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Estimated Amounts of Insecticide Ingredients Used for Imported Fire Ant Control Using Various Treatment Approaches

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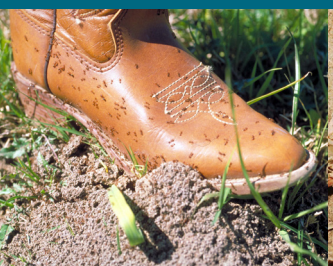
The red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae), is a highly destructive exotic pest ant in the southeastern United States. It produces an average ant mound density of 68 mounds per acre (168 mounds/hectare) (Porter et al. 1992). Control methods depend largely on using insecticides as recommended by one or more programs (see *Managing Red Imported Fire Ants in Urban Areas*). Demonstrations of community-wide management programs have used methods that dramatically reduce the cost of insecticides while attaining superior control (see *Community-Wide Red Imported Fire Ant Programs in Texas*). Implementing these methods throughout fire-ant-infested portions of Texas and the southeastern United States can also dramatically reduce the amount of insecticides applied in the landscape.

The following analysis helps calculate insecticide use and the potential to reduce pesticides applied in urban areas for red imported fire ant control by using broadcast applications of imported fire ant bait products (part of the Two-Step Method of fire ant control), particularly in larger-scale, community-wide management programs (see *Managing Red Imported Fire Ants in Urban Areas*). This analysis does not address other issues related to selecting insecticides such as the cost of formulated products, labor, and the equipment costs necessary to make applications (see *Broadcast Baits for Fire Ant Control*), although some toxicological and performance differences of specific treatments are considered.

Environmental Problems Associated with Imported Fire Ant Control Insecticide Use

A press release by the Water Department of the City of Fort Worth (1997) states:

> The City of Fort Worth is urging residents to team with their neighbors to treat for fire ants using bait products during the month of September. The Let 'em Eat Bait campaign is designed to make residents aware of an effective way to treat for fire ants using less





toxic pesticides. The city is targeting fire ants because a 1997 survey revealed fire ants are the primary reason residents use pesticides, and diazinon is the primary pesticide used to treat fire ants. Diazinon causes problems for the city when it enters the wastewater system or gets into local creeks and rivers. Diazinon has caused the city to periodically fail monthly tests required by the state and federal wastewater plant discharge permits. The city's federal storm water permit, managed by the Environmental Management Department, requires the city to periodically monitor diazinon levels in local creeks and rivers. The Two-Step Method for controlling the imported fire ants was developed by researchers at Texas Agricultural Extension Service [now Texas A&M AgriLife Extension Service] to help consumers best use fire ant control products on the market.

Similar environmental threats exist throughout this pest's geographical range because of the overuse and misuse of imported fire ant insecticide treatments.

Sources of Information

The use patterns of insecticides for imported fire ant control are not generally available. Some insecticide product manufacturers have privately conducted marketing analyses (Appendix 1), and the Texas A&M AgriLife Extension Service (AgriLife Extension) and the Texas Imported Fire Ant Research and Management Project have conducted surveys (Appendix 2).

These are the best sources of information, but are somewhat out-of-date because of major changes in insecticide products available to the general public. Specifically, beginning in 2003, diazinon and chlorpyrifos (Dursban) were no longer sold, in part, as a reaction to the effect of the Food Quality Protection Act (FQPA). This has caused a major shift to the use of pyrethroid insecticides (bifenthrin, cyfluthrin, cypermethrin, deltamethrin, fenvalerate, fluvalinate, lambda-cyhalathrin, permethrin, s-bioallethrin, s-fenvalerate, tefluthrin, tralomethrin) for imported fire ant control.

New products, such as ones containing fipronil were added to the spectrum of products available to consumers. Pyrethroid and fipronil products generally contain far less active ingredients than older organophosphate and carbamate insecticides. As a result, insecticide quantities applied to the environment continue to change. However, the effects of changes in pesticide-use patterns can be modeled or estimated using available data sources or specific sets of assumptions.

