Evidence Supporting the Use of Termite Baiting Systems for Long–term Structural Protection (Isoptera)[1]

by

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ABSTRACT

The efficacy of the Sentricon™ *Colony Elimination System* containing Recruit™ II termite bait (Dow AgroSciences LLC, 0.5% hexaflumuron) in controlling active subterranean termite infestations has been demonstrated in numerous studies. This baiting system and other termite baiting systems are now widely used, and generally accepted tools for remedial termite control in North America, Hawaii, and other parts of the world. The role of baiting systems in prevention of termite damages and long–term structural protection, however, is more controversial than their use in remedial control. We discuss three lines of evidence in support of the use of baits for long–term structural protection: (1) successful control of termite populations with baits in remedial studies allows a conceptual leap to preventative efficacy, since baits target colonies and populations and cannot be evaluated directly for prevention in the manner of soil insecticide barriers; (2) field and laboratory studies demonstrate that termite colonies feed on multiple resources and continue to radiate outward from each of those resources in search of additional food, increasing the likelihood of rapid bait discovery; and (3) results of our long–term field studies over the past decade demonstrate that newly invading termites will reuse existing galleries in the soil left by earlier colonies that lead to monitoring stations, were detected in monitoring stations, and were subsequently eliminated without any noticeable evidence of structural infestation or damage.

INTRODUCTION

The efficacy of the Sentricon™ *Colony Elimination System* containing Recruit™ II termite bait (Dow AgroSciences LLC, 0.5% hexaflumuron) in controlling active subterranean termite infestations has been demonstrated in numerous studies. This baiting system and other termite

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baiting systems are now widely used, and generally accepted, as tools for remedial termite control in North America, Hawaii, and other parts of the world. The role of baiting systems in prevention of termite damages and long–term structural protection, however, is more controversial than their use in remedial control. In part, this is due to the fact that baits cannot be evaluated as prophylactic treatments in the same manner as soil insecticides applied as barriers to subterranean termites. In the present paper, we discuss three lines of evidence in support of the use of baits for long–term structural protection or preventative control: (1) the need to make a "conceptual leap" from successful remedial studies to preventative efficacy rather than requiring direct demonstration of prevention using inappropriate test methods developed to test soil insecticide barriers; (2) current information on termite foraging behavior indicating continual exploration of the area for new food resources via tunneling patterns that increase the likelihood of discovering nearby food; and (3) results of long–term field studies where newly invading termites were detected in bait monitors and subsequently eliminated without any visible evidence of structural infestation.

Indirect Demonstration of Bait Preventative Efficacy

Use of the Sentricon System and hexaflumuron baits to eliminate all detectable subterranean termite activity has been demonstrated numerous times in the past six years at a variety of locations with a variety of different termite species, to the point where citations to the published literature are superfluous. However, with respect to *preventative* efficacy, baits do not lend themselves to the sort of field screening typically employed with soil insecticides (e.g., Kard 2000), and commonly used in registration of insecticides for termite control in the United States. In this type of field test, a block of wood is placed on top of soil treated with the candidate insecticide, and the barrier is judged to have failed if and when termites are able to feed on the wood.

It is possible to envision a variant of this soil insecticide procedure in which a wooden block, simulated miniature structure, or other cellulosic resource, might be placed adjacent to one or more bait stations. However, in a design like this with a relatively small number of replicates, probability dictates that termites may locate the wooden block first or simultaneously in some cases. Should this be treated as a failure of the baiting system? An assumption of failure under these conditions ignores two considerations: (1) baits are not a barrier to termites and protect against continued infestation and damage, not against simple encounter between termites and the structure; and (2) inspection, monitoring, and maintenance are just as critical to the success of a baiting system as the active ingredient. In the "real world" scenario where baits are employed for remedial control, success could be achieved by careful bait station placement (and by follow–up placement of auxiliary stations); by replacement of monitors and/or the bait substrate as they deteriorate in the environment or when the bait is consumed by termites; and by regular inspection of the structure and the immediate surrounding area and installation of either above-ground bait stations or additional in–ground stations in response to any signs of termite activity. None of this is feasible in a simple field screening test based upon soil insecticide screening methodology, where the test materials are simply placed in the field and observed at regular but infrequent intervals.

