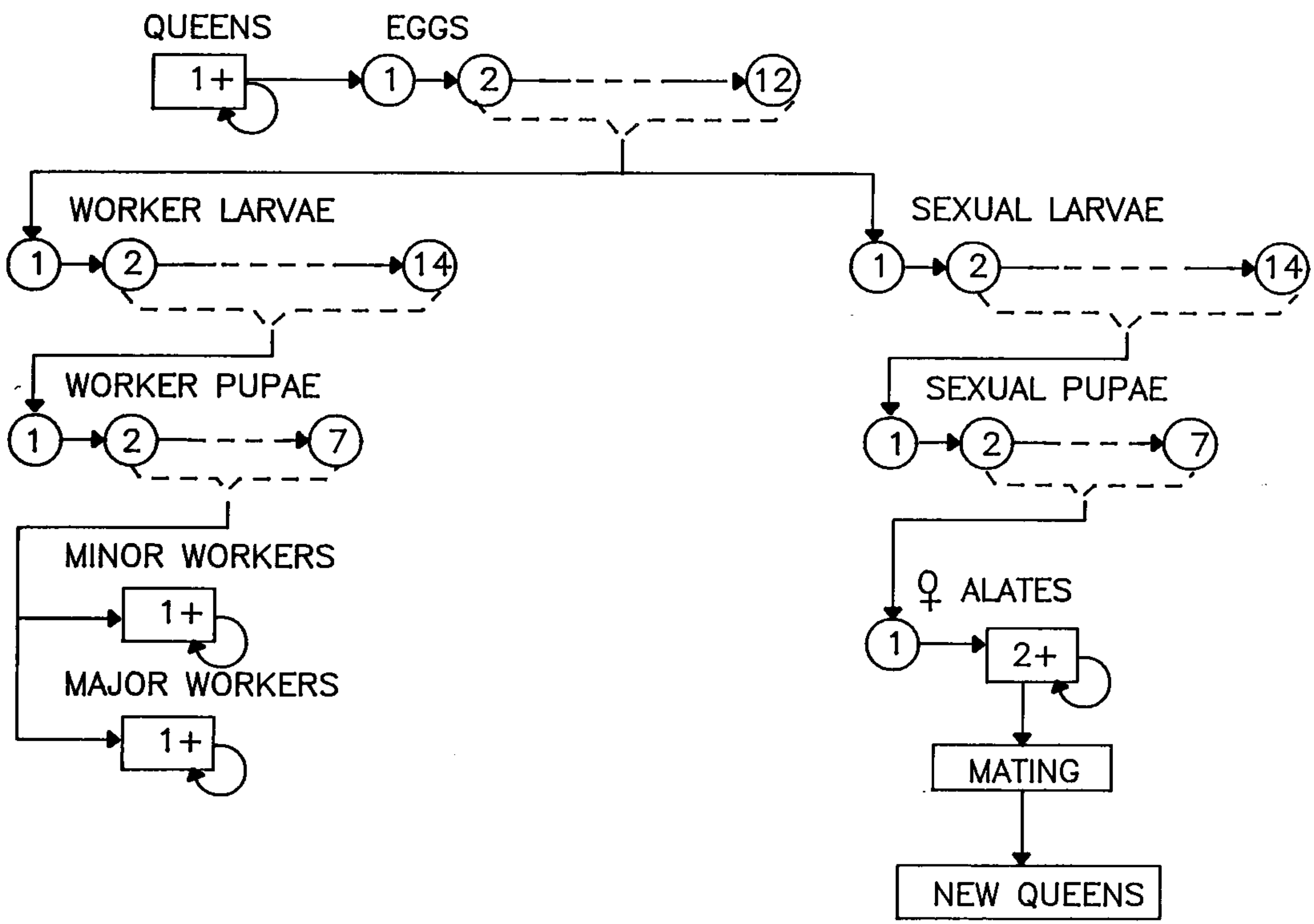
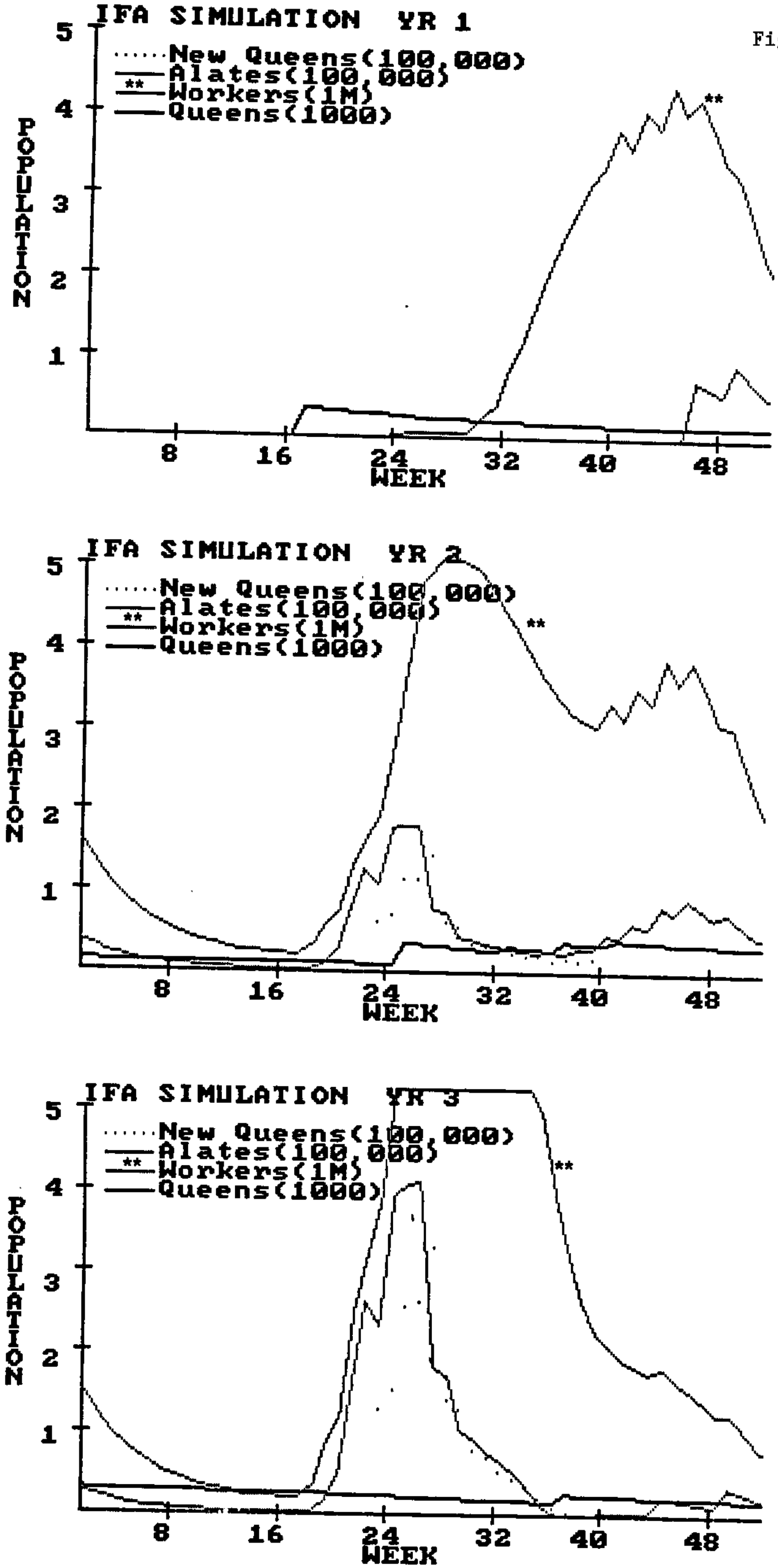


Figure 2


IFA SIMULATION YR 1
New Queens(100,000)
Alates(100,000)
Workers(1M)
Queens(1000)
POPULATION
WEEK
IFA SIMULATION YR 2
New Queens(100,000)
Alates(100,000)
Workers(1M)
Queens(1000)
POPULATION
WEEK
IFA SIMULATION YR 3
New Queens(100,000)
Alates(100,000)
Workers(1M)
Queens(1000)
POPULATION
WEEK

TEXAS DEPARTMENT OF AGRICULTURE

MARK R. TROSTLE

1988 IMPORTED FIRE ANT CONFERENCE

GROUND APPLICATION OF BAITS TO CONTROL IFA IN SOD FARMS

ATHENS, GEORGIA

PROJECT TITLE: GROUND APPLICATION OF BAITS TO CONTROL IFA IN SOD FARMS

PROJECT LEADERS: Lisa Alexander; Mel Clark; Tony Dooley; Tavo Garza; Robert Dixon; David Davis; Arthur Mason; Mark Trostle and additional assistance from Val Garcia; Skeeter Stolz; and Roger Mulder.

A. LATE SUMMER AND FALL 1987 TEST

I. INTRODUCTION:
Eleven treatments (four formulations of AMDRO, five formulations of LOGIC, one formulation of AFFIRM and an untreated Check) were evaluated at eight sites in the late summer and fall of 1987 series of trails. All treatments were applied in August except Plot I, Subplot 1-14 which were treated early July. The TDA field staff used Chevrolet S-10 pickups, equipped with the Herd Spreader Model 77-A.

II. EQUIPMENT SPECIFICATIONS:
1. Chevrolet one-half ton S-10 pickup.
2. Delivery system--Herd spreader, Model 77-A.
3. Eleven to twelve miles per hour operating speed of S-10 pickup.
4. Herd spreader switch at full speed.
5. Twenty-four foot working swath.
6. Operated by TDA Inspectors Tavo Garza; Lisa Alexander; Tony Dooley and assisted by Mel Clark, Robert Dixon and Mark Trostle.

III. GUIDANCE:
Vehicle guidance and swath spacing were provided by flag persons.

IV. TREATMENTS APPLIED AND TEST SITES:
Treatments were formulations of AMDRO, LOGIC and AFFIRM. Test sites were Sod Farms located in Matagorda, Wharton and Brazoria counties.

V. PROCEDURES USED TO DETERMINE EFFICACY:
A. Prior to treatment fourteen one-fourth acre efficacy plots were established within each test site. The center of each efficacy plot was marked with a wooden engineering stake with a yellow plastic lid attached by a roofing tack and a wire survey flag. Sketches showing locations and distances of each plot were done to facilitate location of the center stake during the post treatment assessment.
B. While pivoting around the center stake, a team of 8 to 9 people closely searched each plot for the presence of IFA colonies. After locating a colony, the mound was opened with a shovel and the types

of relative abundance of live forms present were observed. According to Banks et al. (1981), presence of worker brood in an ant colony is strong evidence that the queen is present and the colony is normal. Williams et al. (1979) reported that AMDRO* may cause death of the queen without total elimination of the worker force. In theory, such a colony will eventually die unless the queen is replaced by adoption of a newly mated queen. The colony classification system described by Lofgren and Williams (1982) was used to categorize all IFA colonies to compute population indices before and after treatment.

Two types of data were recorded for each subplot examined:

(1.) Total number of ant colonies present.

(2.) The relative size and type of colonies present. (See attached IFA Field Data Form.)

Quite obviously, a fire ant population composed of predominantly Class 25 colonies with a population density of 50 colonies per acre represents a far greater threat and nuisance to man than would a population comprised of predominantly Class 2 colonies with a population density of 10 mounds per acre.

VI. RESULTS AND DISCUSSION:

Results of this test to date are shown in Table 1. These results show AMDRO* provided far better early control at all test sites than did the other formulations due to it's mode of activity. Colony mortality with the AMDRO* averaged 88% eight weeks after application and showed a -92% change in population index. The LOGIC averaged 55% colony mortality at eight weeks and a -92% change in population index. The AFFIRM averaged 57% colony mortality at eight weeks and showed a -89% change in population index.

Applications of LOGIC and AFFIRM applied late summer to fall will result in a long delay in control of IFA colonies. Maximum results with these two products will not be achieved until mid-summer of next year. Spring applications demonstrate the most desirable results when using LOGIC and AFFIRM.

Additional efficacy evaluations will be needed during the Spring 1988 to complete the test results.

TABLE 1.

TEST SITE	TOXICANT	PRETREAT COLONIES /SUBPLOT	AVG. COLONIES PER SUBPLOT	AVG. POP. INDEX/SUB- PLOT	AVG. % COLONY MORTALITY	AVG. % CHANGE IN POP. INDEX	NUMBER COLONIES WITH SURVIVING WORKER BROOD
I 1/	LOGIC	458	22.9	308	59	-89	14 out of 188 2/
II	AMDRO*	148	10.5	155	97	-97	3 out of 5
III	AMDRO*(85)	122	8.7	122	81	-85	20 out of 23
IV	AMDRO*	145	10.3	170	94	-96	7 out of 8
V	AMDRO*	205	14.6	236	79	-91	14 out of 44
VI	AFFIRM	178	12.7	209	57	-89	7 out of 77
VII	CHECK	343	24.5	421	+13	+12	384 out of 386
VIII	LOGIC	91	6.5	102	59	-93	0 out of 36
IX	LOGIC	132	9.4	165	59	-93	0 out of 54
X	LOGIC	145	10.3	167	39	-90	0 out of 88
XI	LOGIC	136	9.7	160	57	-93	0 out of 59

1/ Test site I composed of 20 subplots due to rain occuring in area after treatment of first 14 subplots.

2/ Twelve of these surviving colonies located in subplots which received 2" of rain within 15 minutes of application of LOGIC.

3 All treatments applied at one pound per acre.

4. All treatments applied August 10 thru 13, 1987. Treatments began on the average after 5:00 P.M. in the afternoon and lasted to midnight on the average.

5. Block I, Subplots 1 thru 14 were treated July 7, 1987.

6. Test Site III treated with AMDRO* formulated in 1985. Material slightly on rancid side.

PROJECT TITLE: GROUND APPLICATION OF BAITS TO CONTROL IFA IN SOD FARMS

PROJECT PERSONNEL: Lisa Alexander; Mel Clark: Tavo Garza; Tony Dooley; Robert Dixon; Will Calcote; Arthur Mason; Mark Trostle and additional assistance from Roger Mulder.

PROJECT TIME: April 11 thru 12, 1988.

This report includes the 35 week efficacy of the various bait products applied to Sod Farms in Matagorda, Wharton and Brazoria counties. This copy will need to be attached to the report sent to David Davis on 10-21-87 detailing IFA sod farm bait treatment results for fall 1987.

A. RESULTS AND DISCUSSION: Results of this evaluation to date are shown on attached table. The results of this 35 week evaluation show AMDRO* providing an average percent colony mortality of 86% and a average percent change in population index of -92%.

The LOGIC averaged 81% colony mortality at 35 weeks and a -98% change in population index.

The AFFIRM averaged 47% colony mortality at 35 weeks and a -87% change in population index.

The CHECK averaged a 56% increase in active mounds and a plus 27% increase in population index.

The only product which showed an increase in control at 35 weeks was the LOGIC. LOGIC increased from a average of 55% colony mortality at 8 weeks to a average of 81% colony mortality at 35 weeks. The population index increased from -92% at 8 weeks to -98% at 35 weeks.

Additional efficacy evaluations will be needed at approximately 45 to 52 weeks.

EFFICACY TABLE

TEST SITE	TOXICANT	PRETREAT COLONIES /SUBPLOT	AVG. POP. INDEX/SUB-PLOT	AVG. % COLONY MORTALITY AT 8 WEEKS	AVG. % CHANGE IN POP. INDEX AT 8 WEEKS	AVG. % COLONY MORTALITY AT 35 WEEKS	AVG. % CHANGE IN POP. INDEX AT 35 WEEKS	COLONIES PER SUB-PLOT 35w
I	LOGIC	458	6150	59	-89	80	-95	80
II	AMDRO*	148	2164	97	-97	97	-97	5
III	AMDRO*(85)	122	1707	81	-85	86	-91	17
IV	AMDRO*	145	2385	94	-96	88	-91	18
V [1/]	AMDRO*	205	3297	79	-91	77	-91	*47
VI	AFFIRM	178	2926	57	-89	47	-87	94
VII	CHECK	343	5894	+13	+12	+56	+27	535
VIII	LOGIC	91	1425	59	-93	77	-96	21
IX	LOGIC	132	2315	59	-93	79	-91	28
X	LOGIC	145	2341	39	-90	72	-96	40
XI	LOGIC	136	2245	57	-93	89	-99	15

1/ At the 35 week efficacy check Plot V had lost subplots 2 thru 13 due to being plowed up. The number of colonies and population index from the 8 week check of this plot were used for a average. Subplots 1 and 14 were rated at 35 weeks.

Survey of Monogyne and Polygyne Fire Ant Colonies in Texas

D.J. Clair, R. Mulder, S. Porter[1], A. Bhatkar[2], S.B. Vinson[2]

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The red imported fire ant (RIFA), <u>Solenopsis</u> <u>invicta</u> (Buren), continues to be a major urban and agricultural pest in Texas, and to increase its distribution within the state, despite educational, research, and regulatory efforts by federal, state and local agencies. Recent work also has suggested that the distribution of polygyne (multiple-queen) fire ant colonies might be spreading in Texas.

Multiple-queen colonies, with more queens per mound and more ants per acre, represent a more difficult control problem and may require new recommendations. The Texas Department of Agriculture (TDA) and RIFA researchers at the University of Texas decided to conduct a field survey to determine the present distribution of multiple-queen colonies in Texas. RIFA researchers at Texas A&M University were enlisted to help design the survey and verify the results. It was decided that several objectives could be met by this one survey.

Objectives

1. Determine the distribution of monogyne and polygyne fire ants in Texas.

2. Determine density of monogyne and polygyne colonies at sampling sites throughout infested area of Texas.

3. Correlate distribution and density with physical and biotic environmental factors.

4. Standardize sampling techniques and sites to provide basis for long-term population study.

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[2]Department of Entomology, Texas A&M University, College Station, TX

METHODS

Field sampling is being conducted by TDA personnel in all Texas counties within the known RIFA distribution plus those counties along its western edge. County maps were used to preselect four road intersections widely distributed over each county. Actual sampling sites were located on the right-of-way .2 miles in a random direction from the preselected intersection. If the first location could not be sampled the field person would continue another .2 miles down the road until a suitable site was located. Right-of-ways were chosen as sampling sites because they are fairly natural and undisturbed RIFA habitat, they are convenient, and they help standardize sampling over area and time.

At each site, soil temperature was measured at two locations to correlate foraging activity with temperature. Soil moisture and structure, size of rocks, slope of the ground and percent bare ground were also estimated. Lastly, the type and size of vegetation on the right-of-way as well as the surrounding habitat were recorded.

A transect of eight bait stations was laid out in the middle of the right-of-way on each side of the road to measure ant activity. Stations were ten paces apart and consisted of a hot dog disc placed on the ground and marked by a wire flag. After 30 minutes each station was rated as having 0, 5, 10, 20, 50, 100, or 200 ants. Ants were identified as either fire ants or not fire ants. This part of the study should allow an assessment of the impact of RIFA on the native ant community.

Along each border of the right-of-way and on both sides of the road, a transect of 70 paces was walked parallel to the bait station transect. Active RIFA mounds within reach using a four foot survey stake while standing were counted and rated as small (<1′ diam), medium (1-2′) or large (>2′). Walking parallel to the 70 pace bait transect allowed field workers to concentrate on counting and rating mounds without having to count their paces.

RIFA workers and queens were collected from several mounds at each site, and the queens later dissected by Texas A&M researchers to check for insemination. Worker ants were collected by placing a vial whose inner lip was coated with fluon on top of a shovelful of soil dug from a mound and thrown on to a plastic tarp. Queens were found by sorting through the soil and placed in the vial using forceps. For each mound sampled, workers were rated as small or large, and the density of alate males and females, plus worker and sexual brood was rated on a scale from 0 to 3.

RESULTS

Fig. 1 shows the distribution of RIFA in Texas in 1987, counties sampled to date in 1988, and counties with polygyne colonies based upon our preliminary assessments. Multiple-queen RIFA appear widely distributed throughout the state. Good evidence exists for their presence in all but 8 of the 67 counties sampled thus far. It is possible that polygyne colonies will be found in these 8 counties as well when further sampling is completed.

Data on RIFA density and correlations to environmental factors have not yet been analyzed. Results from queen dissections to determine insemination and verify polygyny also have not been completed.

