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Chemical Control of the Imported Fire Ants

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INTRODUCTION

The fire ants *Solenopsis invicta* Buren and *S. richteri* Forel, accidentally introduced into the southern United States ca. 50 and 70 years ago respectively, presently infest more than 100 million ha of land in eleven states and Puerto Rico. *S. invicta* colonies have been found in Arizona and California, and on St. Croix (US Virgin Islands), but have been eliminated. Lofgren (1986) gave a detailed history of fire ants in the U. S.

The first organized control of fire ants began eight years after Loding (1929) reported their presence in the United States. A cooperative Federal, State, and County program began in Baldwin Co., Alabama (1937) using calcium cyanide dust (Eden & Arant 1949).

By 1953 imported fire ants were present in 102 counties in 10 states (Culpepper 1953) and by 1957 infestations were so severe that large area control was required. The U. S. Congress, acting upon a resolution by the Southern Association of State Agriculture Commissioners, provided funds and authorized the U. S. Department of Agriculture to initiate a cooperative Federal-State control/eradication program. Large-scale insecticide treatments began in late 1957 and research was initiated to improve existing and develop new, control methods. (For details on the use of the residual chlorinated hydrocarbons, and the development and use of mirex bait in the control program see Bellinger et al. 1965, Adkins 1970, Alley 1973, Lofgren et al. 1975).

Mirex bait gave > 95% fire ant control over large areas (Lofgren et al. 1975); however, its persistence resulted in animal residues (Markin et al. 1972) and ultimately an EPA ban on its use in the U. S. (Johnson 1976). With mirex no longer available, research was accelerated to discover and develop new fire ant control technologies. This paper discusses the development of delayed-action toxicants and insect growth regulators for use in baits, and quick-acting insecticides for individual mound treatment.

TOXIC BAITS

We directed most of our research on fire ant control toward toxic baits because they represent the most economical and environmentally sound

method for large-area control. Lofgren et al. (1975) reviewed early studies in the development of fire ant baits and Williams (1983) and Banks et al. (1985) discussed more recent studies.

Effective baits must have (1) a toxicant that exhibits several hours delayed toxicity so the chemical can be distributed to a substantial portion of the colony before ants begin to die, is effective over at least 10-fold, and preferably greater range of dilutions, is not repellent to ants, and is easily formulated with foods and carriers (Stringer et al. 1964, Banks et al. 1977, Williams 1983), (2) an attractive food material, preferably only to the target species and (3) a cheap, easy to obtain, formulate and apply carrier. Unfortunately, the limited availability of such materials hampered the development of baits.

Only fifteen of the over 4,000 chemicals we tested since 1977 met enough of the requirements of an effective fire ant bait toxicant to warrant field tests (Banks, unpublished data). Only three materials passed the additional tests of safety, availability, developmental costs and marketability and have been pursued commercially. These are hydramethylnon, the active ingredient in Amdro^{R}, (American Cyanamid Co., One Cyanamid Plaza, Wayne, NJ 07470); abamectin, the active ingredient in Affirm^{R} (MSD AgVet, Div. Merck & Co., Inc., P. O. Box 2000, Rahway, NJ 07065); and sulfluramid, one of a group of fluoroaliphatic sulfone insecticides (Vander Meer et al. 1985, Williams et al. 1987), which will probably be available in a commercial fire ant bait (Griffin Corp., P. O. Box 1847, Valdosta, GA. 31601) within the next year.

Insect growth regulators (IGRs), although essentially nontoxic to adult fire ants, meet the other requirements of effective toxicants. Several of the 85 IGRs tested in the laboratory caused the death of >85% of treated colonies (Banks 1986, Banks et al. 1978, 1988). Death occurred because the IGR prevented the replacement of workers through low level toxicity to immatures, reduction or cessation of egg production by the colony queen, and a shift in caste differentiation so that any eggs laid produced only sexual forms. Two IGRs, fenoxycarb and pyriproxyfen (S-31183, Sumitomo Chemical Co., Ltd., 15-5 chome, Kitahama, Higashi-ku, Osaka, Japan), caused a mated queen's ovaries to retrogress and prevented ovary development in fire ant virgin females (Glancey and Banks 1988, Glancey et al. 1989).