Another protocol that has been suggested to demonstrate protection by baits as a preconstruction application is installation of the baiting system around structures that are not thought to have ever been infested, although termites are present somewhere in the vicinity. In this scenario, continued absence of any visible termite infestation in the structure would represent success, while presence of termites in the structure would indicate failure. Again, this fails to take into consideration the factors described above that contribute to bait success, and introduces the additional difficulty of accurately detecting termites in a building (where much cannot be seen), and beneath the soil outside of the structure.

The outcome of this type of evaluation protocol can be affected more by the termite population pressure than bait efficacy itself. In the absence of termites, for example, a non–efficacious bait may appear to be effective (false positive); while in a site heavily infested by termites, even a potentially efficacious bait, which may eventually eliminate all termites and thus provide long–term protection, may be deemed to fail if any termites are noted in the structure during the prolonged baiting period.

Because baits act upon individuals, and through them upon colonies and populations, the key to bait efficacy evaluation is to determine the effects at this level i.e., against active termite colonies. This is no different than evaluating the efficacy of ant or cockroach baits, but differs significantly from the accepted methods of evaluating soil insecticides as barriers to termites. It should be noted that the procedures developed to evaluate soil insecticide barriers are rather unique among insecticide evaluation protocols, since most insecticides are designed to control pest populations rather than to serve as barriers. With baits, reinvasion of the baited area at some later date is an expected occurrence, and the goal is to prevent structural damage by a prescribed system of inspection, monitoring, maintenance, and rebaiting as necessary. Thus, prevention of structural damage is the goal of termite baiting systems; and *preventative* efficacy cannot be directly demonstrated in the manner of a soil insecticide barrier, but rather must be extrapolated from the results of *remedial* studies with active termite infestations.

Subterranean Termite Foraging Behavior

Over the past two decades, field studies with a number of commercially important subterranean termite species (e.g., Su *et al.* 1984, Su & Scheffrahn 1988, Grace *et al.* 1989) have demonstrated that it is not uncommon for the foraging galleries of these species to extend over large areas, and that they feed on a variety of cellulosic resources throughout these areas. Recent research in the laboratory using glass or plastic foraging arenas is helping to explain this diffuse, rather than narrowly focused, foraging strategy.

The fact that associated groups of termite foragers feed on various resources scattered over a given area supports the likelihood of initial bait station discovery by foraging subterranean termites, and the likelihood that multiple stations will eventually be discovered and fed upon by that colony. Recent research in each of our laboratories, with Formosan subterranean termite, *Coptotermes formosanus* Shiraki, workers and soldiers confined in foraging arenas consisting of thin sandwiches of plate glass has demonstrated, among other things, that termites tunnel outward from a given point in a radial pattern, like spokes of a wheel (e.g., Campora & Grace 2000). When one of these tunnels intersects a new cellulosic resource, that resource then becomes the center of a new series of outward–radiating tunnels (Campora & Grace 2000). This represents an effective foraging strategy for finding adjacent resources, and also gradually fills the area with overlapping patterns of intersecting galleries.

Clearly, then, termites do not stop to exhaust a resource (whether a bait station or a building) when it is discovered, but instead again radiate outward from that resource in search of more food. Thus, termites "missing" bait stations around a structure and reaching the structure itself will very likely soon encounter baits as they radiate back out from the point where they intersect the structure. Termites encountering a bait station will also be very likely to encounter adjacent bait stations. This can be capitalized upon still further by an alert pest control technician by careful monitoring for termite activity and installation of auxiliary stations nearby so as to deliver a greater quantity of the bait toxicant in a shorter period of time to the target colony.