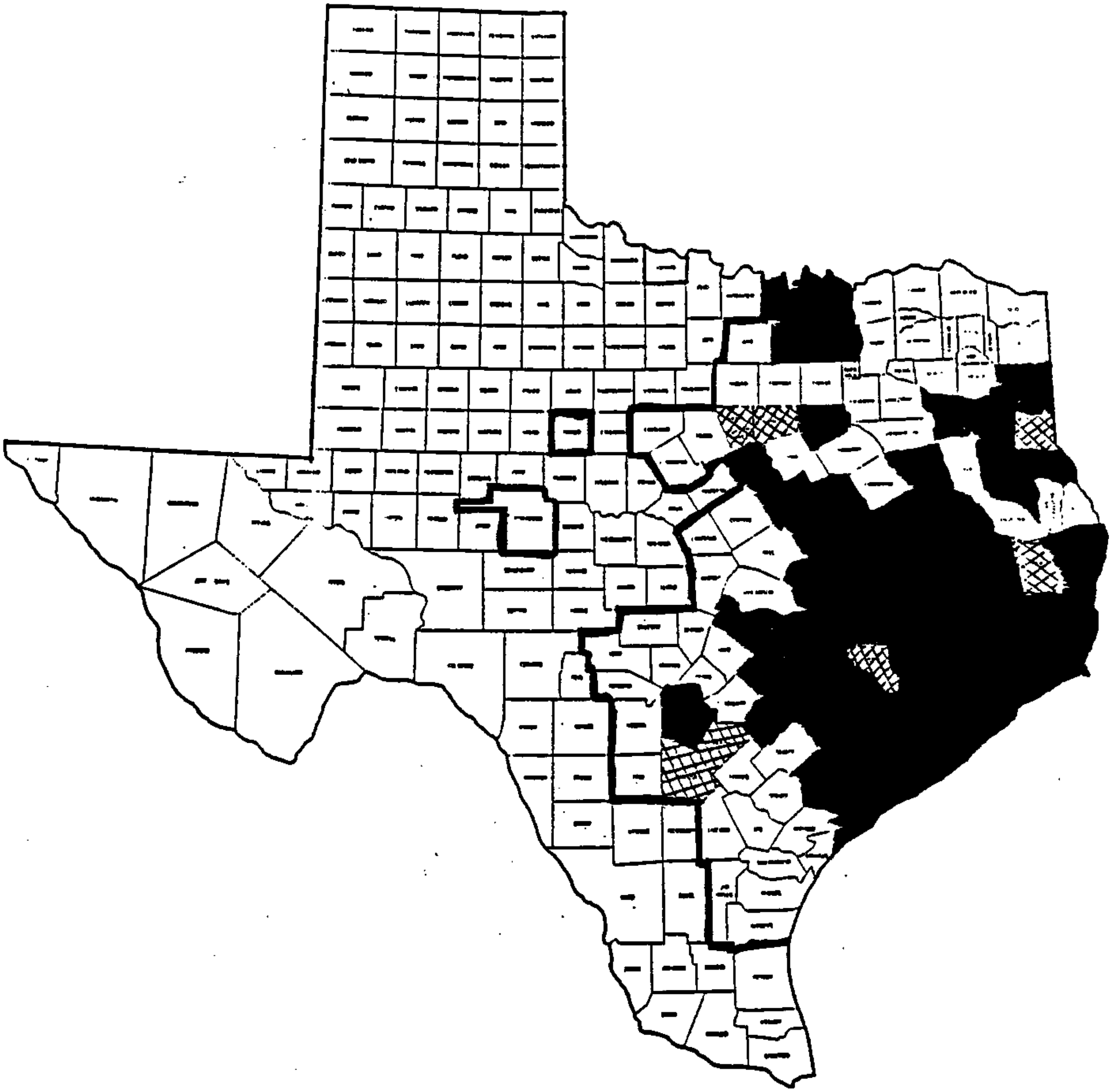

Fig. 1. Distribution of monogyne and polygyne Solenopsis invicta in Texas. The dark line represents the boundary between infested and non-infested areas in 1987. Sampling showed good evidence for polygyny in solid counties and little to no evidence in hatched counties. Unmarked counties within the infested area have not yet been sampled.

Effects of Boric Acid Baits on Laboratory Fire Ant Colonies

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Abstract Boric acid baits killed large numbers of fire ant (Solenopsis invicta) workers and larvae in laboratory colonies. Queens and pupae, however, were not eliminated, and most treated colonies resumed brood production after 3-5 weeks. These results indicate that boric acid is not a suitable toxicant for large-scale or long-term control programs. Nevertheless, boric acid might be useful in combination with growth hormones or for small areas that can be retreated every few months.

Introduction

Boric acid is a well-known insect poison with relatively low toxicity to vertebrates (Linden et al. 1986). It has been used for control of Pharaoh's ants (Newton and Coombes 1987) and cockroaches. A potential advantage of boric acid for fire ant control is that it is a slow acting toxicant that could be disseminated throughout a colony by trophallaxis (communal feeding).

Several boric acid formulations have been field tested with fire ants, including mound drenches (Lemke et al. 1985) and baits (Diffie et al. 1987). Results of these tests have been disappointing. The purpose of this investigation was to test the effectiveness of various boric acid bait formulations under controlled laboratory conditions.

Materials and Methods

Laboratory tests were carried out using standardized test colonies of the fire ant, Solenopsis invicta. Test colonies initially contained 5 queens, 5 g of workers and 1 g of brood. These colonies were formed from a mixture of five polygyne field colonies. Field colonies were mixed to provide a large and relatively homogeneous source of workers and brood for the test colonies.

Care and handling procedures were similar to those described by Banks et al. (1981). Test colonies were maintained at 32°C and fed crickets and 1 M sugar water every other day. Poison baits were introduced about 2 wk after the test colonies were set up. Sugar water and solid food were withheld for 2 days prior to treatment.

The experiment contained a control group and four treatment groups, each with five test colonies. The first treatment group received a 1M solution of sucrose and 2% boric acid. A higher concentration of boric acid was not used because boric acid is rather insoluble in water. This solution was presented in small balls of saturated tissue paper. The second group received a solid bait formulation with 17% boric acid. This formulation was provided by Bethurum Research & Development, Inc., P. O. Box 3436 Galveston, TX 77552 under the trademark of "Bushwhacker". Besides boric acid this bait contained ground fish meal, various grains, fish oil, shrimp, preservatives, and vitamins. The third group received a 4:1 mixture of Bushwhacker™ and pulverized Logic® (batch number R6353-2). This bait contained 19% boric acid. The fourth group received the standard preparation of Logic®. Excess quantities of all baits were provided for 24 h; baits not collected during this period were removed and discarded. Several similar pilot studies were also conducted. Results were analyzed using analysis of variance. Means are shown ± SE.

Results

Several preliminary tests were conducted to determine which concentrations of boric acid were most effective. For sugar solutions, this was about 2-4%, because higher concentrations are not soluble. For dry bait formulations (Bushwhacker), 15-20% boric acid appeared to provide maximum results; higher concentrations reduced bait palatability while lower concentrations (e.g. 5%) were much less effective. Extending the duration of access to baits for longer than 24 hr produced little benefit, probably because feeding had ceased before this time.

Results of the main experiment are shown in Figure 1. Control colonies continued to grow vigorously over the three-week period. Colonies receiving boric acid in a sugar solution declined moderately (ca. 30%) from their original size at setup, but all five had resumed vigorous worker brood production by three weeks. Both groups receiving Bushwhacker bait declined substantially in size (ca. 70%). The major difference between the two Bushwhacker treatments was that three of the five colonies receiving only Bushwhacker bait had resumed worker brood production, while none of the colonies receiving a Bushwhacker- Logic mixture contained worker brood and the few larvae were all sexualized. The Logic group of colonies showed little decline over the three week period and all remaining larvae were sexualized.

Overall, the Bushwhacker bait formulation was very attractive. In the main experiment, foragers collected 2.3±0.4 g of the Bushwhacker bait compared to 0.7±0.1 g of the Logic and 1.4±0.1 g of the mixture. The shelf-life of this product was not tested, but bait in a once-opened container stored at 24°C remained attractive after four months. A mixture of peanut butter and 20% boric acid was also tested with four colonies in a separate experiment. Substantial worker kill resulted in two of the four colonies, but as with the Bushwhacker and sugar formulations, brood production resumed after about four weeks.

The general effects of different boric acid bait formulations on experimental colonies were quite similar: About 24 hr after feeding on these baits, workers began clustering over the brood as if the colony was severely dehydrated. This behavior continued for 2-3 days. A distinct reduction in the number brood resulted during this period and many workers began roaming about in the feeding tray. Substantial worker mortality began after about one week and continued for two or three more weeks. Queens and pupae were not killed. Pupae were not affected because they do not feed during this stage, but it remains a mystery why the queens were unaffected.

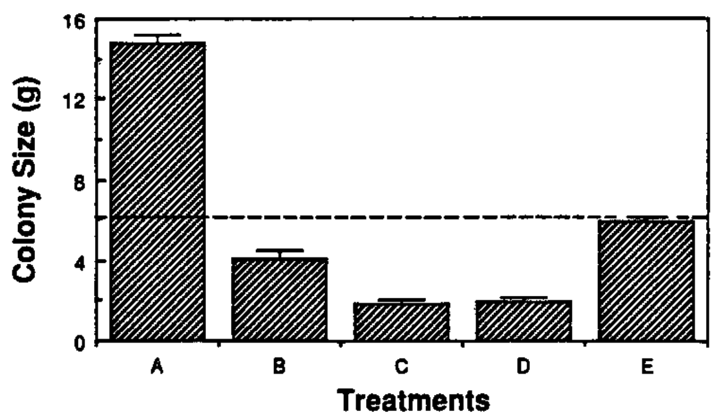

Fig. 1. Impact of boric acid baits on the size of standardized laboratory colonies three weeks after treatment. Dashed line shows initial size of colonies at set up. Treatments were as follows: A) control, B) 2% boric acid in a 1 M solution of sucrose, C) Bushwhacker™, D) Bushwhacker™ + Logic®, E) Logic®. All means were significantly different except C and D (Scheffé's F-test, $p < 0.05$).

Discussion

Boric acid baits are probably not suitable for long-term or large-scale control programs. Ingestion of boric acid eliminated brood production in test colonies for several weeks and killed a substantial portion of the workers. Unfortunately, queens were not killed and worker brood production generally resumed after 3-4 weeks. In other words, these baits severely reduced colony size, but their impact on the colony as a whole was not lethal.

Nevertheless, boric acid baits might be useful in small yards or gardens where repeat applications are practical and where other baits are not registered for use. Field tests have not been done, but it is possible that applying boric acid baits at 1-3 month intervals could provide fairly effective control even though colonies were not actually eliminated.

Another interesting possibility is a bait combination including both boric acid and a growth hormone such as Logic. This mixture appears to combine the short-term impact of boric acid (Fig. 1) with the long-term effectiveness of a growth hormone. Such a product would be most useful in yards or public parks where the 2-3 month delays associated with most growth hormone baits are unacceptable. The addition of boric acid, however, may not improve the long-term effectiveness of growth hormones; conceivably, long-term effects could even be reduced by killing off workers that would otherwise serve as a reservoir for the hormone. Field tests would be necessary to resolve the effectiveness of a combination bait and its potential limitations.

Acknowledgements - These tests were funded by a grant from the Texas Department of Agriculture to L. E. Gilbert (IAC (88-89)-0490 TDA). G. M. Bethurum kindly provided samples of his product for testing.

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PARK USERS' RESPONSE TO RED IMPORTED

FIRE ANT IN TEXAS

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ABSTRACT

Red Imported Fire Ant (RIFA), Solenopsis invicta (Buren), is currently known to infest approximately 198,983 sq. km of Texas soil representing 29 percent of the state. This study reports the impact of RIFA infestation on recreational visitation to Texas state park facilities. Data representing an eighteen year period were analyzed for twenty-six Texas state park facilities. Results indicate that RIFA presence in Texas state park facilities at the infestation levels existing in the study period did not decrease visitation to those facilities.

Spreading in a fan like fashion, Red Imported Fire Ant (RIFA), Solenopsis invicta (Buren) was first recognized to be in Texas in 1953 (Culpepper, 1953). Since then, RIFA's territory within the state has reached approximately 76,827 sq. miles, representing 29 percent of the state (Cokendolpher and Phillips, in review).

With the spread of RIFA comes an increase of infested Texas state parks and public exposure to the pest. Michaelson (1975) reported that Washington state recreational park visitors were willing to incur the expense and/or inconvenience to travel to parks which were not infested by Mountain Pine Beetle, Dendro'ctonus pondero'sae (Hopkins). Similarly, Texas state recreational facilities infested by RIFA may be losing park visitors due to visitors attempting to avoid this pest. Or, park visitors may view RIFA as an unavoidable nuisance similar to flies and mosquitoes, continuing to visit parks when RIFA is present. Whether recreational park visitation is affected by RIFA's presence has not been determined. The primary objectives of this paper are to determine how the presence of RIFA affects visitation to the Texas state park system, and estimate any economic impact.

According to the Texas Parks and Wildlife Department "Park visitors are not bothered by RIFA very much. Our cleanup crews complain more about RIFA than park visitors." (Riskind, 1988) Persons visiting RIFA infested parks may be coming into contact with the pest and establishing attitudes about any change in utility caused by the presence of RIFA.

DATA

Secondary data from both state and federal agencies were used in this study. Texas Parks and Wildlife Department (TPWD) provided in-house summaries of annual number of visitors and revenues generated representing individual parks (TPWDa-c). Another publication provided by TPWD described available facilities, size and location of each park in the state park system (TPWDd). Population and per capita income were obtained from the U. S. Bureau of Census. Population between census time periods was extrapolated at an average rate between years. A study by Cokendolpher and Phillips (in review) described the movement of RIFA and years in which counties became infested with the pest, establishing RIFA infestation dates for the state parks.

Criteria for those parks selected to be used in the study were i) they represent an outdoor recreation state park facility used primarily for overnight camping, ii) annual data for the seventeen years during the study period were complete, and iii) a park either had RIFA during the entire 18 year period or never had RIFA. Because of the length of time required for RIFA to be introduced, established and increase in numbers within an area for visitors to become aware of their presence, the last criterion was applied. Thus, parks becoming infested with RIFA during the study period were not considered. The final data set represented twenty-six parks comprising twenty-two infested and four non-infested parks (Figure 1). Acreage of parks without RIFA ranged from 573 to 1869 acres, while parks with RIFA ranged from 105 to 4860 acres.

MODEL SPECIFICATION AND METHODS

Previous work provided by Clawson and Knetsch (1966) serves as a basis for much of the current work in recreational demand. The initial functional model was:

$$PV = f(TPCI, PVE, ACR, RIFA) \qquad (1)$$

where: PV = number Park Visitations per 100,000 people,

TPCI = Texas Total Per Capita Income, dollars per year,

PVE = gross receipts from Park Visitor Expenditures,

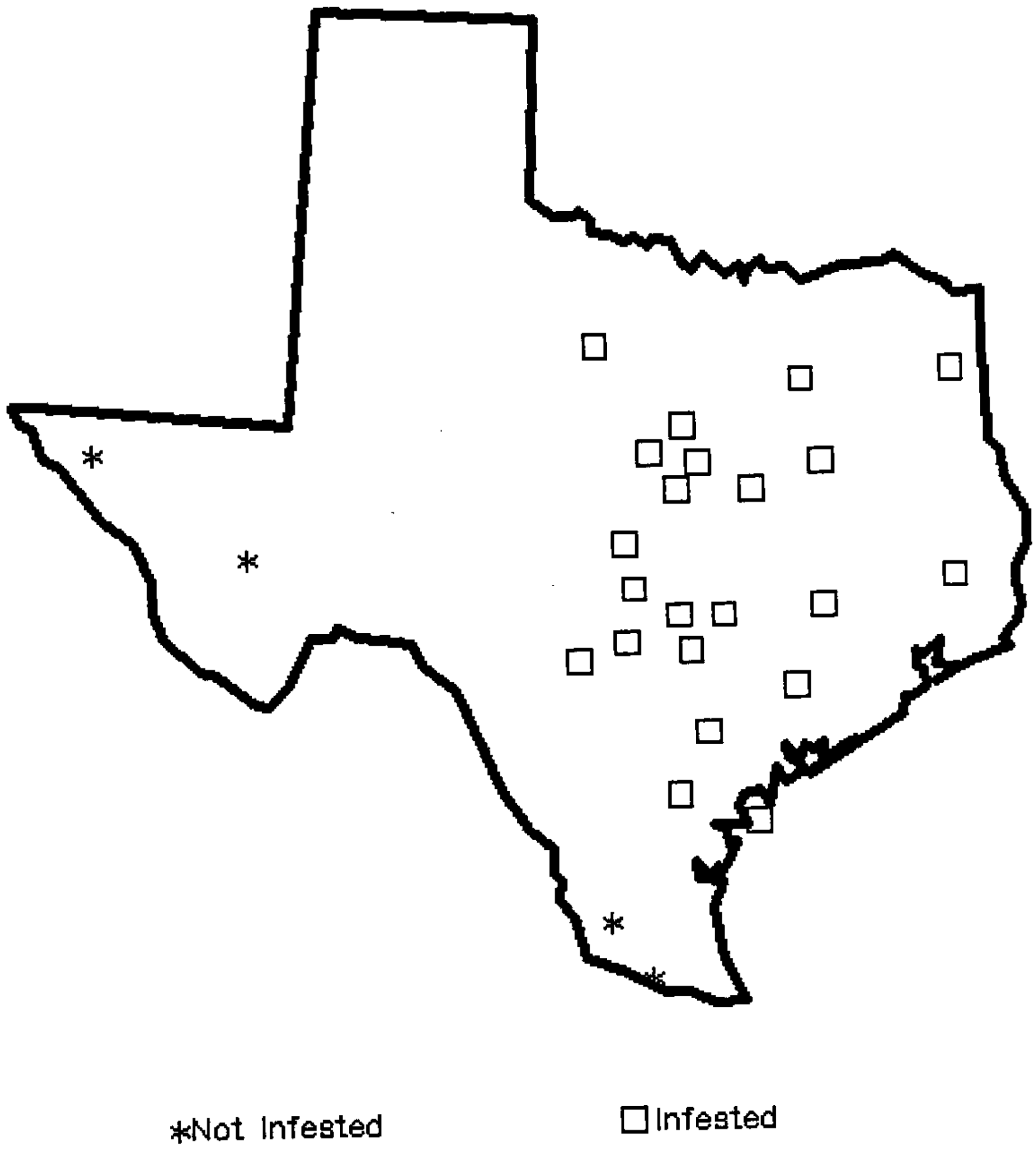

Figure 1. Location of parks used in study.

ACR = park size in ACRes,

RIFA = dummy variable representing the presence (1) or absence (0) of RIFA.

Annual park visitor numbers were transformed to a 100,000 per capita basis as suggested by Brown, Sorhus, Chou-Yang, and Richards (1983).

The choice of mathematical functional form for outdoor recreation demand was addressed by Ziemer, Muesser and Hill (1980). They reported that the selected form can have a significant impact on resulting recreation demand equations. Linear, semilog (involving the natural logarithm of the dependent variable), and log-log models were considered. To alleviate any problems in data transformation to the logarithmic form, the RIFA dummy variable assumed the value of 2.7183 in the presence of RIFA, and 1 in the absence of RIFA.

The data used in this study represent park observations made over time, and observations made over groups of parks within periods. The combination of both types of data is referred to as "pooled time-series and cross-section data". Time series data often pose problems of correlation between periods (i.e. serial correlation) while cross-sectional data often result in unequal variances (i.e. heteroskedasticity) between experimental units, or parks as in this case. Therefore, because of the potential problems which may result from using this data, residuals from the ordinary least squares (OLS) estimation of equation (1) were tested for heteroskedasticity by park, and for serial correlation over time. The estimated Durbin-Watson statistic was 0.5446, indicating the presence of positive autocorrelation. The assumption of homoskedasticity was rejected using the Goldfeld-Quandt test ($P \leq .01$). To correct the data for the combined problems of autocorrelation and heteroskedasticity the data were transformed using pooling procedures outlined by Kmenta (1986, p. 618). Therefore, differences between parks such as distance from populated areas or varying attractions will not affect analysis results.

RESULTS AND DISCUSSION

Results of analysis using equation (1) indicate that RIFA does not impact the Texas state park system. Table 1 shows the estimated coefficients and Student t-values of equation (1) in linear, semilog, and log-log functional forms. Both ACR and RIFA are insignificant at the 10 percent level in the linear and semilog models. With the exception of RIFA, the log-log model provides signs of the estimated coefficients which are consistent with _a priori_ expectations and are significantly different from zero ($P \leq .01$). Nevertheless, lack of significance of the RIFA variable in equation (1) indicates that RIFA does not impact visitation to the Texas state park system.

It has been shown that the current level of RIFA infestations within the Texas park system has not affected park visitations to date. This implies that RIFA has caused no discernible economic impact to the state park system. Perhaps factors other than RIFA are more important to park visitors in determining park visitation rates if RIFA are considered in the same category by visitors as flies, mosquitoes, etc. The results of this analysis apply only to those levels of infestation considered within the study. Therefore, RIFA infestation levels greater than those considered cannot be estimated from the results of this study. This hints at the need for pertinent data which properly addresses the objectives of this study. Needed data should indicate infestation density levels in each park, potential levels of suppression that would produce additional revenue, and the threshold level of tolerance park visitors have for RIFA infestations. Without this information no conclusions pertaining to potential additional revenues generated from suppression programs

Table 1. Results of Model Analysis for Three Functional Forms

Independent Variables	Functional Form Linear	Semilog	Log-Log
Intercept	1103.0000	6.8352	-1.3326
	(3.2838)[†]	(30.4220)	(-1.2428)*
TPCI	0.0630	0.0001	0.6600
	(4.1033)	(6.3952)	(7.0754)
PVE	-1322.9000	-1.3809	-0.5609
	(-13.5130)	(-18.3070)	(-15.5170)
ACR	0.1160	0.0001	0.2792
	(0.9936)*	(1.0868)*	(2.9763)
RIFA	-150.0600	0.1670	0.2177
	(-0.4824)*	(0.8713)*	(1.2324)*
R^2	0.8326	0.8520	0.8476
Adjusted R^2	0.8310	0.8507	0.8464

[†]Student t statistics are in parenthesis

*insignificant at the .10 level

can be made, nor can the required levels of suppression be known. This lack of knowledge may result in an excess of dollars being spent to control RIFA. Further research should address the limitations of this study.

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AN INTEGRATED FIRE ANT MANAGEMENT PLAN FOR TEXAS

TEXAS DEPARTMENT OF AGRICULTURE
Roger Mulder

This is the third year in which the Texas Department of Agriculture has had a team of about 15 fire ant specialists work on managing fire ants, and that program continues to evolve. We began three years ago with an emphasis on showing others how to successfully manage fire ants in various situations, later added an enforcement effort, especially on sod farms, and this year we included a survey project. The stated purpose of this year's program is to safely and effectively manage fire ant infestations, where mangement is desirable. To utilize a combination of education, regulatory and enforcement efforts to achieve an integrated program which acknowledges both the beneficial and pest aspects of the imported fire ant.

