



Termites and their management

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Abstract

Termites are medium-sized, soft-bodied, light-colored, polymorphic, cellulose-eating social insects living in large communities of several hundred to several million individuals. The word Isoptera originated from the Greek, in which “isos” means equal and “pteron” means wing, and refers to the two pairs of identical wings in the adult. There are about 2,650 species of termites in 280 genera and seven families worldwide. The individuals are differentiated morphologically into distinct forms, i.e., reproductives (king and queen), workers, and soldiers. The parent termites, the king and queen are the functional reproductives. The phenomenon of fungus cultivation is practised and an indirect method of cellulose and lignin utilization is carried out by the termites. Termites are considered a culinary delicacy in most parts of Asia and Africa. As food, termites provide protein and carbohydrates, fat and essential aminoacids to human beings and other primates. About 300 species have been reported to cause significant damage to agricultural crops and have been recorded as pests. Species of *Microtermes* and *Odontotermes* have been found to damage different crops such as sugarcane, wheat, barley, maize, vegetables, garden crops, valuable ornamental crops, and even forest trees. Termites also feed on and often destroy various other materials that people use, i.e., wooden portions of buildings, furniture, books and utility poles. Baiting is the most recent method of termite pest control. The best method of eliminating dry wood termites is by chemical fumigation using the fumigant.

Keywords: Termites, isoptera, microtermes, odontotermes, chemical fumigation

Introduction

Termites are social insects that belong to the order *Isoptera*. The name *Isoptera* is derived from Greek, where “isos” translates to equal and “pteron” means wing—referring to the adult termites' two identical pairs of wings. These insects are medium-sized, soft-bodied, light in color, and exhibit polymorphism. They feed primarily on cellulose and live in complex colonies that may range from a few hundred to several million individuals. Fossil evidence suggests termites originated approximately 220 million years ago. They are believed to have evolved from a group of wood-inhabiting cockroaches, which is supported by their obligatory symbiosis with gut-dwelling protists, and in some advanced species, the cultivation of external basidiomycete fungi. Termites are distributed across tropical and some temperate regions, with their greatest diversity and population densities observed in the rainforests of Africa, Southeast Asia, and South America. Globally, about 2,650 termite species are classified under 280 genera within seven distinct families.

Termite colonies are highly structured and organized, with individuals divided into different castes: reproductives (king and queen), workers, and soldiers. The king and queen are responsible for reproduction, with the queen also releasing pheromones that help regulate caste differentiation. Workers and soldiers are sterile, wingless forms, which may be either male or female. Soldiers, constituting roughly 10% of the colony, are specialized for defense and possess hardened, elongated heads adapted for this role. Workers, the most populous caste, are responsible for tasks such as nest

maintenance, food gathering, and feeding other colony members. Mature colonies produce winged reproductive forms, called alates, which emerge in large numbers during swarming events for mating and colony establishment.

Ecologically, termites are crucial to tropical ecosystems due to their ability to break down cellulose-rich organic matter like dead wood and leaf litter. However, around 300 species are recognized as pests due to their capacity to inflict economic damage on agricultural systems. Species from the genera *Microtermes* and *Odontotermes* have been implicated in damaging various crops including sugarcane, maize, wheat, barley, vegetables, ornamental plants, and even forest trees.

In addition to agricultural damage, termites can destroy man-made structures and materials, such as wooden buildings, furniture, books, utility poles, and fabrics. In the United States, subterranean termites (family *Rhinotermitidae*) are responsible for approximately 95% of wood damage, with associated annual economic losses estimated between \$750 million and \$1 billion (Mauldin, 1986; Su and Scheffrahn, 1990).

Chemical control strategies typically involve applying insecticides to soil or directly to infested wood. Fumigation with chemicals like sulfuryl fluoride, methyl bromide, or combinations with carbon dioxide is commonly used to eliminate drywood termites. Presently, termiticides such as chlorpyrifos, bifenthrin, imidacloprid, endosulfan, and lindane are employed to protect both crops and stored wood products from termite attack.

