ANTS AND SUBTERRANEAN TERMITES IN THE URBAN ENVIRONMENT: THE TERMINOLOGY OF POPULATION MANAGEMENT CONTROL TACTICS

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Abstract - Ants and subterranean termites are economically important insect pests in the urban environment. Managing populations of these pests through bait-toxicant control tactics is a viable option that requires a thorough understanding of their biology. The terminology used in describing a bait-toxicant control strategy must accurately reflect the intent of the strategy within the context of what is known about the biology of the pest. This article discusses selected aspects of the biology of both ants and subterranean termites as a platform for discussion of consistent use of terminology concerning development and implementation of effective bait control programs aimed at population management of these pests.
Key words - Ants, subterranean termites, bait strategies, foraging, detection, monitoring

INTRODUCTION

Ants and termites are among the most common pests in the urban environment. The economic and aesthetic pest status of these two groups is well established (see Fenner, 1992; Su and Scheffrahn, 1990). Both ants and termites live in organized colonies that are characterized by a division of labor among colony members. Ants are considered highly evolved social insects and termites are considered more primitive and eusocial (Wilson, 1971). Features such as food sharing and grooming between nest mates, that are important to colony success, have been exploited as a means of control. Modern pest control tactics for ants and termites include the use of toxic baits that target the entire colony. The use of baits for the control of these and other household and structural pests has increased in recent years, and is likely to increase. Associated with this control strategy for ant and termite pests are a set of terms that are used to describe some of the methods, materials, and intent of particular treatment tactics.

Understanding differences in the life histories of these two social insect groups is essential for developing biologically correct terminology to describe the intent and efficacy of population management control tactic(s). In this paper we will attempt to provide a forum for discussion of the terminology used to describe toxic-bait programs as population management tactics for ants and termites. We will restrict our comments to two urban pest genera *Linepithema* (Hymenoptera: Formicidae) and *Reticulitermes* (Isoptera: Rhinotermitidae) to illustrate selected differences in the biology of these insects relative to the language used to describe insect population management tactics.

Bait control tactics have been developed for use against both ants and subterranean termites (Hedges, 1997; Potter, 1997). The objective of these control programs is to utilize aspects of their social behavior, such as feeding and foraging, to distribute small quantities of a toxicant through the targeted population with the goal of reduction or elimination of that population (Stringer *et al.*, 1964; Beard, 1974). Attempting to control ant or termite populations using baits requires an understanding that these two groups of insects are very different and therefore will require different methodologies and terminology.

Colony structure

Aside from the basic feature of being social insects the similarities between ants and subterranean termites are few. Ants undergo complete metamorphosis and termites incomplete. The majority of the members of an ant society are sexually immature (sterile) individuals that appear physically mature

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(Holldobler and Wilson, 1990). In contrast, subterranean termites live in societies composed almost entirely of sexually and physically immature individuals that retain the capacity to transform to a sexually and physically mature state (Thorne, 1998). This basic life history difference is important to recognize because understanding the life-stage of the insect pest that is being targeted is crucial to the efficacious use of baits. To be effective a bait-toxicant must be ingested by a majority of the colony members or targeted toward particular, critical, caste members within the colony. Therefore, knowledge of simple life history attributes like those described above should be reflected in the bait control tactic if the intent is to target the reproductive caste. For example, targeting the reproductive castes in ants is an identifiable goal in a population reduction scenario. However, this same goal is more difficult to achieve with termites because one must target a diffuse population comprising 80-90% of that insect society.

Foraging and feeding

The differences in metamorphic development mentioned above also relates to differences in foraging and food transfer efficiencies when comparing ant and termite societies. In turn, these efficiencies are important to effective toxic bait distribution within the pest population. For an insect bait control strategy to be effective the bait must first be located by the foraging members of the targeted pest population. By definition foraging is the search for food and a forager should be that individual involved in the process of locating or gathering food. Understanding what proportion of the individuals within a social insect society are engaged in the task of foraging and how those individuals share the resources they locate is important to predicting the outcome of a baiting control attempt.