Our stated overall goal for 1988 is to help slow the spread of the imported fire ant into previously non-infested areas and help prevent the spread of the IFA into otherwise isolated areas outside the normal migration; and to help manage IFA populations at acceptable levels where infestations already occur. That overall goal encompasses an added emphasis on non-chemical management techniques as well as the safe and effective use of chemicals needed to suppress fire ant densities, and a better understanding of how ants fit into and can benefit the total environment.

We kicked off this year's program in early March when we brought our fire ant specialists together in Austin and asked them to begin a survey of the roughly 128 counties already officially classified as infested with fire ants. It was becoming increasingly obvious that multiple queen mounds were presenting much more complex treatment strategies compared to single queen mounds. In fact, those areas with single queen mounds may be left untreated when possible in order to slow the spread of multiple queen mounds. The problem was, nobody knew where we had single queens and where we had multiple queens. That survey began in Mid-March and is continuing. Dr. Dan Clair has the full report on that project.

The next project was to divide the fire ant specialists into two basic groups. One group taking on the federally mandated survey of newly infested counties spelled out in the compliance agreement TDA signed with USDA and the other group returning to the Bay City area to do another check of the test plots and to enforce the quarantine provisions on sod farms and nurseries shipping out of the quarantined areas.

We had seven specialists do the federal survey of newly infested counties. We've been encouraged by the low number of counties that have been listed as newly infested. The protocol called for checking approximately 46 counties. It appears that only a few will be added to the quarantine this year.

As I said, the other specialists returned to Bay City, first to re-check the test plots we put out last August, and then to inspect about 200 nurseries and sod farms capable of shipping fire ants outside the infested areas.

Last year, we told the sod producers we were coming, but they didn't believe us. We showed up, and immediately ran into a lot of problems. Many of them were going broke, all of them were hurting financially. Almost none of them could afford to do anything about fire ants. We issued stop sales on almost every sod farm we visited.

We suggested they use one of the baits to get their infestations down to a manageable level. Their response surprised us because they were nearly unanimous in saying the baits don't work. Since we do believe in the baits, we set up the test plots to prove it.

That was a year ago at this time. In August, we put in the test plots, checked them in October, went back to check them two weeks ago, and will check them again in August. Mark Trostle has the results on the test plots, but let me make this point.

One year ago at this time, Arthur Milberger, Jr. of Milberger Turf in Bay City had just spent over $57,000 for the purchase of chemicals, primarily Dursban. He estimates it took another $33,000 in labor to apply those chemicals. The man spent $90,000, and for his efforts, he was able to enjoy our stop sales just like everyone else. Milberger was the primary participant in our test plots and this year, Milberger's chemical bill stands at $2640, or the cost of one pallet of Logic. From TDA's perspective, we showed one man how to safely and effectively suppress fire ants at a manageable level, and saved him about $87,000 in one year to boot. Not a bad return on our investment or his.

We believe our message is catching on. All last week, we had four two-person teams checking close to 200 sod farms and nurseries in the four counties around Bay City: Matagorda, Wharton, Fort Bend and Brazoria. This year we told them we were coming and those that have survived were ready for us. We found very few sod farms so infested with fire ants we had to issue stop sales. Even more gratifying was the number of sod farmers who heard about, read about or went over and looked at our test plots, and decided we really did know what we were talking about.

We have a lot of work left to do. We want to establish model treatment programs and get the schools, parks, cities, counties and others signed up to follow the appropriate model program that fits their needs. It's anticipated that in almost every case, that model program will involve some broadcast application with baits as we move away from harsh chemicals and mound by mound treatments as much as possible. We have just begun negotiating with the Texas Parks and Wildlife Department to set up a model treatment program for all state parks.

We also plan to produce a music video to take to school children to enlist their help in getting their parents to safely and effectively manage fire ants.

We believe we do have a good program and one of the major reasons for that is the valuable information we pick up at these annual conferences. Thank You.

UNIVERSIDAD DE PUERTO RICO
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MAYAGUEZ, PUERTO RICO

Observations on the Imported Fire Ant Solenopsis invicta on Some Crops of Puerto Rico

Osvaldo Cotte[1], Juan A. Reyes[2] and Alfonso Dávila[3]

INTRODUCTION

The red imported fire ant Solenopsis invicta Buren has become a major problem in some crops of Puerto Rico as well as in the urban environment. IFA came from the United States to Puerto Rico possibly in about the 1970's. It was properly identified by Dr. William Buren, Professor of the University of Florida, in 1981. By that time APHIS personnel conducted a survey and found the ant has spread along the south coast from Yabucoa on the east to Añasco on the west. As near as 1987 the ant was firmly entrenched in a large section of the central mountain area and southern coast covering at least half the island. It appears that it will remain in Puerto Rico in spite of all control attempts.

Fire ants pose problems in areas such as:

Sugarcane:

Fire ants are important pests in sugarcane fields. The main complains are problems related with field laborers. Another negative aspect is the increasing number of aphids and mealybugs.

1/ Cooperative Extension Service Specialist
2/ American Cyanamid
3/ Puerto Rico Department of Agriculture

Some benefits are related to white grubs (Phillophaga and Diaprepes) and sugarcane borer (Diatraea saccharalis) control as shown by Castro in 1983.

Forages, Lawns, Pasture Land:

In such areas IFA creates hazards to man or his animals. In hay fields they are important pests. It has been reported that equipment may be broken when it hits large mounds. Laborers are frequently stung while gathering and stacking hay bales. Also hay bales has been important in fire ants dissemination.

Vegetables and Legumes:

Some harmful effects have been reported specially on ants feeding on seeds and germinating seeds and girdling young plants of watermelon, cucumbers, pumpkins, eggplants, pigeonpea and cabbage. The problem increases when farmers use flood irrigation or cover the rows with plastic. The IFA has also been reported affecting drip irrigation systems.

Coffee:

IFA was identified affecting coffee by 1985. Now it is present in more than half of the total coffee area. Possibly the infestations were accelerated, by the use of soil and organic matter from the south coast infested with fire ants, to prepare coffee seedbeds and nurseries. From the nurseries it was spread to coffee plantations. Natural mating flights has also contributed to infest new areas.

Some problems are anticipated in new and old plantings. Increases of aphids, mealybugs and scales populations are observed and the incidence of Fusarium root disease is also increasing.

This condition is caused by mounds surrounding the coffee trunks. The coffee is grown mainly in the hilly region. Therefore, problems with laborers and the applications of control methods are the main concerns. One positive aspect may be the reduction by the ants of coffee leaf-miner damage (Leucoptera coffeella). Further studies should be conducted to determine the role of IFA in coffee plantations.

Plantains, Bananas and Starchy Crops:

IFA nesting close to clumps of plantains and bananas are affecting mainly the seedlings. In old and new plantings it interferes with farm works. IFA could favor aphids, mealybugs and scales populations but decreases the banana root weevil (Cosmopolites sordidus). Laborers on yams and taniers plantings are affected while in yams white grubs population (Diaprepes) damage may decrease.

Pineapple:

No significant increases in IFA populations have been reported, but there shall be awareness so as to avoid mealybugs and problems with farmer workers. Mealybugs are vectors of viral wilt in pineapples specially in the Smooth Cayenne variety.

Control Practices:

Eradication of this ant appears unlikely and we must plan activities to live with and control it only in areas where it damages crops and poses hazards to man and animals. Products labeled for red imported fire ant control are limited to be used in forages and lawns but not in food crops. We need to solve this dilemma providing information to determine the effectiveness of various pesticides and treatments for IFA control under local conditions.

NOT FOR PUBLICATION

Susceptibility of Hybrid Fire Ants and Their Parent Species to Insecticide Residues

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Tifton, GA 31793

With the advent of "hybrid" fire ants, the question arises - will they exhibit hybrid vigor and be more difficult to control than their parent species, Solenopsis invicta and S. richteri? A quick way to gain some insight into this problem was to expose workers of these ants to residues of insecticides and compare mortality rates.

Colonies of hybrids, and S. invicta were collected in soil from Floyd and Tift Counties respectively, in Georgia. Solenopsis richteri was collected in Itawaba and Tishomingo Counties in Mississippi. These colonies were held in soil in a greenhouse in Tifton.

In each test, 300-900 foragers of each type of ant were exposed to a single level of residue of insecticide on a filter paper similar to the technique of Sheppard and Hinkle (1987). Mortality was recorded at 1-4 hours when death of any given ant type was judged to be approaching 50%, but less than 100%. Significant differences were determined using a modified Z test. Insecticides tested and residue levels are given in Table 1.

The hybrid did suffer less mortality in two tests with diazinon, but was intermediate in response to fenvalerate, chlorpyrifos, and carbaryl. So, on the whole, this limited testing indicates that the hybrid is probably not more difficult to control. Results of field trials in Georgia confirm this.

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Table 1. Percent mortality of three fire ant types to insecticide residues - 1988.

Test Date	Chemical	Residue per Cm²	Exposure Time	Percent Mortality invicta	hybrid	richteri
2/15	Diazinon	2.0µg	4h	21a	8b	45c
1/26	Diazinon	2.5µg	1h	69a	25b	83c
1/22	Fenvalerate	12.5µg	2.5h	29a	36b	44c
1/15	Chlorpyrifos	2.0µg	2.5h	29a	51b	59c
1/15	Carbaryl	250µg	2.5h	32a	47b	48b

CURRENT FIRE ANT RESEARCH ACTIVITIES AT TEXAS A & M UNIVERSITY *

by S. Bradleigh Vinson

I will speak on the research of a great many individuals at Texas A&M University. I will start with the interactions of the imported fire ant with electricity. Dr. Bill Mackay has been working with this particular problem. For example, the Highway Department in Texas has been very concerned with the impact fire ants have been having on their highway signal system equipment. Fire ants get into the signal cabinets and short out flasher boxes. Accidents could occur when these flasher units are shorted out by the fire ants. Not only were ants damaging this system, but they also damaged other components of the system such as chewing off the insulation from the wires and doing other sorts of damage as well.

We set up flasher boxes in the lab which showed that active flasher boxes were attractive to the ants. Contact points covered by ants which short them out. Ants accumulate and die on the plug-in pins of the flasher cabinets and also short out the system. Short term solutions to this problem have been investigated. We have been looking at various ways to control the ants in these signal boxes. One of the approaches was to look at different kinds of flasher boxes. A flasher box can be sealed to preclude the ants from entering the box which solves part of the problem. However, the ants can still destroy the insulation from the electrical wires. Also the contact points are vulnerable.

Insecticidal control is also being evaluated. One, called Rainbow Ant Control is a granular material utilizing Dursban which has been effective in keeping the ants out of these cabinents for a yet undetermined period of time.

Our data shows that fire ants definitely are attracted to active electrical circuits. We have looked at many different things regarding this electrical attraction to fire ants. For instance, ozone has not shown any real effect. It might show some repellent properties under certain circumstances. We have found that heat generated by transformers, in particular during the cool times of the year, can attract fire ants. They will accumulate in warm spots in the cabinents. But it seems to be a rather seasonal situation occurring in cool weather. In the hot Texas summer, it is quite the opposite problem even though ants do get into the cabinents. In very hot weather, a cooling fan in the cabinets cool and prevent them from getting extremely hot.

Ants are effected by electrical currents. We designed a little unit to which we can put static electricity of various programmable voltages. From 0 to

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* Text transcibed from an oral presentation and edited by Dr. Michael E. Mispagel.

15 volts DC, our data shows that there is an increase in ants when the power is on, and when the power is turned off, they disperse from that particular unit. With AC current from 0 to 100 volts, the same effect is seen. With AC in particular we see that when the power is turned off, the ants do not disperse right away. They leave rather slowly. In fact the ants seem to be not only attracted to these powered up areas, but they seem to be rather euphoric. They lie very quiet and still, and antennate the area. And even after the power is turned off, it takes them a while to leave.

Their response to the AC current is different from that to the DC current. If you turn the current on too soon a second time, they don't respond as well. The DC current is a little different in this regard. If you repeat this the next day, you get the same response. But if you don't wait that long, they seem to be less responsive the second time around. What this means at this point we are not quite sure but we are at least getting some kind of handle on what is going on. There is definitely something going on with electrical circuitry.

Fire ants are also a problem for the power and telephone companies as well. The telephone company has a problem in the pedestals. Fire ants not only come in and remove insulation which impacts the wires, but often the problem is not really serious until there is wet weather. The wet weather, high humidity, and dead ants on the wires, which absorb moisture, cause a short circuit.

The phone company has looked for solutions to the problem. They have also used granular material similar to that which the highway department uses. But local citizens have been coming in and removing the material to put on their fire ant mounds in their back yard. So they are looking for other solutions to the problem. They have been covering some of their circuitry with little rubber caps which reduces the impact of the fire ants at these particular sites. However fire ants still chew many of the wires. They also have been trying to seal the cabinents with a rubberized material to keep fire ants out. This has not been really successful. We have been working with them to try and make improvements upon the system. Some cabinents have insecticide strips to help keep fire ants out. All cabinents which have a pesticide in them must be so labelled.

I would like to summarize some of the work that Les Greenberg has been doing with the fire ant populations in Texas. Over the past number of years he has been looking at an area where we have single queen populations at one end of the field and multiple queens at the other end. There is a drainage area between the two that the multiple queens had not gotten across for several years. A little over a year ago, the multiple queens moved across this drainage area in the field and are continuing to invade the area of single queens.

In our multiple queen areas we see a lot of very small workers. In this blend zone we have multiple queen colonies that have workers that are pretty large. There are indications that some of the monogynous colonies are being taken over by multiple queen colonies. We are trying to gather data to verify that. I am curious to know whether some of you have seen a similar phenomenon in your areas as well.

Awinash Bhatkar has been working in our program and has been looking at some aspects of monogyny and polygyny. He has been able to mark ants with paint which lasts months in the field. Using this technique he has been looking at the movement of ants between single and multiple queen colonies. In our single queen colony area, he marked a number of ants. After a period of time he came back and looked for movement between mounds. What his data show is that basically no movement was seen. These ants are pretty restricted to the mounds from which they came. There is a uniform distribution of single queen colonies which are spread out. We also get a lot of movement of mounds in monogynous colonies and the ants are rather loyal to one queen or colony.

This is in contrast to what we see in a multiple queen area where we have a high density of mounds. In Texas, we have up to 500 mounds per acre in some areas, though usually somewhat less than that. We see a much more random pattern of mounds within a particular area, and they seem to be more stable. Since every place is already occupied by ants, they just don't have anyplace else to move to. The other thing about the polygynous colonies is that marked ants move from mound to mound. In essence, as Mike Glancey has said, these are like large super colonies with many mounds or domiciles that they are occupying. Over time these ants have a steady state of traffic among these colonies. These ants keep moving around quite actively. We are also seeing some queens and alates moving between these colonies which Dr. Bhatkar is examining right now.

We have also been concerned about the origin of polygyny. Some years ago we began looking at this in a number of different ways. I have one student who has looked at the development of polygyny. Some data from a number of years ago indicate that there was some internidal mating. We did have two colonies which we studied in this regard, though it has not been repeated. In the last year and a half, both Bill Mackay and Terrell Stamps have done some work on whether mated queens are being taken up by multiple queen colonies or not. One of the things that has come out of this work is that, yes, they are being taken up by multiple queen colonies. We have marked queens that we have put out into the field and they are showing up in these colonies in fairly high numbers.

We have also found that we have much better adoption of these newly mated queens if they are placed under ground than if they are placed on top of the ground. They are not being accepted into monogynous colonies, but often they are not killed in those situations either. If we put out marked queens in monogynous areas, what we find is that the ants know they are there because we put meal worms next to them and the ants kill the meal worms but leave the queen alone. And where we see queen mortality is where the queen begins to produce minims. If you put these queens in a polygynous area, a fair number of them are killed, and a fair number are adopted. Whether the ones killed are from a polygynous colony or from a monogynous colony is a question we are still looking into at the present time. We have both kinds in our area so we do not know what colonies the mated queens came from. But they are definitely adopting queens.

This has led to looking at sex ratios in both of these type of colonies and, similar to what Al Banks talked about this morning, we have been very involved in putting traps out into the field and looking at the sex ratios of both polygynous and monogynous colonies. We (Dr. Bhatkar and Ray Denton) have taken a little different approach. We have a very quick cage we can put out in a few minutes and which doesn't create much shade. We go out on a day that we suspect flights will occur and cage them 'just that particular day and then collect them every half hour. We have done this partially because we are interested in whether there is any separation of flight times in these particular situations as well the sex ratio. This has been done as a cooperative effort between Awinash and several others.

There is a slight difference in the flight patterns between these different colonies. In the area that Les works, both the polygynous and monogynous colonies will fly at a slightly different time. But if you go to sites a couple miles away, they will fly at slightly different times than at the first location. However, if you look at the whole area, they are not flying at different times. Why they are separating in these local areas, I don't know, but those are the types of data we are collecting. It is a little hard to explain these data at this time.

From monogynous colonies, we are getting close to a 1:1 sex ratio. Unlike the data I have seen from other places, we are not getting a 1:1 sex ratio from polygynous colonies. Mostly what we are getting are females. Very few males actually fly from those colonies. As you know, we have a lot of sterile males, and many of those sterile males are attempting to fly, or at least we are catching them in our cages. So between the fact that we have very few numbers of males coming out of these polygynous colonies, plus the fact that a good number of them are sterile, the females are going to have to be mated from males from the monogynous colonies, at least in this particular area.

We have become more involved in the impact of fire ants on wildlife and have been working with the Wildlife Department the past year. We have just completed a study on the impact of fire ants on small rodents. This has been a mark-recapture situation in which we had a grid in an area that had a low ant population consisting of monogynous fire ant colonies and a second area that had a high ant population consisting of polygynous colonies, and then did mark recapture. Basically, a few rodents do survive in the monogynous area. They don't particularly spend a lot of time around the colonies of the monogynous ants, but you can trap a few rodents in those areas and can recapture them on a number of occasions.

In the polygynous area, essentially no rodents come in there at all except in the winter time. If it gets very cool, you will catch transients in these areas. These small rodents will come into these areas when the fire ants are not active, which is kind of an interesting phenomenon. This study will be continued for the next year or two looking at not only the rodents but insects and seeds that the rodents might use for food.

We are also looking at the impact of fire ants on seeds. And in fact they are eating a lot of embryos. Bart Drees is actually doing most of the work in this area. A lot of this work on seeds of sorghum and corn in particular is being funded by Dow at the present time. This is a real problem in Texas. The fire ants are really preventing a lot of our seeds from developing by eating out the embryos.

We are still working on genetics, specifically mitochondrial DNAs, ribosomal DNAs, and total DNA. We are investigating diploidy in the males and are looking further at isozymes. I will leave discussion of those topics for another year when we will hopefully have more complete data than we have now.

Interactions Among Insect, Weed, and Nematode Control Strategies Affecting Sugarcane Arthropod Fauna

(Modified Abstract of Environ. Entomol. MS. E87-289 by A. T. Showler and T. E. Reagan, which has been accepted for publication)

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ABSTRACT. Weed growth in a 2 year Louisiana sugarcane study was associated with more arthropod prey and predators, including the imported fire ant, *Solenopsis invicta* Buren, on the soil surface, weeds, and sugarcane plants, and at least a 25% ($P \leq 0.05$) reduction of sugarcane borer (SCB), *Diatraea saccharalis* (F.), injury compared to weed-free habitats. Weed competition, however, reduced crop biomass by 15% ($P \leq 0.01$), stand density (18%, $P \leq 0.005$), and sugar yields (13%, $P \leq 0.05$). Only when chemical SCB control was not used were weedy habitats more profitable than weed-free habitats. Spring aldicarb (nematicide/ insecticide) applications reduced arthropod prey, particularly plant-sucking insects, for up to 10 weeks. Regardless of weed cover, soil surface-, weed-, and cane stalk-associated predator densities were decreased by the nematicide, and SCB injury was at least 19% ($P \leq 0.05$) increased. Fenvalerate (insecticide) reduced weed-associated prey arthropods and soil surface- and cane stalk-associated predators, including *S. invicta*. Cane foliage-associated Cicadellidae were reduced by the insecticide, but the yellow sugarcane aphid, *Sipha flava* (Forbes), was enhanced by 63% ($P \leq 0.0001$). Fenvalerate did provide at least 70% protection against the SCB, and ratoon crop sugar yields were 8.7% ($P \leq 0.01$) greater than in the insecticide-free regimes. Release of the crop from both weed and SCB pressures was the most economically sound pest management strategy. Future study on weed conservation in the furrows alone is suggested as a cultural practice to enhance predation and interfere less with crop yield.

Susceptibility and Behavioral Response of Imported Fire Ants to Steinernematid and Heterorhabditid Nematodes in Laboratory and Field Trials

R. W. MILLER[1], B. M. DREES[2], S. B. VINSON[3] AND R. GEORGIS[1]

Introduction:

Entomogenous nematodes in the genera Neoaplectana (=Steinernema) and Heterorhabditis have been extensively studied to characterize their ability to parasitize and suppress populations of soil-dwelling insects (Kaya, 1985, Poinar, 1986). Infective juveniles (IJs) of these nematodes are stimulated by environmental gradients allowing them to move toward potential insect hosts when a water film is present in interstitial soil pores. When an infective juvenile encounters a potential host, it enters the insect through a natural opening, penetrates the midgut wall and enters the hemocoel, where mutualistic Xenorhabdus bacteria are subsequently egested from the nematode and multiply within the hemolymph. When the bacteria reach the exponential phase of growth 24-48 hours later, the insect dies of septicemia.