Optimum spacing of bait (or monitoring) stations around the structure is an area of some debate that deserves further study. In our own field studies with the Sentricon System for *C. formosanus*, monitoring stations were typically placed at 2–5m distances from each other, and we were successful in detecting and eliminating all termite activity. On the other hand, it cannot be denied that a "picket fence" (literally, a barrier) of bait stations is also a defensible approach, although the labor cost of monitoring might be prohibitive. Based on our own experiences and observations of commercial bait applications, however, our feeling at this time is the range of 2–5m placement is appropriate, and that more critical factors for long-term protection are frequent and rigorous monitoring and maintenance of the stations, periodic full structural inspections, and installation of auxiliary stations adjacent to newly-infested monitors. We also feel, however, that pest control operators and their clients should have a degree of latitude in judging the appropriate station placement for different situations.

Detection and Supression of Termite Reinvasions Following Baiting

Our field research with the Sentricon System during the past decade has given us the opportunity to monitor properties where termite activity was successfully eliminated for up to seven years post treatment. At some of these field sites, no further termite activity has been detected in monitoring stations, other wooden materials on the property, or the structure itself since the successful termination of bait delivery. At other sites, termites have been rediscovered in the monitoring stations several months to several years after termination of baiting, and subsequently eliminated by additional bait applications. In these cases, the system of monitoring, station maintenance and baiting has functioned to protect the structures from any damage and eliminate the new threat.

Several long-term field sites in Florida and Hawaii offer examples of termite reinvasion and the elimination of such reinvasions. One Florida site is a large condominium building surrounded by a parking lot, located on the inland waterway in Hollywood, Florida. The foraging territory of a Formosan subterranean termite colony (estimated population size 1.2 million) extended as far as 150m along the front side of the building. Structural infestations were reported in the building on several occasions throughout 1990–1993. Baits composed of a sawdust matrix and hexaflumuron were applied in September 1993, and by

December 1993 *C. formosanus* activity ceased. Follow–up monthly surveys revealed no activity throughout most of the 1994; but in October 1994, *C. formosanus* activity was detected in one of the monitoring stations. The building owners and maintenance crews were notified of the presence of termite activity in the front yard, and were instructed to look for any sign of structural infestation. Monitoring continued without further bait application throughout 1995 and 1996, during which no structural infestation was detected, but large swarms were observed outside of the building in the springs of 1995 and 1996. In July 1996, Sentricon stations were installation by a pest control firm under an experimental use permit (EUP) trial. Activity of *C. formosanus* was detected in Sentricon stations immediately after installation in July 1996, followed by hexaflumuron bait (Recruit) application in the same month. Monthly bait applications continued until December 1996, when termites were no longer found in any of the stations. The pest control firm continued to monitor the site throughout 1997 and much of the 1998, during which no termite activity or structural infestation was noticed. In September 1998, activity of the eastern subterranean termite, *Reticulitermes flavipes* (Kollar), was detected in some Sentricon stations, but no structural infestation was reported from the building maintenance crews. Baits (Recruit II) were applied in September 1998, and by December 1998, no termites were found in any of the stations. An on-going monitoring program has been carried out by the same pest control firm since January 1999 and thus far no termite activity, either *C. formosanus* or *R. flavipes*, has been found.

Another Florida site is a one-story single family home infested by *C. formosanus* in a residential area of Tampa. This is the second known infestation of *C. formosanus* in Tampa. The estimated population size of this colony was 3.9 million. Multiple infestations and structural damages were recorded from this house and soil treatments were conducted annually throughout 1990 and 1993. In July 1993, baits composed of sawdust matrix and hexaflumuron were applied in soil, and by October 1993, no termites were found in any of the stations. In November 1993, however, *R. flavipes* was found in one monitoring station, and subsequently disappeared without any intervention. Because the house was under contract with a pest control firm, monthly monitoring and annual inspection were carried out throughout 1994 and 1996, and no structural infestations or termite activity were found during this period. Sentricon stations were installed by the pest control firm under a commercial contract in December 1996. In August 1997, *R. flavipes* activity was detected in the Sentricon stations. Baits (Recruit II) were applied in August and September 1997, and the activity ceased in October 1997. A monitoring program carried out by the same pest control firm since October 1997 has revealed no termite activity or structural infestation.