Fire ant colonies that ingest IGRs die much more slowly than those that ingest conventional bait toxicants. Treated colonies may survive for a year or more in the laboratory despite a constantly decreasing population. In the field, however, treated colonies survive for only four to six months. Although users sometimes object to the slow worker kill, two IGR baits have been developed and marketed for fire ant control. Logic^{R} (Maag Agrochemicals, Inc., P. O. Box 6430, Vero Beach, Florida 32961-6430), containing fenoxycarb, has gained acceptance as an effective fire ant control agent. ProDrone^{R} (ICI Americas, Inc., Wilmington, DE 19897), which contained 1-(8-methoxy-4,8-dimethylnonyl)-4-(1-methylethyl) benzene, was much less effective and is no longer available. We recently discovered that the IGR pyriproxyfen is very effective against the fire ants and development of a commercial bait is under consideration.

The ants must readily accept the food attractant in toxic baits. It must act as the solvent for the toxicant and absorb into the carrier without deleterious effects on either. It should remain acceptable to the ants through

at least several weeks storage. Although omnivorous, fire ants can exhibit a preference for certain food materials depending on the circumstances and time of year (Glunn et al. 1981, Sorenson and Vinson 1981). Nevertheless, vegetable oil-based baits are readily harvested in the field and provide a high level of control when used with an effective toxicant (Hays and Hays 1959, Lofgren et al. 1961, 1964, Howard and Tschinkel 1981, Williams 1983, Banks et al. 1985, Lofgren 1986). The high ant acceptance level plus ready availability, favorable cost, ease of formulation and stability led us to choose soybean oil as the phagostimulant/toxicant solvent. Soybean oil baits give consistent results and recent studies (Vander Meer et al., unpublished) show that soybean oil contains volatiles attractive to fire ant foragers.

Finding suitable carriers for oil baits was always difficult. Lofgren et al. (1963) determined that a granular bait was most practical and, after evaluating a number of materials, found that ground corncobs provided the most consistent results and were the only material available in adequate quantities for the control program. These grits were such an excellent carrier that more than 90% of the over 100 million pounds of mirex bait used for fire ant control in the 1960s and 70s in the southern United States was formulated on corncob grits. Although a number of other materials (hardwood sawdust, pelleted wood fibers, styrofoam beads, etc) were evaluated during this period (Banks et al., unpublished), only Fur-Ag received extensive usage (Banks et al. 1970).

Although an excellent carrier for mirex, corncob grit formulations of hydramethylnon and fenoxycarb gave such poor fire ant control that a new carrier was sought (Banks et al. 1985, 1988). We restricted our search for new carriers to materials that would absorb more oil (corncob grits retained only 15%) because earlier studies had shown that certain toxicants were effective only in high oil content baits (Stringer et al. 1964, Banks et al. 1977). Tests with a variety of materials showed that the ants only accepted puffed cereal-type pellets of corn, rice, or wheat. These were also sufficiently absorptive and flowed through conventional application equipment. Hydramethylnon was more effective in field tests when formulated on extruded corn pellets than on corncob grits (Banks et al. 1985). Two similar materials, pregel defatted and pregel degermed corn grits, proved satisfactory as carriers when available supplies of the extruded pellets were found to be inadequate; the pregel defatted grit was slightly superior. Good handling procedures are necessary because pregel defatted corn grits breakdown rapidly in moisture, disintegrate with rough handling and may become infested by grain beetles or moths. But, with proper handling, they are good carriers for the oil baits. All currently marketed fire ant baits are formulated with pregel defatted grits (Illinois Cereal Mills, Inc., Paris, Illinois 61944).

As individual mound treatments, the baits are used at rates of three to seven tablespoons evenly spread in about a one meter circle around the mound. However, the best results are obtained when the bait is broadcast evenly over the ant-infested area (1.12-1.68 kg/ha).

Table 1 illustrates how effective broadcast applications of soybean oil-pregel defatted corn grit baits containing Amdro, Affirm, sulfluramid, fenoxycarb and pyriproxyfen are against fire ants. The four to eight (or more) weeks required to realize maximum kill with baits may be unacceptable when the ants are causing severe problems. In such situations, contact insecticides may be desirable.

TABLE 1. Effectiveness of baits against red imported fire ants (avg. from 30-50 plots). I = Population index.

Rate of Application		Avg. pretreatment		% reduction in I after 12-13 weeks posttreatment[b]
Bait[a] (kg/ha)	AI(g/ha)	Nests	I	
Affirm (1.12-2.24)	0.12-.25	27	1810	97.4
Amdro (1.12-2.24)	9.8-19.7	52	1018	89.7
Logic (1.12-1.68)	11.2-16.8	54	1018	94.5
S-31183 (1.12-2.24)	8.4-22.4	28	607	87.7
GX-071 (1.12-1.68)	3.4-10.1	28	616	85.5
Control	- -	52	1036	31.1

[a]Baits - Affirm 0.011% abamectin; Amdro 0.88% hydramethylnon; Logic 1.0% fenoxycarb; S-31183 0.75% to 1.5% pyriproxyfen; GX-071 0.3 to 0.6% sulfluramid. [b]See Banks et al. 1988 for method of determining population index and reductions.

