9 Sustainable Termite Management Using an Integrated Pest Management Approach

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Summary

This chapter outlines an integrated pest management (IPM) approach to maintaining termite-free structures termed integrated termite management (ITM). The concept of ITM is based on the following: communication between interested stakeholders; knowledge of the life support requirements for the various species of termite capable of infesting structures; a thorough site-specific inspection; development of an action plan based on the species and site information; enacting the action plan after consultation with stakeholders; and follow-up inspections and communication to revise/modify actions as needed in an ongoing process aimed at sustainable structural protection. Results from the tenth year of a demonstration project are provided to support the viability of the ITM concept.

Introduction

The concept of integrated pest management (IPM) for subterranean termites has been discussed in the US entomological literature for at least 80 years (Snyder, 1927, 1935; Brown *et al.*, 1934; Horner *et al.*, 1934; Anon., 1942; Hartnack, 1943; Johnston, 1960; St. George *et al.*, 1960; Su and Scheffrahn, 1998; Su, 2002; Kard, 2003). However, implementation of the principles outlined in those researches and extension publications is not well documented. None the less, understanding the history of termite treatment practices in the USA is an important prerequisite for explaining the disparity between the theory and practice of termite IPM. The lessons of history should direct the termite management industry towards implementing meaningful and sustainable practices. The beginning of this chapter provides an abridged chronicle of subterranean termite management in the USA. This is followed by a description of the elements required for implementing termite IPM. The chapter finishes with a presentation of results from an integrated termite management (ITM) demonstration project in Athens, Georgia.

The first tome written on subterranean termites, entitled *Termites and Termite Control* was published in 1934 (Kofoid, 1934). This book devoted 350 pages to termite biology, 53 to building construction practices and 53 to chemical control methods. The *USDA Farmers Bulletin* No. 1911 published less than a decade later devoted 33 pages to proper construction techniques and cultural control methods while four pages (11%) discussed the application of soil- and wood-borne insecticide treatments (Anon., 1942). The disparity in pages per topic illustrates the impact that construction and building maintenance have on maintaining structures free of subterranean termite infestation, and underscores what entomologists have long understood – the need to include construction and landscaping practices in the process of subterranean termite management. The *USDA Home and Garden Bulletin* No. 64 19 pages on biology and construction while nine (32%) were devoted to chemical treatments (St. George *et al.*, 1960). The introduction and use of insecticides as soil termiticides was the impetus for a new management model using long residual insecticides to create a barrier to subterranean termite incursions into structures (St. George, 1944; Kowal and St. George, 1948; Hetrick, 1950, 1952, 1957; Ebeling and Pence, 1958; Johnston, 1960; Bess *et al.*, 1966). The last Approved Reference Procedures (ARP) for subterranean termite control published by the (US) National Pest Control Association in 1991 had ten pages devoted to construction and cultural control while termiticide application covered 131 pages (92%) (Rambo, 1991). Today, termite management can best be described as an industry-formalized practice based on soil poisoning, although the latest revision of *USDA Home and Garden Bulletin* No. 64 contains slightly fewer pages on treatment techniques versus biology and construction (eight of 26 pages, or 31%) (Peterson *et al.*, 2006).

The application of soil insecticides for termite management was the standard practice for over 50 years in the USA (Moore, 1986; Lewis *et al.*, 1996; Robinson, 1996). The termite management industry accepted their role as palliatives for bad construction and landscape management because they were 'effective' soil insecticides. The termiticides used during that era (1940–1989) had a long residual period and this could mitigate infestations if the soil was properly treated and, over time, not moved or replaced (Hetrick, 1957; Bess *et al.*, 1966). Training for technicians in the termite management service industry involved education on the proper placement of correct volumes aimed at attaining a 'continuous and uniform barrier' of insecticide (Rambo, 1991; Potter, 1997). Regulatory standards in several states, such as Georgia, dictated inspection and treatment specifications and these further codified the soil barrier concept (GSPCC, 2007). The importance of implementing IPM based on knowledge of an insect's life history and behaviour was relegated to a distant memory because the construction and landscape industries abrogated any culpability for subterranean termite infestation in the light of the pest management industry's willingness to accept responsibility for keeping termites out of structures. Unfortunately, termite biology-conscious design, construction and landscape management is unlikely to be a feature of new construction any time in the near future because that educational component of IPM, although attempted for decades, appears to be falling on 'deaf ears' (Ebeling, 1968; Suiter and Forschler, 2004). Today's termite management professional is saddled with the legacy of their industry's genesis during the heady days of long-lived soil poisoning for subterranean termite control.