Large liquid culture fermentors are now being used to mass-rear entomogenous nematodes. Current liquid culture capabilities for N. carpocapsae All range between 70,000-120,000 IJs per ml in 1500 L fermentors (~ 100 billion per run). Liquid culture experimentation in a 7500 L fermentor is presently underway. By 1990, Biosys intends to step up production to the 50,000 L fermentor level (M. Friedman, personal communication). Eventually, a desiccated formulation of entomogenous nematodes should become available for ease of shipping and extended shelf-life approaching that of conventional insecticides.

Entomogenous nematodes are often broadcast from commercial application equipment at concentrations of 1-3 billion per acre equivalent as an inundative release. Entomogenous nematodes have a typical field persistence of 2-5 weeks or more after application, depending upon species of nematode used, presence or absence of suitable host insects, rate of application, and environmental characteristics of the site. A moderate amount of soil moisture, in addition to soil temperatures ranging between 15-32 C is essential for continued nematode activity and pathogenicity towards a target insect (Molyneux and Bedding, 1984, Molyneux, 1985, 1986).

Many different insects have been identified as suitable hosts for entomogenous nematodes. Examples of turf insects infected by entomogenous nematodes are mole crickets, cutworms, white grubs, billbugs, and Japanese beetles, among others. Another turf pest, the imported fire ant, is the topic of current investigations.

The potential of entomogenous nematodes to control the imported fire ant (IFA), Solenopsis invicta Buren, has been previously investigated (Poole, 1976, Quattlebaum, 1980). Poole determined in laboratory assays that IFA larvae and pupae are relatively susceptible to N. carpocapsae (= Steinernema feltiae) strain DD-136, while IFA workers are much less susceptible. Poole reported 45% reduction in IFA populations in spring field trials with a drench of $1x10^6$ IJs of N. carpocapsae per mound. Quattlebaum reported IFA mound mortality ranging from 60-97% at $1x10^6$ or $2x10^6$ IJs of N. carpocapsae per mound 2 weeks after treatment.

Laboratory Results

Our objective in the laboratory was to verify the susceptibility of IFA brood and alates and to determine which nematode species/strain was the most pathogenic towards IFA. Pathogenicity of IJs of selected Neoaplectana and Heterorhabditis spp. towards reproductive stages of IFA was ascertained under laboratory conditions for each nematode species/strain. Petri dish (5 cm diam) bioassays were conducted with brood (10 larvae and 10 pupae tended by ca. 300 workers per dish, n=5) and alates (20 per dish, n=5). At 10^3 to 10^5 IJs per Petri dish, mortality of IFA reproductive larvae, pupae, and alates ranged from 38-100%, 36-100% and 28-99%, respectively, after 96 hrs at 23-25 C. N. carpocapsae All was the most consistent strain tested, with larval, pupal and alate mortality of 82-94%, 64-96% and 38-99%, respectively.

In additional studies, when small IFA colonies held in crispers with soil-filled brood chambers were treated with nematodes, workers were observed evacuating brood and alates from the nematode-treated soil chamber to the far end of the crisper. IFA workers, while apparently not susceptible to nematode infection per se, were observed to vigorously preen nematodes from brood, alates and themselves during these assays.

Field Trial Results

The potential of N. carpocapsae All at 2 rates ($5x10^6$ and $2x10^6$ IJs per mound drench) was evaluated in July-August field trials compared to aminohydrazone bait (Amdro). At a non-irrigated site in Montgomery, Texas, nematode treatments provided a reduction in IFA activity comparable to the standard chemical treatment 2-6 weeks after treatment (n=25 mounds). Two weeks after treatment, nematode-treated mounds showed a reduction in IFA activity of ca. 95%, however satellite mound activity was associated with 40% of these mounds. Thus, overall IFA activity in nematode treatments ranged from 40-44 %, compared to 48% activity for aminohydrazone. Six weeks after treatment, nematode-treated mounds showed colony activity ranging from 52-80%, compared to 44% overall activity in the aminohydrazone plot.

Discussion

Development of satellite mounds is apparently an effect resulting from nematode treatments in this trial. The apparent "repellancy" effect is supported by laboratory observations, where evacuation of brood and alates from nematode-treated chambers occurred, as did vigorous preening of nematodes from the bodies of brood, alates and workers. Nematode activity may have been limited to 2 or 3 weeks after application, associated with a period of adequate rainfall. Little precipitation occurred beyond the first 2 weeks after application.

In other 1987 field trials, nematode treatments were either comparable to the standard chemical as in the Montgomery, Texas, trial or were less efficacious than aminohydrazone at various assessment intervals. A small non-irrigated trial in Opelika, Alabama (P. Cobb, Auburn University Extension Entomologist, personal communication), resulted in an overall reduction in IFA activity of 70% in both nematode and chlorpyrifos (Dursban) treatments (n = 10 mounds per treatment).

In Gainesville, Florida, a small non-irrigated trial conducted in October-November (C. S. Lofgren, USDA, Gainesville, personal communication), nematode-treated and aminohydrazone-treated mounds were monitored at 1, 2, 4 and 6 weeks after treatment (n = 12 mounds per treatment). Nematode treatments showed reductions in IFA activity comparable to or slightly ahead of the aminohydrazone treatment at 1 and 2 weeks after treatment, but were less efficacious than the aminohydrazone treatment at 4 and 6 weeks after treatment. It is also possible here that nematode activity declined after several weeks, due to a lack of rainfall during that period. Because nematode survival is poor in soils lacking moisture (Molyneux & Bedding, 1984), these results are not suprising. Future trials will examine the effect of irrigation on the efficacy of nematodes towards reduction of IFA activity.

In 1988, researchers are conducting similar IFA field trials with N. carpocapsae drenches in collaboration with Biosys. However, this spring and summer, Biosys is pursuing applications at irrigated sites which more closely simulate the turf environment of a homeowner lawn. In addition, the effect of retreatment of active mounds 3 weeks after the original application is being investigated.

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Footnotes

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New Developments in IFA Quarantine Treatments

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Introduction

Fire ants are notorious "hitchhikers", and can infest and be transported long distances in a variety of cargo, but the commodity most often associated with long distance artificial spread is nursery stock (Culpepper 1953, Lofgren 1986). For the last 30 years State and Federal regulatory agencies have endeavored to prevent artificial spread of imported fire ants. Some very significant program changes have recently been implemented; through a series of cooperative agreements with affected States, USDA, APHIS, PPQ will relegate virtually all enforcement activities of the quarantine to the States.

Chlorinated hydrocarbon insecticides were widely used as preventative treatments to render nursery stock IFA free until cancellation of all uses in the late 1970's. Today I'd like to review treatments that are currently in use and discuss new developments such as recent label acquisitions and changes. Also, I will briefly describe some of our research into alternate treatments.

The term nursery stock is a broad generic term used to describe a variety of plant material. Due to significant differences in agronomic practices, shipping procedures, etc., nursery stock is best divided into three categories:
(1) containerized plants (SLIDE), (2) field grown or balled and burlapped plants (SLIDE), and (3) grass sod. The first category that

I'd like to discuss is field grown nursery stock (SLIDE).

Field-Grown Nursery Stock

Field grown stock was certified IFA free following broadcast application of chlorinated hydrocarbon insecticides until 1978. For the next 10 years the only approved treatment procedure involved immersion of the rootball, in a chlorpyrifos solution (PPQ Manual 805.2500). This procedure was labor intensive, disruptive to the root ball and totally incompatible with nursery operations.

Growers requested an in-field treatment that would not disrupt routine operations. Our tools for developing this type of treatment were very limited. Baits such as AMDRO, LOGIC, and AFFIRM effectively eliminate colonies present before treatment, but provide no residual protection against re-infestation by new queens. Short-term residual pesticides such as Dursban do offer several weeks of residual activity against new queens. However, large mature colonies are often severely weakened, but not eliminated with broadcast applications of short term residual insecticides.

By combining the effects of bait toxicants plus short term residuals we were able to reduce the IFA population to essentiallly zero and maintain it at this level for up to 20 weeks. In 1985, four different field trials were conducted utilizing 1-acre unreplicated field plots (SLIDES). Two studies were also initiated in 1987 (SLIDES). Based upon this data, both LOGIC and Dursban labels were expanded to include this use pattern (SLIDES), and this treatment has been added to the PPQ treatment manual.

Containerized Nursery Stock

The most desirable treatment for containerized stock (SLIDE) is a granular formulation that can be blended into the potting media before "potting up". A minimum of 12-18 months residual activity is required and the product must not be phytotoxic. Granular Dursban has been the sole treatment for this use pattern since 1980. Data generated over the past 3 years have shown that TRIUMPH is also effective for this use. In addition to initial toxicity, residual activity is also very good (SLIDES). The registrant (Ciba-Geigy) has indicated an interest in obtaining registration of TRIUMPH for this use pattern. Once this label is approved (presumably later this year), a second or alternate preplant incorporated treatment will be available.

As previously mentioned, granular Dursban incorporated into potting media is the most often utilized treatment for containerized plants. However, label precautions preclude its use on plants intended for food or feed. Since a large volume of blueberry plants, pecans, etc. are shipped outside the regulated area, a different treatment for this type of plant material was needed.

Efficacy of diazinon against the IFA is well established (Hillman 1977, Morrill 1976, Franke 1983, Williams and Lofgren 1983). Under current labeling, diazinon can be used to treat blueberries and other woody food plants for a variety of other insect pests. We conducted a study to demonstrate the effectiveness of diazinon as a pour-on treatment for certification of IFA infested containerized plants, primarily blueberries. Diazinon was applied as a drench (2.0 pints 2EC/100 gallons of water), with Dursban 4EC at 4 fl oz/100 gallons of water used as the standard. Both treatments were highly effective in eliminating colonies infesting pots at the time of treatment (SLIDE). Residual activity against re-invasion of treated pots by alate queens was determined to be about 4 weeks, which is well within the parameters of a "treat and ship" quarantine treatment (SLIDE). Based on these results, we have requested and Ciba-Geigy has agreed to obtain registration of Diazinon for this use pattern.

Grass Sod (SLIDE)

At the current time the only PPQ approved treatment for grass sod involves a broadcast application of Dursban 10G at either 4.0 or 6.0 lbs AI per acre. Only one product is labeled for this use pattern (SLIDE). This treatment is based upon the assumption that the greatest pest risk associated with movement of grass sod is transport of newly mated queens rather than mature queens, which are well sequestered within the depths of the mound. Therefore, the Dursban sod treatment is not intended to eliminate colonies, but to kill new queens only. This concept has generated some confusion by growers and others who see live IFA colonies within sod fields which have been treated with Dursban.

Summary

To summarize this discussion, all quarantine treatments currently in use involve chlorpyrifos in one form or another. Several treatments based on other chemicals are in various stages of development, but should be available to nurserymen sometime this year. Meanwhile, work continues towards developing treatments that are not only effective but also economical and easy to use. Projects underway at our laboratory include new product screening, evaluation of chemigration, and application techniques. Our goal is to develop three or four different treatments for each commodity in order to provide nurserymen with options that are uniquely suited for each situation.

Test 1: Stennis Airport, Bay St. Louis, Mississippi.
May 23, May 3Ø, 1985.

	Population Index at Indicated No. of Weeks Post-Treatment				
Treatment	Pretreat	4	8	15	19
Amdro + Dursban 1ØG	135	Ø	Ø	Ø	Ø
Check	71.5	76.6	43.3	48	61.6

Test 2: V. E. Howell Nursery, Lucedale, Mississippi.
April 11, April 17, 1985

	Population Index at Indicated No. of Weeks Post-Treatment						
Treatment	Pretreat	1	8	12	16	20	24
Amdro + Dursban 10G	1802	670	10	0	4	98	350
Amdro	926	684	275	130	181	360	625
Check	807	446	305	287	349	180	593

Test 3: Pascagoula Airport, Pascagoula, Mississippi.
August 29, September 1Ø, 1985

	Population Index at Indicated No. of Weeks Post-Treatment			
Treatment	Pretreat	4	8	12
Amdro	135	43	22	1/
Amdro + Dursban 1ØG	185	Ø	Ø	
Dursban 1ØG	8Ø	3	Ø	
Check	115	132	11Ø	

1/ Lost plots due to insecticidal treatment by Airport Authority

Test 4: Windmill Nursery, Folsom, Louisiana.
October 22, October 29, 1985.

Treatment	Population Index at Indicated No. of Weeks Post-Treatment			
	Pretreat	4 Wks	12 Wks	24Wks
Amdro	25Ø	9Ø	55	13
Amdro + Dursban 1ØG	185	2	15	Ø
Dursban 1ØG	27Ø	68	9	62
Check	385	372	272	41Ø

TABLE ___. Efficacy of IFA Baits Used in Combination with Granular Dursban for IFA Control in Field Grown Nursery Stock, 1987.

TREATMENT 1/	Date(s) Applied	Pre-Treatment Population 2/		% Change in Pre-treatment Population Index at indicated weeks post-treatment 2/				
		No. Colonies	Pop. Index	(4)	(5)	(8)	(10)	(20)
TEST I- Windmill Nursery								
Amdro + Dursban 10G	5/19, 5/22	17	275	-100		-100		
Logic + Dursban 10G	5/19, 5/22	13	190	-100		-100		
Affirm + Dursban 10G	5/19, 5/22	26	265	- 96		3/		
Logic Only	5/19	16	215	- 85		3/		
Dursban 10G Only	5/19	21	260	- 81		-96		
Amdro Only	5/19	25	362	- 79		-92		
Affirm Only	5/19	14	187	- 52		-86		
Untreated Check	—	26	348	- 56		-57		
TEST II-Diamondhead Airport								
Affirm + Dursban	6/29, 7/2	33	450		-100		-100	-100
Amdro + Dursban	6/29, 7/2	25	310		-100		-100	-100
Logic Std. + Dursban	6/29, 7/2	25	310		-100		-100	- 97
Logic APE + Dursban	6/29, 7/2	28	355		-100		-100	-100
Untreated Check	—	18	245		-45		- 57	0

1/ Rates if application as follows: Affirm 1 lb./acre; Amdro 1 1/2 lb./acre; Logic 1 1/2 lb./acre; Dursban 10G 60 lb./acre.

2/ Population index described by Lofgren and Williams (1982).

3/ Lost plot due to weedy conditions.

GORDON'S®
PROFESSIONAL
TURF & ORNAMENTAL PRODUCTS

LOGIC®

> NOW APPROVED SPECIFICALLY
> **FOR USE IN NURSERIES AND SOD FARMS**
> Apply LOGIC Fire Ant Bait as directed in and around container and field grown ornamental and non-bearing nursery stock and commercial turf.

FIRE ANT BAIT

AN INSECT GROWTH REGULATOR FOR THE CONTROL OF FIRE ANTS

ACTIVE INGREDIENT

fenoxycarb	
Ethyl (2-(4-phenoxyphenoxy) ethyl) carbamate	1%
INERT INGREDIENTS	99%
	100%

1 lb. contains 0.16 oz. active ingredient

KEEP OUT OF REACH OF CHILDREN
CAUTION

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

May be harmful if swallowed. Avoid breathing dust. Avoid contact with clothing, skin or eyes.

STATEMENT OF PRACTICAL TREATMENT

In case of contact, flush skin or eyes with plenty of water. Get medical attention if irritation persists.

ENVIRONMENTAL HAZARDS

This product is toxic to fish and aquatic invertebrates. Drift and runoff from treated areas may be hazardous to aquatic invertebrates in adjacent aquatic sites. Do not apply directly to water. Do not contaminate water by cleaning of equipment or disposal of wastes.

STORAGE & DISPOSAL

STORAGE: Store in original container in a locked storage area inaccessible to children or pets. Store away from heat. Keep container tightly closed. **PESTICIDE DISPOSAL:** Do not contaminate water, food, or feed by storage or disposal. Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility. **CONTAINER DISPOSAL:** Completely empty bag by shaking and tapping sides and bottom to loosen clinging particles. Then dispose of empty bag in a sanitary landfill or by incineration, or, if allowed by State and local authorities, by burning. If burned, stay out of smoke.

520/388
EPA REG. NO. 35977-4-2217
EPA EST. NO. 33560-TN-1

DISTRIBUTED BY
pbi/gordon corporation
KANSAS CITY, KANSAS [illegible]

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. DO NOT USE ON PASTURE, RANGELAND OR OTHER GRAZED AREAS. LOGIC® fire ant bait is an insect growth regulator with a mode of action specific to insects, and therefore has less influence on non-target organisms. LOGIC® fire ant bait is very easy and convenient to apply (see use directions below). Following application LOGIC® fire ant bait is collected by worker ants and distributed throughout the colony. Within 3 to 5 weeks there is considerable ant mortality and a continual decline of the fire ant colony.

METHODS OF APPLICATION

Apply LOGIC® Bait when ants are actively foraging. This is usually when soil temperatures are above 60°F. Avoid application during excessively hot periods of the day or when the grass is wet. Heavy rainfall within 2 or 3 hours of application may reduce effectiveness.

FOR USE ON TURF, LAWNS AND NON-AGRICULTURAL LAND SUCH AS: LAWNS, TURF, AIRPORTS, PARKS AND GOLF COURSES.

In cases where reinfestation occurs or when very large mounds remain active, retreatment may be desirable after 3 to 4 months.

Do not apply to pasture, rangeland or other areas which may be grazed by cattle, sheep or other domestic animals.

Single Mound: Apply 1 to 3 level tablespoons of LOGIC® bait per mound uniformly distributing material 3 to 4 feet around the base of the mound. Do not contaminate kitchen utensils by use or storage.

Broadcast Application: Apply uniformly with ground equipment calibrated to give the correct dosage. Apply at 1 to 1.5 lb./A.

AERIAL APPLICATIONS

Apply uniformly with aerial equipment calibrated to give the correct dosage. Apply at 1 to 1.5 lb./Acre. Do not apply when weather conditions favor drift from treated areas.

FOR USE IN NURSERIES AND SOD FARMS

Apply LOGIC Fire Ant Bait as directed in and around container and field grown ornamental and non-bearing nursery stock and commercial turf.

WARRANTY:

The manufacturer warrants that the chemical composition conforms to the ingredient statement given on the label and that this product is suited for the labeled uses when applied according to label directions. Because of widely varying use conditions, it is impossible to eliminate all risks even when label directions are followed. Therefore, the manufacturer makes no other implied or express warranty nor is any agent of the manufacturer allowed to do so. Upon purchase of this product, the buyer assumes all risks associated with use of this product. In the event of damage resulting from a breach of warranty, the buyer agrees to accept a refund of the purchase price of the product as full discharge of the manufacturer's liability.

NET WEIGHT FOUR POUNDS

ford's

FIRE ANT 2.5G
INSECTICIDE

Controls the Imported Fire Ant in Nursery Bench and Potting Media and in Field Grown Ornamentals Intended for Use on Ornamental Plants Grown Outdoors in Containers

ACTIVE INGREDIENT:

Chlorpyrifos [0,0-diethyl-0-(3,5,6-trichloro-2-pyridyl) phosphorothioate]	2.5%
INERT INGREDIENTS	97.5%
TOTAL	100.0%

U. S. Patent No. 3,244,586

PRECAUCION AL USUARIO: Si usted no lee ingles, no use esta producto hasta que la etiqueta le haya sido explicada ampliamente.
TRANSLATION: (TO THE USER: If you cannot read English, do not use this product until the label has been fully explained to you.)

CAUTION: KEEP OUT OF REACH OF CHILDREN

PRECAUTIONARY STATEMENTS

Hazards to Humans

CAUTION: MAY BE HARMFUL IF SWALLOWED: Do not take internally. Avoid contact with eyes, skin and clothing. Wash thoroughly after handling. Wash contaminated clothing before reuse.

STATEMENT OF PRACTICAL TREATMENT

IF SWALLOWED: Drink 2 glasses of water and induce vomiting by touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person. Get medical attention. **IF ON SKIN:** In case of contact, remove contaminated clothing and immediately wash skin with soap and water. **IF IN EYES:** Flush eyes with plenty of water and get prompt medical attention.
NOTE TO PHYSICIAN: Chlorpyrifos is a cholinesterase inhibitor. Treat symptomatically. Atropine only by injection is an antidote.

ENVIRONMENTAL HAZARDS

This product is toxic to fish, birds and other wildlife. Birds feeding on treated areas may be killed. Do not apply where runoff is likely to occur. Do not apply when weather conditions favor drift from areas treated. Do not contaminate water by cleaning of equipment or disposal of wastes. Apply this product only as specified on this label.

AGRICULTURAL CHEMICAL

Do not ship or store with food, feeds, drugs or clothing.

USE DIRECTIONS

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

Apply Fire Ant 2.5 Insecticide for the control of Imported Fire Ants in nursery bench and potting media. Thoroughly mix 1 pound of Fire Ant 2.5 Insecticide per cubic yard of media. Use equipment suitable to give uniform distribution of granules.

TO TREAT FIELD GROWN WOODY ORNAMENTALS (Balled and Burlapped Stock)

1. To be used as a preharvest treatment on non-food bearing field grown woody ornamentals. Use this product in combination with an imported fire ant bait approved by USDA (APHIS/PPQ) for use in the fire ant quarantine program.
2. Apply this product 3 - 5 days after approved bait application, with equipment capable of uniform distribution at a rate of 250 lbs. per acre or 4 lbs. per 750 sq. ft. (6 lbs. A.I. per acre). This application will provide a 60-day certification period following a 30-day exposure period.
3. To extend certification period, re-treat areas with this product every 90 days.
4. Use this product only in accordance with USDA guidelines.