Classification of Isoptera

Family	Subfamilies	Important genera
<i>Kalotermitidae</i>	-	<i>Postelectrotermes, Neotermes, Glyptotermes, Kalotermes, Bifiditermes, Cryptotermes</i>
<i>Rhinotermitidae</i>	<i>Psammotermitinae, Heterotermitinae, Stylotermitinae, Coptotermitinae, Termitogetoninae, Rhinotermitina</i>	<i>Psammotermes, Heterotermes, Reticulitermes, Coptotermes, Schedorhinotermes, Rhinotermes</i>
<i>Mastotermitidae</i>	-	<i>Mastotermes</i>
<i>Termopsidae</i>	<i>Termopsinae, Porotermitinae</i>	<i>Stolotermitinae, Archotermopsis</i>
<i>Hodotermitidae</i>	<i>Cretatermitinae, Hodotermitinae</i>	<i>Anacanthotermes</i>
<i>Termitidae</i>	<i>Termitinae, Apicotermitinae, Nasutitermitinae, Macrotermitinae</i>	<i>Eurytermes, Speculitermes, Dicuspiditermes, Hypotermes, Nasutitermes, Termes, Macrotermes, Hospitalitermes, Trinervitermes, Microtermes, Odontotermes</i>

Trophic Groups

Termites consume wide range of freshly dead or decaying plant material including dry grass, leaf litter, decaying wood, dung, and humus. Living plant tissues, including lichen and mosses, are taken by a few species. Termite species can be categorized into five broad trophic categories according to their food, foraging galleries or columns, color of the abdomen, and known biology.

Wood Feeders: These ancestral, wood-consuming termites primarily feed on wood and woody debris, such as dead branches that remain attached to trees. They often inhabit the tunnels they create while feeding, which can sometimes develop into the central area of their colony. The wood taken may include living trees (*Coptotermes*, *Schedorhinotermes*, and *Microcerotermes dubius*), sound dead wood (*Kalotermitidae*), and/or fungus-attacked wood (*Nasutitermitinae*, some *Termitinae*, and *Macrotermitinae*). Most of these termites are arboreal (attached to trees), subterranean, or epigeal nesters.

Soil Feeders: These termites consume mineral-rich upper soil layers that contain high levels of organic material, often exhibiting a preference for fine soil particles like silt and clay. They are typically found throughout the soil profile, within the organic litter composed of fallen leaves and twigs, and sometimes in above-ground (epigeal) mounds. Soil-feeding termites are especially widespread and numerous in many tropical rainforest ecosystems (Wood, 1976). In South-east Asian regions, soil feeders are dominated by the *Termitinae* with a small number of *Nasutitermitinae* and *Apicotermitinae*.

Soil-Wood Interface Feeders: Termites belonging to this group consume heavily decomposed wood, soil located beneath fallen logs or adhered to their surfaces, and soil combined with leaf litter found in stilt-root environments. Soil/wood interface feeders are only found in the *Termitinae*, *Apicotermitinae*, and *Nasutitermitinae*. Most of them nest within dead logs, build epigeal nest, or form colony centers in the soil.

Litter-Foragers: Termites in this trophic category search for leaf litter and small woody materials at different stages of decomposition. These food items are frequently transported back to the nest and temporarily stored there. This group includes some subterranean and other mound-building *Macrotermitinae* (with fungal association), as well as certain *Nasutitermitinae* that forage on the surface of the

ground or litter layers. Genera such as *Laccessitermes* and *Longipeditermes* are also known as arboreal foragers.

Micro-Epiphyte Feeders: This group of termites actively searches for mosses, algae, lichens, and fungi growing on tree bark. Grass-feeding species, which may also consume animal dung or occasionally scavenge on dead vertebrates, are primarily from the family *Hodotermitidae*, typically found in savannas and desert ecosystems. The gut microbiome of termites encompasses a broad range of microbial interactions, from harmful to obligate mutualistic relationships. In lower termites, symbiotic flagellated protozoa inhabit the gut and play a crucial role in breaking down cellulose into soluble, digestible compounds. Additionally, certain lower termites engage in a mandatory external symbiosis with *Termitomyces* fungi, cultivating them within the nest on specialized fungus combs made from fecal matter. This fungus facilitates the breakdown of cellulose externally, while various bacteria and protozoa residing in the gut may contribute to digestion. Fungal combs not only provide the decomposed residue to the termite nests but also elevate temperature due to metabolic activity in decaying organic residues outside the termite gut.