Use Pattern Considerations

The Scripps Howard Texas Poll released in March 2000 (Appendix 2) was one of the best sources of information available on homeowner insecticide use patterns for imported fire ant control. About half of Texans treated their yards to attempt to control fire ants. Most (65 percent) used individual mound treatments and 51 percent treated one or more mounds four or more times a year. Relatively few people (24 percent) reported using broadcast-applied bait-formulated products, and of these, 11 percent used the Two-Step Method (broadcast bait followed by individual mound treatment later). Riggs et al. (2002) have documented that managing imported fire ants on a community-wide basis using broadcast-applied fire ant bait products has dramatically reduced ant mound densities, pesticide cost, and use (see *Community-Wide Red Imported Fire Ant Programs in Texas*).

AgriLife Extension educational programs promote methods that dramatically reduce or eliminate the excessive use of individual mound treatment methods. Individual mound treatments use more insecticide, cost more in product and labor to apply, potentially contaminate surface runoff water, serve as a potential nonpoint source of groundwater pollution, and are less effective under most conditions (small treatment areas such as single yards or properties or where ant mound densities exceed 20 mounds per acre).

Amount of Insecticides Applied to the Environment

Insecticide products are formulated as baits, dusts, fumigants, granules, and liquids. Each of these formulations contains a specific amount of active ingredient(s) (a.i.). These amounts have been computed for selected insecticide products as a basis for calculating the amount applied to treat an imported fire ant mound and for various levels of mounds per acre per year (Table 1). A time element must be included because some products and treatment patterns provide short-term control while others provide longer-term control (see discussion below). The duration of control, depending on the product and how it is applied, can result in the need for multiple applications each season. The amount of materials (ounces) applied over time to a unit area (acre) was determined from values calculated for each product (Table 3). From there, specific insecticide use examples using selected assumptions such as product combinations, cases of different ant forms, and treatment type or inputs (data) from actual demonstrations was calculated (Table 2, also see *Community-Wide Red Imported Fire Ant Programs in Texas*).

Table 1. Ounces a.i./acre for imported fire ant control

Class, ingredient, concentration (product)	Amount active ingredient (a.i.)
Organophosphate insecticides	
acephate 50% (Orthene Fire Ant Killer)	0.075 oz a.i./mound
acephate 75% (Surrender Brand Fire Ant Killer)	0.111 oz a.i./mound
diazinon 5% (Orthol Fire Ant Killer Granules)	0.1515 oz/mound
chlorpyrifos 23.5% (Dursban Pro)	0.125 oz a.i./mound/1 gal
chlorpyrifos 50% (Dursban 50W)	0.124 oz a.i./mound/1 gal
Pyrethroid insecticides	
bifenthrin 0.2% (Ortho Fire Ant Killer Granules)	0.0124 oz a.i./mound
cyfluthrin 1.0% (Bayer Advanced Lawn Fire Ant Killer)	0.0015 oz a.i./mound
deltamethrin 0.05% (Terro Fire Ant Killer and Bengal UltraDust Fire Ant Killer II)	0.0027 oz a.i./mound
Hydramethylnon bait	
hydramethylnon 1.0% (MaxForce Fire Ant Killer Granular Bait)	0.005 to 0.01 oz a.i./mound
hydramethylnon 0.73% (Amdro Fire Ant Bait, AmdroPro, SiegePro)	0.002 to 0.01 oz a.i./mound
Surface treatments:	
Bait Products (From Barr 2002):	
abamectin 0.011% (Clinch, Varsity)	0.00176 oz a.i./acre
fenoxycarb 1.0% (Award, Logic)	0.16 oz a.i./acre
fipronil 0.00015% (Firestar)	0.00036 oz a.i./acre
hydramethylnon bait	
1.0% (MaxForce Fire Ant Killer Granular Bait)	0.16 to 0.32 oz a.i./acre
0.73% (Amdro Fire Ant Bait, AmdroPro, SiegePro, ProBait) 0.002 to 0.01 oz a.i./mound	0.112 to 0.16 oz a.i./acre
methoprene 0.5% (Extinguish)	0.08 oz a.i./acre
pyriproxyfen 0.5% (Distance, Esteem)	0.08 oz a.i./acre
spinosad 0.015% (Justice)	0.0024 oz a.i./acre
Contact insecticides:	
chlorpyrifos 50% (Dursban 50W)	16 oz a.i./acre
diazinon 5% (Spectracide Fire Ant Killer Mound and Broadcast Granules)	69.696 oz a.i./acre
bifenthrin 0.2% (Talstar EZ or PL Granular Insecticides)	3.2 to 6.4 oz a.i./acre
bifenthrin 7.9% (Talstar F Insecticide/Miticide)	3.58 oz a.i./acre
cyfluthrin 0.1% (Bayer Advanced Garen Lawn and Garden Multi-Insect Killer)	1.3939 oz a.i./acre
fipronil 0.0103% (Over 'n Out!)	0.14348 oz a.i./acre

