

program that minimizes costs, as neither pests nor pesticides had been significant concerns. The new law has presented challenges for school administrators, pest management professionals, and regulatory officials. This presentation focuses on some of the challenges that can be expected when IPM is required by law.

Ants
Ballroom West

Moderator
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ANTS: WHERE ARE WE NOW? WHERE ARE WE GOING?

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Urban pest ant control has become a high priority for the pest control industry. The National Pest Management Association (formerly the National Pest Control Assoc.) and trade journal articles have indicated that pest ants are a major concern for the pest control industry. Pest ant problems have significantly impacted pest control operators by causing numerous "callbacks", or return visits to clients, thus impacting profits. This presentation will focus on ant control. To gauge where we are now and where we are going, it is useful to know where we have been. One of the most studied ants in the world is the imported fire ant. The efforts to control this ant have been well documented and provide a chronology of ant control practices that serve as a guide for ant control tactics being developed today and in the future.

Black imported fire ants, *Solenopsis richteri* Forel, and red imported fire ants, *S. invicta* Buren, were inadvertently introduced into the United States around 1918 and sometime between 1933-45, respectively, through the port of Mobile in Alabama. Government organized control programs began in 1937 with the application of calcium cyanide dust applied to individual nests on about 2,000 acres in Alabama. In 1948, Mississippi initiated a control program using chlordane dust applied to nests, and in 1957 Arkansas implemented an eradication program with the aerial application of granular heptachlor (@ 2 lbs per acre) to 12,000 acres. "Excellent results" were obtained with this latter method, and thus heptachlor applications were expanded to area-wide applications by ground and air in 1957. By 1958, there were environmental concerns over the use of heptachlor, hence, rates and application intervals were reduced in the spring of 1959-1960 (Lofgren 1986). The area-wide use of heptachlor for imported fire ant control was one of the programs criticized in Rachel Carson's "Silent Spring"(1962). Meanwhile, in 1957, a

USDA Methods Development Laboratory was organized to improve fire ant control techniques. In 1960, Hays and Arant developed an ant bait consisting of kepone in peanut butter. In 1961, the USDA Methods Development Laboratory developed mirex ant bait, which consisted of mirex in a soybean oil attractant soaked onto a corncob grit carrier (Lofgren et al. 1963). This bait provided 98% control, which unlike kepone, caused no apparent harm to wildlife. Because of political pressure to eradicate imported fire ants, large-scale eradication trials (three sites of 255,892 to 2,130,993 acres!) were conducted to work out logistics and determine feasibility. By 1970 these trials were completed, resulting in 96% control using 3 applications of mirex bait at rates of 1.25 to 2.5 lbs per acre by aircraft. Because technical difficulties were thought to be surmountable, Banks et al. (1973) stated that "total elimination of imported fire ants from large isolated areas may be technically feasible". Prior to that, Lofgren and Weidhaas (1972) indicated that in theory it would be possible to eradicate imported fire ants with 3-9 applications of mirex if the level of control provided by each bait application ranged from 90 to 99.99%. Meanwhile from 1967 to 1975 mirex bait was applied to most infested states for a total of 111,845,009 treated acres (37,281,669 acres treated 3 times).

In 1977 the use of mirex was halted for several reasons including: persistence in the environment, accumulation in non-target organisms, toxicity to estuarine organisms, and carcinogenic potential. From the imported fire ant control effort using mirex, one could see that there was a pest ant crisis that led to political mandates of fire ant eradication. While eradication may have been possible, that goal was unobtainable given the restrictions on treatment applications and the biology of imported fire ants with its high reproductive rate, mobility, and diverse habitat range. With the cancellation of mirex, there was an intensive search to find a replacement. From 1976 to 1981, 3,052 chemicals were screened at the USDA-ARS laboratory in Gainesville, Florida against imported fire ants (Williams 1983). In 1980, Amdro fire ant bait, which contains the metabolic inhibitor hydramethylnon, received conditional registration. In the latter half of the 1980's, other fire ant baits containing fenoxycarb and abamectin were registered. These baits inhibited the production of new fire ants, and thus did not cause colony mortality as fast as mirex or hydramethylnon. In the late 1990's other insect growth regulating fire ant baits containing methoprene and pyriproxyfen were registered. The most recent fire ant bait registered this year contains spinosad, which affects the insect nervous system. Thus, despite the negative publicity surrounding mirex, there was still a mandate to find an alternative to it for fire ant control. In addition, the market potential of fire ant control products resulted in development of other imported fire ant baits and this development still continues. Methods and procedures used to develop the mirex bait continue to serve as a basis for the development of new fire ant and other ant baits.

