IMIDACLOPRID USE in TERMITE CONTROL OPERATIONS GLOBALLY and CHANGING USE PATTERNS in the UNITED STATES

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Abstract The soil-applied termiticide, imidacloprid (Premise®, Hachikusan®) was registered for termite control in Japan in 1993. This non-repellent termiticide causes mortality in termites foraging near treated structures, and is transmissible to other termites not directly exposed to treated soil. A two-year study, conducted to determine the performance of precision placement of termiticide, involved treatment of 56 termite-infested structures in the United States. Forty-four (78.6%) of these sites achieved complete control of the structural termite infestation with initial application. Twelve sites (21.4%) required minimal spot treatments to control newly discovered termite activity. Termite control with non-repellent termiticides can be less disruptive to occupants of infested-structures and at greatly reduced labor costs. In this project, total termiticide use was reduced by nearly 50%, and interior use of termiticide was reduced by more than 70%, without compromising the long-term effectiveness of integrated termite management programs.

Key Words chloronicotinyl subterranean termites *Reticulitermes Coptotermes Heterotermes*

INTRODUCTION

The chloronicotinyl insecticide imidacloprid is a widely used insecticide in the world, based on a unique combination of characteristics (Elbert et al., 1990; Elbert et al., 1991; Kagabu, 1997; Cox et al., 1997; Cox et al., 1998). These include: 1) a novel mode of action; 2) excellent systemic and contact activity; 3) a wide variety of application methods; 4) low application rates; 5) long residual control; 6) strong binding to soil organic matter; and 7) favorable toxicological and environmental profiles. Nihon Bayer Agrochem first synthesized imidacloprid in 1985 (Elbert et al., 1998); its discovery followed earlier research on heterocyclic nitromethylenes (Soloway et al., 1978). These compounds evolved from nicotine, whose mode of action is to interfere with normal nerve impulse transmission by binding to post-synaptic nicotinergic acetylcholine receptors. Imidacloprid was the first commercially available compound in a new insecticide class discovered by Bayer, the chloronicotinyls, which act at this unique site of action.

The development of imidacloprid for termite control began in the late 1980s (Zeck, 1992), and culminated in the registration of Hachikusan® in Japan in 1993. Premise® was registered in the United States, Australia, and other countries (Figure 1). Imidacloprid soil treatments have been evaluated for termite control efficacy in more than 25 distinct trial locations on 4 continents. These trials have challenged the effectiveness of imidacloprid-treated-soils by exposure to more than 20 species of termites, including *Allodontermes*, *Amitermes*, *Coptotermes*, *Heterotermes*, *Macrotermes*, *Mastotermes*, *Microcerotermes*, *Microtermes*, *Nasutitermes*, *Reticulitermes*, and *Schedorhinotermes*. Results from some of these trials are summarized in Table 1. In North America, Japan, Australia, and South Africa, imidacloprid has proven to provide residual control ranging from 5 to more than 10 years. Residual has proven to be shorter in tropical climates, such as in the Philippines, northern Australia, and elsewhere in Southeast Asia.

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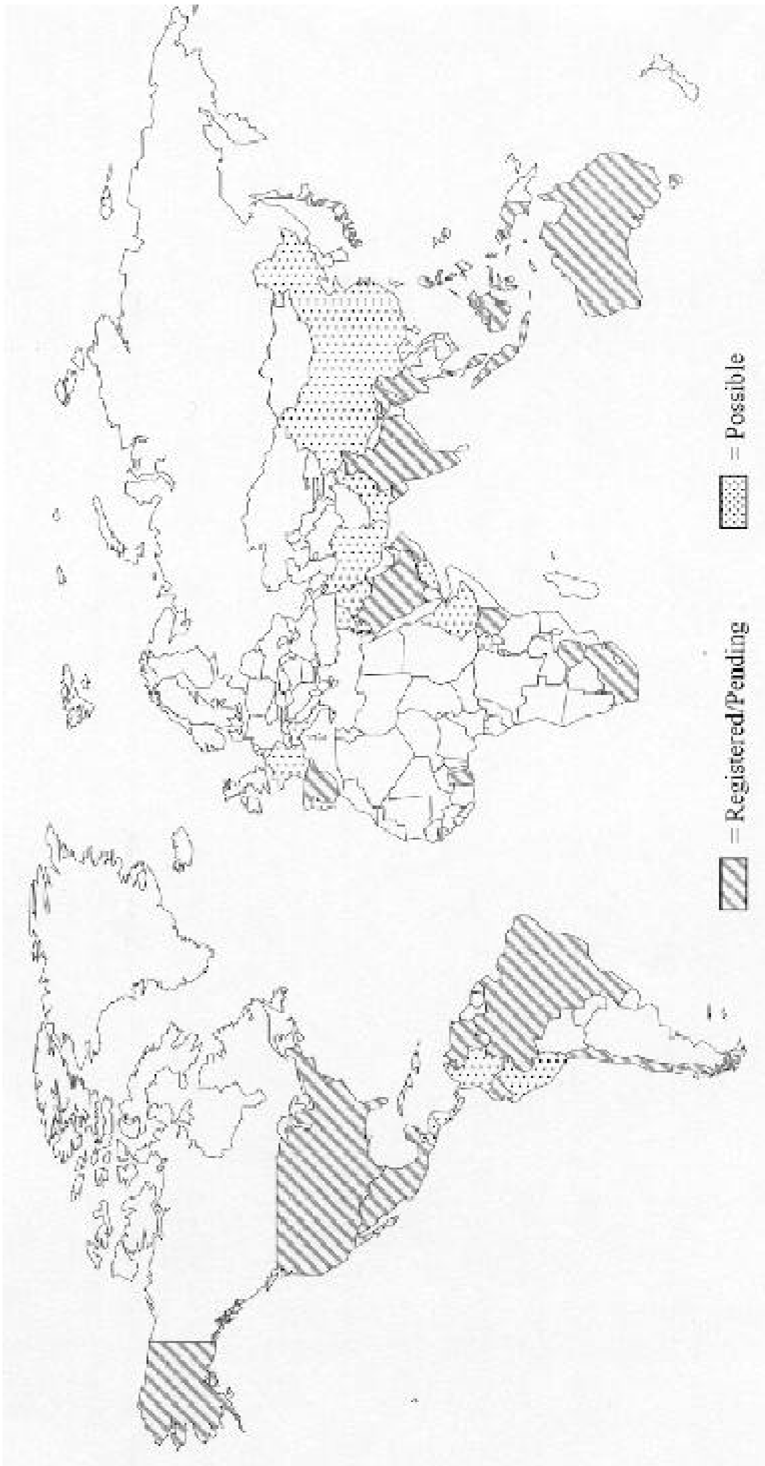