USE PRECAUTIONS

Do not use plants for food or feed purposes which have been exposed to soil treated with Fire Ant 2.5 Insecticide.

STORAGE AND DISPOSAL

Prohibitions: Do not contaminate water, food or feed by storage or disposal. Open dumping is prohibited. **Pesticide Disposal:** Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility. **Container Disposal:** Completely empty bag into application equipment. Then dispose of empty bag in a sanitary landfill or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke. **General:** Consult Federal, state or local disposal authorities for approved alternate procedure, such as limited open burning.

NOTICE: Seller warrants that the product conforms to its chemical description and is reasonably fit for the purposes stated on the label when used in accordance with directions under normal conditions of use, but neither this warranty nor any other warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE, express or implied, extends to the use of this product contrary to label instructions, or under abnormal conditions, or under conditions not reasonably foreseeable to seller, and buyer assumes the risk of any such use.

EPA Reg. No. 10370-141
EPA Est. No. 10370-TX-1

1/88

NET CONTENTS:

Manufactured By

ford's Chemical & Service, Inc.
2739 Pasadena Blvd.
Pasadena, Texas 77502

121487 FCS

CPS-0645

Fig Dosage mortality curve—toxicity of Triumph to IFA workers.

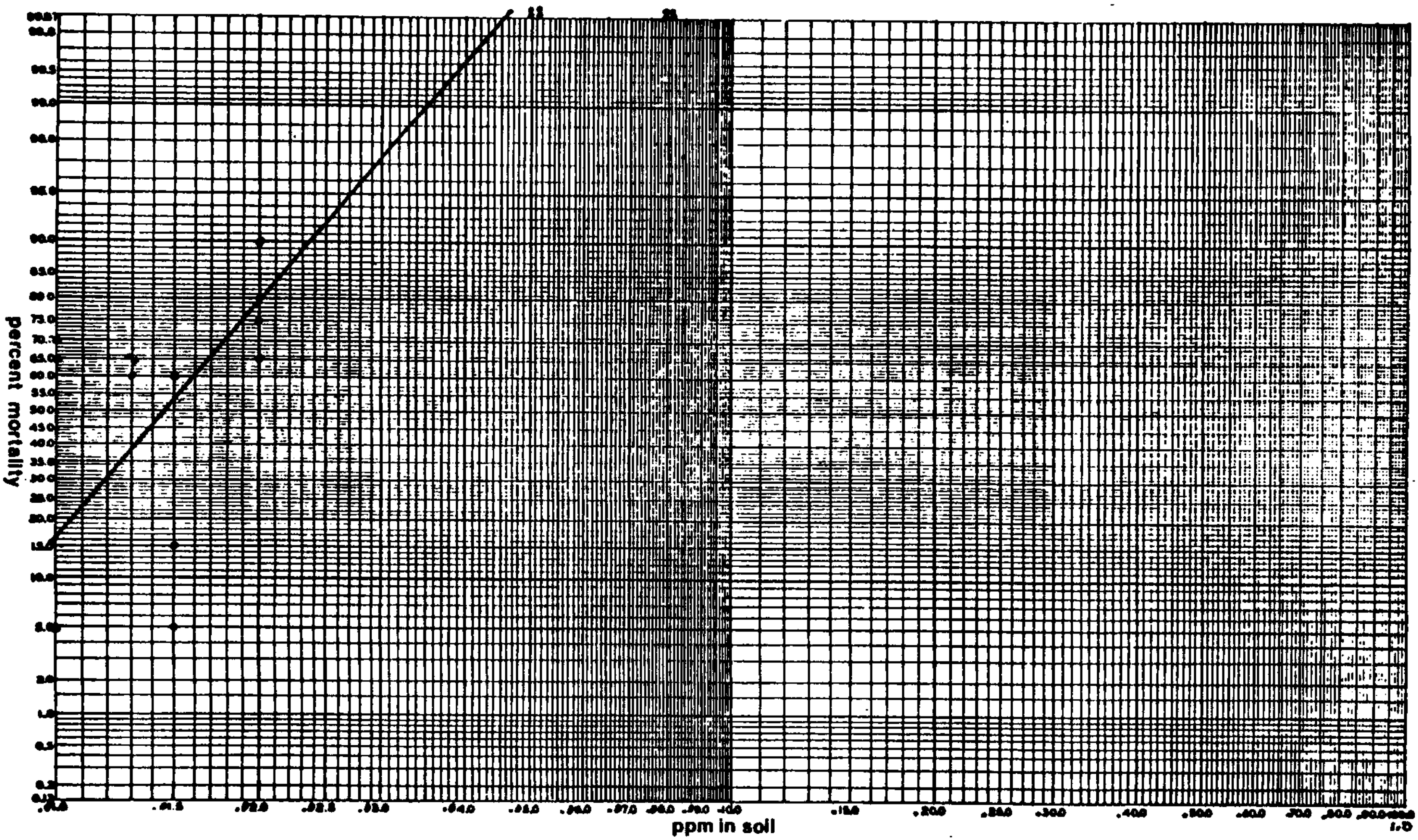
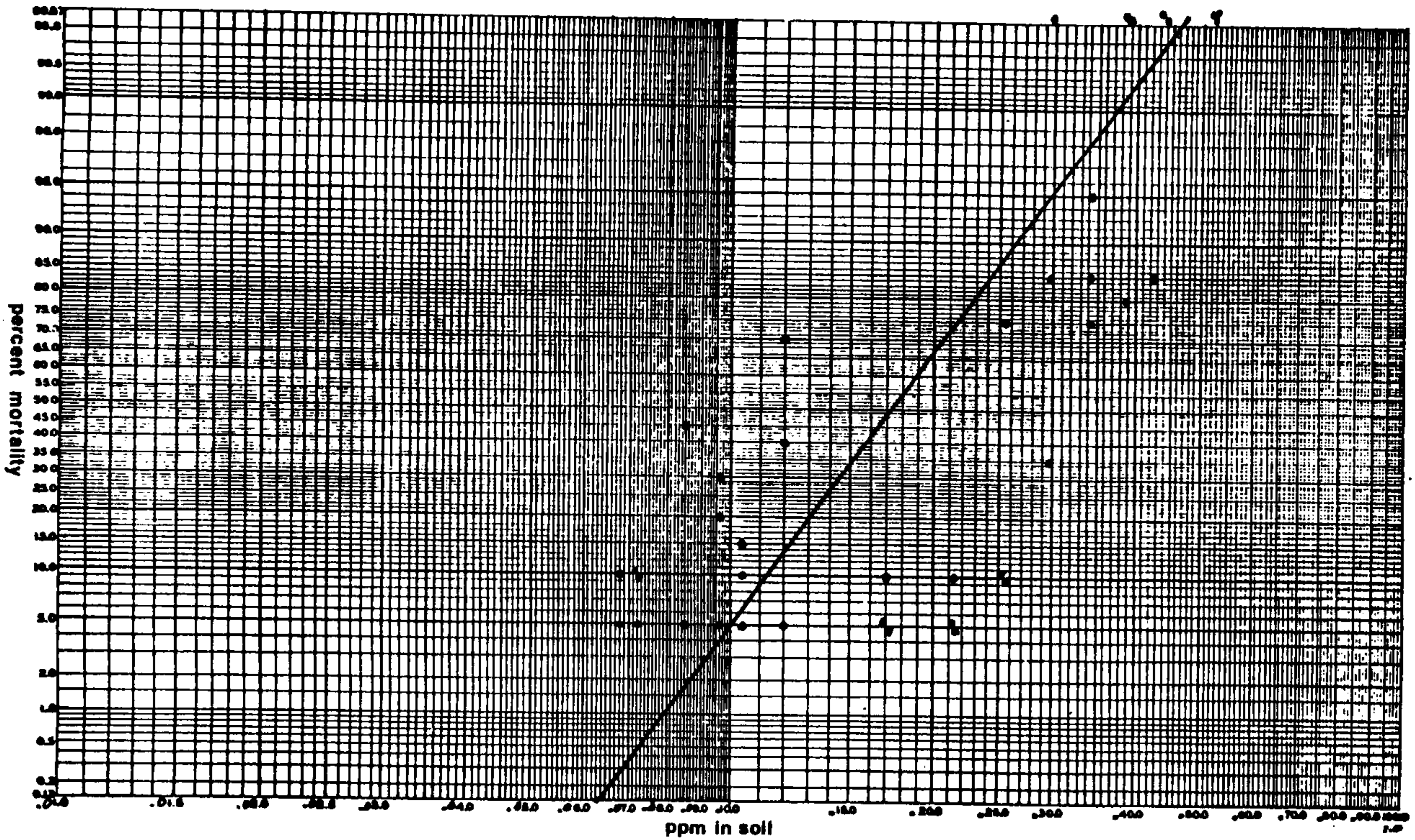


Fig Dosage mortality curve - toxicity of Triumph to IFA alate queens.



EFFECTIVENESS OF DIAZINON 2EC POUR-ON TREATMENT FOR ELIMINATION OF IFA COLONIES INFESTING NURSERY POTS

TREATMENT 1/	TRIAL I % Colony Mortality	TRIAL II % Colony Mortality	TRIAL III % Colony Mortality
2.0 pints Diazinon 2EC/ 100 gallons water	100	100	100
4.0 fluid oz. Dursban 4EC/ 100 gallons water	100	100	100
Check	0	0	0

1/ 3 colonies/treatment/trial

TABLE __ . Residual Activity of Diazinon Drench Against Alate IFA Queens.

Treatment	% Mortlaity at Indicated Post-Treat Interval				
	24 Hr.	1 Wk.	2 Wk.	3 Wk.	4 Wk.
Trial 1 - 7/27/87					
2.0 pints Diazinon 2EC/ 100 gal. water	100	100	15	—	—
4.0 fluid oz. Dursban 4EC/100 gal. water	—	—	—	—	—
Untreated Check	0	15	10	—	—
Cumulative Rainfall (inches)	0	3.75	8.62	—	—
Trial 2 - 12/14/87					
2.0 pints Diazinon 2EC/ 100 gal. water	100	100	100	100	100
4.0 fluid oz. Dursban 4EC/100 gal. water	100	95*	100	100	100
Untreated Check	5	0	0	10	15
Cumulative Rainfall (inches)	0.10	1.27	3.77	4.87	5.32
Trial 3 - 12/16/87					
2.0 pints Diazinon 2EC/ 100 gal. water	100	100	100	100	100
4.0 fluid oz. Dursban 4EC/100 gal. water	100	100	95*	100	100
Untreated Check	0	5	0	0	15
Cumulative Rainfall (inches)	0	1.77	3.67	4.77	5.27

* Escape of one queen from one replicate.

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METABOLISM AND ELIMINATION OF A FLUORINATED SULFONAMIDE INSECTICIDE IN THE RAT, R. O. MANNING & J. V. BRUCKNER

N-ethyl perfluorooctane sulfonamide is a highly fluorinated sulfonamide which is being investigated as a possible fire ant pesticide. This compound, which I will refer to as GX-071, is currently being studied by several groups at the University of Georgia. The group which I work with is responsible for investigating the metabolism of GX-071. Hopefully, this work will provide information to: 1) contribute to the risk assessment of the chemical in regard to its intended uses and anticipated human and animal exposures; and 2) facilitate product registration. Specific aims of our project include: determination of the pattern of disposition among tissues and organs; determination of the amount and rate of uptake; characterization of route(s) and rate(s) of elimination; and determination of bioaccumulation or bioretention of the compound. When we were brought onto the project no reliable analyses were available for GX-071 in biological samples such as urine, feces, and tissues, but a quantity of previously synthesized carbon 14 labeled GX-071 was provided. The data I am presenting today is from a study to determine if the carbon 14 labeled GX-071 could be used to study the disposition and elimination of GX-071 in the rat.

The carbon 14 label on the GX-071 was located near the end of the molecule, on the ethyl group (Figure 1). It would have been preferable to have the label in the middle of the fluorine chain but that was not possible due to the method of synthesis. We were concerned that the label might be easily lost from the molecule so special cages were used during the study. Sprague-Dawley rats were acclimated, one per cage, in glass Roth metabolism cages for 24 hr prior to the beginning of each trial. The cages were designed for the separate collection of urine, feces and expired air. Room air was drawn through the cages by vacuum at a rate of 200 ml/min. Twelve rats, 6 females and 6 males, weighing 200 gm were used. Data from previous studies of the oral administration of GX-071 to rats, conducted at the College of Veterinary Medicine, were used to determine the dose administered in the present study. A dose of 50 mg GX-071/kg BW was chosen to allow disposition and elimination of the compound to be studied in an animal that was not suffering from any severe toxic effect of the test chemical. The rats were administered a single oral bolus of GX-071 by gavage which contained 10 uCi of radioactivity. CO_2 in expired air was trapped in an organic trap for 4- or 12-hr intervals. Urine was collected at 12-hr intervals in graduated glass collectors. The collectors were mounted in double-walled beakers, which contained an antifreeze-water mixture circulated and chilled to $-5^{o}C$ by a refrigerated bath circulator. The ^{14}C activity in the CO_2 trap fluid and urine was counted in toluene based scintillation fluid. Feces were collected at 12-hr intervals, freeze dried, and ^{14}C activity quantitated as $^{14}CO_2$ using a Packard Biological Oxidizer. At the termination of the study, which was 72 hr, rats were sacrificed with CO_2 and tissues taken for analyses. Tissue subsamples were freeze-dried and ^{14}C activity quantitated as $^{14}CO_2$ using the Biological Oxidizer. The residual carcass, excluding head, feet and tail, was digested in 4.0 N KOH for 24 hr and homogenized. An aliquot of the homogenate was also analyzed for ^{14}C activity using the Biological Oxidizer.

Visual observations during the 72-hour study indicated that there were no gross effects of a single oral bolus of 50 mg/kg GX-071. Rats continued to consume normal quantities of feed and water after the dose was administered. Necropsies of rats at the end of the study also revealed no gross pathology.

The recovery and disposition of ^{14}C in the rat after administration of GX-071 by oral bolus is shown in this Table (Figure 2). Approximately 80% of the radiolabel was recovered by the end of the 72-hour trial. The largest quantities of ^{14}C were recovered in the expired air (approx. 55%) and feces (approx. 25%). This histogram (Figure 3), emphasises that only small quantities of radiolabel were recovered in the urine, tissues, cage rinse, and residual carcass. There were no significant differences in the recovery or total distribution of ^{14}C between males and females.

Radiolabel recovered in the expired air, feces, and urine was plotted against time to estimate elimination half-lives. Cumulative elimination plots and Amount-Remaining-to-be-Eliminated (ARE) plots were constructed and used to determine elimination half-lives for each route. The next two figures illustrate the elimination of ^{14}C as CO_2 in rats. The elimination of ^{14}C as CO_2 (Figure 4) was very similar in males and females, with the only significant difference appearing 4 hours (first sample time) after dosing. By 8 hours and for the remainder of the experiment, the curves were identical. The ARE plot (Figure 5) indicated that the elimination half-life of ^{14}C in expired air as CO_2 was 9 hours.

There were no significant differences in elimination of ^{14}C in feces between males and females (Figure 6). The cumulative elimination curve for females was higher than that for males; however, the difference was not statistically significant due to the large variation in this type of sample. Half-life, estimated from the ARE plot (Figure 7), was 16 hours for this route. The longer half-life indicates that elimination of the radiolabel is slower in feces than in CO_2. A longer elimination half-life in feces may be related to intestinal transit time of the parent compound or the time required for metabolism and biliary excretion.

The elimination of radiolabel in urine of rats is illustrated in the next figure (Figure 8). The cumulative elimination plot for ^{14}C is significantly higher at each time point for females than for males. This appears to be due to the significantly greater quantity of ^{14}C eliminated in urine in the first 12 hours by the females. Because of the difference in the cumulative elimination plots of the males and females, separate half-lives were calculated for each ARE plot (Figure 9). The elimination half-life for ^{14}C in urine was 12 hours and 8 hours, respectively, for males and females.

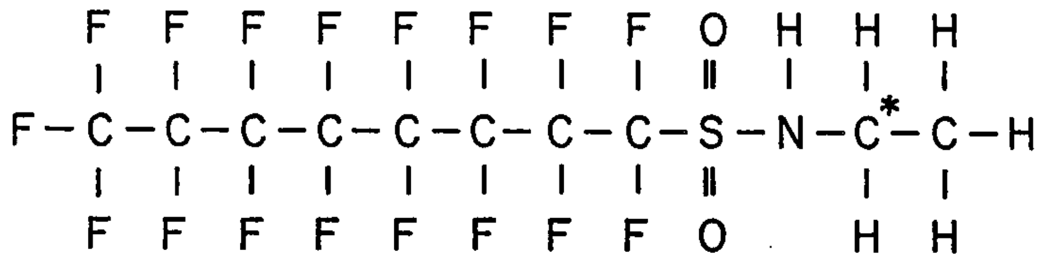
The distribution of radiolabel in tissues 72 hours after oral administration of GX-071 is illustrated in the next two figures. Concentration of ^{14}C was highest in the liver, kidney, and adrenal glands 72-hours post dosing (Figure 10), regardless of sex as shown on this slide of male tissue concentrations of ^{14}C. The quantity of radiolabel in kidney, gonads, and adrenal glands was significantly higher in females than in males (Figure 11). However, there were no significant sex-related differences in radiolabel distribution in any other tissues monitored in the study.

In conclusion, the major route of elimination of ^{14}C in the rat after oral administration of ^{14}C labeled GX-071 was as CO_2 in the expired air. The rapid appearance of substantial quantities of radiolabel in expired air indicated that the N-ethyl group was readily removed from the molecule. This occurrence causes the test compound to be undesirable as an experimental tool for the study of the distribution and elimination of GX-071, because all measurements are of ^{14}C activity per se. A distinction cannot be made as to whether the radioactivity measured is as free ^{14}C or as a part of the parent compound, prior to deethylation. Nevertheless, several conclusions can be drawn form the results of the present study. As previously stated, the major route of elimination of ^{14}C in the rat after administration of ^{14}C-GX-071 was as CO_2. This finding suggests that rapid and complete removal of the ethyl group occurs after oral administration of GX-071. Whether this process requires the action of a specific enzyme or is strictly a chemical reaction cannot be determined from the present study.

The extremely low quantities of radiolabel in the tissues and the residual carcass of the rats after 72 hours suggest that relatively little ^{14}C remained in the carbon pool of the rat. If ^{14}C, released from the labeled parent compound, entered the carbon pool, one would expect radioactivity to be evident in higher levels in different tissues at 72 hours, and to have longer estimated half-lives of elimination than found in the present study. The data presented herein suggests that little of the radiolabeled GX-071 was left unmetabolized as the parent compound by 72 hours post dosing. ^{14}C remaining as part of the parent compound should have resulted in longer elimination half-lives and in higher radiolabel levels in adipose tissue, due to the high lipophilicity of GX-071.

Half-lives of elimination for ^{14}C were similar in CO_2 (9 hr) and urine (approx. 10 hr), but longer in feces (16 hr). Elimination of radiolabel was also relatively complete by 48 hours after dosing. The rapid rate of elimination and the relatively small quantity of ^{14}C recovered from the urine suggest that urinary excretion is not an important route of elimination of labeled GX-071 or its metabolites. The large quantity of radioactivity present in feces and the longer half-life for this route of elimination may have been related to the time required for metabolism and biliary excretion and/or recirculation, or simply to the intestinal transit time of unabsorbed parent compound.