Table 2. Examples of fire ant mound density in Texas community-wide fire ant management pilot programs (Riggs et al. 2002)

Location	Mounds/1,000 sq ft	Mounds/acre
Jade Oaks	1.18	51.4
Countryside	0.15	6.5
Mt. Bonnell	1.70	74.0
Apache Oaks	2.27	98.9
Average	57.7	
Mt. Pleasant	6.80	296.2

43,560 sq ft = 1 acre

Note: Levels cited in this table are pre-program implementation mound densities in these communities. As such, they represent levels of ant mounds existing using current methods of treatments by residents before implementing community-wide programs employing broadcast application of bait-formulated products.

The use of individual fire ant mound treatments, thus, results in an additive load of insecticides used per unit area depending on the initial mound density and the reinfestation rate. The organophosphate insecticides (such as acephate, chlorpyrifos, and diazinon) contain more active ingredient per mound treatment than pyrethroid insecticides (such as bifenthrin, cyfluthrin, and deltamethrin) (Table 3). Even within groups of active ingredients, refinements in formulations (acephate 50 percent versus 75 percent dust) can result in applying less active ingredient.

Bait-formulated insecticides contain 1 percent or less active ingredients (such as MaxForce, the bait containing the highest percent a.i.) (Table 1). When applied as ant mound treatments, the application rates are similar to pyrethroid products used in the same manner. However, broadcast application of bait products results in using far less active ingredient on an area regardless of initial mound density. Fipronil granular formulations, broadcast-applied to the surface, are formulated in an amount equivalent to some bait-formulated products (such as fipronil at 0.14348 ounce a.i. per acre versus hydramethylnon 0.73 percent at 0.112 ounce a.i. per acre using 1 pound of granulated product per acre).

Re-treatment Considerations

When comparing one treatment to another, the number of ant mounds to be treated over time should be considered. In small plot (or yard) demonstrations, reinvasion from surrounding, untreated areas is relatively rapid. Often, these plots are reinvaded within the 30-day duration of the trial, although the ant mounds are often in different locations than where they were at the beginning of the trial. Thus, a more accurate assessment would also address the need for re-treatment. The concept of managing imported fire ants on a community-wide basis rests on the assumption that because a larger area is treated, reinvasion occurs more slowly. This assumption has been verified by Hooper-Bui et al. (2000). For example, if an acre of land was infested with 50 mounds per acre and treated with an individual mound treatment, four applications per year might be necessary to maintain control, requiring 200 mound treatments. One or two broadcast-applied bait treatments could achieve the same level of control.

Estimated Pesticide Use Reduction

Using the weighted average active ingredient applied to ant mounds based on Kline & Co. 1995 product sales estimates (see calculation, Appendix 1) along with the national average mound density estimate of 68 mounds per acre (Porter et al. 1992), the use of individual mound treatments alone would require 1.14 ounces a.i. per acre for a single treatment. Compared to applying hydramethylnon 1 percent as a broadcast application using 0.240 ounce a.i. per acre, the reduction in insecticide use to the environment would be 79.73 percent. Similarly, using the average mound density of 57.7 mounds per acre reported in community-wide fire ant programs (see *Community-Wide Red Imported Fire Ant Programs in Texas*), the reduction is 74 percent. (Note: Using the low, 1 pound per acre rate of hydramethylnon, reduction would be 84 percent.) These estimates are probably low because areas treated with mound treatment would most likely require re-treatment. Conversely, the shift away from the availability of organophosphate insecticide products, notably chlorpyrifos and diazinon, to

pyrethroid insecticides has undoubtedly reduced the weighted average ounce a.i per acre values calculated from product sales data of Kline & Co. for 1995 (Appendix 1). Unfortunately, these new data are unavailable. However, using methods employed here, alternate assumptions of the product use spectrum could, theoretically, be made.