So here we have a chronology of control tactics for imported fire ants that go from treating individual nests with a contact insecticide, to broadcast applications of a contact insecticide, to the broadcast application of an ant bait. Ant control in the pest control industry had a relatively similar pattern, where there was reliance on applying contact insecticides after the development of DDT and related insecticides, and followed by the development of ant baits. However, it is interesting to note that before DDT, ant baits containing sodium arsenite, tartar emetic, and thallium sulfate had been used for other pest ants, such as Argentine and Pharaoh ants, before mirex was developed (Flint and McCauley 1936, Smith 1936, Eckert and Mallis 1937). These

baits were formulated as liquids or semi-liquids and thus were confined to stations. Similarly, the methoprene bait developed by Edwards (1975) for Pharaoh ant control was formulated in a liver-powder/honey/sponge-cake carrier that required spot placements, unlike the mirex formulation and subsequent fire ant baits which could be broadcast.

So where are we now? Well, besides imported fire ants, we are now seeing a greater awareness of other pest ant species. This has led to the development of baits for other pest ants instead of just imported fire ants. Pest ant control has become a high priority due to several reasons. It is a public health concern, where mechanical disease transmission has been reported by Pharaoh ants (Beatson 1972) and deaths due to fire ant stings (deShazo et al. 1999). With regard to deaths attributed to fire ants, this represents a huge liability concern, and being able to identify ant species can be critical in alleviating fears and unnecessary treatments. Some pest ant species can be extremely invasive, where they may be a detriment to the biodiversity of habitats. Some examples of relatively recent introductions of invasive ants include red imported fire ants in California and the little fire ant, *Wasmannia auropunctata* (Roger), in Hawaii. Earlier invasions by the Argentine ant, *Linepithema humile* (Mayr), into the gulf coast states and California, and the white-footed ant, *Technomyrmex albipes* (Fr. Smith), in Florida and Hawaii have since increased in populations and are now serious problems.

With the need to control other ant species besides imported fire ants, several ant baits have been developed which target other pest species besides imported fire ants. Examples of such baits and their active ingredients are listed in Table 1. Note that many of the active ingredients were originally developed for imported fire ant baits.

Table 1. Examples¹ of commercially available baits for imported fire ants, for other ant species², and their active ingredients.

Fire Ant Bait	Active Ingredient	Ant Bait²	Active Ingredient
Amdro, Siege	hydramethylnon	MaxForce granules	hydramethylnon
Award, Logic	fenoxycarb	MaxForce FC	fipronil
Ascend, Clinch, Varsity	abamectin	Advance granular	abamectin
Extinguish	methoprene	Pharorid	methoprene
Distance	pyriproxyfen	Dual Choice, FluorGuard	sulfluramid
Bushwhacker	boric acid	Advance liquid	boric acid
Eliminator	spinosad	Dr. Moss's	boric acid
		Drax	boric acid
		Drax Liquidator	boric acid
		OutSmart	boric acid

¹Mention of trade names or proprietary products does not constitute an endorsement or recommendation for use by the U.S. Department of Agriculture.

²Imported fire ants may be included on label with other ant species.

Ant baits containing boric acid have been available for many years, but the percentage of active ingredient was usually around 5%. Research within the last decade has shown that liquid ant bait containing sucrose solution and a lower percentage of boric acid was effective against several

species of ants (Klotz and Moss 1996, Klotz et al. 1996). More recently, Klotz et al. (1998) have documented control of field populations of Argentine ants using a strategy of placing large volume bait stations on the exterior perimeters of buildings, and frequently replenishing these stations with a 0.5% boric acid in a 25% sucrose-water solution. Thus, we see a strategy of using a slow acting toxicant in a liquid attractant that is provided in high volume on the outside of structures. As a result, there has been an increase in commercially available liquid ant baits that contain 1% boric acid and also a variety of high volume bait stations that can dispense liquids. Studies have documented ant control with the exterior placement of numerous small bait stations (Forschler and Evans 1994, Oi et al. 1994, Blachly and Forschler 1996). However, high volume stations placed on the exterior of buildings at infrequent intervals may be more efficient to install and service, and may enhance the foraging efficiency of ants.