Figure 1. Global registrations and possible future registrations for imidacloprid termiticides.

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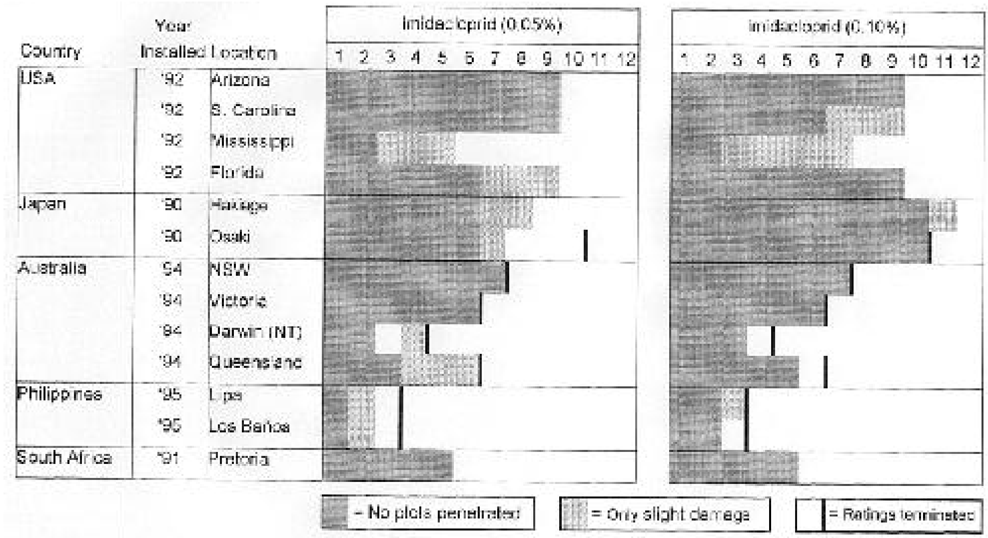
Table 1. Control efficacy of imidacloprid from trials around the world



Termites acquire a lethal dose of imidacloprid as they tunnel into treated soil; over time termites are killed, and attacks on the protected structure are not sustained.

Kuriachan and Gold (1998), Gahloff and Koehler (1999, 2001), Reid (2001), and Thorne and Breisch (2001) have reported that non-repellent termiticides, and imidacloprid in particular, control termites in fundamentally different ways from earlier, liquid termiticides. Because it is non-repellent, imidacloprid treatment zones in soil are more than barriers. Non-repellency causes reductions in the size of termite populations around treated structures by attrition, as more foraging termites enter the treated soil and eventually die. Second, since these termites do not rapidly die, individuals that are exposed to imidacloprid are able to transfer the toxicant to nest mates that were not directly exposed to treated soil, much like the actions of bait insecticides. Data in a two-year mark-recapture research project have quantified that termite populations exposed to partial soil treatments have been reduced by more than 90% and have remained at these reduced sizes for more than two years.

Despite the dramatic changes in the effects caused by new types of active ingredients registered as soil-applied liquid termiticides, the labels and treatment standards for soil-applied, liquid termiticides have not changed appreciably since the days when products such as chlordane or heptachlor were commonly used in termite control. Despite the contribution of EPA's Pesticide Regulation Notice 96-7 to standardizing certain directions for use, precautionary language, and other label text, the underlying treatment procedures in termite control have not changed much in more than 40 years. Potter (1999) wrote, "Assuming that the treated zone is non-detectable by termites and functions not as a barrier, but as a killing field whose effects are transmissible to other termites in the area, why must every inch of every conceivable termite entry point be treated?" He then went on to postulate "Perhaps the day will come, supported by adequate data, when companies no longer have to drill and treat customers' floors and walls unnecessarily, and can achieve a satisfactory level of protection mainly by thorough trenching and rodding of the exterior, supplemented by interior spot treatments to infested or high-risk areas."