The pest management industry suffered the consequences of over-reliance on soil termiticides when in the late 1980s chlorinated hydrocarbon insecticides were removed from registration (Su and Scheffrahn, 1990; Lewis *et al.*, 1996). The application of soil termiticides moved from trench and treat applications during the 1950s to rodding only, as illustrated by termiticide labels that described 'trenching *and/or* rodding' as an appropriate application technique (St. George *et al.*, 1960; Rambo, 1991). The inability of rodding to create a continuous insecticide barrier was highlighted in the early 1990s in the trade magazines (Craft, 1993), but was never discussed in the entomological literature. Nevertheless, appreciation of this fact was reflected in labels published after 1996 that provided instructions for 'trenching *and* rodding' – a subtle semantic difference but very important in influencing proper application of a continuous barrier. The pesticide manufacturers responded to the deluge of reports of subterranean termite infestations with increased funding for research on termite biology and management (Reay-Jones and Mascari, 2007). That influx of investment in investigation has rewritten our understanding of termite biology and provided the impetus for revisiting IPM for subterranean termite management.

The peer-reviewed literature has little information on the field efficacy of termite management practices because the heterogeneous urban habitat prevents meaningful replication and experimentation on valuable property; the latter has been used as a justification to forgo the designation of non-treated controls. The data available on field experiments involving liquid termiticide efficacy are, therefore, most frequently found in pest management trade publications, including the annual USDA Forest Service termiticide reports (Clark, 1993; Mampe and Bret, 1994; Potter *et al.*, 1994; Wagner *et al.*, 2005, 2008). The commercialization of termite baiting in the late 1990s has produced a wealth of information on bait product efficacy (without controls). That efficacy is assumed to apply to structural infestation but has not been directly tested on infested structures (Su, 1994; Forschler and Ryder, 1996; Getty *et al.*, 2000; Gulmahamad, 2003; Messenger *et al.*, 2005; Haverty *et al.*, 2010). The dearth of information provided by the termite presence/absence data accumulated during the 'monitoring' phase of commercial termite baiting precludes the implementation of meaningful action thresholds because false positive data remain unresolved (Su and Scheffrahn, 1996; Thorne and Forschler, 2000); for instance, the abandonment of a bait station cannot be related to impacts on termite colonies. Subterranean termite baiting must include a thorough inspection programme to ensure structural protection (Thorne and Forschler, 2000; Forschler *et al.*, 2007) and when used as 'stand-alone' termite control should not be considered IPM.

The Philosophy of IPM

Stern *et al.* (1959) originally defined integrated control as combining and integrating biological and chemical management practices. The concept of IPM, since its inception, has been refined and redefined to be applicable to a variety of pest management disciplines, and the reader is directed to other sources for a comprehensive review of the evolution of IPM theory (Kogan, 1998; Ehler, 2006). IPM is essentially a knowledge-based decision-making process. The foundation of IPM is an understanding of a pest's biology, which is used to identify vulnerable attributes that can be addressed by an action plan aimed at reducing the economic, public health, regulatory or aesthetic impact of that pest. The implementation of IPM has been driven by monitoring pest populations to measure when numbers, signs or complaints warrant initiation of an intervention based on a predetermined action threshold. The type of intervention is dictated by the available technologies, by economics and by capability for reducing a pest population's ability to sustain numbers relative to an injury index. The injury index is based on attributes of a commodity or some other societal precept of injury or loss of value. Mosts pests' biologically-based vulnerabilities afford action plan developers with several viable intervention options. Targeted application of pesticides is advised only after other interventions fail to provide an appropriate reduction in pest population pressure. Evaluation of a successful urban IPM programme is recorded using two quantifiable measures: first, reduced pest numbers or 'complaints' and, secondly, reduced use of pesticides (Greene and Briesch, 2002).