In addition to baiting, another approach to ant control is to reduce food sources utilized by ants. This strategy is being used against honeydew feeding ants such as Argentine or white-footed ants that have extraordinarily large outdoor populations. The strategy entails preventing ants access to aphids and other homopterans either by using insecticides as barriers to exclude ants from the homopterans or directly eliminating the honeydew producers. By removing a major food resource, it is thought that ant colonies will not develop huge, intolerable populations, and/or will move elsewhere. This approach can also be used to enhance feeding on baits. In essence, this tactic is a form of sanitation where favored food resources are made unavailable.

As mentioned previously, non-repellent contact insecticides with long residual activity was one of the early methods used against imported fire ants. Recently, broadcast applications of a granular formulation of fipronil have reportedly provided over one year of control of imported fire ants (Collins et al. 1999 unpublished interim report, Gulfport Plant Protection Sta. pp. 66-70). If this method of control is successful and widely used, there is a possibility that there will be a shift away from baiting as an ant control strategy, and a return to perimeter or even larger area treatments.

Finally, the use of self-sustaining biological control agents for ants are currently being evaluated for imported fire ant control. Phorid flies in the genus *Pseudacteon* have been released in several locations in the U.S. and to date have over-wintered in Florida at six of six release sites. Other locations in Louisiana, Alabama, and Mississippi have reported sightings of flies (S. D. Porter personal communication). The microsporidian (protozoan), *Thelohania solenopsae* has been recovered in 7 of 10 states where it has been introduced. Fluctuating reductions in fire ant populations have been documented in Florida over a 3-year period. This pathogen has been found naturally in several areas in Florida as well as in Mississippi, Texas, and Louisiana. If these biological control agents have a significant impact on imported fire ant populations, perhaps interest will be generated for future attempts to discover and release biological controls for other invasive pest ants.

As outlined above, ant control today has evolved, or more appropriately revolved, around some basic control tactics of contact insecticides, baits, and sanitation. Ant control research activity can provide an indication of the interest in ant control now and potential trends in the near future. "Formis99: Master Bibliography of Ant Literature" (currently being maintained by S. Porter & D.

Wojcik, USDA-ARS, Gainesville, FL) is an excellent database of ant literature that includes citations not available on most common literature databases. In the 1999 version there is a total of 28, 871 citations. Using the search words "pest ant or control or management", 4,363 citations, or 15.4% of the citations, were listed. Figure 1 shows a general decline in the number of citations from the Formis99 database using the same search words for each year since 1990. However, there is an increasing trend in the number of ant presentations made in the Formal Urban Entomology Conference and in the Urban Entomology section at the annual meeting of Entomological Society of America since 1996 (Fig. 2) [Note that in 1998 ant and termite presentations were reduced probably because the ESA meeting coincided with the International Union for the Society of Social Insects meeting]. Similarly, there is an increasing trend in the number of submitted presentations on ants at the National Conference in Urban Entomology over the last five conferences (Fig. 3). In this year's meeting there were 7 submitted papers plus 2 invitational ant presentations. Thus, one can see an increase in research presentations on ants, and perhaps this will result in a reversal of the recent decline in pest ant control publications. A driving force for the increase in research activity/presentations on pest ants is increased funding. This is currently being illustrated in the imported fire ant research community, where universities in Arkansas, Texas, Alabama, Oklahoma, South Carolina, and Louisiana were appropriated extra funding by their state legislatures for imported fire ant research and extension. Correlated with these funding increases has been a rise in the number of presentations at the annual Imported Fire Ant Conference (Fig. 4). This rise can be directly attributed to research coming from the states with additional funding. With the 1998 discovery of imported fire ants in southern California, significant funding for fire ant control has been appropriated in this state resulting in increased research activity. Hopefully, the increase in fire ant research activity will expand to other pest ant species in the future.

With the increased interest in pest ants and their control, there is more potential for the development of new control strategies that account for the different biologies of individual pest ant species. Since most structure invading pest ants nest outdoors, ant control tactics will be directed toward the landscape. This approach will probably require more technical expertise and be more costly to implement. In contrast, the development of effective non-repellent, residual contact insecticides may result in ant control strategies reverting back to perimeter applications, requiring less expertise and implementation costs. A determining factor of which method will predominate, will be the duration of control. Ant control in landscapes may entail habitat modification, elimination of food sources, and baiting which presumably will result in long-term control. Profit from implementing and servicing such a program, as well as customer satisfaction, will determine if this type of control strategy is viable. If perimeter applications of residual insecticides provide control of similar duration as managing ants in landscapes and its use pattern is acceptable to the customer, then the simplicity of this method should make it the dominant ant control method. However, research on new active ingredients for either approach will most likely continue.

