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Community-wide suppression of *R. flavipes* from Endeavor, Wisconsin – Search for the Holy Grail

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ABSTRACT

In 2006, the Forest Products Laboratory, in collaboration with Alternative Pest Solutions Inc. and the UW-Madison Entomology department, developed a strategy for sustained suppression/elimination of *R. flavipes* from Endeavor, Wisconsin. Our commitment includes a minimum of five years of active treatment followed by at least one year of monitoring. The Whitmire Micro-Gen Advance baiting system (a.i. 0.25% diflubenzuron) was chosen to be the main method of termite treatment in the Village as the collaborating pest control company had access to this system. The efficacy of these baiting treatment cartridges were assessed in field and laboratory situations. Initial results after the first treatment season suggested a significant effect of the active ingredient on *R. flavipes* populations as activity in the buildings located in the central treatment zone appeared to be eliminated. However, the two following treatment seasons seemed to show reduced effectiveness of the baiting cartridges in controlling termite populations. In order to improve the efficacy of the commercial bait system, supplementary termiticidal dusts were tested including: borates, N'N-napthaloylhydroxylamine, zinc and boron oxide (nanoparticles) as well as dusting with the Micro-Gen cartridge itself. Liquid fipronil was also examined. Although preliminary laboratory tests involving dusting with N'N-napthaloylhydroxylamine did not show the dust to transfer to undusted termites, subsequent field and laboratory tests support this compound for used with commercial systems in treatment of northern colonies of *R. flavipes*.

Keywords: area-wide, community wide, commercial termite baiting, diflubenzuron, insecticidal dusts, *Reticulitermes flavipes*

1. INTRODUCTION

Endeavor is a small village in central Wisconsin with a population of approximately 450 persons and a land area of 0.6 square miles – comparable to the size of the French Quarter in New Orleans. This village has experienced a continuing problem with the eastern subterranean termite, *Reticulitermes flavipes* (Kollar), since around the mid-1980s. Dow AgroSciences ran a small Sentricon bating trial in the village beginning in June 1995, however, they were not successful at eradicating the termite colony (DeMark and Thomas 2000). The isolated nature of this population, as well as support from the community and village board, aids in the potential for sustained elimination of *R. flavipes* from Endeavor (Arango *et al.* 2007).

This colony of termites is located about 100 miles north of the expected field range for *R. flavipes* in Janesville, Wisconsin, on the Illinois border. We suspect that nearby Buffalo Lake and low-lying sandy soil moderates winter temperatures and permits the colonies to over winter within city limits. It is also possible that the termites utilize

heated buildings and sewer lines within the village, and could not survive in Endeavor outside of an urban environment. Changes in global temperatures and weather patterns, however, may eventually allow for natural populations of *R. flavipes* this far north. For example, in recent years increased snow cover appeared to keep the ground from freezing, allowing for termites to remain active well into the winter season.

The three stage proposal developed in 2006 to eliminate *R. flavipes* from the Village is as follows (Arango et al. 2007):

1. To place in-ground monitoring bait stations on public and select private properties to identify the scope and location of the termite colony or colonies.

2. To conduct a survey of homeowners by mail to assess the extent of in-home damage and obtain permission for home inspections to determine termite infestations.

3. To design a treatment program with the goal of complete, sustained elimination of termites utilizing the Micro-Gen commercial baiting system (Vreysen *et al.* 2007).

This program was designed to ensure a high probability of systematically reducing and/or eliminating termite damage to public buildings and private structures resulting in improved property values and overall long-term benefit to the residents of the Village. The potential use of diflubenzuron in termite colony eradication was also assessed. Through this comprehensive baiting strategy, we seek to maintain a termite-free condition on village proprieties through ongoing monitoring and re-baiting as required. Although the French Quarter in New Orleans has been the target of an ongoing termite bait program for five years, this is the first instance of a village-wide termite baiting program designed to free the community of termites, as well as the first attempted community-wide eradication project using the Whitmire Micro-Gen system.

2. PROGRESS 2006-2008:

1. 2006 – Installed 200 Whitmire Micro-Gen cellulose monitoring stations around the perimeter of the village to assess the range of *R. flavipes* populations in Endeavor.

2. 2007 – Installed concentrated stations in the center of the village and main areas of termite activity following results of the written survey and termites observed from the stations installed in 2006. Main areas of termite activity were overloaded with additional stations and monitoring devices in order to increase accessibility to termites (Smith *et al.* 2006, Ripa *et al.* 2007). Final 2007 results suggested 100% suppression/elimination of termites in the central village area (Appendix 1).