For the past four years, Bayer has been working on generating data from field trials in termite-infested structures on just such treatment practices, which will be referred to throughout

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this paper as the Perimeter Protocol. The principle of the Perimeter Protocol treatment strategy was to only use termiticide inside the structure where termites were known or suspected to occur, and then to supplement the targeted interior treatment with complete soil treatments on the perimeter of the foundation wall. Results in these field trials are necessary to gain regulatory approval to change the way imidacloprid is used to control termite infestations. This paper presents a summary of results of long-term monitoring of the structures treated in this work.

MATERIALS and METHODS

Beginning in 1999, Bayer researchers set out to evaluate the real-world performance of imidacloprid, following this Perimeter Protocol for the control of subterranean termite infestations. Over a two-year period, a total of 56 structures with active termite infestations were treated using the Perimeter Protocols. Trial sites were located in 12 states across the country (Figure 2). A third of the sites (18 of 56) were established in Florida and, together with Louisiana (3) and Texas (4), these three states account for nearly 45% (25 of 56) of test sites (Table 2). Since Florida and Texas are the two largest markets in the United States, and Louisiana is home to the largest infestation of Formosan termites in the continental United States, this concentration of sites is representative of the overall termite control market. The three main genera of subterranean ter-

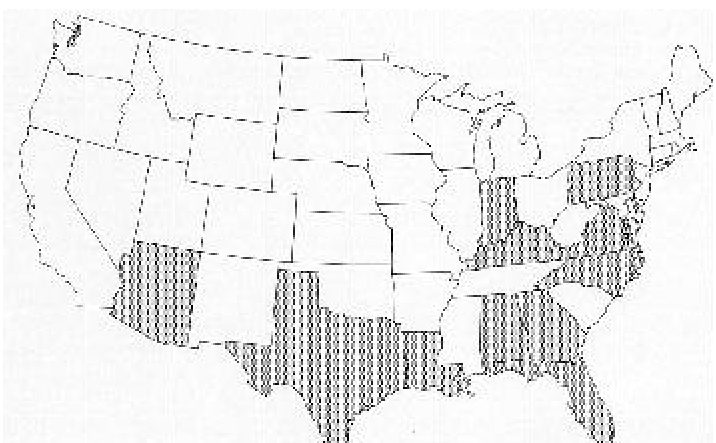

Figure 2. Geographic distribution of study sites for imidacloprid in the Perimeter Protocol.

Table 2. Geographic distribution and pest species in the Perimeter Protocol test sites

State	Total	Native[1]	Formosan[2]	State	Total	Native[1]	Formosan[2]
AL	1	1	–	KY	2	2	–
AZ	4	4	–	LA	3		3
DE	3	3	–	NC	3	3	–
FL	18	15	3	PA	6	6	–
GA	2	2	–	TX	4	4	–
IN	5	5	–	VA	5	5	–
Total:	56 sites	50 native	6 Formosan				

[1] Native subterranean termites include *Reticulitermes* sp. and *Heterotermes aureus*.
[2] The Formosan subterranean termite, *Coptotermes formosanus*.

mite (*Reticulitermes* sp., 46 sites; *Coptotermes formosanus*, 6 sites; *Heterotermes aureus*, 4 sites) were represented. The geographic and related climatic variations represented in the distribution of the test sites included eight distinct soil classes represented in the test population, varying from pure sand through various clay soils (Figure 3). In addition to variation in soil structure, soils at the test sites had a wide range of soil pH, ranging from moderately acidic (5.1) to mildly alkaline (8.3) soils.

Construction Survey

All of the most common construction types were represented (Table 3). Typically, a structure built on a monolithic slab does not have expansion joints on the interior of the foundation wall that require drilling and sub-slab injection of termiticides. However, in every case in this study, monolithic slab construction was composed of multiple monolithic slabs and/or combinations with abutting slabs that would have required treatment under conventional treatment stan-

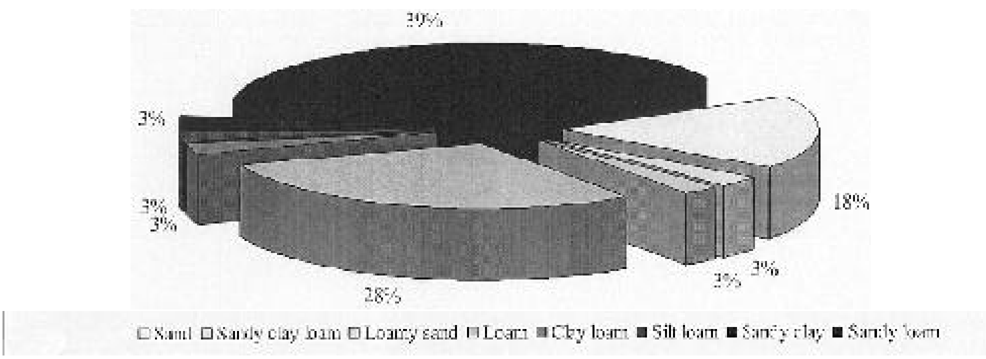

Figure 3. Distribution of soil types among study sites in the Perimeter Protocol.