A site in Hawaii is a large commercial building adjoining the Honolulu Airport which had suffered from *C. formosanus* infestation and damage for several years, despite repeated soil insecticide treatments. In fall 1993, 45 monitoring stations were placed around the building, and approximately 20m from the building across an asphalt parking lot where Formosan subterranean termites were actively infesting several pieces of scrap lumber on the ground. Using mark–release–recapture, a large foraging population of 5.4 million termites was found, foraging over the entire site from the front of the building to the area across the rear parking lot. In 1994, hexaflumuron (Recruit) bait tubes were placed in five of these 45 stations and replaced as necessary (a total of 17 tubes), with termites consuming the equivalent of 9.4 bait tubes. No termite activity could be detected at this location after 15 weeks of baiting, in September 1994. Stations were inspected monthly for the next year, and then quarterly thereafter. During this period, interior inspections were also performed by the building maintenance personnel, and some interior remodeling also occurred. However, no evidence of termite activity was detected in the monitoring stations, around the perimeter of the building, or inside the building for 3.5 years after baiting. At that point, in April 1997, Formosan subterranean termites were again found in three of the monitoring stations on the far side of the parking lot, and only in those stations. It was assumed that these termites had moved into the site from the immediately adjacent vacant lot. However, only 15 days after this discovery, active termites were found in 16 of the stations, distributed around the entire perimeter of the field site. Hexaflumuron baits (Recruit II) were placed in eight of these active stations. Nine weeks after initiation of baiting, all termite activity was again eliminated from all the monitoring stations. As an added precaution to aid in monitoring for termite activity, 101 softwood (Douglas-fir) stakes were installed at 1m intervals around the entire site in September 1997. However, no termites have been detected anywhere on the site for two years now, since the end of the last baiting episode. Fairly extensive interior remodeling was also performed in one part of the building, with no evidence detected of either termite activity or termite damage.

We conclude from these and other long–term field studies with the Sentricon System, that the monitoring system is effective in detecting the presence of new termite colonies before significant damage to the structure takes place, and follow–up baiting is effective in eliminating termite activity. At other field sites, termites have not reappeared for up to eight years (the current duration of these ongoing studies). However, reinvasion is not an unexpected event, and continued monitoring and structural inspection are essential components of a successful system. Moreover, it appears that a new termite colony invading a site where baiting has eliminated earlier colonies will reuse existing termite gallery systems in the soil, if those gallery systems still exist and the new foragers find their way into them. This means that diligent monitoring is essential to avoid rapid reinvasion of the structure and attendant damage. However, this also increases the likelihood of the new colony entering and being discovered in monitoring stations where termites were previously feeding.

CONCLUSIONS

Several lines of evidence support the use of baiting systems for long–term protection of structures from subterranean termite attack. With the Sentricon System, a large number of successful case histories have now been documented where all detectable termite activity was eliminated from structures and the vicinity of structures for long periods of time (years). Since baits cannot be evaluated for preventative efficacy in the manner of soil insecticide barriers, we can extrapolate from the successful use of baits remedially to the conclusion that termites entering a given area for the first time and encountering a baiting system can also be controlled, so long as the bait system has been maintained and regular monitoring is taking place.

Although we cannot make broad statements about all termite species, our field studies with the severe structural pest species *C. formosanus* and *R. flavipes* have demonstrated that these termite colonies feed at multiple locations over a given foraging area, and do not limit their feeding to one resource at a time. Studies in laboratory arenas have demonstrated that *C. formosanus* continues to tunnel outward in a radial pattern from resources upon which the colony is feeding. These field and laboratory studies indicate that termite foraging patterns (continuous and radiating) are such that there is a very high likelihood that monitoring stations will be discovered before termite colonies entering an area are able to infest a structure to the degree that significant damage occurs. Again, monitoring is obviously essential.

Lastly, we have now had an opportunity to monitor field sites where research on the Sentricon System was conducted for as long as eight years. At a number of these field sites, new termite invasions have occurred, have been detected by monitoring of the stations with no evidence of any structural damage, and have been eliminated by applying baits. It also appears that the gallery system left behind in the soil when a colony is rapidly eliminated can serve to guide new invaders to monitoring stations, decreasing the time until their detection, and subsequent rebaiting of the stations. Thus, the evidence from our studies to date indicates that baiting systems can be used effectively for long–term protection of structures from subterranean termite damage.

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