CONTACT INSECTICIDES

The following chemicals are registered and marketed in the southern United States as drenches, dusts, granules and aerosols or vapors for control of imported fire ants: acephate, bendiocarb, carbaryl, chlorpyrifos, diazinon, malathion, pyrethrins and certain pyrethroids. These chemicals will kill the ants by direct contact when applied or within one week through their residues. They are generally favored by homeowners and others who desire the quick elimination of a few colonies. Although primarily used for treatment of individual fire ant nests, these insecticides can be used as broadcast treatments for small areas.

Although effectiveness of these insecticides varies with formulation, soil type, size of mounds, rate and method of application, and time of year when treatments are made, all have been reported to give > 80% fire ant control in at least one test (Morrill 1976, 1977, Hillman 1976, 1977, Gardner 1980, 1981, Francke 1983, Williams and Lofgren 1983, Drees 1986, Lemke and Kissam 1987, Diffie et al. 1988). Because the formulations, rates and methods of application, and evaluation procedures vary specifics should be obtained from the cited publications.

Mound drenches with an insecticide aqueous emulsion or suspension are a common method of individual mound treatment. They can give excellent control if the volume of liquid is adequate to saturate the nest. We have found that mounds up to 20 cm in diameter require ca. four liters of solution and larger mounds require ca. eight liters. The best application method for drenches entails wetting the top of the mound, then soaking the soil in a ca. 30 cm circle around the mound's base. Finally the remaining solution is poured onto the top of the mound from a height to insure penetration. The height will vary depending upon the soil, but generally one to two meters is adequate.

Drenches work best when applied about mid-morning on sunny days after cool nights in the early spring or late fall. The ants, and the queen, are concentrated near the top of the mound at such times and are more likely to

be contacted by the insecticide. Applications made during hot weather are rarely effective because the ants are usually deep in the mound. Drenches are usually more effective in heavier soils because the mound's tunnel structure remains intact, allowing the liquid to better penetrate.

Dusts and granules are scattered over the surface of the mound and the surrounding soil. They may be left undisturbed or watered into the soil with a sprinkling can or hose. Dusts or granules are generally less effective than drenches, although acephate dusts and diazinon granules sometimes give excellent kill of individual colonies (Hillman 1977, Drees 1986, Diffie et al. 1988, Lemke and Kissam 1987).

Aerosols of chlorpyrifos alone, or combined with pyrethrins, have been utilized for individual IFA mounds. For these treatments, a standard pushbutton aerosol cap, fitted with a 74 cm long x 8 mm diameter fiberglass probe, is attached to an aerosol container containing 1.0% of the insecticide. The spray is activated, the probe inserted into the mound at from one to four sites, depending on size, and the chemical released for ca. five seconds at each insertion site. Although the chemical is neatly packaged for easy handling, this application method does not give significantly better control than chlorpyrifos drenches (Horton et al. 1982, Drees 1986, Lemke and Kissam 1987, Diffie et al. 1988). The cost per mound is somewhat higher for the aerosol than for the drench.

Thermo-fumigation is a variation of the aerosol injection method. Insecticide is vaporized in a special heating chamber and then injected under pressure through a metal probe into the fire ant mound (Evans 1988). Although the system usually uses resmethrin as the insecticide, other pyrethroids can be substituted. Thorvilson et al. (1989) obtained very quick kill of fire ants with a mean colony size reduction of 98% four weeks after treatment. We did not obtain as good results in our tests with the system in 1986 (35% and 40% after 4 and 8 weeks respectively) (Banks et al. unpublished).

Methyl chloroform (1, 1, 1-trichloroethane) is registered in some of the fire ant infested states as a pour-on fumigant for individual mound treatment. In most efficacy tests the recommended rate of 60-90 ml of technical liquid per mound provided only 40-65% control (Williams and Lofgren 1983, Drees 1986, Lemke and Kissam 1987), although it gave >90% control in one study (Scarborough et al. 1982).

If individual mound treatment is less than 100% effective, the surviving ants often abandon the original mound and build one or more new mounds nearby. In such cases, additional treatment is necessary to eliminate the colonies.