Table 3. Construction types among test sites

Construction types	Slab-on-ground	Slab combinations	Basements	Crawlspace Pier & beam
Number (% of 56)	40 (71.4%)	7 (12.5%)	9 (16.1%)	0 (0%)

Table 3(a). Slab types among test sites

Construction types	Floating slab	Supported slab (includes basements)	Monolithic slab	Slab combinations
Number (% of 56)	24 (42.9%)	15 (26.8%)	12 (21.4%)	5 (8.9%)

Table 3(b. Foundation types among test sites

Foundation type	Solid, poured foundation	Hollow block foundation	Stone or rubble foundation
Number (% of 56)	23 (41.1%)	31 (55.4%)	2 (3.6%)

Table 3(c). Depth from grade to top of the footer among test sites

Depth of footer	< 1 foot	1 to 2 feet	> 2 feet
Number (% of 56)	36 (64.3%)	8 (14.3%)	12 (21.4%)

dards. The two predominant types of foundations represented in the structures were either solid or poured concrete or hollow block foundations. Nearly 2 out of 3 foundation walls extended no deeper than 30.4 cm from grade level to the top of the footer. Approximately 1 in 5 structures had what are considered deep footers, where the foundation walls extended more than 60 cm from grade level to the top of the footer. The average foundation wall extended 63 cm from grade level to the top of the footer. On average, structures included in this study covered 177.5 m^2 (maximum 353 m^2), and had a linear measurement around the foundation of 201.6 feet (maximum 570 feet).

Given the geographic distribution of these test sites, and the consequent variety of climatic conditions, termite species, soil types, and types of construction, the efficacy of imidacloprid used by Perimeter Protocols is representative of the overall, national picture in the termite control industry.

Perimeter Protocol

The focus in these treatment specifications was to minimize needless interior treatments, and especially to minimize drilling through concrete slabs, where there are no signs of termite activity at expansion joints on the interior of the structure. All structures were treated using a 0.05% dilution of imidacloprid (75% a.i. water-soluble packaging), which is the low label rate. Treatment of the test structures in the Perimeter Protocol was pursued as a two-phase strategy: (1) A full volume, outside foundation wall treatment was made to establish a continuous, vertical treated zone in soil on the structure's exterior. Any further direction on this treatment procedure was referenced to the appropriate section of the registered label. (2) Targeted applications were then made to all known infested sites inside the structure. Optional interior applications were allowed for vulnerable or critical areas such as plumbing or utility entry points, bath traps, expansion joints, or settlement cracks in the slab, and dirt-filled porches or stairs.

One or more of the following methods was used, at the researcher's discretion, in making these targeted interior applications. (1) Sub-slab injections through the slab at or near where termites are penetrating the slab and/or at or near sites of active infestation. To achieve best soil coverage from these sub-slab treatments, combinations of liquid and foam application techniques were encouraged. These were: (a) Sub-slab injections were required to extend a minimum of 2 to 3 feet on either side of every known infested site along expansion joints or cracks in slabs; (b) at or near utility penetrations, an area not less than 1 square foot was treated at a rate of 1 gallon of dilution per square foot. (2) Void treatments using injection of sprays, mists, or foams into structural voids, termite carton nests, and other infested locations. (3) Wood treatments using injection techniques and/or surface applications, to treat active infestations inside structural timbers. More specific directions on particular treatment procedures were derived from the relevant section(s) of the label appropriate to the construction type, or from the Control of Wood-Infesting Pests section.

It is important to stress that aside from improving the precision in where treatments are required to be made, the Perimeter Protocol did not differ from existing, registered labels in terms of how treatments are made at a given location or a given element of construction. The one exception to this statement is with respect to making soil treatments along foundation walls with deep footers, where it was required only to extend treatment 2 feet deep in the soil, instead of the standard 4 feet. All treatments were conducted by certified applicators employed by termite control firms licensed in their respective states to conduct termite control. A Bayer researcher was always present on the initial treatment, and was present for most subsequent follow-up treatments. All treatment information was recorded on standard forms, and transmitted to Bayer for archiving.

Inspections

Structure-types eligible for inclusion in this program were limited to slab constructions; no crawl space or pier & beam constructions were included unless they had an attached slab integrated into the living space (i.e., porches or patios alone would not qualify). Once a structure had been selected for the study, a thorough inspection was conducted to identify all termite activity in or adjacent to the structure. The perimeter of the foundation wall was inspected for signs of termite activity, and the interior of each structure was inspected to identify infested locations that require spot treatments under the Perimeter Protocol. Finally, an inspection was made of likely points of termite entry or construction features conducive to termite entry. Inspections were made both prior to treatment and at regular intervals after treatment. Structures were inspected often in the first 6 months to confirm efficacy, and to provide opportunities for corrective actions to infested locations that had gone undetected in the initial inspection. Thereafter, each structure was inspected every 6 months to determine whether control was maintained. All inspections were conducted by certified applicators employed by termite-control firms licensed in their respective states to conduct termite control. A Bayer researcher was always present on the initial inspection, and was often present for subsequent inspections. All inspection information was recorded on standard forms, and transmitted to Bayer for archiving.

