

DESCRIPTIONNOVEL METHODS AND MATERIALS FOR PEST MANAGEMENTCross-Reference to a Related Application

This is a continuation-in-part of co-pending application Serial No. 07/891,896, filed June 1, 1992.

Background of the Invention

Subterranean termites most often enter structures from the surrounding soil to feed on wood, or other cellulosic material, of the structure and its contents. If unchecked, termites can cause considerable damage. As a result, efforts to erect physical or chemical barriers to prevent the entrance of termites into a structure or to exterminate the termites after they have invaded a structure have proven a considerable expense to the public (Su, N.Y., J.H. Scheffrahn [1990] *Sociobiol.* 17(1):77-94). The cost to control termites in the United States exceeds one billion dollars annually (Mauldin, J.K., S.C. Jones, R.H. Beal [1987] The International Research Group on Wood Preservation Document No. IRG/WP/1323).

Subterranean termites construct an extensive foraging gallery beneath the soil surface. A single colony may contain several million termites with foraging territory extending up to 300 feet (Su, N.Y., R.H. Scheffrahn [1988] *Sociobiol.* 14(2):353-359). Since subterranean termites are a cryptic creature, their presence is not normally known until after some damage, foraging tubes, or live termites such as swarmers, are found.

Currently, there are two basic approaches for the control of subterranean termites: (1) preventive control, and (2) remedial control.

(1) Preventive control: In most of the United States, it is mandatory that the soil underlying the foundation of newly constructed buildings be pre-treated with a pesticide to prevent termite infestation. Pesticide is typically sprayed over the soil prior to construction. This pre-construction treatment produces a horizontal barrier

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beneath the building. Because of the lack of communication between pesticide applicator and construction workers, the barrier often loses its continuity during the construction. Moreover, the currently available soil termiticides tend to lose their biological activity after five or more years to the extent that the treated soil is no longer effective against termite invasion. Established termite colonies in the soil may then invade the structure.

(2) Remedial treatment: When a house or other building is infested by subterranean termites, efforts are made to create a barrier beneath the building and the soil where the subterranean termites are provided access to the building. A common method of creating this barrier is to introduce termiticide around a building foundation by injection into soil underlying concrete foundations, drenching the soil surrounding the building perimeter, or a combination of both. This type of post-construction treatment is labor-intensive and may not produce a continuous barrier (Frishman, A.M., B.L. Bret [1991] *Pest Control* 59(8):48, 52, 54, 56; Frishman, A.M., A. St. Cyr [1988] *Pest Control Technology* 16(4):33, 34, 36).

Other remedial treatments include spot treatments such as dusting or injecting termiticides within the walls of the building. Robert Verkerk has described arsenic trioxide dust treatment using termite lures. *Building Out Termites*, Verkerk, Robert. Pluto Press Australia Limited, P.O. Box 199, Leichhardt, NSW 2040. 1990. Verkerk describes the use of stakes or blocks of termite susceptible timber to lure termites. Once termite activity is observed, arsenic trioxide is injected. Alternatively, a portion of the termites may be dusted with arsenic trioxide.

Most spot treatments are done to eliminate existing termite infestations but generally affect only a small portion of the subterranean termite population, i.e., those termites which come into direct contact with the pesticides. Because of the extensive foraging populations and expansive territory of the subterranean termites, the vast majority of the termite population is not affected by such spot treatments.

One termite control method comprises placing a highly toxic material, such as an arsenic-containing dust, at a site of infestation in the hope that this will directly control an effective number of termites at the site and also other termites back in the

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colony. However, this method relies on pumping toxic dust into a termite tunnel and depositing relatively large quantities of dust.

Elaborate schemes of pipes to convey termiticides under and surrounding buildings have also been proposed as a termite control. It has been suggested that these liquid termiticides may be dispensed into the soil surrounding the building through these pipes to provide a barrier to the incursion of termites. This method requires a large quantity of termiticides in order to saturate the soil surrounding the building.

U.S. Patent No. 5,027,546 describes a system which controls termites by freezing with liquid nitrogen. Although the liquid nitrogen is essentially non-toxic in that no toxic residues persist, the method is a spot treatment and will not affect the majority of termites. U.S. Patent No. 4,043,073 describes a method which attempts to circumvent the problem of repeated application of pesticide. The described method functions by encapsulating the insecticide, thus making it more persistent. The overt use of pesticides and their persistence in the environment are not remedied by this system. Another proposed system which fails to alleviate the problem of transferring insecticide directly into the soil is U.S. Patent No. 3,624,953. This method employs a reservoir of insecticide wherein the vapors of the insecticide are permitted to permeate the soil surrounding the reservoir. Thus, exposure of the environment with toxic substances is not avoided by using this method.

Toxins which have less environmental effect and which show activity against termites are known (Su, N.Y., M. Tamashiro, M. Haverty [1987] *J. Econ. Entomol.* 80:1-4; Su, N.Y., R.H. Scheffrahn [1988] *Florida Entomologist* 71(1):73-78; Su, N.Y., R.H. Scheffrahn [1989] *J. Econ. Entomol.* 82(4):1125-1129; Su, N.Y., R.H. Scheffrahn [1990] *Sociobiol.* 17(2):313-328; Su, N.Y. [1991] *Sociobiol.* 19(1):211-220; and Su, N.Y., R.H. Scheffrahn [1991] *J. Econ. Entomol.* 84(1):170-175). However, none of these toxins have previously been used in conjunction with a method which efficiently and efficaciously delivers the toxin to a target pest.

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Australian Patent No. 1,597,293 (the '293 patent) describes a method which involves mixing insecticide with a food matrix comprising cellulose and a binding agent. The method described in the '293 patent relies on the termite ingesting the insecticide along with the bait, then returning to the colony to introduce the insecticide to other termites through the natural process of trophallaxis (food exchange between termites). However, even though the '293 patent describes usages only when termites are known to be present, the described method fails to ensure that the termites will initially find the bait and relies on those termites finding the bait to transfer sufficient amounts of the insecticide to the colony solely by trophallaxis. The method of the '293 patent requires that the bait is more attractive to the termites than surrounding materials, but only relies on the moisture in the bait (supposedly retained by the binding agent, agar) to attract termites. The described method, therefore, can be used only for termite species that are attracted to moisture (or those under "water stress"). Moreover, the '293 method fails to assure that the moisture will remain in the baits when applied in the field awaiting termite arrival. This is an unrealistic requirement for a practical application, because even a moistened sawdust-agar matrix will desiccate within a few days when placed in a dry soil.

It should be noted that attractants other than water for termites have been investigated. For example, the extract from brown-rot fungi chemically resembles the trail-following pheromones of termites. Natural pheromones, however, are species- and even colony-specific. A pheromone that is "attractive" to one species or colony of termites may repel termites of other species or colonies. It is impractical, therefore, to incorporate pheromone mimics (such as the brown-rot fungi extract) in a bait, especially if a bait is to be used against a wide range of termite species.