As previously indicated, treatment of individual mounds is a very popular control method over small areas, such as backyards, playgrounds, small parks, cemeteries, and schoolyards. It usually provides rapid control at nominal cost and is relatively safe to humans, animals and the environment. For areas larger than 0.5 ha where there are large numbers of mounds, individual mound treatment is too labor-intensive and becomes impractical. In such situations, the quantity of insecticide applied, and the cost per unit area of treatment becomes much higher and the level of control lower. Thus, broadcast application of an effective bait should be used for wide area control.

REFERENCES CITED

ADKINS, H.G. 1970. The imported fire ant in the southern United States. Assoc. Am. Geogr. 60: 578-592.

ALLEY, E.G. 1973. The use of mirex in control of the imported fire ant. J. Environ. Qual. 2: 52-61.

BANKS, W.A. 1986. Insect growth regulators for control of the imported fire ant. *In* C. S. Lofgren and R. K. Vander Meer [eds.], Fire ants and leaf-cutting ants: biology & management. Westview, Boulder, CO., 434 pp.

BANKS, W.A., C.E. STRINGER, C.S. LOFGREN, N.W. PIERCE and F.J. BARTLETT. 1970. Fur-Ag: An alternate carrier for soybean oil-mirex bait for control of the imported fire ant. J. Econ. Entomol. 63: 1990-1991.

BANKS, W.A., C.S. LOFGREN, C.E. STRINGER and R. LEVY. 1977. Laboratory and field evaluation of several organochlorine and organophosphorus compounds for control of imported fire ants. ARS-S-169, 13 pp.

BANKS, W.A., C.S. LOFGREN and J.K. PLUMLEY. 1978. Red imported fire ants: effects of insect growth regulators on caste formation, and colony growth and survival. J. Econ. Entomol. 71: 75-78.

BANKS, W.A., D.F. WILLIAMS and C.S. LOFGREN. 1988. Effectiveness of fenoxycarb for control of red imported fire ants (Hymenoptera: Formicidae). J. Econ. Entomol. 81: 83-87.

BANKS, W.A., C.S. LOFGREN and D.F. WILLIAMS. 1985. Development of toxic baits for control of imported fire ants. pp. 133-143. *In* T.M. Kaneko and L.D. Spicer [eds.], Pesticide Formulations and Application Systems: Fourth Symposium. Amer. Soc. Test Mater., Special Tech. Publ. 875.

BELLINGER, F., R.E. DYER, R. KING and R.B. PLATT. 1965. A review of the problem of the imported fire ant. Bull. Ga. Acad. Sci. 23: 1-22.

CULPEPPER, G.H. 1953. The distribution of the imported fire ant in the southern states. Proc. Assoc. Agric. Workers 50: 102.

DIFFIE, S., D.C. SHEPPARD and T.D. CANERDAY. 1988. Imported fire ant control results, 1978-1987. Mimeo. Rpt. 2, Univ. Ga. Coop. Exten. Serv., Div. Entomol., Athens. 110 pp.

DREES, B. 1986. Red imported fire ant control result demonstrations, 1979-1986. Mimeo. Rpt. Texas Agric. Exten. Serv., College Station. 121 pp.

EDEN, W.G. and F.S. ARANT. 1949. Control of the imported fire ant in Alabama. J. Econ. Entomol. 42: 976-979.

EVANS, C.W. II. 1988. Method and apparatus for the destruction of imported fire ants of the genus *Solenopsis*. U. S. Patent 4,756,118.

FRANCKE, O. 1983. Efficacy tests of single-mound treatments for control of red imported fire ants, *Solenopsis invicta* Buren. Southwest. Entomol. 8: 42-45.

GARDNER, W.A. 1980. Imported fire ant control by mound drenches, 1979. Insectic. Acar. Tests 5: 209-210.

GARDNER, W.A. 1981. Red imported fire ant control by mound drenches, 1980. Insectic. Acar. Tests 6: 132.

GLANCEY, B.M. and W.A. BANKS. 1988. Effect of the insect growth regulator fenoxycarb on the ovaries of queens of the red imported fire ant (Hymenoptera: Formicidae). Ann. Entomol. Soc. Am. 81: 642-648.

GLANCEY, B.M., W.A. BANKS and M.S. OBIN. 1989. The effect of fenoxycarb on alates of the red imported fire ant. J. Entomol. Science 24: 290-297.

GLUNN, F.J., D.F. HOWARD and W.R. TSCHINKEL. 1981. Food preference in colonies of the fire ant, *Solenopsis invicta*. Insectes Soc. 28: 217-222.

HAYS, S.B. and K.L. HAYS. 1959. Food habits of *Solenopsis saevissima richteri* Forel. J. Econ. Entomol. 52: 455-457.