RESULTS and DISCUSSION

Infestations

Inspections conducted prior to treatment served to characterize the termite pressure at a structure and to direct treatment procedures to those locations where termite activity was detected. Overall, among the 56 structures in this study, there was an average of 3.07 (range 1-9) distinct sites of termite infestation; a distribution of the number of termite active sites per structure is presented in Figure 4. Among the 46 structures infested by native subterranean termites (*Reticulitermes* sp.), there was an average of 2.73 (range 1-7) sites per structure; and among the 6 structures infested by Formosan subterranean termites (*Coptotermes formosanus*), there was an average of 2.83 (range 1-5) sites per structure. However, among the 4 structures infested by the desert subterranean termite (*Heterotermes aureus*), there were considerably higher numbers of

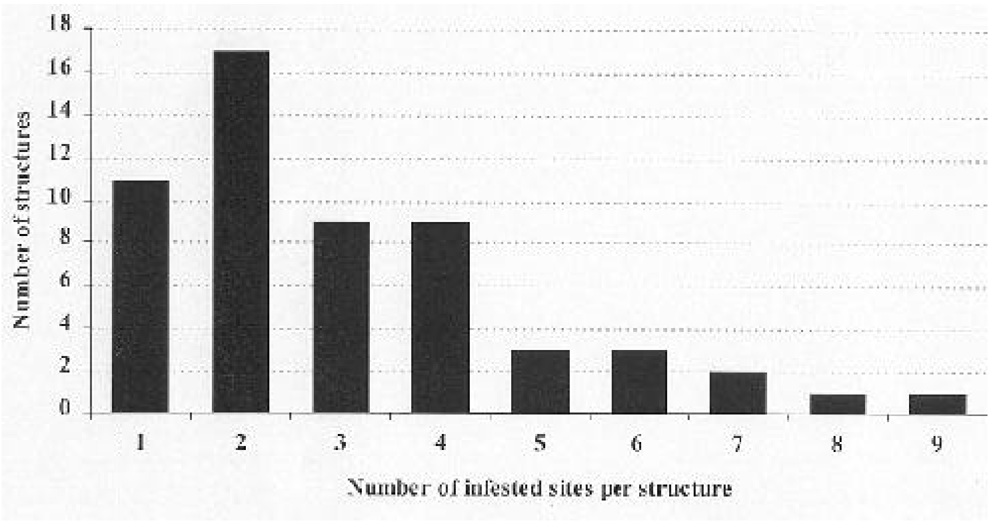

Figure 4. Varying intensity of termite infestation among the structures included in this research.

infested sites, with an average of 7.00 (range 4-9) individual sites of termite infestation per structure; this is likely an artifact of this species' propensity for establishing isolated, above-ground satellite colonies.

To further characterize the infestations, locations where termite activity was detected were classified either as exterior or interior with respect to construction features. Activity at expansion joints in garages, porches or patios, and planting beds were categorized as exterior. Activity in an interior wall adjacent to the perimeter expansion joint along the inside of a foundation wall was categorized as exterior. Interior sources of infestation were associated with penetrations of the slab at some distance from perimeter expansion joints, such as in bathrooms, kitchens, or utility rooms. Outcomes of this classification are shown in Table 4. A common source of exterior infestations, as expected, was the perimeter foundation wall; about 40% of structures had activity on the outer surface of the foundation wall, while about 30% of structures had activity associated with the inner surface. Among interior sites, the propensity for termites to access the structure by following water and utility lines is evident in the activity noted in the kitchen, bathrooms, and utility areas. However, the most common interior sites of activity were identified as various living spaces, including partition walls, door and window frames, and many other sites not obviously associated with the perimeter of the structure. When analyzed over all 56 structures, there was an average of 1.09 exterior sources of infestation per structure, and an average of 1.45 interior sources of infestation per structure. Structures included in this research were not infested merely by termites found on or near the exterior foundation wall, as evidenced by the substantial termite activity within the interior of the structure.