Fig. 1



N-ETHYL PERFLUOROOCTANE SULFONAMIDE
(GX-071)

* denotes ^{14}C label

Fig. 2

RECOVERY AND DISTRIBUTION OF ^{14}C IN THE RAT
AFTER ADMINISTRATION OF GX-071 BY ORAL BOLUS

	Male	Female
% of Dose Recovered	82.6	78.3
% As CO_2	59.1	53.3
Feces	23.6	26.4
Urine	7.9	9.2
Tissues	5.9	3.3
Cage Rinse	2.7	4.9
Residual Carcass	2.5	2.0

Fig. 3

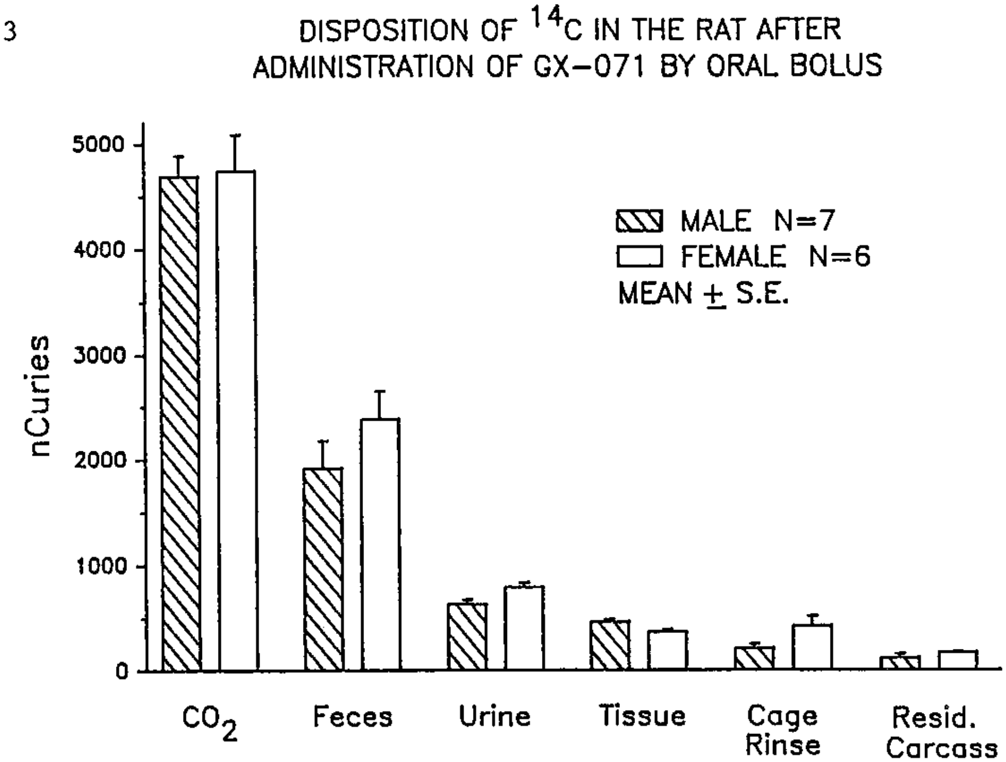

DISPOSITION OF 14C IN THE RAT AFTER
ADMINISTRATION OF GX-071 BY ORAL BOLUS
MALE N=7
FEMALE N=6
MEAN ± S.E.
nCuries
5000
4000
3000
2000
1000
0
CO2
Feces
Urine
Tissue
Cage Rinse
Resid. Carcass

Fig. 4

CUMULATIVE ELIMINATION OF ^{14}C AS CO_2 IN RATS AFTER ADMINISTRATION OF GX–071 BY ORAL BOLUS

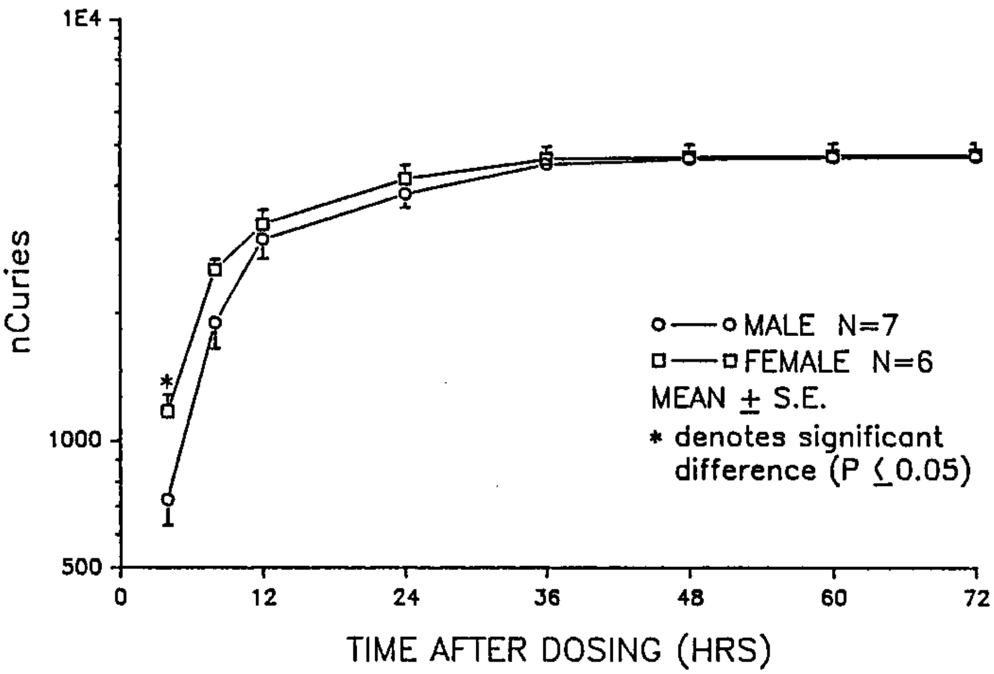


Fig. 5

AMOUNT OF ^{14}C REMAINING TO BE ELIMINATED (ARE) AS CO_2 IN RATS AFTER ADMINISTRATION OF GX–071 BY ORAL BOLUS

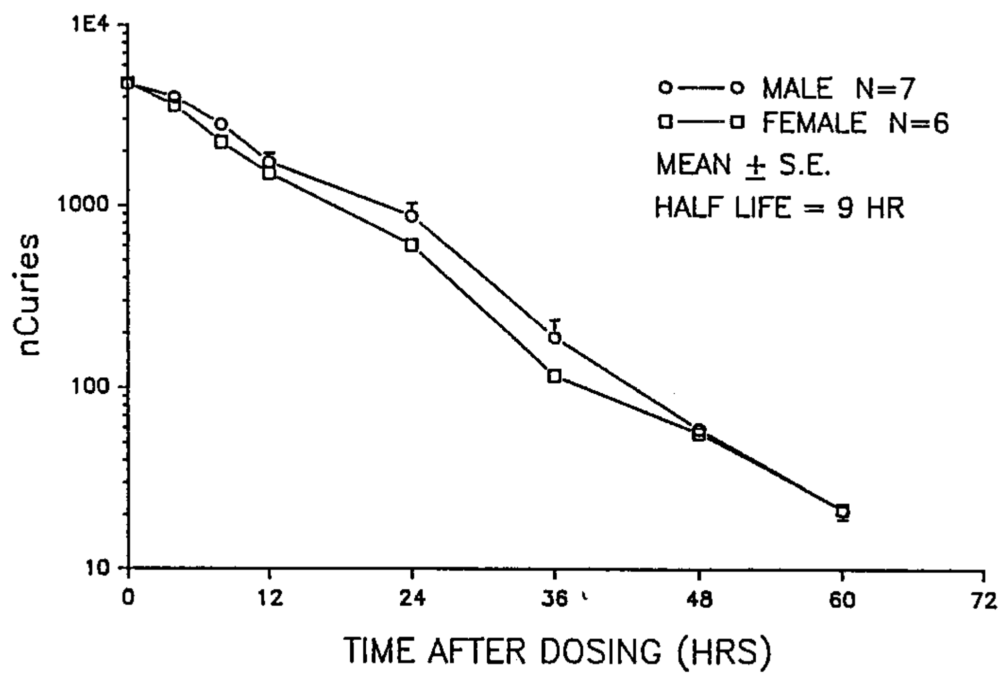


Fig. 6 CUMULATIVE ELIMINATION OF ^{14}C IN FECES OF RATS AFTER ADMINISTRATION OF GX-071 BY ORAL BOLUS

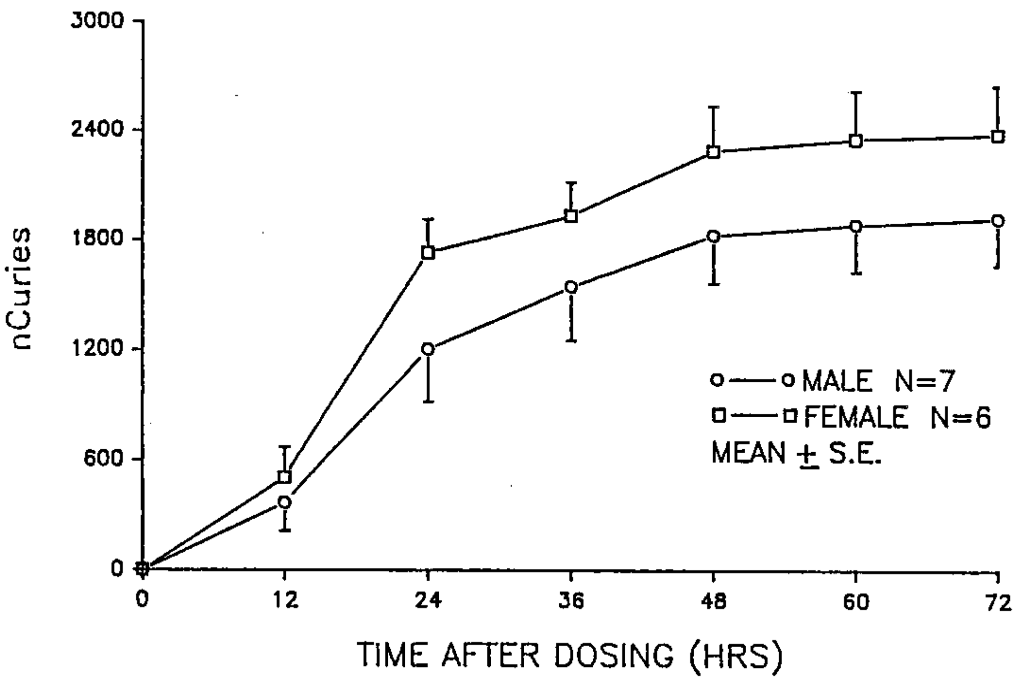


Fig. 7 AMOUNT OF ^{14}C REMAINING TO BE ELIMINATED (ARE) IN FECES OF RATS AFTER ADMINISTRATION OF GX-071 BY ORAL BOLUS

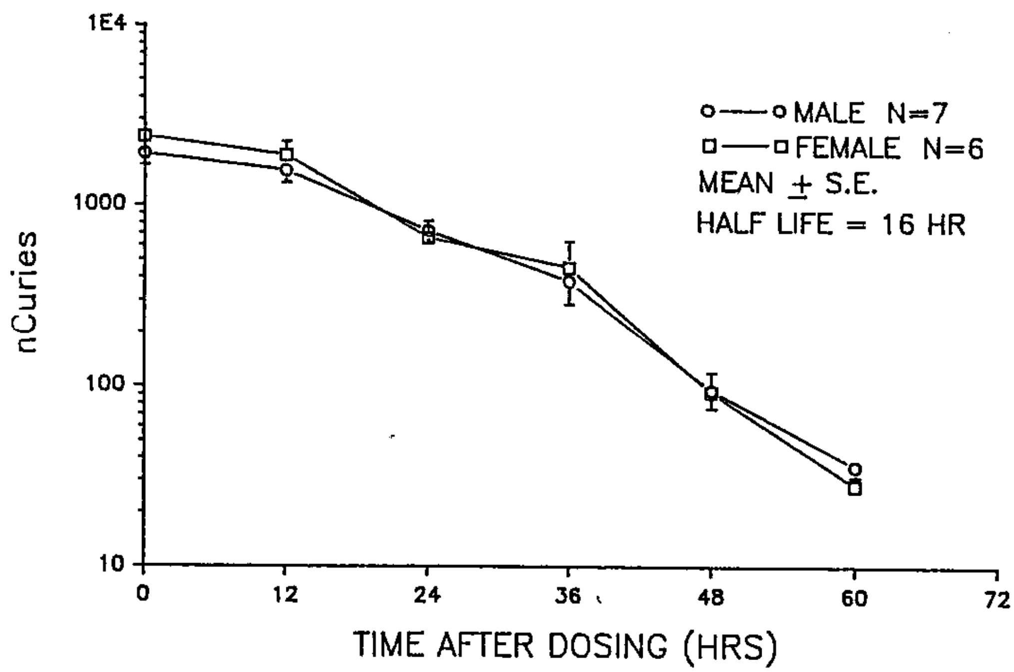


Fig. 8 CUMULATIVE ELIMINATION OF ^{14}C IN URINE OF RATS AFTER ADMINISTRATION OF GX-071 BY ORAL BOLUS

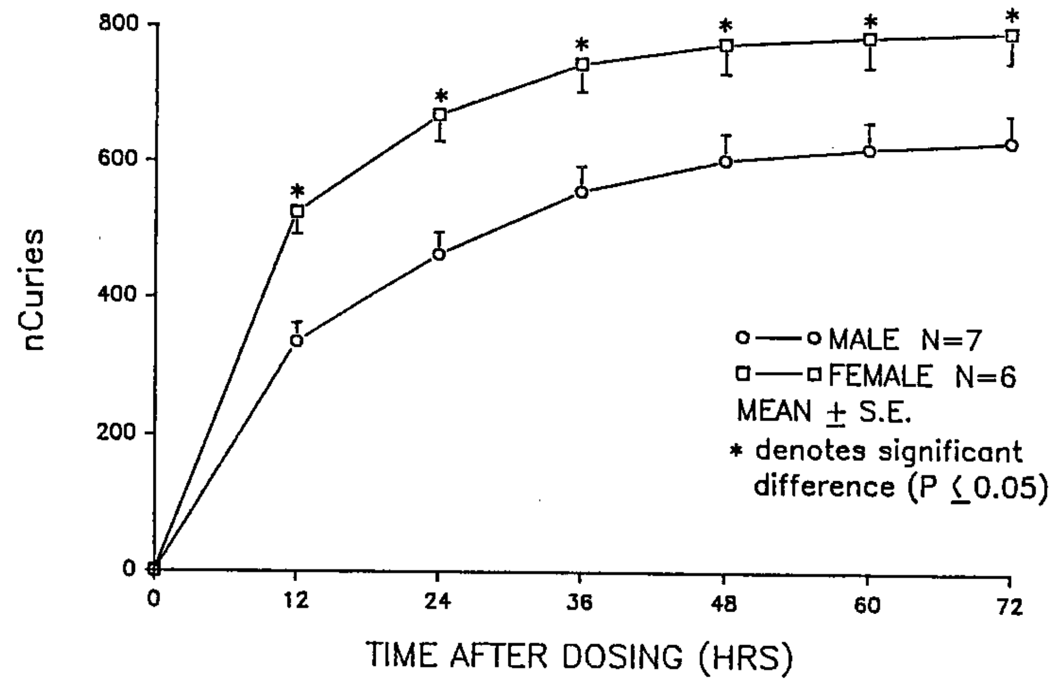


Fig. 9 AMOUNT OF ^{14}C REMAINING TO BE ELIMINATED (ARE) IN URINE OF RATS AFTER ADMINISTRATION OF GX-071 BY ORAL BOLUS

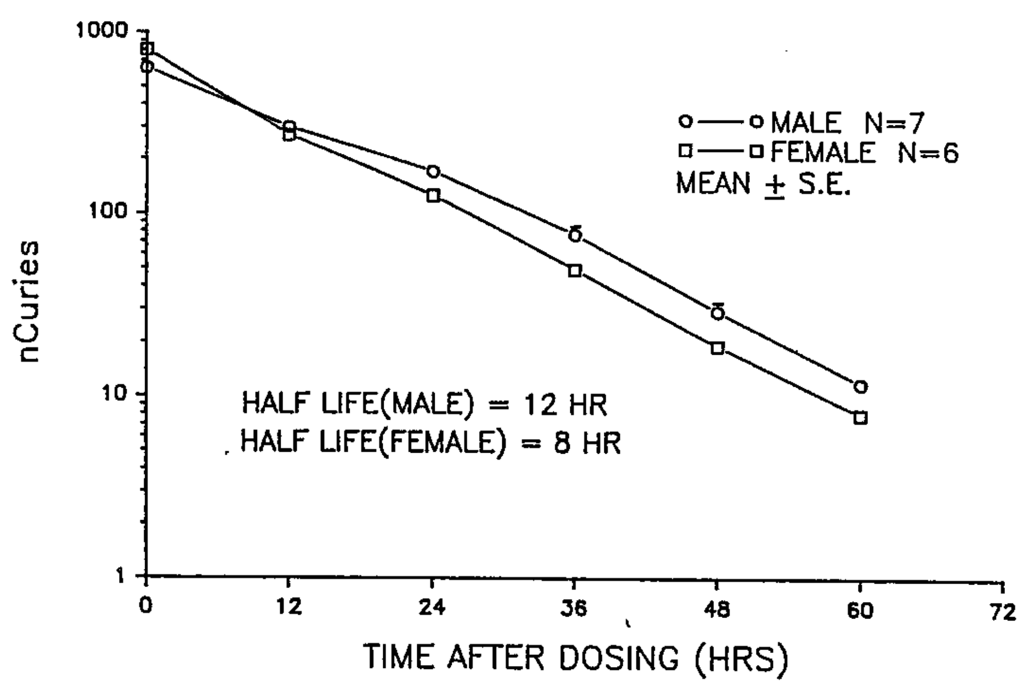


Fig. 10

DISTRIBUTION OF ^{14}C IN TISSUES OF MALE RATS 72 HRS AFTER ADMINISTRATION OF GX–071 BY ORAL BOLUS

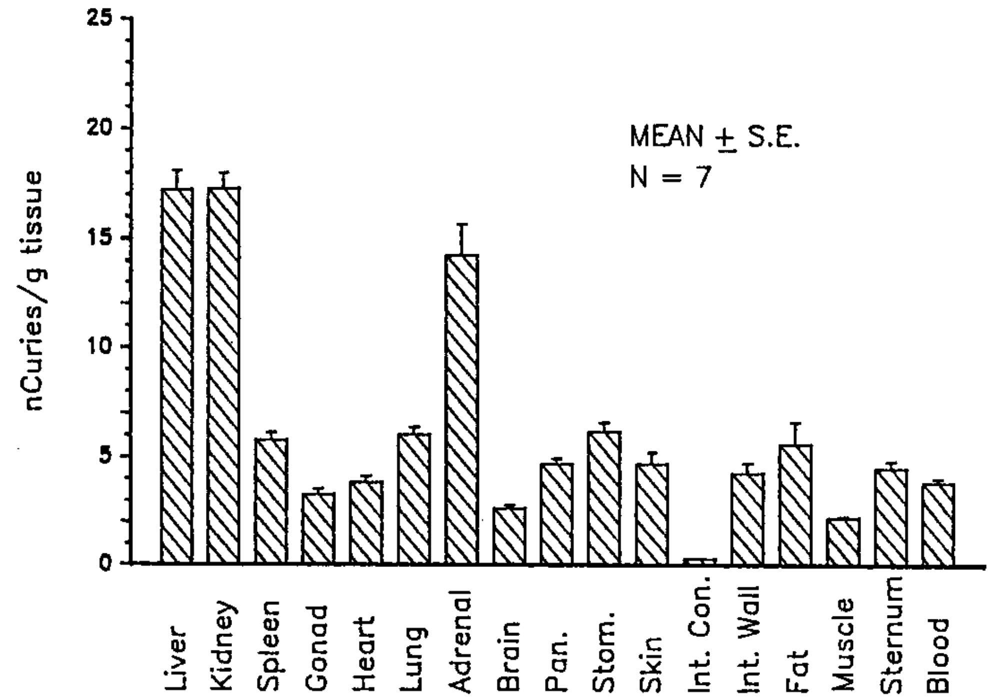
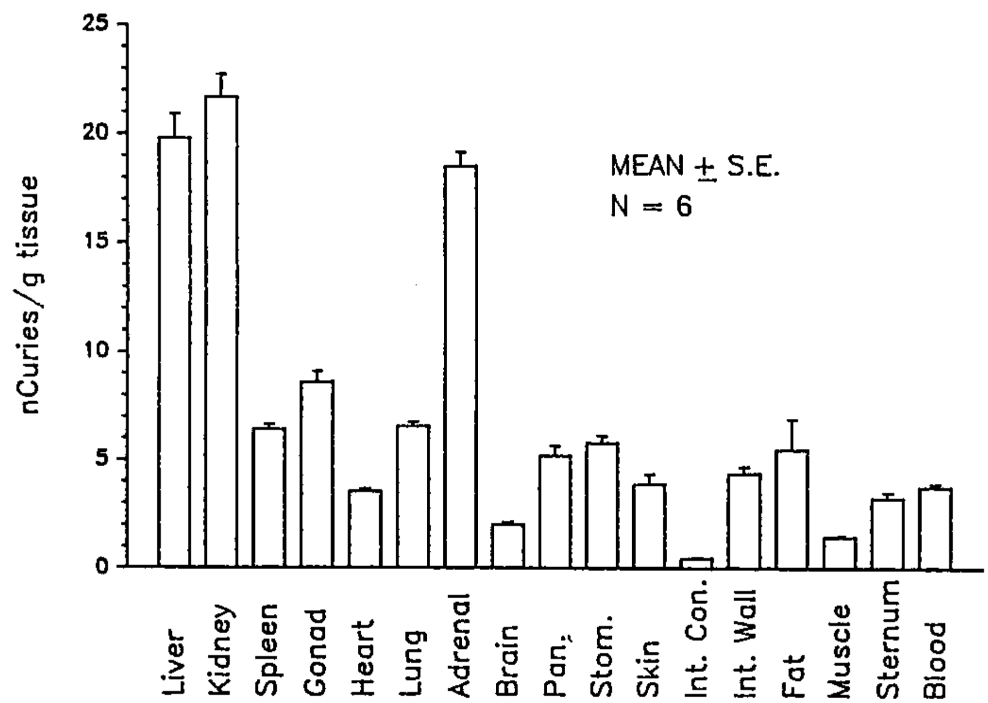


Fig. 11

DISTRIBUTION OF ^{14}C IN TISSUES OF FEMALE RATS 72 HRS AFTER ADMINISTRATION OF GX–071 BY ORAL BOLUS



NOT FOR PUBLICATION

Supercooling Studies and Winter Mortality Studies involving Solenopsis invicta, Solenopsis richteri, and the Solenopsis hybrid

Stan Diffie
and
Craig Sheppard

Department of Entomology
Coastal Plain Experiment Station
University of Georgia
Tifton, Georgia 31793

Spot infestations of fire ants were first detected in Floyd County, Ga. around 1980-1981. By the summer of 1984 the county was completely infested, as were all the counties south of Floyd County. A collecting trip was made to Floyd County and the samples were sent to Dr. Bob VanderMeer (USDA Insects Affecting Man and Animals Laboratory) in Gainesville, Fl. for identification. Cuticular hydrocarbon and venom analyses using gas chromatography identified the ants as hybrids of Solenopsis invicta X S. richteri. Subsequent collecting has found the hybrid in thirteen Georgia counties, twenty-two Alabama counties, and five Mississippi counties.

In addition to questions of control, one of the main questions asked was " Why has the hybrid been able to establish 100 miles above the old infestation line? " S. invicta has also moved above the traditional northern boundry represented by Interstate 20. However, S. invicta is sparsely populated 25 miles north of I-20.