Termite IPM or Integrated Termite Management (ITM)

Management of termite pests within the framework of the IPM philosophy was addressed by Su and Scheffrahn, (1998) from an economic perspective and they concluded that the use of baits constituted IPM. Termite baiting programmes have been designed around a 'monitoring' procedure that assumes a zero-tolerance action threshold and records only the presence or absence of termites in bait stations (Su, 1994; Su and Scheffrahn, 1996; Thorne and Forschler, 2000). The pragmatic approach by Su and Scheffrahn (1998) assumed that structural or landscape modifications are non-viable interventions for termite management and whole-house soil insecticide barriers are the only chemical-based intervention that can provide reasonable structural protection. An alternative model for termite IPM emerges if one assumes that building practices and landscape conditions can be altered to affect subterranean termite incursions into structures along with placement of chemical barriers only at elements of construction that afford access to a structure. Integrated Termite Management (ITM), using an IPM mind-set, should be an on-going process where the treatment event is considered a single intervention in a site-specific action plan developed from an inspection programme that identifies factors that can be altered to favour a reduction in termite activity (Forschler *et al.*, 2007). The process is a knowledge-based programme that involves inspection, action plan development, action plan implementation and continued inspections.

The process of ITM requires a philosophical adjustment to admit that the decision to implement a particular intervention is based on an inspection-driven assessment that takes into account construction, structural maintenance and moisture management issues present at a site. ITM is an exercise in communication and accountability built on the foundation of a thorough inspection. The cryptic lifestyle of termites, in addition to the problems presented by inspection gaps (those areas that could provide termite access to a structure but cannot be visually inspected), prevents consistent verification of the presence or absence of termites in most buildings. An inspection report, therefore, should identify inspection gaps and suggest remedies such as the installation of removable skirting boards (baseboards), bath trap access doors or other inspection ports placed into elements of construction. The inspection report can only record conditions observed at the time of inspection, and thoroughness is critical to developing a site-specific action plan.

Action plan development utilizes information obtained from a thorough inspection to address, in a practical manner, any and all issues that influence termite biology. The knowledge-based decision to include a specific intervention in an action plan against a particular termite infestation is influenced by information from four site-specific areas that must be obtained during the inspection:

- Knowledge of the identity of the termite involved in an infestation.
- Knowledge of the construction practice.
- Knowledge of the landscape conditions that allow termites to be in that area.
- Knowledge of the point(s) at which termites have entered the offended structure.

Action plans should first consider issues relative to moisture management, landscape, building maintenance, alternative food resources and construction before addressing insecticide-based interventions. The cryptic termite lifestyle could require use of more than one type of intervention in order to render a structure termite-free – and maintain it that way. Reducing moisture sources, grading along the foundation, and the removal of stumps or other cellulose resources near the structure are some examples of interventions that could assist the goals of any ITM programme. Interventions using pesticides are only considered under the constraints offered by the attributes and limitations of active ingredients, formulations and the tools that are available for application.

Insecticide interventions can be structure or soil based, and involve altering termite behaviour – not simply killing termites. Structure-based interventions include the topical application of insecticides to wood, which discourages termite feeding or foraging. The use of pressure-treated wood or other non-cellulosic building materials is another choice in a non-palatable-food approach. Termites can be excluded from structures using a variety of physical barriers, including chemically treated plastics, particle barriers (sand, crushed rock, glass beads) or stainless steel mesh. Termites can also be excluded from a structure using termiticides placed into the soil or on to elements of construction, such as expansion joints. All of the aforementioned interventions do not affect termite populations, they simply keep termites away from the structure by altering their collective ability to search an area for food. Termiticidal baits are intended to reduce the number of termites in the vicinity of the structure under the belief that fewer termites provide protection from infestation by reducing the probability of an encounter. The appropriate intervention must always be implemented with care towards the details of proper application and maintenance, which includes a routine of further inspections to ensure efficacy of the original action plan as well as adjustments as new conditions come to light. The process of ITM is continuous because inspections regularly access the site conditions. Findings from an annual inspection may result in alterations to action plans after communication with all involved stakeholders.