It should also be noted that trophallaxis is an uncertain means of delivering the insecticide to the colony because it assumes that digestive enzymes and other metabolic processes do not affect the active ingredient. However, once the insecticide is ingested by the termite, the insecticide may be rendered inactive by the digestive process of the termites. Moreover, suppression of a termite population

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requires that a substantial number of termites in the colony are disabled before their damage potential is diminished. Relying only on trophallaxis to transfer the toxicant does not ensure that adequate numbers of termites will be controlled.

Modifications to the method described in the '293 patent may not increase the bait intake of termites. For example, the '293 method requires that the bait-toxin mixture be applied at a known infestation site such as a termite mound or tree trunk. This method, therefore, can be used only as a remedial treatment. The '293 method cannot be used unless activity of termites is detected. The '293 patent also proposes that a large quantity of toxin bait be placed at random locations as a preventative measure. However, without providing a procedure for detecting termites, the majority of this bait may desiccate or degrade due to fungal growth and become unpalatable to termites. Moreover, an unnecessarily large quantity of toxicant is applied in the environment.

It is therefore highly desirable to more effectively control termites or other insects in a manner which assures that the termites or other insects of interest are exposed to the toxin, which minimizes environmental harm by reducing the amount of insecticide used, and which controls adequate numbers of termites in a colony.

#### Brief Summary of the Invention

The invention disclosed and claimed herein relates to a method for controlling populations of pests. The invention is most advantageously used for controlling the population of social insects which communicate through chemical signals. Specifically exemplified herein are methods and devices for the control of insects of the order Isoptera, particularly, termites.

One preferred method of the subject invention is most easily thought of as comprising two steps. The first step involves monitoring and/or capturing target pests by a means which does not employ the use of any pesticide. The first step functions to detect the presence of pests. In addition, the first step can also function as a means to capture the pest without causing the pest substantial harm. In the embodiment of the invention wherein pests are captured, the captured pest is still

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alive and, preferably, capable of moving, eating, and producing chemical signals which can attract fellow pests. This first step of the process, wherein the pests are detected or captured is hereinafter referred to as the "monitoring" step.

The second step of the process involves controlling a population of pests once they have been detected. The pests are controlled as a result of ingesting or otherwise contacting a toxin. Specific carriers of toxins, such as bait or tracking powder, are aspects of the subject invention, as are apparatuses for presenting the toxin-containing carrier or tracking powder to the target pest. In a preferred embodiment of the invention, the second step of the process can utilize pests which have been captured in step one. Specifically, these captured pests can be used to attract or recruit other pests to the toxin-containing carrier and, in some instances, to deliver toxin to a nest or colony of the pests. Specifically, a captured pest can be forced to chew or move through toxin-containing carrier before travelling to the nest. In a preferred embodiment of the subject invention, the toxin is relatively slow-acting so the pest can travel to a nest or colony before dying. In the course of traveling to the nest, the pest can leave a chemical trail directing other of the target pests to the toxin-containing carrier. Because these chemical trails are species- and even colony-specific, these chemicals are highly advantageous for recruiting nestmates to the toxin-containing carrier. Also, the pest may deliver toxin to the nest, for example, via trophallaxis or cannibalism, where the toxin can kill other nestmates.

The invention also relates to materials and apparatuses used in carrying out the novel methods. One critical element of the subject invention is the toxin-containing carrier which can comprise a toxin and a carrier such as Methocel®, agar, other cellulosic materials, other materials which are non-repellant to the target pest, or a combination of two or more of these carriers. Preferably, the toxin is slow-acting. If a cellulosic material is used, that material may consist of wood particles. The carrier can further comprise components which stabilize or regulate the carrier environment. For example, a humectant such as a hygroscopic component can be added to regulate the moisture content of the carrier.

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Certain novel apparatuses are also used according to the subject invention. Specifically disclosed are apparatuses for monitoring and controlling populations of insects, particularly termites. For example, one such apparatus for monitoring the presence of termites simply comprises a food source as a monitoring bait which can be strategically placed at sites surrounding a structure. These monitoring baits are accessible to the pest management operator so that they can be periodically monitored for evidence of the presence of termites. Other apparatuses, such as electronic devices, can be incorporated in the monitoring baits to alert the homeowner or pest control operator to the presence of termites. Where ground or soil surrounds a structure to be monitored for termites, the monitoring bait can be placed in the soil near the foraging gallery of the pest. Where no soil is around a structure or the foraging galleries are detected above ground, the bait can be placed above ground. Advantageously, the monitoring bait can be constructed so that pests can be removed easily and without substantial harm resulting to the pest, thereby allowing the pest to be used to recruit other pests to the site.

Another apparatus useful according to the subject invention comprises a housing which is specifically designed to enclose either a monitoring bait or toxin-containing carrier. The bait or toxin can be enclosed within the housing and can thus be protected from the environment.

One object of the present invention is to provide a relatively inexpensive, environmentally safe termite control system requiring no complex machinery. The invention provides apparatuses and methods for the monitoring of, and delivery of a toxin to, a target pest wherein the apparatuses may be easily and safely serviced by householders as well as professional pest management workers.

Advantageously, the disclosed materials and procedures minimize the risk of exposure to persons handling toxins and increases toxin intake by termites. The methods of the subject invention can drastically reduce pesticide use in the urban environment. Moreover, this invention can be an important part of an Integrated Pest Management (IPM) system. The first part of the IPM is designed to monitor subterranean termite activity. No pesticide need be used until subterranean termite

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activity is detected. When activity is detected, the second part of the IPM can be employed wherein only a small quantity of pesticide (typically less than one gram to two grams) is used to control the entire colony population.

As described more fully herein, there are a variety of methods and apparatuses which can be utilized to practice the method of the subject invention. The precise methods and apparatuses which would be optimal for a particular target pest and environmental setting would be apparent to a person skilled in this art using the teachings provided herein.

The descriptions and teachings which follow primarily focus on the control of termites. Specific methods and apparatuses for the control of termites are provided, but variations of these methods and apparatuses and their applicability to pests other than termites would be readily recognized and used by a person skilled in this art.

#### Brief Description of the Drawings

Figures 1a-1d illustrate the procedures comprising the monitoring and toxin delivery steps of the subject method. Figures 1a-1d demonstrate the Integrated Pest Management system wherein a single housing apparatus is used to house a monitoring bait stake and a toxin delivery tube. Specifically, Figure 1a shows placement of the monitoring bait stake into a housing apparatus pre-positioned in the soil and placement of a stake cover over the housing and stake; Figure 1b shows termite foraging tunnels which lead to the apparatus housing the monitoring bait stake; Figure 1c shows removal of the monitoring bait stake and replacement with a toxin delivery tube within the same housing apparatus; and Figure 1d shows that the termites captured in the monitoring bait stake are placed into the toxin delivery tube to recruit other termites to the toxin.