HILLMANN, R.C. 1976. Control of red imported fire ants, *Solenopsis invicta* Buren, on home grounds in North Carolina. J. Elisha Mitchell Soc. 92: 69-70.

HILLMANN, R.C. 1977. Red imported fire ant control with conventional insecticides, 1975, 1976. Insectic. Acar. Tests 2: 135.

HORTON, P.M., J.B. KISSAM, S.B. HAYS and G.W. QUERY. 1982. Chlorpyrifos aerosol mound injections for the control of the red imported fire ant. J. Ga. Entomol. Soc. 17: 478-484.

HOWARD, D.F. and W.R. TSCHINKEL. 1981. The flow of food in colonies of the fire ant, *Solenopsis invicta*: a multi-factorial study. Physiol. Entomol. 6: 297-306.

JOHNSON, E.L. 1976. Administrator's decision to accept plan of Mississippi Authority and order suspending hearing for the pesticide chemical mirex. Fed. Regist. 41(251): 56694-56704.

LEMKE, L.A. and J.B. KISSAM. 1987. Evaluation of various insecticides and home remedies for control of individual red imported fire ant colonies. J. Entomol. Sci. 22: 275-281.

LODING, H.P. 1929. An ant (*Solenopsis saevissima richteri* Forel). U. S. Dep. Agr. Ins. Pest Survey Bull. 9: 241.

LOFGREN, C.S. 1986. History of imported fire ants in the United States. pp. 36-47 *In* Fire Ants and Leaf-Cutting Ants: Biology and Management, C.S. Lofgren and R.K. Vander Meer [eds.]. Westview, Boulder, CO.

LOFGREN, C.S., F.J. BARTLETT and C.E. STRINGER. 1961. Imported fire ant toxic bait studies: evaluation of various food materials. J. Econ. Entomol. 54: 1096-1100.

LOFGREN, C.S., F.J. BARTLETT and C.E. STRINGER. 1963. Imported fire ant toxic bait studies: evaluation of carriers for oil baits. J. Econ. Entomol 56: 62-66.

LOFGREN, C.S., F.J. BARTLETT and C.E. STRINGER. 1964. The acceptability of some fats and oils as food to imported fire ants. J. Econ. Entomol. 57: 601-602.

LOFGREN, C.S., W.A. BANKS and B.M. GLANCEY. 1975. Biology and control of imported fire ants. Annu. Rev. Entomol. 20: 1-30.

MARKIN, G.P., J.H. FORD, J.C. HAWTHORNE, J.H. SPENCE, J. DAVIS, H.L. COLLINS and C.D. LOFTIS. 1972. The insecticide mirex and techniques for its monitoring. U. S. Anim. Plant Health Insp. Serv. [Rep.] 81-3, 19 pp.

MORRILL, W.L. 1976. Red imported fire ant control with mound drenches. J. Econ. Entomol. 69: 542-544.

MORRILL, W.L. 1977. Red imported fire ant control with diazinon and chlorpyrifos drenches. J. Ga. Entomol. Soc. 12: 96-100.

SORENSON, A.A. and S.B. VINSON. 1981. Quantitive food distribution studies within laboratory colonies of the imported fire ant, *Solenopsis invicta* Buren. Insectes Soc. 28: 129-160.

STRINGER, C.E., JR., C.S. LOFGREN and F.J. BARTLETT. 1964. Imported fire ant toxic bait studies: evaluation of toxicants. J. Econ. Entomol. 57: 941-945.

THORVILSON, H.G., S.A. PHILLIPS, JR. and A.A. SORENSON. 1989. An innovative thermo-fumigation technique for control of red imported fire ants. J. Agric. Entomol. 6: 31-36.

VANDER MEER, R.K., C.S. LOFGREN, and D.F. WILLIAMS. 1985. Fluoraliphatic sulfones: a new class of delayed-action insecticides for control of *Solenopsis invicta* (Hymenoptera: Formicidae). J. Econ. Entomol. 78: 1190-1197.

WILLIAMS, D.F. 1983. The development of toxic baits for the control of the imported fire ant. Fla. Entomol. 66: 162-172.

WILLIAMS, D.F. and C.S. LOFGREN. 1983. Imported fire ant control: evaluation of several chemicals for individual mound treatments. J. Econ. Entomol. 76: 1201-1205.

WILLIAMS, D.F., C.S. LOFGREN, and R.K. VANDER MEER. 1987. The red imported fire ant, *Solenopsis invicta*, control with fluoroaliphatic sulfone bait toxicants. J. Agric. Entomol. 4: 41-47.