In conclusion, pest ant research seems to be gaining more interest as indicated by the increase in scientific presentations and the number of labs working on them. The renewed interest and funding for imported fire ant control may provide a base for the expansion of research to other

pest ants. With this expansion, it is important to remember the evolution of pest ant control to help guide future research.

Acknowledgments

Reviews of this manuscript by David F. Williams, USDA-ARS Center for Medical, Agricultural, and Veterinary Entomology, and Daniel R. Suiter, Dept. of Entomology, Univ. of Georgia were greatly appreciated.

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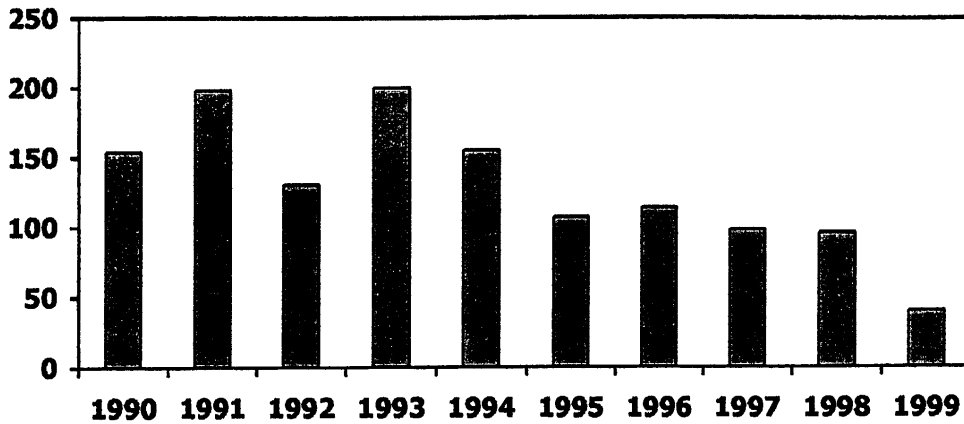


Fig. 1. Number of citations listed in "Formis99: Master Bibliography of Ant Literature" using the search words "pest ant or control or management" for the publication years 1990 to 1999.

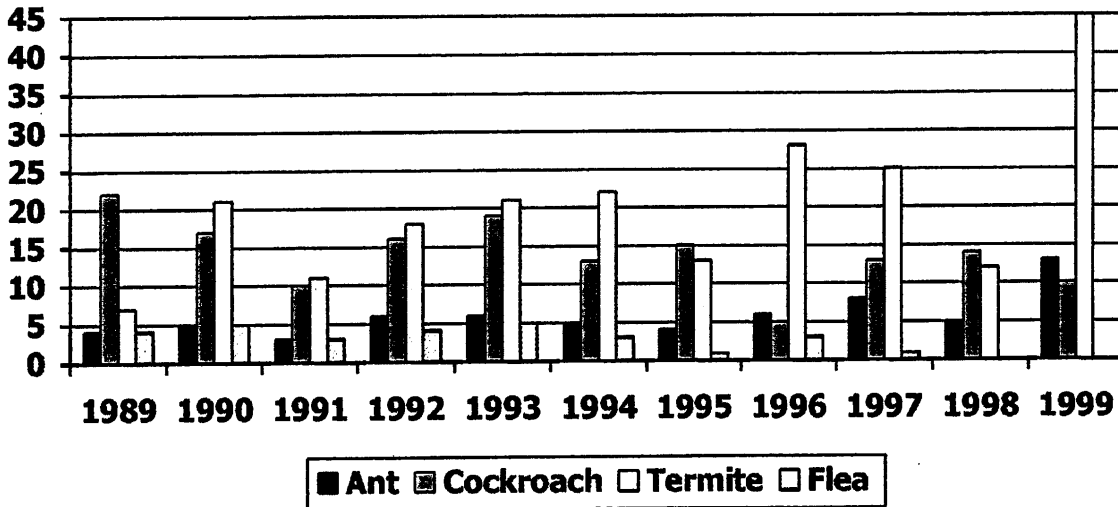


Fig. 2. The number of ant, cockroach, termite, and flea presentations made in the Formal Urban Entomology Conference and in the Urban Entomology section at the annual meeting of the Entomological Society of America (ESA) 1989 to 1999. Note that in 1998 ant and termite presentations were reduced probably because the ESA meeting coincided with the International Union for the Society of Social Insects meeting.