Ants have evolved a forager-based caste whose task is to discover ephemeral food resources and return them to a central nest location for distribution to the nest-bound, leg-less immatures, those caste members involved in brood-care, and the reproductive caste members also confined to the nest (Holldobler and Wilson, 1990). Therefore, ants are prepared to quickly locate bait placed outside of the central nest, to return that bait to the nest, and to distribute it to other non-foraging individuals within the society. Studies have identified the communication system used by certain ants to locate and recruit nestmates to a food resource (Aron *et al.*, 1989; Beckers *et al.*, 1990). This information could be used to determine efficient bait-toxicant placement scenarios. Studies have also identified the proportions of individuals (foragers) within an ant society that leave in search of food resources (foraging) and those individuals nest-bound for various reasons (Markin, 1968). In addition, studies have identified the food groups consumed by the foraging caste and those foods returned to their non-foraging, nest-bound mates (Markin, 1970). Armed with information on foraging and feeding, baits can be more effectively delivered in the urban environment. For example, when baiting for *Linepithema* spp. a carbohydrate or sugar-based bait will most likely be eaten and affect the foraging workers, while oil or protein-based baits will be fed to the brood and reproductives.

Reticulitermes termites, in contrast to the ants, have evolved a worker caste whose task allocation programming has not been fully elucidated (Crossland *et al.*, 1998). The lack of evidence for polytheism and their cryptobiotic lifestyle have prevented definitive identification of those workers specifically involved in the task of foraging. Therefore, the proportions of members within a subterranean termite society that are actually gathering food is unknown. Despite these unknowns it is generally agreed that a termite engaged in foraging performs the task of locating relatively sedentary food resources. It is also generally agreed that once a potential food resource is located other termites are recruited to inhabit the discovered food resource (Thorne, 1998).

Immature worker termites feed as they excavate the food resource which results in a reduced need to transfer food from one colony member to another because most members of the society reside on/in the food source itself (Beard, 1974). Because the movement patterns (hourly, daily, weekly, monthly) of individual subterranean termites between sedentary feeding sites are unknown it may be more appropriate to assume that termites located at a feeding site are involved in feeding at an established site and not in foraging as defined above. Therefore, most termites found at a feeding site (or infestation) cannot properly be termed foragers. That term should be reserved for the caste members whose task it is to

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locate food resources. Termites inhabiting a food resource may more properly be termed consumers, residents, or recruits.

It is known that subterranean termites locate food resources through foraging that is non-random and that foraging termites follow physical and chemical gradients in search of new food resources (see Forschler 1998). Once a potential food resource is located, the processed used by subterranean termites to recruit nestmates to the discovered resource has not been fully elucidated. However, three components of a potential subterranean termite communication system are part of the scientific literature that may hint at how these social insects find, exploit, and move between feeding sites. A trail multi-component pheromone has been identified from *Reticulitermes* spp. termites and shown to contain both long and short-term components (Runcie, 1987). A secretion from the labial gland has demonstrated elicitation of a feeding response in subterranean termite workers (Rheinhard *et al.*, 1997). There also is evidence that termite workers respond to the concentrations of both the trial and feeding pheromones to either aggregate or disperse (Rheinhard and Kaib, 1995). In addition, it has been shown that episodes of feeding by individual termites, confined within a petri dish, are unpredictable (Forschler, 1996a). Therefore it is possible to describe termite movement between feeding sites as defined by individual termite responses to the aforementioned pheromone cues. We propose the following scenario assuming no disturbance or changes in microclimate parameters within the colony; a worker termite not involved in foraging or brood care follows the trail pheromone until it encounters a feeding signal at which time it stops to feed. This worker termite eventually acclimates to the feeding signal and again responses to the trail signal involving movement away from the original feeding site until it encounters another feeding signal at which time it, again, stops to feed. This simple, hypothetical, communication system would result in accumulations of termites at particular sites over time. This is assuming a polyethic society where certain individuals forage to find new food resources, others ‘taste-test’ the newly discovered resources, while a majority of the colony worker caste simply respond to the trail and feeding signals on an individual basis. Despite the fact that the scientific literature contains pieces of the puzzle concerning the mechanisms involved in termite movement between established feedings sites, the actual process as used by these cryptic animals is still subject to interpretation. The act of bait location through foraging activity and, once located, distribution of that bait within a termite society is, therefore, not well understood. In comparison to ants, termite baiting may more accurately be considered a process involving recruitment to the bait site rather than reliance on distribution beyond the point of bait placement.