3. 2008 – Analyzed the efficacy of the various dusting compounds for their potential use in conjunction with the commercial baiting system in areas of continued termite activity (i.e. along Prospect Street). Dusting using N'N-napthaloylhydroxylamine (NHA) in the field (Figure 1) produced an estimated

90% suppression of termite populations three weeks after dusting nearly 1,000 individuals.

4. 2009 – To be continued...

Figure 1: Collection of termites from a cardboard frame for NHA dusting

3. LIMITATIONS OF THE COMMERCIAL BAITING SYSTEM

Although initial results in the center of town after the 2006 baiting season seemed to show a positive effect of the Whitmire Micro-Gen system in reducing/eliminating *R. flavipes* populations from the village, these results were not substantiated in subsequent treatment seasons. Nearly one year after activity was seen at the center of town, the termites repopulated the same baiting stations (in 2008). In addition, other areas of significant activity (i.e. Prospect Street) seemed to show no response to the diflubenzuron cartridges apart from temporary abandonment of certain stations. We concluded that numerous isolated pockets of termites likely exist in Endeavor, of which the initial population in the center of town was probably made up of fewer individuals than the infestation on Prospect Street. It was also hypothesized that previous termite treatments may have actually caused initial separation of the super colony into smaller termite colonies after abandonment of toxic stations.

Therefore, it was determined that the use of the Whitmire Micro-Gen bait stations alone would not be adequate to suppress or eliminate the colony or colonies of termites present in Endeavor. This is supported by what has been observed in other parts of Wisconsin, specifically Janesville, where a home has been treated for three years using this system with no apparent impact on termite population numbers. Four remedies were proposed to potentially remediate this situation:

1. Increase the amount of diflubenzuron in baiting cartridges.

2. Increase accessibility to termites by the addition of rolled corrugated cardboard stations near commercial baiting stations.

3. Aggregating stations in areas of high activity.

4. Utilize cardboard frames for collection of large numbers of termites and directly dust individual termites to increase transfer insecticide by means of grooming (Figure 1).

Based on the results presented by Sheets *et al.* (2000), it became apparent that the concentration of diflubenzuron in the Micro-Gen cartridges may be too low (i.e. 0.25%) to effectively kill *R. flavipes*. Doubling up on the treatment cartridges was proposed to increase the amount of insecticide available to termites, even if not increasing the per cent termiticide within the cartridge. It is also possible that termiticides that are too slow acting may be just as problematic as those that kill too rapidly. Termites fed only the diflubenzuron cartridge for a period of six weeks still showed less than 100% mortality. In a field situation, the availability of additional food sources may dilute the effect of the active ingredient even further, reducing mortality.

Therefore, it was apparent that a supplementary treatment to the baiting cartridges was needed, such as direct application of termiticidal dusts. A recent publication by Smith *et al.* (2006) proposed aggressive addition of supplementary baiting stations in areas of positive termite activity. In a number of active sites additional commercial stations (+5) were added in close proximity to the initial positive station. Rolled corrugated cardboard stations and square frames containing cardboard (Figure 1) were also added to these locations to collect large numbers of termites for dusting.

4. MATERIALS AND METHODS

In the laboratory a number of additional dusts were examined on termites collected from Janesville, Wisconsin during the summer of 2007. Chemical dusts tested included: powdered borax (US Borax Inc., Scottsdale, AZ), NHA (98% 3-Aminophthalhydrazide, Alfa Aesar, Lancaster, UK), and Whitmire-Microgen Advance (0.25% diflubenzuron, St. Louis, MO). Groups of 25 or 50 workers were dusted with the smallest amount of chemical measurable (i.e. 0.005-0.010g) in a plastic weigh boat. Groups of 50 workers were placed in a cylindrical plastic container (90mm x d, 60mm x h) while groups of 25 dusted workers were combined with 25 undusted workers to determine transferability. All termites were maintained in a humidified incubator at 28°C and 85%RH with Whitman #1 filter paper as a food source for 32 days. Termites were inspected daily for mortality. One particular product, Termidor SC (0.06% Fipronil, Research Triangle Park, NC), was tested in liquid form by dipping a round piece of corrugated cardboard in 0.06% Fipronil, dried in a biological hood overnight, and placed with a group of 50 termite workers. The efficacy of direct contact with two additional dust were also evaluated, zinc oxide nanopowder (Nanophase Technologies, Romeo, IL), and boron oxide Nanopowder (99.5%, American Elements, Los Angeles, CA).

Following the methods of Myles (2005) *R. flavipes* individuals were removed from commercial bait cartridges and/or rolled corrugated cardboard stations and dusted immediately in the field with either powdered borax or NHA. Termites were then released back into the site or station from which they were captured. Observations on activity were made at the next inspection date, approximately three to four weeks later.