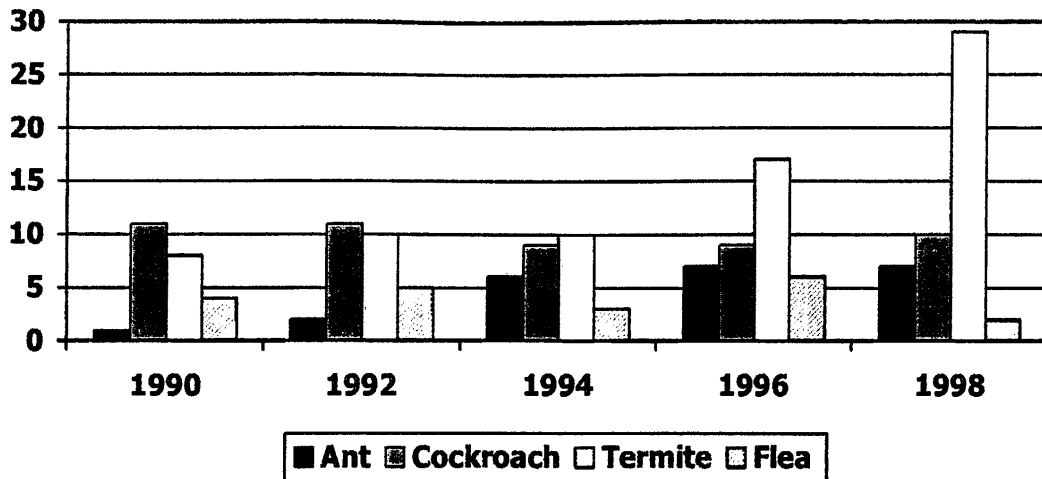


Fig. 3. Number of submitted presentations at the National Conference on Urban Entomology. In 1996 and 1998 ant presentations were allotted a separate section that was limited to a maximum of 8 presentations and were no longer grouped with fleas and other pests.

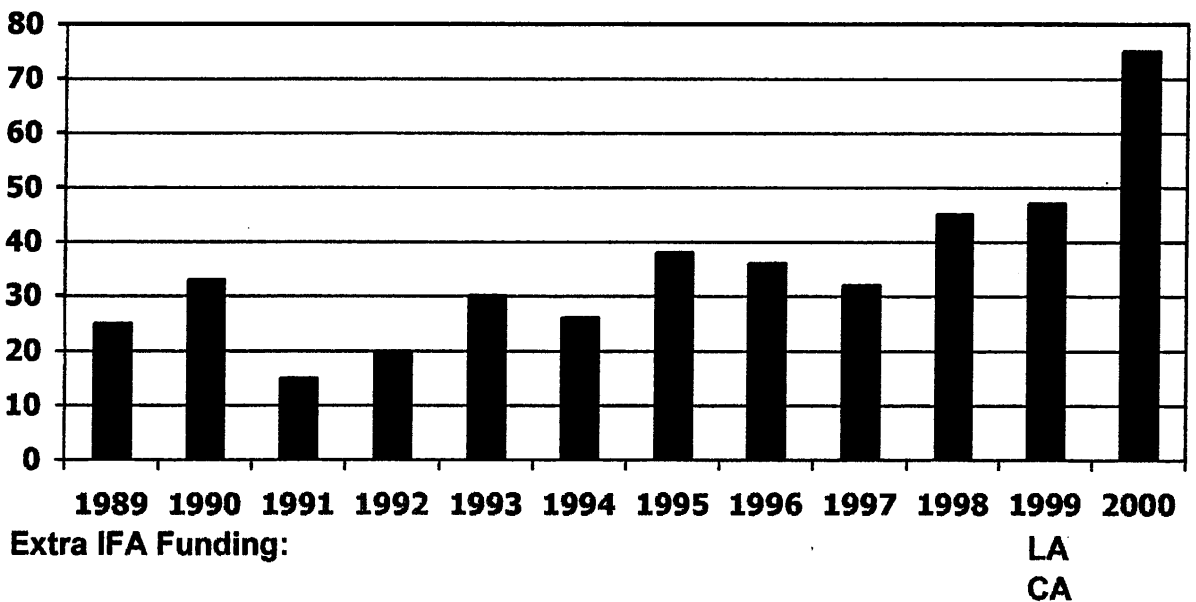


Fig. 4. Number of presentations at the Annual Imported Fire Ant Conference from 1989 to 2000. States with additional funding for imported fire ant control/education are listed under the year that funds initially became available.