Monitoring pest populations

To ensure efficacious implementation the specific life stage affected by particular aspects of a baiting program must be considered. Which insect life stage (or caste) is targeted influences the decision making process involved in determining the appropriate population indices to record, within the context of a realistic monitoring program, to properly quantify population impacts. Unlike measuring control strategies for other household pests, such as cockroaches, evaluating the efficacy of baits on social insect pests may require a sophisticated monitoring program.

In insect pest management the success or failure of a control tactic is measured by monitoring changes in the pest population over time (Metcalf and Luckman, 1982). In general, a population of domicilary ants or subterranean termites is detected, through observation of individuals at non-toxic bait sites, or a thorough inspection of the premises. Following detection a monitoring program is usually initiated. Monitoring is defined as the process of repeatedly sampling a pest population with the goal of recording changes in that population over time. This is accomplished by comparing some measure of activity, such as the number of individuals found at a particular site, before, during, and after a control tactic is initiated.

Ants

Monitoring ant populations is often accomplished by placing feeding stations baited with a non-toxic food substrate and counting the number of ants found at each station (Oi *et al.*, 1994). A monitoring program

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based on non-toxic baits depends on the efficient and timely foraging habits of the targeted ant population, and placing monitoring stations in the same locations over time. It is also important that monitoring stations are checked at the same time of day on each inspection date and seasonal and weather-related data kept for correlation with the counts. Monitoring ant populations using non-toxic baits has been used to determine the success of a variety of ant control tactics (Rust and Knight, 1990). It is generally agreed that a reduction in the number of foraging ants is indicative of a reduction in the pest ant population. However, interpreting a reduction in the number of foraging ants must be done with caution. Reduced ant counts at monitoring stations may simply indicate a reduction in the number of foraging caste members (whose ranks may be replenished by unaffected brood developing safely in the nest), a shift in foraging activity to other, unmonitored areas, or seasonal and weather-related activity.

Termites

Detecting and monitoring subterranean termite populations is no less problematic. Termite colonies are usually detected using wooden stakes placed into the ground (Thompson, 1985). This technique depends on the stakes being a suitable food source and efficient and timely foraging by the resident termite population. It is known that termite foraging is not random but the debate over directed versus patterned placement of detection bait-stakes continues. Regardless, once termites are detected at a bait-stake, monitoring of that population can commence. For research purposes, termite inspection ports or monitoring stations are usually positioned at or near the bait-stake where termites were detected (Forschler and Townsend, 1996). Measures of termite activity at inspection ports have traditionally included the number of termites present at the time the port was inspected, and wood consumption rates during the interval between inspections (Su and Scheffrahn, 1988, 1996; Forschler and Townsend, 1996).

Use of mark-release-recapture of colony individuals has been employed to “connect-the-dots” and identify related use of inspection ports (feeding sites) by single groups of termites, and to measure population size using Lincoln Index or weighted mean models (Su and Scheffrahn, 1988; Grace, 1990; Forschler and Townsend, 1996). There is room for debate concerning the usefulness of the various measures of termite activity recorded from inspection ports in relation to measuring subterranean termite population change as indicated by mark-release-recapture (Thorne *et al.*, 1996; Tsunoda *et al.*, 1998). Subterranean termite visitation to inspection ports is believed to be affected by a number of factors including; the quality and quantity of the food resource placed in the inspection port, disturbance or the time interval between inspections, the number of alternate feeding sites occupied by the population visiting the inspection port, and local weather and seasonal activity patterns (Forschler, 1996b). Partially because of the involvement of these and other not easily quantified parameters, termite movement between established feeding sites is unpredictable. Yet, a realistic definition of a termite colony has not been provided by the research community beyond the pragmatic use of mark-release-recapture, “connect-the-dots” studies, and a better definition must be elucidated (Jenkins *et al.*, 1999).