5. LABORATORY RESULT AND FIELD RESULTS

The groups of termites with all 50 workers dusted were comparable in that all dusted termites died between 6-24 days. In the 25 dusted plus 25 undusted groups, sodium borax killed all termites between 7-18 days, zinc borate killed approximately 77% of all termites by day 32, and NHA killed only dusted termites after 21 days (Green *et al.* 2008). Direct dusting using zinc oxide nanoparticles and ground-up Micro-Gen cartridge produced negligible mortality, while boron oxide nanoparticles killed 100% in about 24 hours. Liquid treated fipronil cardboard was found to kill from direct contact in only 24 hours, and was not shown to be toxic by means of out gassing. These preliminary results indicate that morbidity and mortality varied widely in the response of *R. flavipes* to various dust and other products suggesting varying modes of action. The dilution of dusts by un-dusted termites at the colony level may abrogate any measurable morbidity and mortality of primary-dusted termites and should be studied further.

In the field, sodium borax dusted sites appeared to be repellant to further attack by termites, and therefore did not seem to have a long term impact on termite populations. In contrast, direct dusting using NHA of nearly 1,000 individuals in the field showed a significant decrease in termite activity three weeks after dusting, contradicting laboratory results. The potential use of dust applications in conjunction with commercial baiting systems could substantially improve the success of termite treatment. Myles (2005) suggested dusting to be more effective than direct feeding on bait cartridges with the potential to offer a 1,000 fold multiplier effect over feeding.

6. DISCUSSION AND CONCLUSIONS

Different laboratory tests give different results with the same insecticide or chemical treatment. In general, no-choice tests are more misleading than choice tests, as termites cannot easily avoid the active ingredient. Thus, laboratory results may not translate into similar levels of activity in the field where there are many more choices for feeding and some insecticides may become repellent—thus laboratory testing may be overly biased. Some insecticides appear to function thru direct, rapid contact (e.g. fipronil) while others act as slow-acting stomach poisons (NHA) or both (borates) (Su *et al.* 1982, Green *et al.* 1997, Rojas *et al.* 2004, Woodrow and Grace 2008).

Perhaps minimal or sub-optimal levels of insecticide (i.e. 0.25% diflubenzuron) may limit morbidity and mortality and promote division of existing colonies into walled off satellite or small undetected colonies which can multiply and repopulate existing sites after one to two years. It is also possible that low or suboptimal insecticide levels may actually induce tolerance in the residual population making them more difficult to eradicate in the future (Osbrink and Lax 2002). One report even suggests that the optimal level of diflubenzuron is repellent to *R. flavipes* (Su and Scheffrahn 1993), although this was not observed in the present study.

The low efficacy of the Whitmire Micro-Gen commercial baiting system in treating northern colonies of *R. flavipes* necessitates the addition of alternative treatments such as direct dusting. Some of the benefits of direct dusting compared to baiting according to Myles (2005) are as follows:

1. The topically treated termites act as the delivery system, carrying the pesticide throughout the colony.

2. Cleaning and grooming, a natural social behaviour of the termites, results in the ingestion of the pesticide by grooming individuals and cannibalism of dead or dying termites.

3. By contrast, baiting requires direct feeding of the bait to achieve control.

4. Directly affects the termite colony, suppressing or killing it, whereas traditional chemical barriers only deter or repel termites (Randall and Doody 1934).

5. Is likely to be more environmentally friendly, requiring only milligrams of active ingredient applied directly to the individuals captured.

6. If the termite colony is eliminated, the danger of re-infestation or the development of resistance is eliminated.

7. The relatively small amounts of pesticide used are applied only to the target population, reducing non-target environmental exposure (Myers 2005).

In this study, we saw little or no obvious effects of dusting termites with powdered borax in the field, despite the high rate of killing in the laboratory. It is possible that borates kill too quickly from surface contact, thus minimizing spread via social behavior. On the other hand, NHA appears to operate as a "slow-acting stomach poison" causing the termites to starve to death in 14-21 days (Green *et al.* 2001). We observed a 90% reduction in station hits in one location in Endeavor, WI three weeks post-dusting with NHA and elimination of attack at another single site (Figure 2). These results were also validated in a simulated laboratory field test suggesting further study on the effect of NHA dusting is necessary (unpublished results).

