Search and Destroy

A research report about termite foraging behavior and what it means for effective termite IPM.

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As homeowners and pest management professionals know all too well, termites are remarkable in the execution of their relentless search and destroy missions. While termites have had the benefit of perfecting their tactics over tens of millions of years, researchers have only recently begun to learn how termites organize their foraging activities. Like a potentially costly game of cat and mouse, we employ traditional and novel offensive and defensive control methods to organize *our* search and destroy missions to counter their attacks. If we have learned anything from the history of termite control, it is that we must understand termite biology, especially foraging dynamics, to aid in the development of innovative tools and critical insights needed to detect their presence and protect our structures from infestation and damage. The ultimate key to the successful control of these resourceful insects lies in the knowledge of their foraging and feeding habits and social behavior.

Imagine a hungry termite's "eye"-view of the world. Blind and traveling through a dark gallery with your scouting group, you help extend and build new tunnels in search of food. No map, signs or satellite-based navigation system help guide your way — just hints from odors, texture, moisture, temperature and gravity. A multitude of unpredictable factors, including heat, floods, predatory ants, obstacles (such as boulders) or a simple lack of food could foil your mission. Once a potential food source is located, a reconnaissance team has to confirm its suitability through nutrition and risk assessments. If the decision is made to feed, then foragers must be allocated among this and other sites that the colony is simultaneously utilizing, all the while keeping lines of communication open and active without the convenience of cell phones or e-messaging. These are some of the challenges faced by termite scouts and foragers as they seek to feed themselves and their family.

TERMITE BEHAVIOR. As we've noted, termite foraging involves a methodical sequence of behaviors: the *search* for food, a *choice* of whether or not to eat what is found and a colony's *decision to distribute workers and soldiers* among resources. Is there a pattern? You may have heard the term "random" applied to subterranean termite foraging, but not even "random foraging" advocates suggest that either the search or choice phases actually proceed randomly or in a haphazard way. There are in fact predictable patterns to food search and selection that reflect the energetic efficiency and nutritional benefit of foraging. Termites are remarkably capable at finding a feast of a large fallen tree or even table scrap snacks such as offcuts from a backyard construction project. But what *is* known about the elements of search, choice and movement of foragers among food sources? How do colony members decide to forage in one area or another? And significant to our goal of developing an effective termite IPM program, what are the implications of building a working knowledge of subterranean termite foraging behavior for detection, interception and control?

While searching for new food sources, termites are influenced by factors that are logically linked to their biology. Soil moisture and temperature, including short-term effects caused by shade or the warming, cooling and insulating effects of rocks and other surface objects, affect termite activity and gallery building. Similarly, there are seasonal lows and highs in termite search and activity, influenced by daily temperature ranges and precipitation. In most parts of the United States the search for new food sources (as measured by new "hits" on monitors) tends to peak in the spring or early summer, followed by a renewed pulse in the fall, coinciding with seasons of moderate temperatures and relatively moist soils. Physical factors such as vegetation, soil type, degree of compaction and topsoil depth affect moisture retention and ease of tun-

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neling and thus impact search and exploration. Another predictable pattern of termite travel is guideline orientation — their preference for moving along a physical object (such as a water pipe or the junction between a floor and wall) or adjacent to a chemical gradient (such as a "plume" of chemicals leached from fungus-decayed wood) or along a soil density gradient (such as the boundary between two different types of soil). Studies on the geometry of search show that gallery construction tends to minimize repeating search in the same area.

For example, if the subterranean termite *Reticulitermes flavipes* builds two galleries, they tend to be about 180 degrees apart. If three galleries are constructed, they are separated by roughly 120 degrees and four-branch galleries divide the ground to be searched into approximately 90 degree sectors. How this gallery orientation is accomplished is not known, but termite foraging with respect to search is certainly not random. Another key feature of termite travel is that if a gap is discovered in soil, termites will follow it rather than excavating a new path, thus conserving energy. New exploratory tunnels are typically dug only from the gap's end point.

Search tunnels constructed by *Reticulitermes flavipes* that were brought into a lab in large bolts of wood. Note the branching patterns that result in comprehensive exploration, and guideline orientation along the junction between the wall and the floor behind the left bolt. (Photo: © B.L. Thorne, University of Maryland.