Action thresholds

Insect-pest population management tactics use the concept of an action threshold. This is usually based on pest population trends as indicated by the number of insects counted at a monitoring site(s). The role of an action threshold is determination of the need to initiate a control program or action plan (Metcalf and Luckman, 1982). There are, however, no established action thresholds for insect pests, including ants or termites, in the urban environment (Robinson, 1996). It is our opinion that there are two major reasons why research-based action thresholds have not been established for urban ant and termite pest species. First, research designed specifically to provide background information for action threshold establishment has not been conducted, or the available scientific literature has not been collated to provide both the monitoring program and measure(s) of population indices needed. Second, monitoring an insect pest population is labor-intensive and time consuming. As a result, most practitioners and consumers are not willing to underwrite the maintenance of a monitoring program because of the inherent cost involved.

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Ants

Action thresholds for ant control are generally determined by the tolerance level of the human inhabitants at a particular site. From a practical, commercial pest control operator point-of-view, monitoring is usually accomplished by counting the number of complaints registered by the building inhabitants. Most often this is done without regard to the species of ant involved in the complaint, despite the fact that efficacious ant control must be based on proper identification of the offending ant to the species level. Although ant bait control tactics are often considered a secondary control tactic to location of the nest and insecticide application to that site, for polygynous, multiple-nest species like *Linepithema humile*, bait control programs are often the only practical alternative (Hedges, 1997). However, most practitioner-based ant control programs are initiated following a report of the presence of a few ants and population impacts are measured by recording the incidence of complaints.

Termites

Subterranean termite control has traditionally centered around two basic concepts, preventing or removing an infestation from a structure (Potter, 1997). In the past, there was no emphasis placed on indices of termite population size. A renewed interest in termite population dynamics has occurred as a result of the commercialization of termite bait control strategies. However, as with ants, monitoring termite populations is beyond the purview of the pest control practitioner. The most commonly encountered action threshold for a termite bait control program is based on the assumption that any termite population detected within the immediate vicinity of a structure places that structure at risk toward infestation. From a commercial standpoint, determination of this action threshold consists of recording the presence or absence of termites at detection devices (often misnamed as monitoring stations) placed around the property. Therefore, termite bait control programs are predicated on the installation and inspection of detection devices. A control tactic is initiated following detection of termites without regard to measuring any of the population parameters typically used in an insect pest management program. The current action threshold concept for termite control using baiting strategies is based on detection of a population with the assumption of zero tolerance. Following initiation of a control tactic success or failure is measured by continuation of the detection program without regard to real population indices.

REALISTIC PEST MANAGEMENT

Development of realistic action thresholds for both ant and termite control programs, that are aimed at population reduction through baiting control strategies, are needed to properly implement these control tactics. Action thresholds must be developed using monitoring systems that can accurately measure population size or risk to infestation. Until realistic measures of risk can be calculated for ant and termite populations detected near structures, there can be little reason to discuss IPM programs in relation to the control of these urban insect pests. It is important that the research community take the lead in relaying the message that urban insect pest management programs require the steps outlined for other insect pest management programs (Robinson, 1996). Because we do not currently have the data to support realistic ant and termite population management practices we cannot ignore the possibility that ant or termite populations can exist within the urban landscape and not pose an economic threat.

Gathering data on measures of population parameters that could be useful to the practitioner and homeowner interested in effective, environmentally friendly, meaningful urban pest management should be a goal of the urban insect research community. This must begin with agreement on terminology and not using language that confuses the basic life history requirements of the pests we are studying. Therefore, we propose that ant control aimed at population reduction should account for what is known about the percentage of foraging individuals within a particular species. That knowledge must be incorporated into studies of ant population control tactics to realistically evaluate monitoring ant

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numbers as an indicator of success of a baiting program. In regard to termite population management researchers face a more difficult task. This task should begin with the need to more clearly define termite population parameters including what constitutes a colony, a forager, and not confuse monitoring with detection.

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