ITM Demonstration Project

A review of the literature on subterranean termites indicated the features of their biology that were amenable to exploitation in an ITM demonstration project. Subterranean termites occur in relatively small populations (Howard *et al.*, 1982; Forschler and Townsend, 1996; Grube and Forschler, 2004; Parman and Vargo, 2008), follow physical guidelines while foraging for food (Goldberg, 1973; Pitts-Singer and Forschler, 2000; Swoboda and Miller, 2004), and require moisture to survive (Thorne, 1998; Cornelius and Osbrink, 2010). The combination of these three features intuitively increases the probability of structural infestation (Brown *et al.*, 1934). Termite life history is also designed for a prodigious increase in population once adequate food and moisture are located (Lenz *et al.*, 2009). Therefore, a subterranean termite management programme was initiated with the intent of reducing access to physical guidelines in structures, reducing food resources in 'close' proximity to the foundation, and keeping the soil around the foundation dry (Brown *et al.*, 1934; Hartnack, 1943). Targeted application of pesticides was employed to aim at elements of construction that afforded physical guidelines for foraging activity around known or suspected entry points (Ebeling, 1968). Lastly, population reduction using baits was used in cases where entry points were extensive or inspection(s) indicated that the original termite control interventions were moving the foraging activity to other locations around the original infestation site.

In 2000, the Household and Structural Entomology Research Program (H&SERP) at the University of Georgia reached an agreement with the Physical Plant Division (PPD) to conduct all termite management on the 145 primary structures situated over 2.5 km^2 of campus in Athens, Georgia. PPD personnel were to notify the H&SERP staff when termite activity was reported in any campus building. The H&SERP staff would respond by conducting an inspection at the location of the reported sighting aimed at finding the point(s) where termites had entered the structure and complete an inspection report. Inspection reports included information relative to termite activity at each site and used digital photographs along with written descriptions of site conditions. An action plan was developed for each infestation based on the site-specific inspection results and interventions implemented by H&SERP or PPD staff. Inspection reports were, over time, amended to include action plans developed/enacted in addition to listing all the interventions that had been conducted and were, therefore, a running journal of programme activity at each site. Sixty-six action plans were implemented between February 2001 and August 2010 that involved 66 termite infestations in 47 separate structures.

The results of the programme indicated an infestation rate of 32% of the primary buildings over 10 years, with an average of 5% of the buildings reporting subterranean termite activity on an annual basis. Entry points were identified for each of the 66 separate infestations and placed into four categories: expansion joints (83%); gaps in stone foundations (11%); weep holes in brick veneer (2%); and wood to ground contact (4%). Seven types of interventions were implemented: injection of termiticide into infested wooden structural members (n = 19), soil application of termiticides (n = 17), application of termiticide to elements of construction (i.e. expansion joints and wall voids, n = 26), termite baits (n = 10), landscape alterations (n = 4), building repairs (n = 4) and no action (n = 5). Fifty-two infestation sites had action plans that called for only one intervention and these 52 involved all intervention types except for landscape alterations. Six action plans involved the combination of wood injection and soil application. The combination of wood injection and baits was used at one site, and termiticides applied to the elements of construction along with bait were employed at three sites. Two sites had action plans that involved application of termiticides to the elements of construction and landscape alterations, while two other sites used a combination of four interventions.

Treatment success was measured by two methods. The first was callbacks from building occupants reporting a post-intervention swarm or other evidence of continued termite activity. The second was determined by conducting site reinspections using visual inspection and at least one alternative inspection device – either a proprietary acoustic amplification device or microwave device (Termatrac®). The five sites where no action was taken were infestations reported as a result of a swarm that occurred in structures with no wooden structural components. All of the no-action interventions were determined to be successful because termites have not swarmed at any of those locations since the original report – two having gone for 1 year, one for 2 years, one for 8 years and the last for 9 years. Three of the four building-repair action plans (two gutter repairs and one replacement with treated lumber) were successful as 'stand-alone' actions. The fourth building repair action plan (removal of form boards) cannot be deemed a success because termites are still present in the structure, yet the intervention has not been implemented by the PPD. The four landscape interventions were recommended as part of multi-intervention action plans and all involved reducing grade that was above a slab foundation, yet none of those landscape-alteration interventions have been implemented by the PPD. Forty-four of the remaining 48 action plans (that are at least 1 year post-action plan implementation) have been deemed successful because termites are no longer present at the location where they were noted during the original inspection. One failure was a 2009 application of 0.05 l of liquid termiticide to an expansion joint below an exterior door, but termites swarmed again the following year from the same door frame. Failure of this intervention is likely to have been the result of inadequate coverage of the entry point. The volume of termiticide used was not adequate to cover the entire expansion joint – highlighting the importance of attention to the details of insecticide application. The other three failures were wood injections where termites appeared 1–3 years later in other parts of the same room. Most of the buildings involved in this demonstration project were large and termites did return to other parts of the building, albeit many metres away from the original interventions; these were assumed to be separate infestations. The data therefore indicated a 92% success rate for all the initial interventions. However, the success rate of these same action plans, if examined from an industry standard of 'termites not reported from the same building', provided a success rate of only 70%. Another measure of IPM success – reduced insecticide applications – was clearly documented. This ITM programme used 99% less insecticide than required by the Georgia Structural Pest Control Commission standard of whole-house treatment for termite infestation (GSPCC, 2007).