Notably, the "action threshold" of 20 mounds per acre for using broadcast bait versus individual mound treatments (see *Managing Red Imported Fire Ants in Urban Areas*) closely approximates to an equivalent amount of active insecticide ingredient applied to the environment as an individual mound treatment (0.240 ounce a.i. per acre for 1 percent hydramethylnon versus 0.320 ounce a.i. per acre from Kline & Co. in Table 3).

Monogyne Versus Polygyne Forms of Imported Fire Ants

The density of mounds is greater in areas infested with the polygynous or multiple queen form of the red imported fire ant (see *Differences in Worker Size and Mound Distribution in Monogynous and Polygynous Colonies of the Fire Ant Solenopsis invicta Buren*). Areas infested with the monogyne (single queen) colonies range from 40 to 150 mounds per acre (rarely more than 7 million ants per acre). In areas with multiple-queen colonies, there may be 200 or more mounds and 40 million ants per acre (see *Managing Red Imported Fire Ants in Urban Areas*) although polygyne colonies can also occur in lower mound densities. Texas, unlike the other southeastern United States, is infested largely with the polygyne form and has, on the average, higher mound densities than the national average of 68 mounds per acre (Porter et al. 1992).

In one published study conducted in Texas in 1986, polygynous red imported fire ant mound densities required 640 individual mound drenches per acre, using 79.36 ounces or 4.96 pounds of the active ingredients of chlorpyrifos (Dursban 4E applied at 0.124 ounce a.i. per gallon per mound). Only 29 individual mound drenches, using 3.60 ounces or 0.22 pounds a.i., were required to treat monogynous ant mounds. The percent reduction of polygynous mound densities was initially greater but mound reinfestation after approximately 10 weeks occurred at a higher rate for the polygynous ant (Drees and Vinson 1990).

The effect of the monogyne versus the polygyne forms of fire ants on the amount of insecticide required for control is shown in Table 3. For organophosphate insecticides, almost a pound or more (11.250 ounces to 18.6 ounces) active ingredients must be applied to treat mound densities of 150 or higher. Using the Mt. Pleasant example from *Community-Wide Red Imported Fire Ant Programs in Texas* and the weighted average from Kline & Co. (1995), the 296 mounds per acre in this neighborhood would have required 4.739 ounces a.i. applied as mound treatments verses 0.240 ounces a.i. hydramethylnon 1 percent bait broadcast-applied, a difference of 94.9 percent active ingredients applied to the environment.

Considerations for Surface Broadcast Applications of Contact Insecticides

Although, historically, homeowners have not used surface broadcast applications of contact insecticides very often, according to the Scripps Howard Texas Poll (Appendix 2), it has been a common treatment used by professional pest control companies. Values of the amounts of active ingredients calculated for contact insecticide surface treatments (Table 1) can help determine mound densities and justify a shift from individual mound treatments to broadcast treatment for these products. For instance, diazinon was broadcast-applied at a rate of 69.696 ounces per acre. At 0.152-ounce a.i. per mound, that amount would treat slightly less than 500 mounds (Table 3). Similarly, chlorpyrifos, broadcast-applied at 16 ounces a.i. per acre as a mound treatment (0.0125 ounces a.i. per mound) would treat just over 100 ant mounds per acre. And, bifenthrin broadcast applied at 6.4-ounces a.i. per acre could treat just

over 51 mounds at 0.0124-ounce a.i. per mound. The fipronil granular product, Top Choice, potentially reduces pesticide load applied to the environment using only 0.14348-ounce a.i. per acre, which was comparable to several bait-formulated insecticide product-use rates. Unlike baits, granular fipronil treatment provides residual control, preventing reinvasion for many months following application.