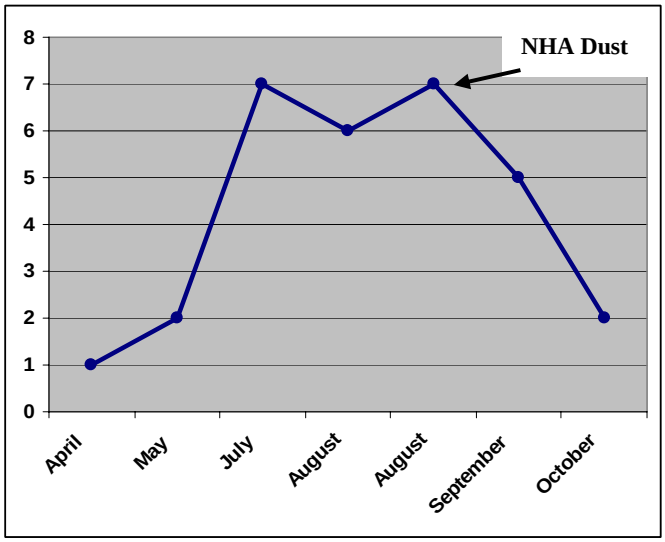
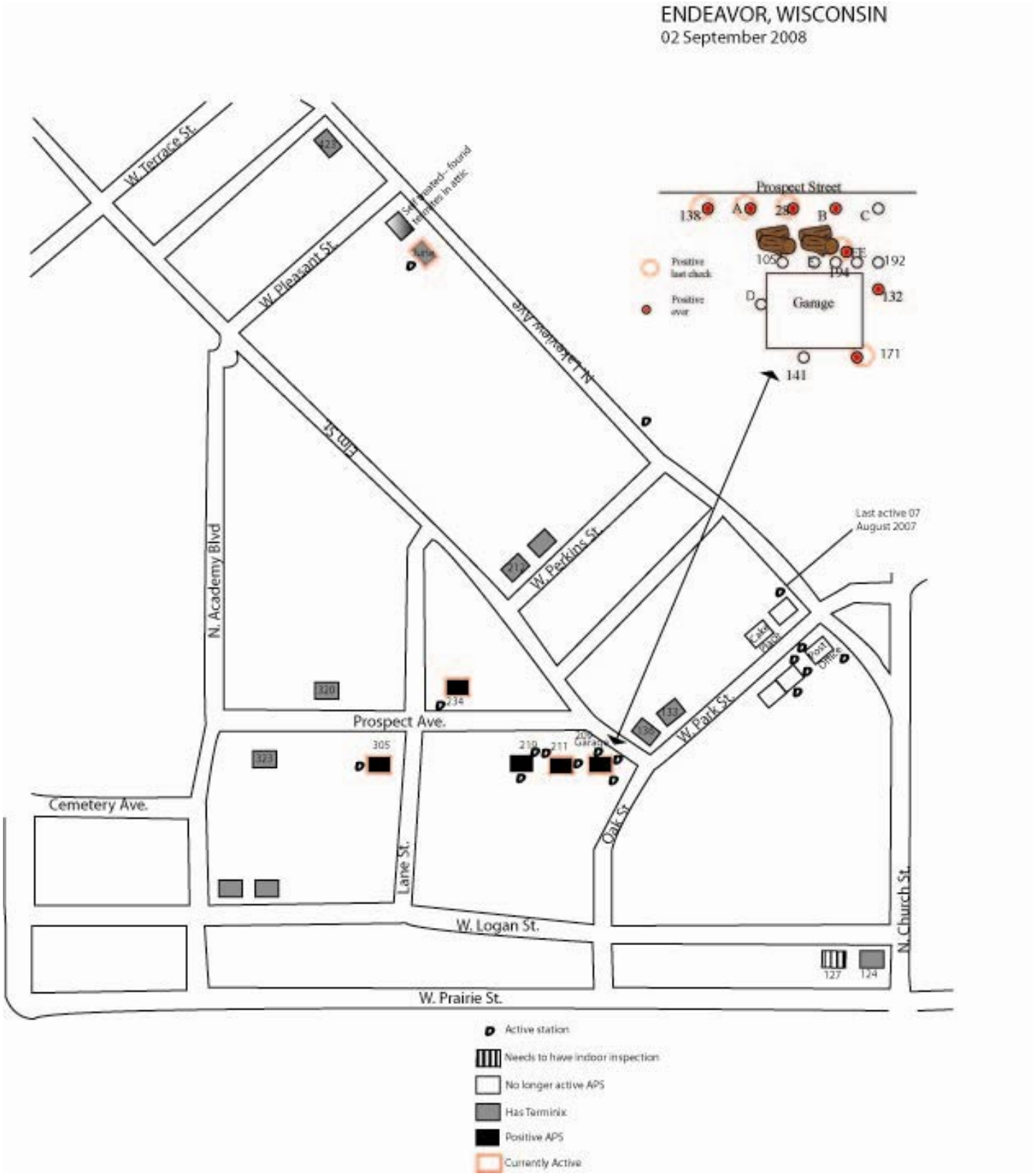


Figure 2: Suppression of *R. flavipes* in field following dusting of 5-6 grams of termites with NHA. Seven positive stations reduced to 2 after three weeks.



Appendix 1: Street map of Endeavor, Wisconsin stations with termite activity

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