Treatment Description

Analyses of treatment procedures used describe how the Perimeter Protocol influenced where termiticides are applied in and around a structure. These data are summarized in Table 5. Overall, the average volume applied in the initial treatment to these structures was 127.7 gallons per structure, with a maximum of 318 gallons. Of this total, the volume applied by trenching or trenching and rodding to the soil adjacent to the exterior of the foundation wall was 103.1 gallons, with a maximum of 288 gallons. Thus, fully 80.7% of the overall volume was used to treat soil on the exterior perimeter of the foundation wall. On average, only 24.6 gallons, or 19.3% of the volume, was used to make applications to all other sites at the structure. While these other treatment procedures were not always used on each structure, the data presented in Table 5 can be weighted by their frequency to give an indication of the distribution of the overall volume at the

Table 4. The frequencies of infestation sources/locations identified among the 56 structures included in this research

Exterior sources of infestation	No. (%) of 56 sites	Interior sources of infestation	No. (%) of 56 sites
Perimeter OFW	22 (39.3%)	Bathroom	18 (32.1%)
Perimeter IFW	16 (28.6%)	Kitchen	8 (14.3%)
Garage	11 (19.6%)	Living space[1]	20 (35.7%)
Patio	8 (14.3%)	Utility Room	10 (17.9%)
Porch	4 (7.1%)	Furnace/Wtr Htr	1 (1.8%)
Basement wall	7 (12.5%)	Aerial colony	2 (3.6%)
Piers/Posts	2 (3.6%)	Attic	2 (3.6%)
Planting beds	6 (10.7%)	Other interior	6 (10.7%)

[1]Denotes termite activity in interior partition walls, door and window frames, and other locations within the general living space of the structure.

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treated structures (Figure 5). This analysis shows that more than 95% of the total PREMISE dilution used was applied to soil, either by exterior soil treatment (103.1 gallons) or by interior injections through the slab (16.7 + 1.8 gallons). The balance, or about 7 gallons of PREMISE dilution, was used to treat void spaces, either in the foundation or within structural walls.

Test Site Retention

To date, all 56 structures have remained available for inspection in this study (Table 6). In our research, from time to time, a particular structure was unavailable for inspection due to scheduling difficulties between the termite control firms and homeowners. However, every structure was inspected on at least two occasions following the initial treatment. On average, all structures have been inspected 3.84 times after the initial treatment over the course of this study.

Table 5. Where imidacloprid was applied in Perimeter Protocols

Treatment technique	No. (%) of 56 sites	Avg. dilute gal. applied	Notes:
Outside foundation walls (vertical[1] treated zone)	56 (100%)	103.1	All by trenching alone (11) or by trenching and rodding (45)
Foundation Wall[2]	9 (16.1%)	14.7	8 block foundations 1 rubble foundation
Sub-slab injection, (vertical[1] treated zone)	33 (58.9%)	28.4	Included 25 exterior (attached) slabs and/or 20 interior slabs
Sub-slab injection, (horizontal[3] treated zone)	21 (37.5%)	4.9	"Spot" treatments around utility penetrations
Structural void treatments	20 (35.7%)	12.4	14 wall voids - dry foam 6 dirt fill stoops - wet foam

[1]Whether by trenching and rodding from outside, or by sub-slab injection adjacent to the inside, these treatments are all applied at a rate of 4 gallons of end-use dilution for every 10 linear feet per feet along the foundation.
[2]Hollow voids within the foundation wall are treated at a rate of 2 gallons of end-use dilution for every 10 linear feet per feet along the foundation.
[3]In sub-slab applications, these treatments were made at a rate of 1 gallon of end-use dilution per 1 square foot of soil around utility penetrations or other openings in the slab away from the foundation.

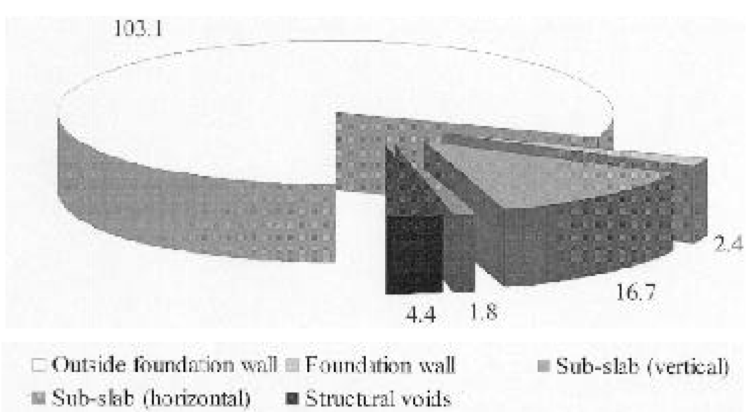

Figure 5. Weighted distribution of application volume (gallons), by treatment techniques.

Table 6. Retention of test sites in the Perimeter Protocol trials

Months after treatment	1.5	3	6	12	18	24
Total structures	56	56	56	56	56	56
Structures dropped	0	0	0	0	0	0
Cumulative)	(0)	(0)	(0)	(0)	(0)	(0)
Structures remaining in the program	56	56	56	56	56	56
Missing inspections	2	28[1]	6	7	37[2]	41[2]
Structures with completed inspections	54	28	50	49	19	15

[1]Only ½ of all sites were inspected at 3 months; this was an "optional" inspection timing, as the original protocol called for the first inspection to occur between 30 - 45 days, with the next inspection at approximately 6 months. Several cooperators took the initiative to conduct an additional inspection at 3-month timing.
[2]The number of missing inspections at 18 and 24 months is higher because some structures (treated in the first half of 2000) had not reached latter inspection intervals.