Figure 2 shows a side and top view of a monitoring bait stake, with support bracket and outer housing.

Figure 3 shows top, side, and bottom views of a stake cover used as a thermal shade.

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Figure 4 shows a contiguous monitoring/baiting housing containing monitoring blocks placed in soil adjacent to a structure foundation. A thin strip of metal foil is embedded in the monitoring block. When the monitoring blocks are connected together to surround the structure, a contiguous circuit is formed. Severe infestation by termites in the monitoring block would result in the breaking of the circuit, which can be easily detected by an electronic device.

Figures 5a-5b show a monitoring and self-recruiting procedure to deliver toxin-containing carrier to termites when a contiguous baiting block configuration is used.

Figures 6a-6c show how an above-ground termite monitoring/capturing/toxin-delivery apparatus. Figures 6a and 6b show a section cut out for placement against a wall having a molding. Figure 6c shows an exploded view of the box, toxin carrier, and lid as appropriated mounted against a wall.

Figures 7a-7b show a modified above-ground termite control apparatus having interlocking walls.

Figure 8 shows one example of a horizontal monitoring device and station.

Figures 9a-9d show one example of the use of a horizontal monitoring device and toxin delivery system.

Figure 10 shows one example of monitoring device, monitoring station, and toxin delivery unit.

#### Detailed Disclosure of the Invention

The subject invention pertains to novel methods and apparatuses for controlling populations of pests. The present invention is based on the concept of providing a suitable toxin in a carrier which is non-repellant to the species of pest to be controlled. In a preferred embodiment, the invention further comprises a self-recruiting method of bringing additional pests to the toxin.

The described method is most readily applicable to insects which live in colonies and which communicate by chemical signals such as, for example, pheromones. Pheromones are naturally produced chemotactic compounds that

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termites and other insects are known to use as communication signals. The described method can be used, for example, to capture and control insects of the order Isoptera, and is particularly useful for controlling populations of subterranean termites. It would be readily apparent to persons of ordinary skill in the art that the method and apparatuses are adaptable to a variety of pest species. Examples of termite species which can be controlled by use of the disclosed method include *Coptotermes formosanus*, *Reticulitermes flavipes*, *R. hesperus*, *R. virginicus*, *R. tibialis*, and *Heterotermes aureus*, as well as termite species of the families (and pest genera) Mastotermitidae (*Mastotermes* species), Hodotermitidae (*Anacanthotermes*, *Zootermopsis* species), Rhinotermitidae (*Coptotermes*, *Heterotermes*, *Reticulitermes*, *Psammotermes*, *Prorethotermes*, *Schedorhinotermes* species), Kalotermitidae (*Cryptotermes*, *Incisitermes*, *Kalotermes*, *Marginitermes* species), Serritermitidae, and Termitidae (*Allodontermes*, *Microtermes*, *Odontotermes*, *Nasutitermes*, *Termes*, *Amitermes*, *Globitermes*, *Microcerotermes* species), and other pest species of termites. For purposes of brevity, the emphasis herein is directed to subterranean termites.

A preferred embodiment of the invention features two primary steps: (1) population monitoring/capturing (hereinafter referred to as monitoring), and (2) delivery of a toxin to a pest through the use of a toxin-containing carrier. The first step comprises monitoring a particular location to detect any termite activity. This step may further comprise capturing termites. The second step involves providing a slow-acting toxin in a carrier which is eaten or otherwise contacted by the termites. The slow-acting toxin allows termites to return to their nest before dying. Nestmates then follow the trail back to the toxin. Each of the two above-referenced steps is described in more detail below. Also discussed below in greater detail is the self-recruitment aspect of the toxin delivery step and new apparatuses useful in carrying out the methods of the subject invention.

A. Monitoring. The primary objective of the monitoring step is to detect the presence of subterranean termites and not to attract termites from other locations. If termites are present, this step provides an opportunity to collect them. If termites

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are collected, these termites can then be used for recruiting other nestmates to a toxin according to the second step of the invention. Therefore, it is preferred that termites be collected in a manner which does not adversely affect the termite's viability. The terms "without affecting viability" and "remain viable" mean that the captured termite is relatively unharmed and that it is able to forage and, preferably, has sufficient mobility to return to the nest.

Certain devices can be used to monitor for termite activity. The monitoring devices can be placed in, on, or above the ground. These devices may be placed individually or interconnected to surround structures to be monitored. The materials used for the monitoring device should not repel or deter termites. Preferably, these materials should be durable to maintain structural integrity in variable environments (high humidity, aridity) for a period sufficient for termites to locate and access the monitoring devices. The monitoring device should be able to withstand foraging activity by a large number of termites so the materials are not totally consumed within a reasonable time interval between inspections.

In a preferred embodiment of the monitoring step, a cellulose article can be used to detect and/or capture the target termites. The cellulose article is, thus, the "monitoring bait," or "monitoring article." The cellulose article employed in this monitoring step preferably allows the capture of termites with a minimum amount of harm to the termites. The article can be of any cellulose material which is susceptible to termite infestation.

The cellulose article used in the monitoring/capture step can be comprised of at least two interfacing, separable pieces which can be bound together. The two-piece construction allows for easy collection of termites within the cellulose article. For example, a wooden stake can be comprised of two or more interfacing pieces which are bound together at the two ends of the stakes. The binding which holds together the pieces can be flexible metal bands, an adhesive tape, or the like. As shown in Figure 2, the interfacing pieces can be enclosed within a bracket device comprised of horizontal bands which are interconnected by longitudinal supports

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which form a bracket and which further has a handle at one end to facilitate removal of the monitoring stake from the ground even when badly damaged by the termites.

One preferred embodiment of the monitoring step utilizes an outer housing which is separate from but surrounds the monitoring article. In one embodiment, the outer housing can have a plurality of entry points which allow termites access to the monitoring article. The outer housing can further comprise a reinforced tip at one end to facilitate placement into the ground. The outer housing may further comprise, at the end opposite the reinforced tip, a locking means which engages a cover. One embodiment is shown in Figure 2. The monitoring article and/or the outer housing can be readily adapted for above-ground use, for example, in trees or on structures. When an outer housing is used, the same housing can be used for both the monitoring step and the toxin delivery step. For example, once termites are observed in the monitoring step, the monitoring article (without toxin) can be removed from the housing and replaced with a toxin-containing carrier. One advantage to the use of the outer housing is that the termite foraging tunnels will not be greatly disrupted by removal of the monitoring article if the housing remains in place. Thus, when the monitoring article is replaced with a toxin-containing carrier, foraging can commence readily without extensive restructuring of the foraging tunnels of the termites.