Other Toxicological Property Considerations

Reducing the amount of insecticide active ingredients applied to the environment alone does not address all of the toxicological properties to consider when selecting a fire ant control strategy (see *How to Select, Apply, and Develop Insecticides for Imported Fire Ant Control* and *Broadcast Baits for Fire Ant Control*). Even within the organophosphate insecticide group there are toxicological differences between active ingredients. For instance, acephate is much less persistent in the environment than are chlorpyrifos or diazinon, breaking down rapidly when in contact with organic material. Furthermore, acephate has a relatively lower toxicity to aquatic organisms such as catfish. Pyrethroid insecticides, as formulated and applied, have lower amounts of active ingredients than do organophosphate products. Pyrethroids are relatively less toxic to mammals (higher oral and dermal LD50 values). They are less water soluble, more persistent, and have higher toxicity to aquatic organisms. Fipronil, although formulated and applied at rates even lower than pyrethroid insecticides, is even more persistent, and the active ingredient is relatively more toxic to mammals and aquatics. Both pyrethroid and fipronil product label directions restrict application near bodies of water.

In general, bait products must be consumed in order to have an effect on target and nontarget organisms. And, with the notable exception of fipronil, they persist for shorter periods in the environment. Hydramethylnon can be degraded by sunlight and degrades in the soil in about 3 days. Aquatic toxicity is less of a problem, particularly for some bait products. For instance, Extinguish contains the active ingredient methoprene and is formulated for the treatment of aquatic larval stages of mosquitoes and other flies (Diptera). Furthermore, insect growth regulator baits (fenoxycarb, methoprene, pyriproxyfen) are not known to have acute toxic effects on vertebrate animals, although fenoxycarb has been designated as a Class B carcinogen by the Environmental Protection Agency. The ingredients abamectin and spinosad are produced by microorganisms through a fermentation and extraction process and are considered by some to be "of natural origin" and could arguably be "organic" (see *Natural, Organic, and Alternative Methods for Imported Fire Ant Management*). For these reasons, all insecticides should be used judiciously and only when necessary.

Consider cost-effectiveness, environmental effects, and labor-intensiveness in any pesticide selection process. When considering imported fire ant control, the analysis presented here may be useful for choosing methods that reduce the amount of insecticide active ingredients that are applied to the environment.

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Marketing analyses conducted by Kline & Company, Inc., 1995, used by permission of Joe Chamberlin of Valent USA.

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This current version included reformatting and copyediting. However, no major technical changes were made.

Table 3. Ounces of a.i./acre for Imported Fire Ant Control

		Organophosphates				Pyrethroids			Bait		
Mounds/ acre/yr	Examples of infestations	acephate 50%	acephate 75%	diazinon 5%	chlorpyrifos 50%	bifenthrin 020%	cyfluthrin 1.00%	deltamethrin 0.05%	hydramethylnon 1%		Kline & Co. 1995
									Mound	Broadcast	
1		0.075	0.111	0.152	0.125	0.012	0.002	0.003	0.008	0.240	0.016
6.5	Countryside	0.488	0.722	0.988	0.806	0.078	0.010	0.020	0.049	0.240	0.104
20		1.500	2.220	3.040	2.480	0.240	0.030	0.060	0.150	0.240	0.320
50		3.750	5.550	7.600	6.200	0.600	0.075	0.150	0.375	0.240	0.800
51.4	Jade Oaks	3.855	5.705	7.813	6.374	0.617	0.077	0.154	0.386	0.240	0.822
57.7	Avg. Community-wide	4.328	6.405	8.770	7.155	0.692	0.087	0.173	0.433	0.240	0.923
68	National Avg.	5.100	7.548	10.336	8.432	0.816	0.102	0.204	0.510	0.240	1.088
74	Mt. Bonnell	5.550	8.214	11.248	9.176	0.888	0.111	0.222	0.555	0.240	1.184
98.9	Apache Oaks	7.418	10.978	15.033	12.264	1.187	0.148	0.297	0.742	0.240	1.582
100		7.500	11.100	15.200	12.400	1.200	0.150	0.300	0.750	0.240	1.600
Polygyne											
150		11.250	16.650	22.800	18.600	1.800	0.225	0.450	1.125	0.240	2.400
250		18.750	27.750	38.000	31.000	3.000	0.375	0.750	1.875	0.240	4.000
296.2	Mt. Pleasant	22.215	32.878	45.022	36.729	3.554	0.444	0.889	2.222	0.240	4.739
500		37.500	55.500	76.000	62.000	6.000	0.750	1.500	3.750	0.240	8.000
1000		75.000	111.000	152.000	124.000	12.000	1.500	3.000	7.500	0.240	16