Termite Control Efficacy

In reporting efficacy, three terms need to be defined: (1) Successful control — Termite infestation known to exist at the time of the initial and/or follow-up inspections was completely controlled by the initial and/or follow-up treatments. (2) Follow-up treatment — An area/location not known to be infested at the initial inspection, and thus not treated, was found in follow-up inspections to be infested. All follow-up treatments were made in compliance with the treatment standards outlined for the initial treatment. (3) Re-infestation — A re-infestation was declared when termites were discovered in an area/location of the structure that had been treated during either initial or follow-up treatments.

After the initial treatment, there were occasions when termite activity was discovered at one or more previously untreated locations in the structure (Table 7). Twelve structures (21.4%) re-

Table 7. Performance summary for imidacloprid in Perimeter Protocol trials

Months after treatment	1.5	3	6	12	18	24
Structures with completed inspection	54	28 [1]	50	49	19 [2]	15 [2]
No termite activity detected after initial treatment	54	26	47	44	17	15
An initial follow-up treatment was required	0	2	3	5	2	0
No termite activity detected after follow-up treatment	54	28	46	49	15	15
A second follow-up treatment was required	0	0	1	0	1	0
Termite re-infestation was detected	0	0	0	0	0	0

[1]Only half of the sites were inspected at 3 months; this was an "optional" inspection, as the original protocol called for the first inspection at 30 - 45 days, with the next at 6 months.
[2]The number of inspections at 18 and 24 months is lower because structures treated in the first half of 2000 have not yet reached these latter inspection intervals.

quired a follow-up treatment to eliminate a newly discovered source of infestation. Thus, 44 structures (78.6%) achieved successful control with an initial application of imidacloprid under the Perimeter Protocol and remained termite-free at all subsequent inspections. Nine (16.1%) of the structures requiring follow-up treatment were discovered within 12 months of the initial treatment; to date, 3 (5.4%) structures requiring follow-up treatment were discovered in the second year.

After the first follow-up treatment, there were two structures (3.6%) where further termite activity was discovered and a second follow-up treatment was required to eliminate newly discovered infestations. Therefore, 54 structures (96.4%) achieved successful control with an initial application and a single, follow-up spot application under the Perimeter Protocol. These structures have remained termite free at all subsequent inspections. Thus far during the inspections, termite activity has never been detected in the vicinity of an area/location that has been treated at any structure, either in the initial or a follow-up treatment (Figure 6).

Follow-Up Treatments

As noted earlier (Table 6), a total of 12 structures required some manner of follow-up treatment. In all cases, follow-up treatments were prompted only by the discovery of termite activity at a location(s) of the structure that had not previously been treated. On average, these 12 follow-up treatments required only 10.8 gallons of the 0.05% dilution. Six of these 12 follow-up treatments (50%) were directed against infestations discovered on the interior of the structure, while the remaining were on the exterior. Among interior treatments, which averaged only 1.8 gallons of treatment dilution, three (50%) were treatments to soil beneath the slab and required an average of 2.7 gallons of treatment dilution, and three (50%) were a structural void treatment with less than 1.0 gallon of treatment dilution. Exterior treatments required higher volumes to complete the treatment, with an average of 20.2 gallons of treatment dilution. Four treatments were to infestations discovered at expansion joints in attached garage slabs and required an average of 16.0 gallons of treatment dilution. The remaining two were treatments of expansion joints at other attached slabs (e.g., porches and patios) that averaged 27.5 gallons of treatment dilution. Despite

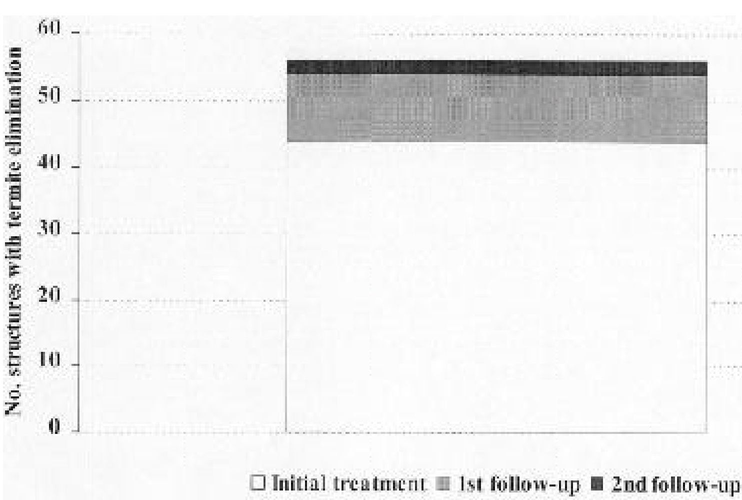

Figure 6: Control efficacy, describing the number of sites achieving successful control after initial or any subsequent follow-up treatments with imidacloprid in Perimeter Protocol field trials.

the higher volumes used in follow-up treatments to exterior sites, half of these exterior treatments required less than 5 gallons of treatment dilution.

Finally, two structures required a second follow-up treatment to control termite infestations in locations that had not been treated in either the initial or the first follow-up treatment. Both of these were made to treat soil beneath the slab, and they required only an average of 3.0 gallons of treatment dilution.