The monitoring article (or housing containing the monitoring article) can be placed in the ground or other appropriate location for a time sufficient to allow termite infestation. The monitoring article can be placed in the ground directly by being driven into the soil or placed into a pre-existing hole or location of sufficient dimension to allow the article to remain in position. Alternatively, the monitoring article can be placed inside the outer housing which is placed on or in the ground. The monitoring article and/or outer housing may lie flat on the ground or be placed upright in a hole.

In one embodiment of the monitoring step, the monitoring device is modified chemically and/or physically to increase the possibility that the target pest will enter and move within the device. A variety of chemical means, such as food, moisture, and pheromones or their mimics (e.g., glycol compounds), and physical characteristics,

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such as shape, size, and texture, can be used to achieve this objective. One example of a physical modification would be a cover placed over the monitoring and toxin delivery devices. Subterranean termites congregate beneath an object on the soil surface because soil temperature and moisture beneath such an object are different from the surrounding soil. One embodiment of the cover is a circular or disc-shaped device having a convex top and concave bottom side. Insulation material such as styrofoam may be incorporated in the cover material to further maintain stable temperature and humidity beneath the cover. The cover may be, for example, four inches or more in diameter. The bottom side of the cover can be radially ribbed or grooved. The top side can be smooth-surfaced. At the center of the cover can be a closeable opening. The opening can be of sufficient dimension so that the bait station housing can be passed therethrough. The lid can also serve as an inspection window. In addition, located approximately between the center and outer edge of the cover can be small holes so that nails or similar fasteners can secure the cover to the ground. One embodiment is shown in Figure 3.

Once infested by termites, the monitoring article can be gently removed from the soil or from the outer casing. As stated above, it is advantageous to utilize an outer housing to minimize disruption to foraging tunnels. Upon removal of the monitoring article, a toxin-containing carrier can then be placed in the housing or other location previously occupied by the monitoring article. In this way, toxin is not used until the presence of termites is determined by the monitoring step.

In a preferred embodiment described more fully below, termites collected in the monitoring step are used to recruit more termites to the toxin. Therefore, the monitoring article can be specifically designed to facilitate capture of termites. Such an article, as described above, may have interfacing sides. After removal from the ground or the housing the interfacing sides of the monitoring stake are unbound so that the sides can be separated and termites extracted from them. The dimensions and shape of the stakes are designed so that termites foraging in the wooden stakes can be extracted with minimum harm. "Minimum harm" means that the termites which are captured remain viable and are capable of foraging and producing

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pheromone and, preferably, are able to return to the nest for recruiting nestmates. The extracted termites are then used to recruit other termites from the soil into a toxin-containing carrier. Termites foraging in the monitoring article can be transferred to a toxin delivery station by gently removing or tapping them from the article into the toxin delivery station. The toxin delivery station can comprise a chamber above the toxin-containing carrier into which the termites are placed. To exit the station, the termites must then tunnel through the toxin-containing carrier.

One example of how the monitoring step may be conducted is as follows:

(a) Placement of the monitoring article. A hole can be made in the soil of appropriate dimension for positioning of the housing apparatus. The housing apparatus is placed into the hole. The monitoring article is placed inside the housing apparatus. A cover can be placed over the monitoring article and the cover secured to the surface of the ground. Alternatively, the monitoring article can be placed inside the housing apparatus and the monitoring article can be hammered into the soil until the housing apparatus opening is near the soil surface. Also, the monitoring article or housing may be placed flat on the ground. Also, the monitoring article or housing can be adapted for above ground use.

(b) Inspection of monitoring articles. The monitoring article can be inspected periodically for evidence of termite infestation by visually examining the article for signs of infestation. Inspection of the monitoring articles can be performed weekly, bi-weekly, monthly, etc. as needed or desired. Inspection may be done visually, or automatic monitoring devices may be used. For example, termites are known to chew through soft metal. Therefore, thin strips of metal may be incorporated into the monitoring article and connected to an electronic device. When termites chew through the thin metal, the circuit is broken, thus evidencing the presence of termites. See Figures 4 and 5. Also, the monitoring device may be designed to detect the sound produced by termites as they feed on the monitoring article.

(c) Detection of presence of termites. Upon the detection of the presence of termites in the monitoring article, the monitoring article is removed from

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the housing apparatus and replaced with a toxin-containing carrier, thus creating a toxin delivery station. Termites that are captured in the monitoring device can be extracted and gently tapped into an upper chamber of the toxin delivery station. No toxin will be used unless termites are detected from the monitoring procedure (or one otherwise known to be present), thereby eliminating the use of any unnecessary toxin. When termites are detected, the toxin-containing carrier is utilized until no termite activity is detected in the toxin delivery station. At that time, monitoring devices can be used again. In addition to the practice of replacing monitoring articles with toxin-containing carrier, another embodiment of the invention comprises a monitoring article which remains in place and a toxin delivery station which can be added to, or fitted around, the monitoring article if the need arises to deliver toxin.

B. Toxin delivery. The objective of the toxin delivery step is to induce as many pests as possible from a colony to contact or eat a toxin. The details of the toxin delivery step are herein described as pertaining to termites, particularly. However, as stated above, the method can also apply to other insects, especially those subterranean insects which live in colonies or nests and which communicate by chemical signals, i.e., pheromones.

The essential elements of a toxin delivery system comprise the presentation of an active ingredient (AI) and a suitable carrier in a manner that induces the target pest to ingest or contact the AI. The toxin-containing carrier should be delivered in, on, or above the ground in a manner which eliminates unnecessary exposure of the environment, applicator, and other non-target organisms to the toxin. For example, a suitable carrier can be a coatable, suspendable, impregnable natural or artificial food source. The carrier does not need to attract pests, but should not repel them. The presentation of the carrier (in a housing, etc.) may induce pests to contact the toxin. The suitable carrier further can be capable of being formed into a desired shape for placing or packing into a housing apparatus, or can achieve the desired consistency by the addition of a liquid thereto. More specifically, suitable carriers can be formable cellulose-containing materials including, but not limited to, wood particles or wood flour, Methocel®, or recycled paper. A preferred cellulose-

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containing carrier is sawdust or wood flour from a low-resin-containing hardwood. For use with termites and other pest species which are attracted to, or reliant on, the presence of sufficient moisture, the carrier can further comprise a humectant for maintaining moisture content. An appropriate humectant can have hygroscopic characteristics. The monitoring step and toxin delivery step could use the same carrier, except that no toxin is impregnated into the carrier used for the monitoring step.