STAYING FOR KEEPS? Once a potential food source is located, will the termites stay to feed? Food choice is a complex decision based on resource quality and quantity and further influenced by an individual colony's alternatives and particular nutritional needs. Many patterns and tendencies are consistent, although under certain unusual (or perhaps desperate) circumstances, a colony may stray from their traditional menu and chomp through a "can you believe it?" substrate such as a lead pipe or mahogany. Regarding food quality, some generalizations are common, although — as with the food preferences of many animals — exceptions occur. Subterranean termites prefer partially decayed wood rather than live or freshly dead wood and their interest is affected by the type and extent of fungi infesting the wood. They normally prefer sapwood to heartwood (due to both density and chemical compounds) and they usually select softwood species over hardwoods, although wood species preferences are also influenced by the cocktail of defensive and metabolic compounds in wood. If a "jackpot" delicious log or resource is already colonized by ants or another termite colony, hungry workers may elect to dine elsewhere.

A remarkable aspect of termite food choice that heightens our respect for their hidden talents is that these insects pace their speed of wood consumption depending on the volume of the resource, inferring that they employ impressive mechanisms for evaluating the size of the wood. The mechanism(s) that termites use to assess volume is unknown, but this capability is clearly an important element of their selection and consumption process with obvious implications for monitoring and baiting. Relatively large baits may offer an advantage for termite interest and potentially extend intervals between servicing accounts, however, station size will be influenced by the practical realities of inventory shipping, storage and installation.

MOVING AROUND. Once they discover and accept a food source, how do workers move and distribute among all of the feeding sites used by a colony? This question generates intense interest because the answer is directly related to how baits and non-repellent termiticides work. If it is true that individual foragers within a colony travel and feed among different substrates and locations at random, i.e., with no preference or fidelity to particular resources, then over time all foragers will feed directly on pesticidal baits. This would mean that bait efficacy would be less dependent on social exchange of toxicant through trophallaxis, grooming, social contact or cannibalism. Similarly, if workers move within their colony's gallery system "at random," or circulate in any pattern that eventually results in all workers moving through tunnels that penetrate soil treated with a nonrepellent termiticide, colony movement patterns alone — over time — could directly expose all foragers to the toxicant. However, many scientists do not accept that termites forage randomly.

Foraging paths and the distribution of foragers among a colony's food resources are inherently difficult to study in the lab or the field. Only two experimental studies, both on the genus *Coptotermes*, attempted to address this subject in the field: Su et al. 1984 and Evans 2002. These research programs followed the distribution of termites feeding on a dye or dyed and released at a single location and subsequently recovered from nearby monitoring stations. Based on dye concentration measurements and a "uniform" redistribution of dyed foragers among all monitors, Su et al. concluded that "foragers select their foraging sites from among available foraging sites at random." Evans' results and interpretations (involving colonies of a species of *Nasutitermes* as well) were markedly different. In his study of several colonies, he found a consistently uneven distribution of dyed workers, inferring at least temporary site fidelity and concluding that termites forage at specific sites preferentially and "do not move randomly between feeding sites in their natural habitat." The study of this aspect of subterranean termite foraging merits further field research on a broad range of species and habitats before general patterns and conclusions can be determined. Foraging patterns may well be dynamic, changing with the age and "value" of a resource, i.e., from discovery until depletion. Foraging site fidelity, if it exists, may occur until the food source is depleted relative to other resources.

Subterranean termites do not have the convenience of collecting fast food at each of their highway intersections, but their tastes are broad enough and resources are sufficiently plentiful that with energetically efficient investment in search they usually find adequate nutrition. The exact nature of search, choice and the distribution of members of individual colonies remains unpredictable, but patterns are sufficiently understood that with a bit of experience we can now use available tools to identify "conducive conditions" and intercept foragers by encouraging them to feed at monitoring or bait stations. Termites are immensely important as global recyclers of nutrients in dead trees and other cellulose sources. Humans can appreciate their initiative and community service, but at the same time exploit termites' natural tendencies in order to protect structures from termite attack.

CONCLUSION. How does knowledge of subterranean termite foraging biology help in their detection and control? Regarding detection, monitors in place to catch the spring and early summer search season will be advantageous and their placement in hospitable areas such as the relatively moist zones near downspouts or warm and moist areas under mulch is prudent (although positioning monitors around an entire structure is recommended because termites can't be trusted). Monitors and baits designed with termite preferences in mind, i.e., offering highly preferred food in a readily accessible, larger-sized matrix can most likely focus termites' interest. Active ingredients that are readily transmitted from termite to termite by social food flow, behavioral contact or cannibalism offer the advantage of speed in spreading the toxicant. If forager traffic and movement patterns direct most workers to visit toxic baits or to travel through soil treated with a non-repellent termiticide, any cascade of pesticide from termite to termite will accelerate impact of the treatment. As with strategic design of IPM programs for any pest, knowledge of when, where and how they look for and exploit food sources provides insights on how to effectively intercept and target these insects.

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FOR FURTHER READING

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