Three possibilities arose as explanations to this movement:

(1) The ability of hybrid fire ants to supercool at lower temperatures than the parental forms

(2) The ability of hybrid colonies to survive winters better than S. invicta

(3) The ability of the hybrid to avoid competition from S. invicta

Supercooling

Supercooling is the ability to avoid freezing at temperatures below the melting point. Franke et. al. began work on determining the supercooling points of the four fire ants found in Texas and S. richteri from Mississippi. Personal communication with Dr. Franke convinced us to persue a similar technique in identifying the supercooling points of S. invicta collected in Tift County, S. richteri collected in Mississippi, and the Solenopsis hybrid collected in Floyd County.

Fire ant colonies were collected from Itawamba County, Mississippi, Floyd County, Georgia, and Tift County, Georgia. The colonies had been collected in ten gallon plastic trash cans. The upper inside edges of these cans had been treated with fluon to prevent the ants from escaping. The collected ants were then transported back to the laboratory at Tifton where they were maintained. Samples from the collections were identified by gas chromatography as S. richteri from Mississippi, S. invicta from Tift County, and the Solenopsis hybrid from Floyd County.

Foraging ramps were established in each of the colonies. This allowed the selection of foraging workers and thus eliminated age as an influence in the tests. Fifty major workers were collected randomly from each set of colonies. These workers were then taken to the laboratory and individually tested. Each ant was measured by attaching it to a Bailey Instruments MT-29/1 microprobe. The readings were displayed by a Bailey Instruments digital thermocouple thermometer BAT-12. The microprobe had a small amount of Vasoline gel applied to the sensing end. This provided a sticking medium to adhere the ant. Each ant was then placed inside the chest containing dry ice. The point at which the ant froze was recorded.

The alates were collected in petri dishes from the field.

They were then taken to a work station and frozen immediately. These ants were not transported back to Tifton to be reared.

Mean temperatures listed in the table show the S. richteri major workers froze at a slightly lower temperature.

This could be correlated in field conditions since S. richteri is found north of S. invicta. The hybrid (also found north of S. invicta) had a slightly higher supercooling point than S. invicta, though the difference was not significant. The only alate to show a difference was the S. invicta male. This would appear logical since it is found south of the other two ant types.

The only correlation between supercooling points and the locale of the ant's habitat is with the male alate. It is very doubtful that the male alates are the limiting factor in the northward movement. It is more reasonable to assume that the small differences found in the supercooling points are insignificant in the field.

Winter Mortality Studies

There have been several hypotheses concerning cold weather as the limiting factor in the northward spread of the imported fire ant. Since the hybrid fire ant has exceeded the boundry of most of these hypotheses a study was undertaken to determine how much colony mortality can be attributed to winter conditions.

During the past 3 1/2 years mounds have been marked in the fall of the year. These mounds were left undisturbed until the spring of the following year. The number of marked mounds that were inactive in the spring was recorded and a percent mortality due to the winter was calculated. This was carried out in Floyd County representing the hybrid population and in Morgan County representing the northernmost population of S. invicta. Each year mounds were marked in south Georgia to serve as controls.

The data presented in the table shows very little mortality has been suffered by S. invicta in Morgan County. The hybrid suffered 12% mortality in 1987. This is a very small amount of mortality and is in fact comparable to S. invicta in south Georgia. The south Georgia ants have suffered the most mortality in each of the past three seasons.

Data from the National Weather Service has shown at the 4" soil level there have been 0 days below freezing during the past three years at either the Tifton or Calhoun Stations, representing Tift County and Floyd County, respectively. The Watkinsville Station had 4 freezing days in January 1986. This station is representative of Morgan County. Even with the four freezing days, the Morgan County population suffered as little mortality as the other two populations.

Competition

The hybrid exists in areas thought to be too far north for S. invicta. The hybrid has also been identified in areas thought to contain S. invicta. Whether the hybrid has always existed in these areas and it was misidentified or whether it has displaced S. invicta is unknown. Constant collecting and monitoring of the areas where the two populations meet will allow us to determine which population is out competing the other.

Conclusions

(1) The small differences found in the supercooling points are not significant in the field

(2) The hybrid fire ant in north Georgia has survived mild winters as well as S. invicta has in south Georgia

(3) The Solenopsis hybrid can compete with and may even out compete S. invicta

WINTER MORTALITY STUDIES

County	1985 - 1986		1986 - 1987		1987 - 1988	
	Number of Mounds	% Mortality	Number of Mounds	% Mortality	Number of Mounds	% Mortality
Cook	82	4.8	--	--	--	--
Ben Hill	--	--	71	11.8	--	--
Tift	--	--	--	--	46	10.8
Morgan	91	3.2	61	3.3	69	5.8
Floyd	40	2.5	50	12.0	44	2.3

SUPERCOOLING TEMPERATURES
mean temperature in ^{o}C

	Major Workers		Female Alates		Male Alates	
	n	$\overline{x}$	n	$\overline{x}$	n	$\overline{x}$
Solenopsis invicta	49	-6.57a	55	-6.18a	42	-5.30b
Solenopsis hybrid	49	-5.90a	41	-5.96a	23	-6.52a
Solenopsis richteri	49	-7.01b	18	-6.16a	19	-5.83a

Field Trials of LOGIC for Red Imported Fire Ant Management1/

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An experimental use permit program was completed during the summer of 1987 to evaluate the effectiveness of fenoxycarb [ethyl (2-[4-phenoxyphenoxyl] ethyl) carbamate] against the red imported fire ant in central Texas pastures and hay fields. Five ranches in Kerr and Kendall Counties, Texas were the experimental sites. Individual field plots ranged in size from ca. 6 to 30 acres.

MATERIALS AND METHODS

Within each field plot, 1/4-acre, non-overlapping sampling circles were located. Colonies within each circle were rated by opening the mounds with a shovel, estimating the number of observed workers, and noting the presence or absence of worker brood. The mound-rating system (Lofgren and Williams 1982) was used to obtain a population index for each circle.

Fourteen plots totaling 137 acres received a 1 lb./acre application of LOGIC bait (1% fenoxycarb) on 7,8, or 9 May, and 42 of these acres received an additional application of 1 lb. bait/ acre on 7 or 15 June, an interval of 29 to 39 days after the first application. Five plots totaling 58 acres were untreated control plots. Broadcast applications of LOGIC bait were made with a Herd Seeder model GT-77A mounted on the rear of a pick-up truck. Posttreatment counts in each 1/4-acre sampling circle were made 5-7 June, 18-19 July, 16-18 August, and 18-19 September. The total of mean population indices of RIFA mounds in all treatment plots were compared using ANOVA of repeated observations (Little and Hills 1978) using the 0.05 probability level.

RESULTS AND DISCUSSION

Pre-treatment counts of red imported fire ant (RIFA) mounds in May indicated an average of 48.6, 43.1, and 53.3 mounds/acre in control, 1 lb. bait/acre, and 2 lb. bait/acre plots, respectively (Table 1).

Table 1. Total acres and pre-treatment mean number of mounds per acre; LOGIC field trial, 1987.

Treatment	total acres	mounds/acre	Range
control	58	48.6	(15.2-105.3)
1 lb bait/acre	95	43.1	(18.8-116.0)
2 lb bait/acre	42	53.3	(32.0-120.0)
Total	195		

The population indices (PI) of RIFA mounds among treatments were not significantly different before the May chemical applications (Table 2.). The population index of colonies in the control plots fell during the experimental period, as expected due to normal stresses of the central Texas summer. The population indices in plots treated with 1 lb. LOGIC bait/acre and 2 lb. bait/acre also decreased during the summer and were significantly different from the control plot colonies during June through September.

Table 2. Totals of mean population indices in treatment plots.

Treatment	Mean Population Index				
	May	June	July	Aug.	Sept.
control	1031.5a[1]	911.0a	674.4a	543.1a	608.4a
1 lb./acre	732.5a	138.9b	40.6b	27.2b	28.1b
2 lb./acre	1222.9a	173.3b	16.5b	2.4b	2.7b

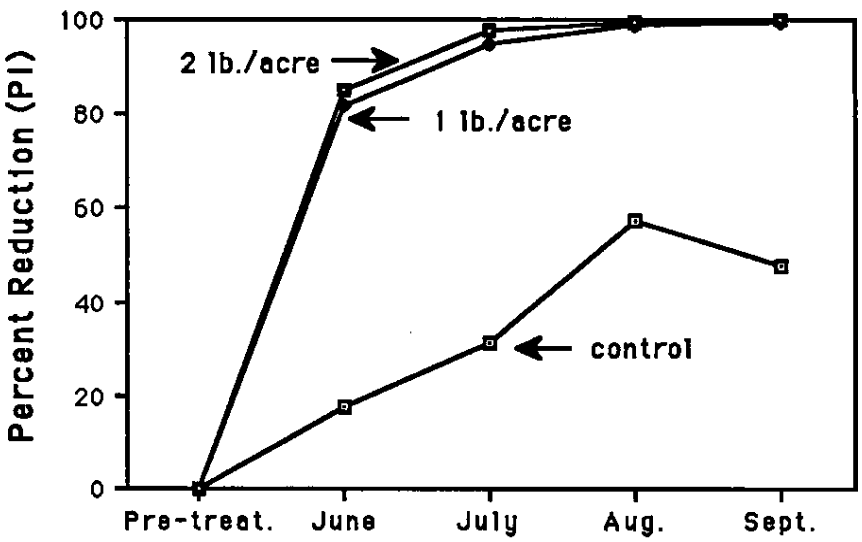
[1]Same letter within column indicates no significant difference (ANOVA; P>0.05)

By September, the population indices of 1 lb./acre and 2 lb./acre treatment plots had decreased to 99.6% and 99.9% of pre-treatment levels, respectively (Table 3.). During the same time period, the mean PI of control colonies was reduced by 47.8%. When the data are expressed graphically (Fig. 1), the 82.0% and 85.4% reduction in population indices by June in LOGIC plots is readily apparent. After the second application of LOGIC bait to the 2 lb./acre plots in June, the PI was further reduced but the response was probably not significantly different from the response in 1 lb./acre plots.

Table 3. Mean percent reduction in population index in treatment plots.

Treatment	Mean Percent Reduction in Population Index				
	May	June	July	Aug.	Sept.
control	0.0	17.5	31.1	57.6	47.8
1 lb./acre	0.0	82.0	95.0	98.8	99.6
2 lb./acre	0.0	85.4	97.7	99.7	99.9

Fig. 1. Mean percent reduction in population index.



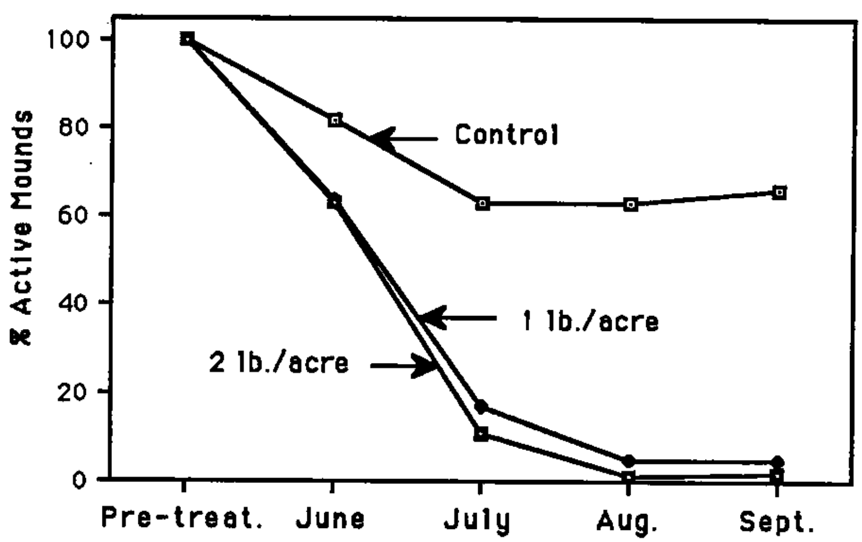
The number of active mounds in control plot circles decreased during the experimental period. However, the decrease in numbers of active mounds in LOGIC-treated plots was greater, especially when considering the greater number of active mounds in circles at the beginning of the experiment (Table 4.). The number of active mounds in control plot circles dropped 36.0% from May to September, whereas numbers of active mounds in plots receiving 1 lb. bait/acre and 2 lb. bait/acre chemical applications dropped 95.5% and 98.1%, respectively (Fig. 2.).

Table 4. Total number of active RIFA mounds and mounds with worker brood

Treatment	May	June	July	Aug.	Sept.
control	389[a] (367)[b]	320 (292)	244 (228)	247 (173)	249 (229)
1 lb./acre	550 (501)	354 (11)	96 (5)	28 (18)	25 (20)
2 lb./acre	466 (431)	292 (8)	53 (0)	3 (1)	9 (0)

[a] No. of active mounds
[b] No. of mounds with worker brood

Fig. 2. Percent active mounds as compared to pre-treatment numbers.



The number of active mounds containing worker brood fell precipitously after the first application of LOGIC and remained at low levels throughout the summer (Table 4.). In contrast, 92% of control plot colonies had worker brood in September. The number of active mounds dropped from 43.1 to 2.0 and from 53.3 to 1.0 mounds/acre in plots treated with 1 lb. bait/acre and 2 lb. bait/acre, respectively (Table 5.).

Table 5. Mean pre-treatment numbers of active RIFA mounds per acre compared to numbers in September

	Mounds/acre	
Treatment	Pre-treat.	Sept.
control	48.6	31.1
1 lb bait/acre	43.1	2.0
2 lb bait/acre	53.3	1.0

In conclusion, early summer applications of 1% LOGIC bait in pastureland in central Texas effectively controlled RIFA populations during the season. However, the long-term control of RIFA was not addressed in this study. Applications of 1 lb.LOGIC bait/acre and 2 lb. bait/acre were equally effective. Therefore, the additional expense of a second pound per acre application is probably not necessary. Landowners were impressed with the results of this study. In fact, some ranchers were able to cut and harvest hay from fields for the first time in several years and were anxious to have additional supplies of LOGIC to control RIFA on the remainder of their property.

ACKNOWLEDGMENTS

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1/ This manuscript reports the results of research only. Mention of a pesticide does not constitute a recommendation by Texas Tech University.

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Disturbance Effect of the Red Imported Fire Ant on Ant Community Structure in Central Texas.

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Introduction

A common question addressed by all ecologists is which factors are most influential in the dominance/diversity interactions of a community? In other words, how are communities shaped? An excellent opportunity for study is provided by the introduction of a competitor into an already established community (Schoener 1983). The red imported fire ant, *Solenopsis invicta*, provides this opportunity.

The red imported fire ant has been associated with the disruption of ant communities throughout the southern United States. Reports of the selective extinction of native fire ants, as well as other ants, after the appearance of *S. invicta*, are numerous (Baroni Urbani and Kannowski 1974, Glancey et al. 1976, Whitcomb et al. 1972, Wilson and Brown 1958). Unfortunately, long term efforts to identify and quantify changes in ant community structure after the invasion of *S. invicta* are few.

The objectives of our study are: 1) to determine the structure of ant assemblages with and without *S. invicta*; and 2) to identify and quantify changes of community structure associated with *S. invicta*.

Materials and Methods

The study area was established within Kimble and Kerr Cos. located in central Texas. A transect was established paralleling interstate highway 10, from non-infested to heavily infested *S. invicta* areas. The community was monitored monthly from August 1986 to November 1986, and again from March 1987 to October 1987. However, November 1986 and March 1987 were excluded from the analysis, along with the months in between to minimized variance due to seasonal fluctuations (Samways 1983).

The transect consisted of twelve plots, labeled from A to L, approximately 4.8 km apart. Pitfall traps were used as sampling units, and each plot consisted of 24 traps. Each time the transect was monitored, the traps were in place for 72 hrs (Jansen and Metz 1979).

Cluster analysis was performed to identified distinctive assemblages, using the centroid method (Pielou 1984). The data were analyzed using the PROCEDURE CLUSTER, SAS, Version 5 (SAS 1985). The dendrograms were generated by the PROCEDURE TREE (SAS 1985). A Principal Components Analysis (PCA) was used to identify principal sources of variation in diversity among plots (Digby and Kempton 1987). The eigenvalue matrix for the species was generated by the PROCEDURE CLUSTER (SAS 1985). The densities of the *S. invicta* were excluded in the PCA to identify the effects of this species on the native ant fauna. Species with eigenvalue less than 1 were dropped from the analysis. The PCA analysis of the plots was produced by the Cornell Ecological Programs. Because plots k and L were exclusively infested with *S. invicta* they were excluded from the analysis.

Results

A total of 7,697 specimens were collected representing five subfamilies and 35 species (Table 1). *Solenopsis invicta* accounted for 41.9% of the total sample. Voucher specimens were deposited in the entomology collection of the Department of Agriculture, Horticulture and Entomology, Texas Tech University, Lubbock, Texas. The only specimen of *Leptothorax terrigena* is in the private collection of G. and J. Wheeler. The specimens of *Solenopsis* (*Diplorhoptrum*) sp. 2 were sent to J. Trager. We thank these researchers for the identification of those species.

Through cluster analysis four distinctive assemblages were identified (Fig. 1). The first bifurcation separates clusters between high and low densities of *S. invicta*. The second division separates those clusters that

Table 1. Species collected between August 1986 and October 1987

PONERINAE		ECITONINAE	
Pachycondyla harpax	56	*Neivamyrmex nigrescens*	485
Leptogenys elongata	14	*Labidus coecus*	312
FORMICINAE		DOLICHODERINAE	
Paratrechina terricola / vividula [a]	582	*Forelius pruinosus*	482
Camponotus discolor	39	*Conomyrma insana*	163
Formica sp.	7	*Forelius foetidus*	152
Brachymyrmex depilis	3	*Tapinoma sessile*	36
Camponotus sp.	2	*Conomyrma flava*	17
MYRMICINAE			
Solenopsis invicta	~3,225	*Solenopsis* (*Diplorhoptrum*) sp. 1	23
Pogonomyrmex barbatus	408	*Atta texana*	19
Monomorium minimum	398	*Crematogaster laeviuscula*	13
Solenopsis xyloni	389	*Pheidole* sp. 1	12
Solenopsis geminata	265	*Pogonomyrmex imberbiculus*	11
Tetramorium spinosum	173	*Crematogaster pilosa*	6
Pheidole crassicornis tetra	142	*Pheidole* sp. 2	3
Pheidole tepicana	108	*Leptothorax* sp.	2
Monomorium pharaonis	76	*Leptothorax terrigena*	1
Pheidole hyatti	39	*Solenopsis* (*Diplorhoptrum*) sp. 2	1
Aphaenogaster cockerelli	33		

[a] Unable to differentiate between species.

contain *S. invicta* from those that do not. The final division separates clusters that occur in an undisturbed habitat from those occurring in disturbed habitats.

The first assemblage (Table 2) is found in an 'undisturbed' habitat (it has not been mowed or grazed in at least 8 years). It possesses the highest diversity and contains highly specialized forms, such as *Pachycondyla*

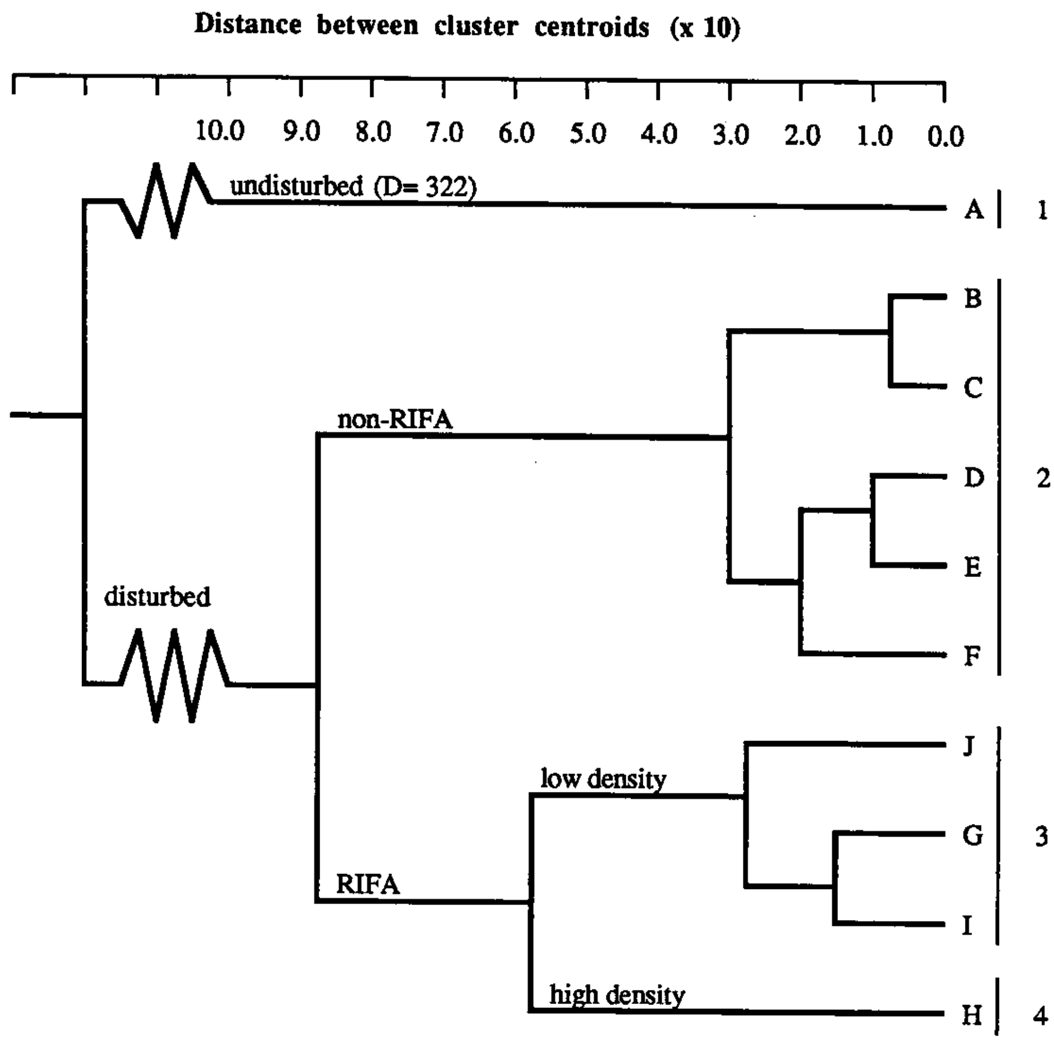

Figure 1. Dendrogram of plots located between Kimble and Kerr Cos. Plots followed by a continuous line belongs to the same species assemblage.

harpax, *Labidus coecus*, *Leptothorax terrigena*, and *Tetramorium spinosum*. Most of the species were continuous through time.