The preferred active ingredient should be slow-acting, lethal at concentrations which do not repel target insects, and capable of being combined with the carrier matrix as described above. It is intended that pests directly contacting or ingesting the toxin will not be killed immediately but will travel to a colony to recruit other pests to the toxin, thereby resulting in the control of large numbers of insects. The term "delayed lethal effect" in the present specification means that death does not occur immediately or within a short time such as a few seconds or minutes after ingestion or contact of the active ingredient by a termite. Rather, it is preferred that the pest die hours or, preferably, days or weeks after encountering the toxin. This delayed lethal effect permits the termites to return to the colony before death occurs, thus allowing the location of the toxin delivery system to be communicated to nestmates within the colony. It is preferable that the communication be effected by pheromones because these chemical signals are a highly efficient means of communication, often being specific to a particular colony. In addition, communication by trail-following pheromones is initiated by their deposit directly into the toxin-containing carrier by captured termites which return to the colony, thereby recruiting these nestmates to the toxin bait, ensuring their exposure to the slow-acting toxin.

The active ingredient can comprise chemical insecticides, insect growth regulators, or microbial pathogens or their toxin preparation. Examples of toxins include, but are not limited to, borates (boric acid, disodium octaborate tetrahydrate), mirex, sulfluramid and related fluoroalkyl sulfonamides, hydramethylnon, avermectin, A-9248 (diiodomethyl para-tolyl sulfone), fluorosulfonates, imidacloprid, azadirachtin,

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cyromazine, juvenile hormones (JHs), juvenile hormone analogs (JHAs), or juvenile hormone mimics (JHMs) such as methoprene, hydroprene, triprene, farnesinic acid ethyl and alkoxy derivatives, pyriproxyfen (Nylar), fenoxycarb, and chitin synthesis inhibitors (CSIs) such as hexaflumuron and other acyl ureas, diflubenzuron (Dimilin), and azadirachtin. Biological control agents which can be used as the "toxin" include, but are not limited to, entomogenous fungi such as *Metarhizium anisopliae* and *Beauveria bassiana*, entomogenous nematodes such as *Neoplectana carpocapsae*, insect viruses, pathogenic bacteria such as *Bacillus thuringiensis*, *Aspergillus flavus*, and *Serratia marcescens*, or the toxin preparations derived from *B. thuringiensis* or other biological control agents.

In addition, other insecticides can be used as microencapsulated formulations. Microencapsulation can slow the activity of otherwise fast-acting toxins. An example of the invention disclosed herein uses hexaflumuron, which can be impregnated into the cellulose material during the formulation of the toxin-containing carrier.

As discussed above, a novel feature of one embodiment of the subject invention comprises a "self-recruiting system" to use collected termites to recruit other termites to the toxin delivery station. It is widely recognized that certain insects utilize chemical signals such as pheromones, which can be deposited along a trail by an insect which has located, for example, a food source. Subsequently, other insects, usually from the same colony, detect the chemical signal and are thus directed to that food source. Such trail-following pheromones of some subterranean termites have been identified; however, synthesis of such natural products or their analogs is difficult, costly, and impractical. Moreover, the proper concentration and composition of these pheromones can be species- and colony-specific. Therefore, reproducing functional synthetic pheromones would be nearly impossible for the desired purpose of widespread use in attracting termites.

An advantageous feature of the "self-recruitment" embodiment of the subject invention is to utilize a captured target pest to produce the species- and colony-specific pheromone for recruiting other pests to the toxin. The method is particularly well suited for aggregating a great number of pests from a single colony to a toxin.

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In accordance with the self-recruitment embodiment, termites collected in the monitoring phase are placed in the station with toxin-containing carrier and must chew or move through the toxin-containing carrier before returning to their nest. In this manner, the termite ingests or contacts the toxin and leaves appropriate communication signals throughout the toxin-containing carrier, which encourages other termites to locate the toxin-containing carrier and initiate feeding activity.

In one embodiment of the self-recruiting system, termites in the monitoring stakes are gently tapped into an empty chamber situated at the top of the bait station. This chamber may be, for example, about 3.0 cm in diameter and about 2.0 cm deep. Smaller or much larger chambers could also be used. The open end is then closed. These termites must then enter the toxin-containing carrier. Vertical tubes of plastic can be supplied to encourage this process. The termites then tunnel through the toxin-containing carrier before returning to their galleries, thereby leaving trail-following pheromones in the toxin-containing carrier. The exiting process may be encouraged by horizontal tubes. This arrangement forces termites to remain in the bait station and thus leave trail-following pheromone in the stations to recruit nestmates into the toxin-containing carrier. As discussed above, the self-recruiting procedure advantageously uses termites to leave the species- and colony-specific composition of pheromones to recruit nestmates, as compared to the use of synthetic pheromones which can fail because of their lack of specificity. The deposit of specific pheromone in the toxin by the captured termites thus aids in recruiting other termites to the toxin, whereupon they forage, are exposed to toxin, and deposit more pheromone, thus creating a cyclical, self-recruiting termite control method.

C. Apparatuses. Employed at each step of the method are novel apparatuses. As described above, one method for the monitoring step employs a novel, separable article placed into the ground (or into a housing) for attracting and capturing termites indigenous to an area. The termites are captured in such a way so that they remain viable and can be easily transferred to the toxin delivery apparatus used in the second, or toxin delivery, step. Alternatively, for monitoring above-ground, an apparatus which houses a food source such as sawdust, or a modified stake, can be

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placed on or attached to (or inside) the wall of a structure or a tree. The above-ground monitoring apparatus is also easily accessible for periodic monitoring and capture of pests for use in the toxin delivery step.

The monitoring and toxin delivery steps employ novel housing apparatuses. The novel housing apparatuses of the subject invention are designed to protect and enclose the monitoring article and toxin-containing carrier and, preferably, to encourage termites to contact the toxin-containing carrier wherein the termites are exposed to lethal doses of a toxin. For purposes of the subject invention, the housing apparatus should be durable enough to contain the monitoring article or toxin-containing carrier in variable environments (i.e., wet vs. arid), and should be constructed in a manner or of a material that will allow target pests to pass through the housing, i.e., with pre-formed entry points, or of a material in which insects can form their own openings. The housing should be non-repellant to target insects. A preferred housing would be capable of repeated use, environmentally acceptable, and an effective barrier between the toxin and the handler or the environment. Materials from which the housing can be constructed include, but are not limited to, polymers such as plastic, metal, wax, cellulose-based materials such as cardboard, particle board, paperboard, and the like. Housings which are not eaten by termites are preferred.

The housing is designed to minimize direct contact of persons handling the bait station with toxin-containing bait, and to allow termites collected from the monitoring procedure to return back to the foraging galley for recruiting other nestmates.

The housing should be of a size and shape that is large enough to contain an effective amount of toxin while still being easily handled by individuals. The housing should further be of a size and shape that is accessible to the target insects. The various shapes of the housing can include, but are not limited to, cylinders, discs, rectangles, and cones.