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Broadcast Baits for Fire Ant Control
www.agrilifebookstore.org/product-p/e-628.htm

Differences in Worker Size and Mound Distribution in Monogynous and Polygynous Colonies of the Fire Ant Solenopsis invicta Buren
www.jstor.org/stable/25084596

How to Select, Apply, and Develop Insecticides for Imported Fire Ant Control
u.tamu.edu/ento-030

Natural, Organic, and Alternative Methods for Imported Fire Ant Management
u.tamu.edu/ento-009

Fire Ant Control: The Two-Step Method and Other Approaches
www.agrilifebookstore.org/product-p/ento-034.htm

Appendix 1. Fire Ant Product Sales and Market Share - 1995 Home Market Segment Summary (U.S. Fire Ant Market 1995, Kline & Company, Inc.)

	Thousands			
Product	**lb**	**gal**	**$**	**% of total/HO**
diazinon	13,425.8	57.0	$8,298.5	26.0/26.2
chlorpyrifos/Dursban	8,182.5	76.7	7,180.0	22.5/22.7
hydramethylnon/Amdro	1,353.4	0.0	7,037.6	22.1/21.9
acephate/Orthene	236.4	116.6	6,053.3	19.0/19.1
fenoxycarb/Award and Logic	117.0	0.0	1,194.0	3.7/2.6
pyrethroids	0.0	40.8	818.8	2.6/3.0
carbaryl/Sevin	982.4	5.6	661.6	2.1/2.1
Other	589.7	7.7	661.2	2.2/2.4
Totals	24,887.1	304.4	31,907.0	100.2
HO	19,204.0	239.9	24,342.0	100.0

HO = urban/suburban household market
Note: Solid products accounted for 65.6% of sales, while liquid products (with higher a.i. content) counted for 34.4%

Calculation of Weighted Average Used in Table 3 for Kline & Co. 1995:

Product (formulation) use/a.i. use	**% of sales**	**a.i/mound***	**a.i. x % of sales x 100**
diazinon (5%)	26.2%	0.1515 oz	0.03969 oz
chlorpyrifos (23.5%)	22.7%	0.125	0.02838
hydramethylnon (0.73%)	21.9%	0.006	0.00131
acephate (50%)	19.1%	0.075	0.01433
pyrethroids (deltamethrin)	3.0%	0.0027	0.00008
Total:	89.9%	0.3714	0.08379
Other	7.1%		
Average of 5 top (90%)		0.07428 oz	
Weighted average			0.016758 oz a.i./mound

*Values from Table 1

Appendix 2. "Fire Ants in Texas" March 2000. Scripps Howard Texas Poll

1. Have you treated for fire ants in the past year?

	February 2000 % (N=1,000)
Yes	56
No	44
Don't know/no answer	—

2. How often did you treat for fire ants in the past year?

	February 2000 % (N-568 who treated for fire ants)
Once	11
Twice	18
Three times	16
Four or more	51
Don't know/no answer	4

± 4.1 percentage point margin of error

3. When treating for fire ants, which of the following treatments are you most likely to use?

	February 2000 % (N=568 who treated for fire ants)
Apply insecticide directly/on mounds	65
Broadcast slow-acting bait/over entire yard	8
Broadcast fast-acting insecticide/over entire yard	5
Use non-chemical methods/such as boiling water/or digging them up	3
Broadcast bait followed by/individual mound treatment later	11
Other	3
Don't know/no answer	5

± 4.1 percentage point margin of error

For more information regarding fire ant management, see Extension publications *Managing Red Imported Fire Ants in Urban Areas, Broadcast Baits for Fire Ant Control*, or *Fire Ant Control: The Two-Step Method and Other Approaches* posted on http://AgriLifeBookstore.org.

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