Follow-up treatments under the Perimeter Protocol required only very small volumes of treatment dilution. Fully 9 of the 12 (75%) initial follow-up treatments, and both second follow-up treatments, required less than 5 gallons of treatment dilution (Figure 7).

CONCLUSIONS

Our results amply demonstrate that imidacloprid can be successfully used to achieve structural protection without requiring the indiscriminate treatment of locations within structures that are not infested by termites. Termite control and structural protection were achieved with an initial application in 44 of 56 structures (78.6%) and required only a single, follow-up ‘spot’ application to highly localized areas in a small percentage (21.4%) of cases. The unique properties of imidacloprid and its non-repellent mode of action were able to control termites by directed or targeted applications to only those infested areas without elevating the risk of re-infestation from adjacent, untreated areas. These findings have significant consequences for the amounts of insecticide that are required to achieve termite control and structural protection.

The average structure included in this study measured 201.6 feet along the perimeter of the foundation wall, and the average depth of soil to the top of the footer was 2.07 feet. If this average structure were to be fully treated, following the existing label directions for soil-applied liquid termiticides, it would require more than 160 gallons of termiticide solution be applied to soil around the house. Then to treat all termite entry points at interior expansion joints on a supported or floating slab would require another 80 gallons of termiticide solution to be applied through holes drilled in slabs from within the home. This 80 gallons figure is conservative, in that additional, interior applications are common where utility services penetrate the slab, to interior voids in the construction, etc. Therefore, a complete treatment of the average structure following exist-

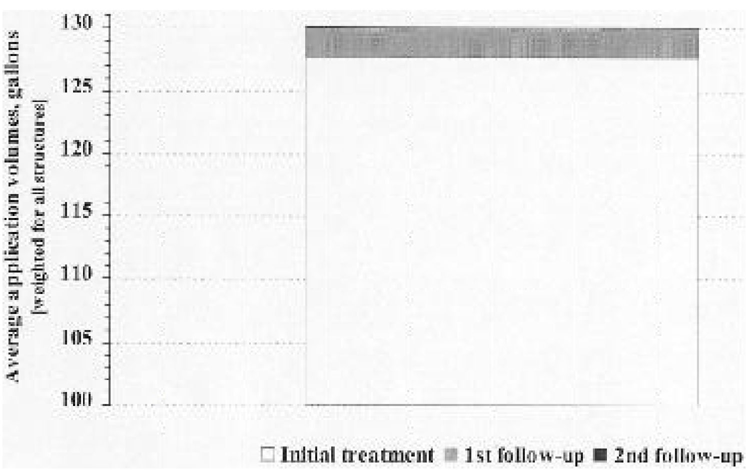

Figure 7: Cumulative average treatment volumes for the initial and any subsequent follow-up treatments with imidacloprid in Perimeter Protocol field trials.

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ing treatment standards would require 242 gallons of termiticide solution. Treatments under the Perimeter Protocol, on average, required just 127.7 gallons of termiticide solution (Table 5); this figure represents a 47.2% reduction in pesticide use compared to the existing treatment standards. With the Perimeter Protocol, treatments required on the interior, on average, were just 24.6 gallons of dilute termiticide solution (Table 5); this is a 69.5% reduction in indoor pesticide use compared to existing treatment standards. Even when the subsequent, follow-up treatments required to control spot infestations are factored into these totals and weighted for the entire sample of test structures, these reduction figures do not change materially: 130.1 gallons overall (46.2% reduction), and 25.1 gallons on the interior (68.9% reduction).

Of the total gallons of dilute termiticide solution required to treat structures in this research, fully 80.7% of this volume was applied to soil outside the home. Further, on considering where termiticide solutions were applied (Figure 5), more than 95% of the pesticide application was to soil on the perimeter of or beneath the structure. Therefore, only a small fraction of the total volume of termiticide solution was applied above ground in building voids, used for wood treatments, and other procedures to directly treat sites infested by termites.

Compared to the estimated 242 gallons of termiticide dilution (equal to 462.9 grams of imidacloprid) that would be required to complete treatment following existing treatment standards, the average house treated in this study required just 130.1 gallons (248.9 grams of imidacloprid), when the follow-up treatments are factored into the total. This figure amounts to a reduction in technical active ingredient use of 213.9 grams of imidacloprid (7.55 ounces or 0.47 pounds) per structure. If this magnitude of pesticide reductions were magnified over the hundreds of thousands of structures that are treated for termites each year in the United States, the total pesticide use reduction to be realized by adopting the Perimeter Protocol would be very significant.

In general terms, this reduction in pesticide use by itself represents a benefit to both the public at large and to the environment. Further, reducing the absolute quantities of pesticide used for termite control inherently provides the opportunity to lessen already low potentials for exposure in applicators and residents alike. These reductions in pesticide use for termite control can be realized without compromising the protection from termite damage. Bayer has submitted to EPA these same data and an imidacloprid termiticide label describing this new use pattern, and is the process of obtaining regulatory approval for the use of imidacloprid following the principles of the Perimeter Protocol in this research.

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