One embodiment of the subject invention can utilize a single housing unit which can house the monitoring article for use in the monitoring step and then, after

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removing the monitoring article, can also house the toxin-containing carrier. When the monitoring step employs sawdust or other cellulose-containing material as a component of the monitoring article, the sawdust can be packaged for convenient placement into, and removal from, the housing. Preferably, the material used to package the monitoring mixture can also be a cellulose-containing material such as paper, cardboard, paperboard, or the like, so that it is palatable to termites. Similarly, the toxin and its carrier can be packaged in a cellulose-containing package wherein the packaging serves as a barrier to prevent the handler from exposure to the toxin.

Following are examples which illustrate procedures, including the best mode, for practicing the invention. These examples should not be construed as limiting. All percentages are by weight and all solvent mixture proportions are by volume unless otherwise noted.

#### Example 1 -- Preparation of Toxin-Containing Carrier

The toxin-containing carrier can comprise cellulose, preferably in the form of a powder or small particles, and the active ingredient of a toxin. Cellulose in the form of powder allows for a more homogeneous mixture of cellulose and toxin and facilitates packing and handling. A humectant component can be added to the carrier to maintain moisture content. In one embodiment of the invention, a Methocel® solution of about 1% to about 5% can be used effectively. An about 1-2% solution is preferred. Moisture content can be varied according to the preferences of different termite species. A preferred embodiment of the invention employs a carrier comprising sawdust, preferably of a hardwood which has a low resin content, as the cellulose component, and water sufficient to yield a moisture content of approximately 50% to about 90% by weight. A moisture content of about 60-80% is preferred. Water content can be varied but should be adequate to thoroughly moisten the dry components of the carrier, but should not be so much as to result in a soup-like consistency. The preferred consistency of the final matrix is that of a

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semi-solid paste whereby the sawdust or wood flour can be compacted together and formed or shaped. Sawdust containing about 70% water was found to stimulate feeding by the native subterranean termites (*Reticulitermes* species) and the Formosan subterranean termite, *C. formosanus*.

Further studies have shown that sawdust from hardwood species such as, for example, oak, beech, birch, or maple was preferred by termites. This was a surprising result because it previously was widely assumed that termites preferred soft wood which was easier to eat. As used herein, reference to "sawdust" means fine wood particles which may be so fine as to be known as wood flour, and which may be produced from wood by any suitable process as well as by sawing wood. Furthermore, the bait can be made a preferred food by suitable choice of the species of timber and also suitable choice of the maximum particle size. The exact species of termite to be eradicated will indicate the optimum wood flour and the optimum particle size.

A procedure for the preparation of the toxin-containing carrier used for the toxin delivery step is conducted as follows:

1. Hardwood sawdust or wood flour is mixed with water in proportions of approximately 70% water (w/w). Alternatively, the water component can be 1-2% Methocel® solution.
2. Toxin is mixed into the sawdust/water matrix to result in a final concentration of approximately 5000 ppm.
3. The toxin-containing mixture is thoroughly mixed to ensure homogeneity of the components.
4. The toxin-containing mixture can be adjusted with additional water or sawdust to achieve a semi-solid formable consistency which can be packed into the housing apparatus or into a cellulose-containing packaging material.
5. The toxin-containing composition can be stored in a moisture-tight and air-tight packaging to maintain the appropriate moisture content.

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### Example 2 – Construction of Bait Station Housing

In one embodiment of the invention, the housing can comprise a rigid tube which is pointed at one end and closeably open at its opposite end. The tube is preferably made of a shock-resistant plastic (polymer), or can be any such material which resists decay or corrosion when exposed to moisture, especially when buried underground for a period of time. Preferably, the texture of the bait station housing apparatus is coarse. Numerous entry points on the side of the housing can lead to inner tubes that may be bent to attach to the inner wall of the toxin delivery tube. In this embodiment, termites entering the housing from the soil are directed sideways and into the toxin. The bent inner tubes provide entry points for termites in the soil. Because they are bent sideways, the toxin-containing carrier cannot be directly accessed from outside. Preferably, the entry points have a diameter which is larger than the head of the termite but smaller than the width of its head and two antennae. These holes can have, for example, an inner diameter of about 0.25 cm. Toxin-containing carrier is added to the tube to a level lower than the closeably open end. This level may be, for example, about 2.0 cm below the end. A plastic insert with a plurality of holes can be placed into the toxin-containing carrier at the closeably open end of the bait station. There may be, for example, six holes having an inner diameter of about 0.25 cm. Vertical tubings extending from the holes of the insert can be punctured into the toxin-containing carrier. This arrangement helps to tamper-proof the bait station because the toxin-containing carrier cannot be accessed from any external opening of the bait station. A detachable cap can be placed to leave a closed chamber (for example, 3.0 cm diameter x 2.0 cm deep) at the closeably open end of the bait station. The detachable cap is either engaged with a snap-on attachment or can be threadedly engaged. The closed chamber provides a location to place termites to be used for self-recruitment.

### Example 3 – Above-Ground Monitoring and Toxicant Delivery

In urban areas where the soil which surrounds a structure is often paved with cement, or asphalt, or some like material, the placement of the monitoring and/or

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toxicant delivery systems in or on the ground may not be practical. Termite infestation, however, is no less of a problem in these urban areas. Therefore, an alternative application and design of the described invention comprises a monitoring and/or toxicant delivery station which can be used in an above-ground system.

The above-ground design is illustrated in Figures 6 and 7. This above-ground system can comprise a housing which is placed or mounted in or on the wall of a structure. The housing can comprise a frame which is designed to simultaneously fit snugly against the wall and a wooden door frame, a molding, or the like. In one embodiment, the housing can enclose a toxin-containing carrier, substantially as described above, wherein the toxin-containing carrier can be packaged in various shapes and sizes, for example, a rectangular box shape, to facilitate their use with the above-ground system housing. The above-ground housing can be substantially open at the side which faces or is mounted to the wall. The side of the housing facing outward is closeably open, wherein a hinged lid or a separate lid can be placed over the opening. The lid serves to prevent exposure to toxins by persons handling the toxin-containing carrier. The lid can further comprise a locking means to prevent inadvertent exposure by children or others. The cover can also serve to prevent moisture loss from the toxin-containing carrier. Moisture loss can also be prevented by the packaging of the toxin, wherein it is preferable to package the toxin bait in a material which is edible by termites. Such edible materials can be cardboard, paperboard, paper, and the like. A preferable material for packaging the toxin-containing carrier is wax-paper due to its moisture-retaining characteristics.

After a housing is attached to a wall or other structural member, contact with the termite galleries can be facilitated by drilling a hole through the structural member into the gallery area. Initially, a cellulose monitoring article may be placed in the housing. If termites are detected, the monitoring article can be replaced with a toxin-containing carrier and collected termites used for recruitment. In case of severe termite activity, a toxin carrier may be placed in the housing without the placement of a monitoring article.