The success of the ITM demonstration project is unequivocal when using the metric of reduced application of pesticides, and validates the principle of 'spot treatments' (Ebeling and Pence, 1965) when managing subterranean termite infestations. The variable success rate for removal of infestation highlights the role of communication in an IPM programme. The industry standard of whole structure contracts provided a 70% success rate, which is an unmitigated failure from any perspective. Yet the same data also provided a 92% success rate of initial intervention, which was accepted by the PPD because the reports documented every step of the process from inspection to action plan development, implementation and reinspection. That 92% success rate was later improved to 98% by re-evaluation of the action plans and implementation of additional interventions (the one failure was the one action plan that the PPD was responsible for conducting – the removal of infested form boards in a cramped, unventilated crawl space). The customer, PPD, was satisfied that termites were removed from the immediate site of infestation and understood that later reports from the same building often constituted separate infestations. This understanding and acceptance of the upper limits of the aforementioned success rates is attributed to the lines of communication that were maintained using updated reports.

Conclusion

Implementation of IPM practices in the human habitat is complicated by numerous factors, including: technical, conceptual, economic, educational and research aspects and public perceptions, (Moore, 1986; Robinson, 1996; Kogan, 1998; Ehler, 2006). Although the concept of using attributes of the biology of termites as the foundation of a management programmme are well known, their use by the pest management professional has been tempered by reliance on chemical treatments. Application of an IPM philosophy for managing termite infestations requires a thorough inspection aimed at identifying known or potential entry points, designing a site-specific action plan aimed at mitigating alternative food sources and based on the construction and moisture issues unique to each infestation. Inspection findings must be communicated along with the interventions enacted to justify ongoing efforts. An ITM demonstration project provided a 98% success in eliminating infestations and 99% reduction in insecticide use, thus validating an inspection-centric, ongoing programme of communicating efforts towards managing termite infestations in structures.

Hagen writing in 1876, stated: 'We live surrounded by such enemies that have the potential to create great damage and the remedy must be a reasonable one'. His words provide sound advice today – over 120 years later (Hagen, 1876). The pest management community has many interactive stakeholders who should be in a dialogue to effect termite management in a cost-effective and environmentally responsible, efficacious manner. The termite management practitioner is operating under a 50-year-old insecticide-based business model that has little relevance to the academic knowledge base, while consumers and regulatory agencies, for different reasons, are largely unaware of the gulf between knowledge and practice. The academic community is remiss in its provision of timely biologically sound information and in combining that with economically pragmatic management practices. The ITM demonstration project outlined in this chapter illustrates a knowledge-based programme based on communication that can realize the goals of the IPM philosophy. Industry acceptance of this model is hindered by a business practice based on one action (insecticide treatment) followed by faith in an outdated lifetime guarantee mentality. The ITM philosophy requires communication and record keeping that has traditionally been the bane of the US termite control practitioner relative to regulatory oversight. The regulatory community must rethink regulations to allow for IPM and consumer protection based on communication and record keeping as the foundation of a new oversight programme. ITM differs significantly from the current termite control business model in that the property owner has responsibilities relative to termite management because the practitioner is not a magician who can use insecticides as a cure-all for bad construction, landscape management or building maintenance. Finally, the academic charge of educating all community members on the role of a termite management professional should be undertaken with a renewed vigour energized by a holistic view that acknowledges the gulf between knowledge and practice, and is fuelled by a sense of responsibility to all stakeholders.

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