Table 2. Species Assemblage 1

Ponerinae	Ecitoninae
Pachycondyla harpax	*Labidus coecus*
Dolichoderinae	Formicinae
Conomyrma flava	*Brachymyrmex depilis*
Forelius pruinosus	*Camponotus discolor*
Tapinoma sessile	*Formica* sp.
	Paratrechina terricola / vividula *
Myrmicinae	
Aphaenogaster cockerelli	*Pogonomyrmex imberbiculus*
Crematogaster laeviuscula	*Pogonomyrmex barbatus*
Crematogaster pilosa	*Solenopsis aurea*
Leptothorax terrigena	*Solenopsis geminata* *
Leptothorax sp.	*Solenopsis (Diplorhoptrum)* sp. 2
Pheidole tepicana *	*Tetramorium spinosum* *
Pheidole sp. 1	

* Indicates the more common species.

The next assemblage (Table 3), as well as the rest, is in a disturbed habitat that has been mowed and/or grazed several times each year. This one is characterized by high diversity, specialized ants such as *Leptogenys elongata*, and *Neivamyrmex nigrescens*, with discrete distribution of several species through time.

The last two assemblages were found within the range of *S. invicta*. The first one (Table 4) has low densities of *S. invicta* (< 2 foragers/day /trap). Most species had discrete distributions, with the exception of *Monomorium minimum.*

The last assemblage (Table 5) has a very low species richness and very high densities, attributed to *S. invicta* (≈200 foragers/day/trap).

Table 3. Species Assemblage 2

Ponerinae	Ecitoninae
Leptogenys elongata	*Neivamyrmex nigrescens*
Formicinae	Dolichoderinae
Camponotus sp.	*Forelius foetidus*
Paratrechina terricola / vividula *	
Myrmicinae	
Atta texana	*Pheidole hyatti*
Monomorium minimum	*Pheidole tepicana* *
Monomorium pharaonis	*Pheidole crassicornis tetra* *
Pogonomyrmex barbatus *	*Solenopsis xyloni* *

* Indicates the more common species.

Table 4. Species Assemblage 3

Myrmicinae	
Monomorium minimum	*Pogonomyrmex barbatus*
Pheidole crassicornis tetra	*Solenopsis invicta* *
Pheidole tepicana	*Solenopsis (Diplorhoptrum)* sp. 1
Pheidole sp. 2	
Dolichoderinae	Formicinae
Conomyrma insana	*Paratrechina terricola / vividula* *
Forelius pruinosus	

* Indicates the more common species.

The PCA scores are provided in Table 6. The results of the ordination are depicted in Figure 2. Dots on the graph represent the actual plots. Marks in the 1,2 axis plane are the geometrical projections of the dots. The PCA by species of the plots produced four aggregations, confirming the previous results. The first axis, the one that accounts for the most variance, was correlated to the disturbance of the habitat. The second axis was correlated to seasonal changes. The variation in the fourth axis was highly correlated to the densities of *S. invicta*. The third axis, even though

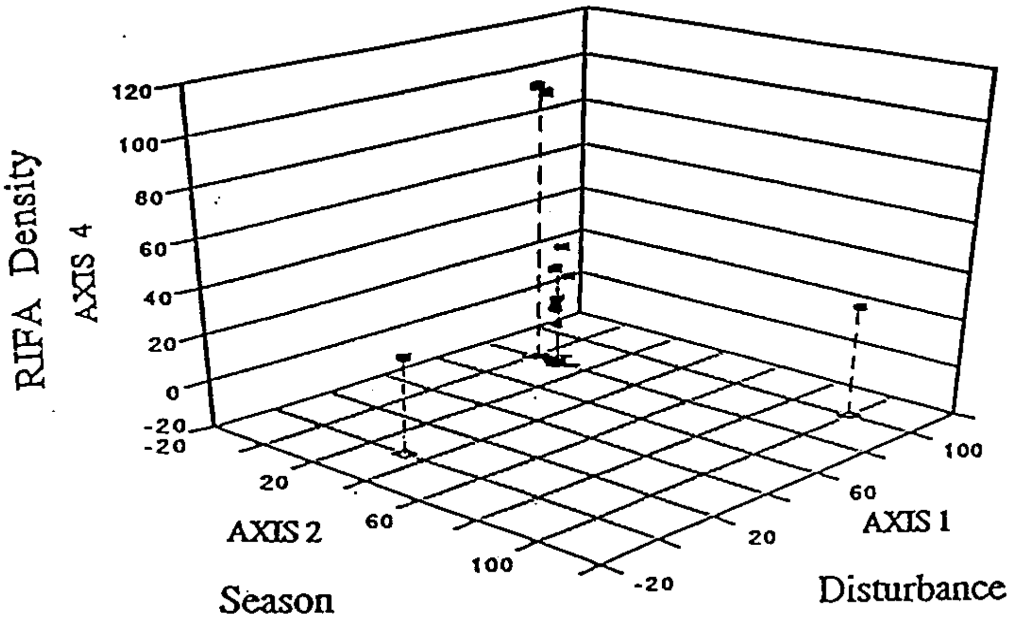

Figure 2. Principal Components Analysis of plots by species. Dots in the 1-2 axis plane are the geometrical projection of the points in the ordination space.

accounting for more variation that the fourth, was found to be biologically meaningless.

Table 5. Species Assemblage 4

Myrmicinae	Dolichoderinae
Monomorium minimum	*Conomyrma insana*
Pheidole crassicornis tetra	Formicinae
Pheidole tepicana	*Paratrechina terricola / vividula*
Solenopsis invicta *	

* Indicates the most common species.

Table 6. Principal components analysis scores-centered by species

	Axis				
Plot	1	2	3	4	Eigenvalue
A	0.0	32.75	83.55	70.60	1.98×10^6
B	79.75	7.49	95.12	68.10	5.92×10^5
C	79.54	8.25	89.46	83.40	1.29×10^5
D	100.0	100.0	87.80	64.65	7.10×10^4
E	81.26	2.01	100.0	2.73	4.50×10^4
F	83.98	5.56	0.0	60.77	2.92×10^4
G	79.73	8.14	9.29	79.69	2.51×10^4
H	79.84	0.0	9.49	0.0	2.31×10^4
I	79.72	12.97	8.49	6.94	2.07×10^4
J	77.51	10.26	89.42	86.99	1.72×10^4
ΣR^2	0.8849	0.9326	0.9791	0.9921	
%	0.8849	0.0477	0.0465	0.0130	

Of the nine species found in sympatry with *S. invicta* (Table 7) four had positive correlations, the rest were negative. Even though the correlation coefficient of *Paratrechina terricola* was positive, it was close to zero. *Forelius pruinosus* was not significant but a trend was evident.

Monomorium minimum and *Conomyrma insana* were significantly correlated to *S. invicta* densities.

Table 7. Correlation of Species Importance Values to Densities of RIFA

Species	Coefficient of Correlation (r)
Conomyrma insana	+ 0.588*
Monomorium minimum	+ 0.489*
Forelius pruinosus	+ 0.424
Paratrechina terricola / vividula	+ 0.079
Solenopsis (Diplorhoptrum) sp. 1	---
Pogonomyrmex barbatus	- 0.111
Pheidole sp. 2	- 0.159
Pheidole tepicana	- 0.345*
Pheidole crassicornis tetra	- 0.584*

*Denotes significance at the 0.05 level.

Conclusions

In areas without *S. invicta* , diversity between assemblages (mostly species turnover) is correlated to disturbance of the habitat. So, as the vegetation stratifies, diversity of the ant community increases. In areas with *S. invicta* the diversity of the ant assemblages was negatively correlated to increasing densities of this species.

Previous studies have indicated that *M. minimum* and *F. pruinosus* coexist with *S. invicta* because of temporal foraging isolation (Baroni-Urbani and Kannowski 1974, Claborn et al. 1986). Our results confirm those findings. On the other hand, *C. insana* seems to be taking advantage of environmental stochasticity, suggesting that the population is below resource-defined equilibrium, thus being able to 'escape' the fire ants.

Finally, ants of the granivorous guild, such as *Pheidole tepicana* and *Pheidole crassicornis* , are being replaced faster than other ants in assemblages containing *S. invicta* .

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Evaluation of Selected Alternative Red Imported Fire Ant Mound Treatments: The Yaard-vark™, the Antser™, the Earthfire® Injection System and Hot Water

B. M. Drees[1/]

Introduction

When it comes to killing red fire ants (IFA, Solenopsis invicta Buren), American ingenuity is alive and well - particularly in Texas. Historically, the first non-chemical fire ant control device was the McCoy Ant Stomper (advertized in the Progressive Farmer, 1978), produced in Lubbock, Texas (Fig. 1). Currently there are several new methods on the market for IFA control. These products are unique in several ways. First, several of them do not use insecticides but rather employ electricity or water to kill ants. Second, several of the new devices are intended for the equipment leasing and service markets rather than for homeowner use. Thus, although they may be initially expensive, their cost over time for killing fire ants in mounds may make these products competitive.

The Texas Agricultural Extension Service (TAEX) has primarily conducted result demonstrations with insecticide products registered by the Environmental Protection Agency (EPA) and the Texas Department of Agriculture. A report entitled, "Red imported fire ant control result demonstrations, 1979-1986" includes 43 chapters documenting the effectiveness of numerous products containing one or more of 20 different active ingredients. This report also includes results of field trials using the straw itch or Pymotes mite, produced by Biofac in Mathis, Texas. These mites are marketed as "fire mites" and advertized as a biological method of IFA control.

Biological control agents and devices currently on the market for the treatment of IFA mounds are not required to be registered by the EPA as long as there is no chemical insecticide involved. Efficacy data for these devices has generally not been generated by research and Extension entomologists. We have initiated a program to test the performance of several of the non-chemical mechanical control devices, home remedies and methods of applying insecticides considered to be less toxic to the user and the environment.

Results of these result demonstration efforts are used to formulate management recommendations. These are published by TAEX in "Fire ants and their control" (B-1536). Products and other methods of IFA control vary greatly in cost, environmental impact, labor involved in application, mode and speed of action and effectiveness. Because there are so many alternatives, there is a great deal of misunderstanding on the part of the general public as to product performance. The educational programs conducted by the Texas Agricultural Extension Service are designed to document product performance, enabling the user to have realistic expectations from investments made for IFA suppression efforts.

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This result demonstration was designed to test the performance of the Yaard-vark™, the Antser™, the Earthfire® Injection System and the hot water method of treating individual red imported fire ant mounds.

Materials and Methods

The Yaard-Vark™ (Fig. 2), donated for experimentation by J. R. McCracken of Bryan, Texas, son of the inventor, uses 10 watts of electricity to electrocute ants attempting to crawl up the device past a wire coil similar to a miniature "bug zapper". The literature with the product claims that the ants' behavior is altered so that the ants "attack one another" and "fight each other to the death". This claim has not been scientifically proven. Although the instructions state that the device should be left in the mound three hours or more until ant activity ceases, Mr. McCracken suggested leaving the device in each mound for 15 to 20 minutes, probing it into several locations within the mound during that period. This treatment is used to "traumatize" the ants producing inactive colonies within 1-2 days (Pers. comm.).

The Anster™ (Fig. 3), developed and promoted by John C. Connolly of the Antser, Inc. of Houston, Texas, is a mechanical devise using a two-cycle engine to rotate prongs or blades arranged to churn the soil of the mound, physically disrupting ants. Water is added during the agitation process, and the resulting slurry encases remaining ants in water-saturated mound medium. This device is being developed for the service sector (Private pest control operators) and/or the lease/rental market.

Ant Fire, Inc. from Beaumont, Texas has developed a device, called the Earthfire® Injection System (Fig. 4), that vaporizes the insecticide, resmethrin (Earthfire®), to fumigate fire ant mounds. Resmethrin is a rapid knockdown product with little or no residual activity. It has a relatively low order of toxicity to mammals. This device is being developed for the service sector (Private pest control operators) and/or the lease/rental market.

The hot water method is probably the oldest tactic used to eliminate fire ant mounds. Recent reports in the scientific literature (Tschinkel and Howard, 1980) reported that 3 gal of hot water (90^{o} C) produced about 60% control of treated mounds. In this trial, mounds were treated using a water heating device rented from Hotsy of Houston to treat mounds with 2-3 gal of very hot ($+170^{o}$ F) water.

Prior to treatment, a random sample of 30 mounds in the testing area were measured, with height and width recorded. Mounds were numerous (probably of the multiple queen or polygynous type). Mounds were 10.03 ($\pm$ 3.91 SD) inches in diameter and 2.43 ($\pm$ 0.98) tall (N = 30). Soil at the pasture site selected was sandy.

During treatments, the time required for each of the devices/methods to treat each mound was recorded for a sample of mounds treated. Results of these treatments for the Earth Fire and Antser devices were subjected to a Student's t test to determine differences in time required to treat each mound.

Each device was used to treat a minimum of 30 marked and staked red imported fire ant mounds, May 27, 1987. An additional set of 30 mounds was marked but left untreated as a control group. Mounds were inspected 7 and 21 days after treatment and rated for ant activity as either active or inactive. Mounds were considered active if worker ants displayed defensive behavior when the marked mounds were minimally disturbed. The presence of a few worker ants was not considered to indicate the presence of an active colony, and thus although noted, these mounds were analyzed as inactive mounds. Conditions in the area of treated mounds were also evaluated for phytotoxicity to vegetation and physical disturbance. During evaluation periods, the existence of "new" mounds within 3 ft of the treated mound were assumed to be satellite mounds resulting from surviving ants in the treated mound selecting a new mound site. Certainly, the possibility exists that some of these "satellite" mounds migrated close to treated mounds from other locations.

Rainfall, monitored during the treatment and evaluation period, was heavy (Table 1), flooding portions of areas containing treated mounds. These areas were abandoned and evaluations continued in areas where flooding did not occur.

For analysis, mound evaluations for each of the treatment and control groups were divided into five consecutive sets of five mounds each (Note: Although a minimum of 30 mounds were treated with each method or device, flooding conditions due to heavy rains prohibited all originally-treated mounds from being evaluated). Percent active mounds and percent of mounds with satellite mounds within a three-foot radius were calculated for each set. The resulting percent values were subjected to an analysis of variance using the Least Significant Difference test at the $P \leq 0.05$ level for each post-treatment evaluation date. Unfortunately, the 7-day post-treatment data for Earthfire was misplaced, and the analysis was performed with existing data.

Results and Discussion

The Yaard-vark required 30 minutes to treat each mound. Five devices were operating simultaneously using a portable generator, and thus treatment of 30 mounds required 3 hours (15 hours if only one device had been available). The Earthfire injection system required significantly less time to treat each mound than did the Antser, requiring 33.36 ($\pm$ 9.42) vs 44.55 ($\pm$ 4.16) seconds per mound (N = 22 and 11, respectively, D.F. = 31, t = -3.776; P = .0004). Hot water treatments were not timed since the water source was located remotely from the treatment site and individual five gallon buckets of hot water needed to be delivered via pickup truck. Producing large quantities of hot water is an obstacle for the practice large-scale use of this method.

All treatments produced an almost immediate effect of ants in mounds except the Yaard-vark. This device did produce a ring of dead ants at the base of the device while it was inserted into the mound. However, the number of mounds rendered inactive using this tool was not significantly different from those in the untreated sets of mounds throughout the observation period (Table 1).

The Antser produced a 12 inch diameter circle of water-saturated mud, having obliterated all vegetation. Shortly following treatment, ants could be seen within the slurry attempting to rebuild the mound. The Earthfire Injection System eliminated all activity in treated mounds within several minutes of application. The use of this system is accompanied with a distinctive odor of the vaporized insecticide formulation. This odor was somewhat persistent, being detected in some of the treated mounds 21 days after application. At both post-treatment evaluation periods, grass around some treated mounds was yellow, indicating some phytotoxic reaction to the treatment. Hot water eliminated ant activity wherever ground was thoroughly soaked. This treatment also killed vegetation that was drenched. After 21 days, treated mounds could easily be spotted because they were surrounded by dead grass.

On the 7 and 21 day post-treatment evaluation dates, the percent of active mounds in sets treated with the Antser and hot water were found to be significantly lower than those of the untreated and Yaard-vark treated mounds, having achieved 80 to 96 percent control of ants colonies in treated mounds. However, the number of satellite mounds occurring in association with these treatments was significantly greater than those associated with the untreated mound sets, except for the hot water treated mounds at the 21 post-treatment evaluation date, ranging from 40 to 68 percent. Thus, "percent control" in the area treated with these methods may be less than that expressed by the percent elimination of ant activity in individually treated mounds when the presence of satellite mounds is taken into consideration.

Satellite mounds are commonly formed by surviving worker ants and may persist for several weeks until the worker ants perish. However, if the queen(s) and brood survive initial treatment as well, satellite mounds can persist and form new permanent mounds. Although brood was detected in some of the satellite mounds, their long-term survival was not monitored.

The Earthfire Injection System treatments resulted in a statistically significant reduction of 84 percent in mound activity relative to the untreated mound sets, but similar to reductions resulting from treatments with hot water or the Antser. Sixteen percent of the Earthfire treated mounds where found to be associated with satellite mounds 21 days after treatment but this value was not significantly different from that of the untreated mounds. Results of this treatment are statistically similar to those produced by the application of hot water.

Finally, these results should be considered to be preliminary. These methods or devices need to be tested under various conditions, including different soil types (clay) and environmental conditions (different times of the year) before their actual performance can be adequately documented. Excessive rainfall during the observation period may have confounded these results, causing an increase in the normal rate of colony migration and satellite mound formation.

Literature Cited

Tschinkel, W.R. and D.F. Howard. 1980. A simple, non-toxic home remedy against fire ants. Georgia Entomol. Soc. 15(1):102-105.

Table 1. Rainfall in Harris County, Texas, from May 17 through June 17, 1987.

Date	Inches	Date	Inches
May 17	1.02	June 9	0.87
20	0.05	10	3.35
24	0.41	11	trace
30	2.40	12	1.75
June 3	0.22	13	1.95
4	0.25	14	trace
5	0.10	17	1.00

Table 2. Percent active red imported fire ant mounds and percent treated mounds with satellite (newly established) mounds within a 3 ft radius, 7 and 21 days after application of alternate fire ant control devices or methods, Harris County, Texas, May 27,1987.

	--% active mounds--		% mounds with satellites	
Treatment	7 days	21 days	7 days	21 days
Untreated	96.00a	60.00a	0.00c	20.00b
Yaard-vark™	96.00a	72.00a	20.00bc	8.00b
Hot water	20.00b	20.00b	40.00ab	32.00ab
Antser™	8.00b	4.00b	68.00a	46.00a
Earthfire® (resmethrin) Injection System	---	16.00b	---	16.00b

1/ Means in columns followed by different letters in columns indicate significant difference according to the Least Significant Difference test at $P \leq 0.05$.

Fig. 1. The McCoy Ant Stomper.

Fig. the Yaard-Vark™.

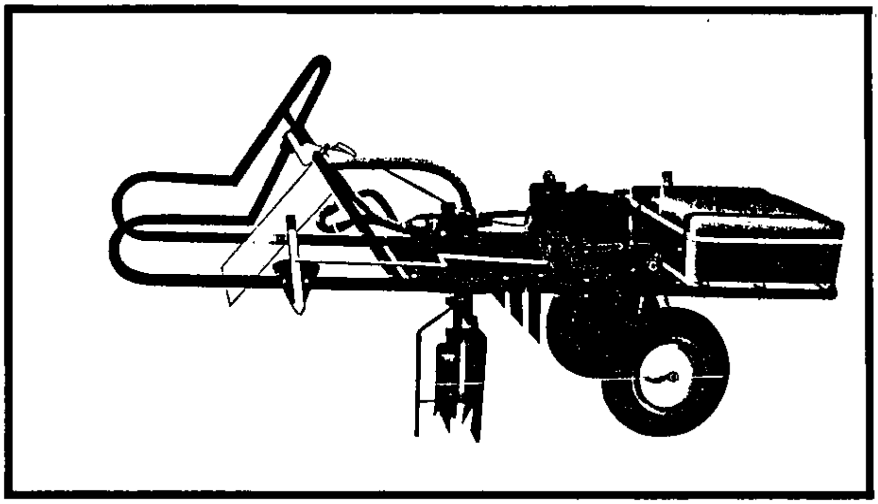

Fig. 3. The Antser™.

Fig. 4. Earthfire®
Injection System.

APPENDIX A

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