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Above-ground monitoring and baiting schemes can also be widely adapted for use in trees.

Example 4 – Field Testing Using Matrix Containing Hexaflumuron

1. Procedures. Field colonies of the Formosan subterranean termite, *C. formosanus*, and the eastern subterranean termite, *R. flavipes*, were selected for testing. Termite activity was measured 1-2 years before the introduction of hexaflumuron treated bait. Monitoring stations contained pre-weighed wood blocks surrounded by plastic containers buried beneath the soil surface. Wood weight loss of a block was determined monthly or bi-monthly to represent activity of the subterranean termite colony being tested. A multiple mark-recapture program was conducted to estimate the foraging population size and foraging territory of each tested colony. Termite activity was monitored throughout the toxin baiting program. When possible, another mark-recapture program was conducted to estimate the post-toxin baiting population of a toxin baited colony.

2. Toxin bait station. Pine or spruce sawdust was impregnated with an acetone solution of hexaflumuron to yield concentrations of 500-5,000 ppm (dry wt AI/dry wt sawdust) upon evaporation of acetone. The bait matrix was composed of 20% treated sawdust and 80% of agar or Methocel® solution (2%). A bait station was composed of a plastic tubing (2.9 cm diam. I.D. by 16.5 cm high, one end closed, the other open) filled with approximately 80 g of bait matrix. This leaves approximately 5 cm height of open space on the open end of the tubing. Six layers of 9 holes (0.238 mm diameter) were pre-drilled in the side of the tubing.

3. Monitoring. Wooden stakes (3.4 cm by 3.4 cm by 30 cm) were driven 20-25 cm into the ground surrounding monitoring stations. Once infested by termites, the wooden stake was gently pulled out of the soil, leaving a hole of ca. 3.4 cm by 3.4 cm and 20-25 cm deep. A toxin bait station was inserted into the hole. Termites were extracted from the infested stakes and placed into the open space (5 cm high by 2.9 cm diameter) on the open end of the toxin bait station. The extracted termites were forced to tunnel through the matrix to return to the colony, and to recruit



nestmates into the bait station. To compare the efficacy of self-recruiting procedure in enhancing the bait-intake, this self-recruiting procedure was omitted in some bait stations. Bait stations were checked monthly and replaced with new stations. The amount of bait matrix consumed by termites from each bait station was subjected to the analysis of variance using a completely randomized design ( $P < 0.05$ ) to determine the significant difference in bait consumption between stations with the self-recruiting procedure and those without.

Results:

Experiment 1. The foraging population of this *R. flavipes* colony was estimated at 476,000 in September. Infestations by this colony were found in the door and door-frame of a nearby building. Wood weight loss from the three monitoring stations was approximately 2 g/station/day during the summer. The activity declined during the winter to approximately 0.5 g/station/day. Three bait stations were introduced in February. By April, no termite activity was found in any of the monitoring stations or bait stations. A total of 26 g of bait matrix was consumed by this termite colony. The amount of active ingredient (AI) consumed was 3.87 mg. Because of the absence of termite activity after April, it was concluded that the entire colony of over 400,000 termites was eliminated by the consumption of 3.87 mg hexaflumuron within two months.

Experiment 2. The foraging population of this *R. flavipes* colony was estimated at 730,000 in September. This colony was located in a non-residential area. Termite infestations were found in trees and fallen logs of pine and oaks. From September through the following spring, wood weight loss from the six monitoring stations was approximately 2 g/station/day. Eleven bait stations were introduced in April. In June, termites maintained the activity level of 1.8 g/station/day. By July, however, the activity was reduced to 0 g/station/day. During the three months (April-June) baiting period, a total of 122 g bait matrix and 20 mg AI was consumed. No termite activity was recorded in this location after July. We conclude the 730,000 termites were eliminated by consuming 20 mg of hexaflumuron.

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Experiment 3. Structural infestation of this *R. flavipes* colony persisted in a two-story building (approximately 1,500 m<sup>2</sup>) for at least 3 years. Residents reported annual spring swarming from the structure for five consecutive years. Soil termiticide treatments had been done by a pest control firm annually since the erection of the building in 1986. Despite the soil termiticide treatments, the foraging population of this *R. flavipes* was estimated at 2,847,000 in May. Foraging territory was approximately 1,782 m<sup>2</sup>. Mean wood weight loss from the 13 monitoring stations ranged 2-4 g/station/day. Following the introduction of 27 bait stations in August, the activity was reduced to 0.1 g/station/day in September. Termites, however, remained active in bait stations in October and November. By December, no termite activity was detected from any of the monitoring or bait stations. During the four month baiting period (August-December), a total of 69 bait stations were used, from which 2,997 g bait matrix and 1,539 mg AI was consumed by this *R. flavipes* colony. Residents of the building reported that this was the first time within the last five years that they did not see the termites swarming. No soil termiticide treatment was done the following year. In March of the following year, termites were collected in one of the monitoring stations. Because no dyed termites were found from this collection, we speculated that a nearby colony might have migrated into the territory of the baited colony. A mark-recapture program conducted in March-April estimated 260,000 foraging termites in this new colony. Assuming this is the remaining of the baited colony, the baiting program conducted in August-December had eliminated over 2.5 million termites.

Experiment 4. Foraging activity of this *C. formosanus* colony has been monitored in an 11-story high rise. Numerous soil termiticide treatments were done to prevent structural infestation by this *C. formosanus* colony. Foraging population was estimated at 1,047,000 in September. The foraging territory extended to 1,614 m<sup>2</sup>. Mean wood weight loss was 2-4 g/station/day. Foraging activity typically declined in winter but often peaked during summer months (5-10 g/station/day). Five bait stations were introduced in April. The foraging activity was reduced to less than 2

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g/station/day, and remained at the same low level until October. By November, no termites were found in the monitoring stations, but slight feeding activity was observed in a few bait stations until February. During the baiting program (April-February), a total of 41 bait stations were used, from which 847 g of bait matrix and 233 mg AI were consumed by this *C. formosanus* colony. We concluded the colony of 1.0 million termites was eliminated after consuming 233 mg of hexaflumuron over a 10-month period.

Experiment 5. Despite repeated soil termiticide treatments and a fumigation following the discovery of structural infestations by this *C. formosanus* colony in a high rise, foraging activity remained strong (mean wood weight loss: 6-10 g/station/day). Activity of this colony did not decline even in winter months. Foraging population was estimated at 2,431,000 in March. Over 90% of the bait matrix of the eight bait stations introduced in May was consumed within a month. Foraging activity in May-July was slightly reduced (5 g/station/day). Subsequently, the mean wood weight loss was further reduced to near zero in July-October. Since November, no termite activity has been recorded in any of the stations. During the 6-month baiting period (May-November), a total of 89 bait stations were used. We concluded that the colony of 2.4 million termites was eliminated by the consumption of 742 mg hexaflumuron.

Experiment 6. Infestations by this *C. formosanus* colony were found in the utility room of a high rise. Foraging activity was detected along the front yard of this building. The foraging territory extended up to 185 m from one end to the other. This *C. formosanus* colony consumed wood at a rate of approximately 5-10 g/station/day from the 10 monitoring stations. The foraging population was estimated at 1,225,000 in April. Following the introduction of bait stations in July, foraging activities steadily declined to near zero in October. No further bait stations have been introduced since December. Since October, slight termite activity (<1 g/station/day) has remained in one monitoring station. Using termites collected from this monitoring station, we conducted a mark-recapture program in March and estimated 104,000 termites in the remaining colony. A total of 42 bait stations were

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used during the 5-month baiting period (July-December), from which 1,182 g of bait matrix and 259 g AI were consumed. We concluded the 259 mg of hexaflumuron reduced the population size of this colony from 1.2 million termites in April to 104,000 the following March.

Example 5 – Effects of the Self-Recruiting Procedure on Toxin Bait Consumption

Significantly more ( $P < 0.05$ ) more bait matrix was consumed from bait stations that received termites collected from the monitoring stakes (referred to as “self-recruited” bait stations) than stations that were simply placed in the holes from which infested stakes were pulled (“not self-recruited” bait stations). The mean weight of bait matrix consumed by *C. formosanus* from self-recruited stations was 35.8 g/station while those of not self-recruited stations was 6.5 g/station. With *R. flavipes*, the mean weight of consumed bait-matrix was 39.2 and 17.2 g/station for self-recruited stations and not self-recruited stations, respectively.

When more than 1% of the bait-matrix was consumed from a bait station, the station was considered attacked by termites. Using this criteria, 83% of self-recruited bait stations were attacked by *C. formosanus*, while only 59.3% of not self-recruited stations were attacked. With *R. flavipes*, the attack rate for self-recruited stations was 94.7%, while 75% of the not self-recruited stations were attacked.

Example 6

Dyes may be incorporated into the matrix to assist the applicator in identifying termite colonies and foraging range of termites feeding on a monitoring article or toxin bait.

Example 7

The procedures, materials, and apparatuses of the subject invention can be readily adapted for use for the control of termites attacking croplands, forests, golf courses, and other non-structural targets. The same general materials and methods

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may be utilized with minor modifications, readily apparent to those skilled in the art, to achieve optimal results.

Example 8 – Horizontal Bait Stations for Population Suppression of Subterranean Termites

Placement of vertical type stations is difficult in some locations with rocky soil. Moreover, some termite species tend to forage near the soil surface, making it unnecessary to place a bait station as deep as that of the vertical type. Therefore, one embodiment of the subject invention involves the use a horizontal bait station that can be placed near soil surface.

Monitoring station. The monitoring device housing can be comprised of a container with a cut-out bottom. As an example, this container may be about 21.5 x 16 x 5.5 cm. Numerous holes can be drilled through the four vertical walls of the container. These holes can be, for example, about 3 mm in diameter inside and about 0.6 mm in diameter outside. This hole arrangement prevents soil invasion into the housing. Inner and outer walls can be sanded to provide a surface suitable for termites to walk on. A monitoring device can be made, for example, of three sections of three wooden pieces bound together with a support strip attached to a handle. The monitoring device can be placed inside the container and can be removed using an attached handle with minimum disturbance to termites (Figure 8).

Toxin delivery. A container that fits within the monitoring device housing can be used as a toxin delivery unit. This container may be, for example, about 19.3 x 13.5 x 4.5 cm. Except for a removable cover, numerous holes through all sides of the container can be provided for termite entry. These holes may be, for example about 0.24 cm in diameter. Holes can extend inside the toxin delivery unit with inner tubes bent at about 90° to prevent tampering with the toxin-containing carrier. The inner and outer walls of the toxin delivery unit can be sanded. The toxin delivery unit can be filled with the toxin-containing carrier up to, for example, about 1 cm from the top of the container and covered with a lid.

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Operating procedure. A monitoring device housing containing wooden pieces is placed beneath the ground and covered with a thin layer of soil (Figures 9a, 9b). This thin layer of soil can be, for example, about 1 cm. Monitoring devices are checked for termite activity. Monitoring devices infested with termites are gently lifted and replaced by the toxin delivery unit containing the toxin-containing carrier (Figures 9c and 10). Termites extracted from the boards are gently tapped into the upper 1 cm deep chamber of the toxin delivery unit (Figure 9d), leaving the colony recognition semiochemicals in the toxin-containing carrier to "self-recruit" nestmates into the toxin delivery unit.

It should be understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and the scope of the appended claims.

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Claims

1. A method for the control of a population of isopteran insects, said method comprising:

- (a) monitoring of a site for isopteran activity; and
- (b) controlling the population of said isopterans through the use of a toxin bait.

2. The method, according to claim 1, wherein said monitoring comprises periodic observation of a cellulose monitoring article for evidence of isopteran activity.

3. The method, according to claim 1, wherein said toxin bait comprises cellulose and a toxin.

4. The method, according to claim 1, wherein said toxin bait comprises a solution of Methocel®.

5. The method, according to claim 1, wherein said toxin bait comprises a toxin selected from the group consisting of encapsulated toxins, slow-acting chemical toxins, and biological control agents.

6. The method, according to claim 1, wherein an outer housing is utilized in step (a) to enclose a cellulose article which is monitored for isopteran activity; said housing also being utilized in step (b) to enclose said toxin bait.

7. A method for controlling a population of isopteran insects living in a nest or colony, said method comprising:

- (a) capturing an isopteran alive; and



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access to said cellulose article or toxin bait of environmental factors as well as humans or animals.

15. The housing, according to claim 14, wherein said housing is adapted for use in the soil, said housing being formed from a rigid polymer which encloses said cellulose article or said toxin bait, said housing further comprising a plurality of entry points of sufficient diameter to facilitate entry of said isopteran to gain access to said cellulose article or toxin bait.

16. The housing, according to claim 15, wherein said entry points have a diameter greater than the average width of the head of an isopteran of the species desired to be captured but less than the width of the head and two antennae of said isopteran.

17. The housing, according to claim 14, wherein said housing is adapted for use above ground, wherein said housing can be attached to a structure or a tree.

18. The housing, according to claim 14, wherein said housing comprises a horizontal cover.

19. A kit comprising a housing for enclosing a cellulose article for monitoring isopteran activity or a toxin bait for delivery of toxin to an isopteran; said kit further comprising one or more of the group consisting of

- (a) a cellulose article for monitoring isopteran activity; and
- (b) a toxin bait.



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