Nest/Mound Formation

Termites inhabit well-structured and cohesive colonies, typically established within hollowed-out wood, underground tunnels, or elevated earthen nests. In certain regions of Africa, some of these nests can rise over 20 feet in height and span up to 12 feet in diameter. These impressive structures are constructed using a mixture of soil and fecal matter, which is bound together by secretions originating either from specialized glands located in the head or from the hindgut region of the termites. Termites nest systems can be classified as mentioned below.

Wood Nesters: Termites in this category typically reside in or near upright trees or decomposing logs. Over time, the decayed wood may be substituted by a material known as wood carton—a lignin-rich, nutrient-poor substance composed largely of undigested residues (Collins, 1989). This includes the *Kalotermitids* (*Kalotermes* and *Glyptotermes*), some *Rhinotermitids* and some *Termitidae* members such as *Microcerotermes* and *Termes*.

Hypogeal or Subterranean Nesters: Some termite species establish their colonies deep underground, making their presence difficult to detect from the surface. They build their nests using either fecal material or a combination of

feces and mineral soil. In certain genera, such as *Macrotermitinae*, *Apicotermes*, and *Homalotermes*, the subterranean nests may include minimal internal structures or a few surface openings despite the complexity of their underground architecture. This group also includes many species that are facultative secondary inhabitants of epigeal mounds: *Microcerotermes*, *Pericapritermes*, and soldierless *Apicotermitinae*.

Epigeal Mound Builders: Termites that establish their colonies in association with live or dead vegetation above ground are often referred to as mound builders. These mounds are typically distinctive and can exhibit highly intricate architecture. Construction materials generally fall into three categories: subsoil with low organic matter, combined with salivary secretions (as seen in *Macrotermes* and *Cornitermes*); wood carton—a dense mixture of feces and finely chewed wood rich in lignin; and a blend of feces with organic-rich topsoil, commonly used by soil-feeding species. Members of the subfamily *Macrotermitinae* and the genus *Dontotermes* are especially known for constructing massive mounds using carefully selected clay-heavy subsoil.

Arboreal Nesters: Termite nests are often constructed externally on trees, positioned at various heights. These structures are typically composed of wood carton material. In many instances, they are linked to the ground through covered passageways, which can help differentiate arboreal termite nests from those built by ants. However, certain arboreal species within the subfamily *Nasutitermitinae*, such as *Hospitalitermes*, create open foraging trails and do not build enclosed pathways between their nests and foraging areas.

Caste Production

By far the largest family of termites is the termitidae which is divided into five subfamilies, Serritermitinae, Amitermitinae, Termitinae, Macrotermitinae, Nasutitermitinae. In this highly evolved group of termites, caste differentiation is most advanced. The worker caste can be clearly distinguished from the immature, undeveloped individuals of other castes. Within a single colony, it is common to observe multiple forms of workers and soldiers that differ in size, shape, or both.

The worker:

The worker termite is characterized by its lack of wings or wing pads and has a relatively uniform thorax. Its eyes—both compound and ocelli—are either entirely missing or greatly reduced, and its reproductive organs remain underdeveloped. The head is notably large and rounded to accommodate powerful mandibular muscles. Most of the abdominal cavity is occupied by a well-developed digestive system, and due to the thin, pale cuticle, the dark contents of the gut are often visible when the termite is active. Externally, males and females cannot be distinguished, as the terminal abdominal segments appear identical. However, in some species, worker size may reflect sexual differences even at similar developmental stages.

In the family Termitidae, worker termites undergo two developmental stages (termed *nymphs*) before reaching maturity, except in the subfamily *Macrotermitinae*, where three instars are observed. These immature workers are white in color and possess delicate mouthparts, which

prevent them from collecting food independently. Instead, they are nourished by mature workers through the regurgitation of digested food and saliva. Upon shedding their final nymphal exoskeleton, workers of the Termitidae typically undergo an abrupt transformation into their adult form, whereas in other termite families, this process is more gradual. Mature workers may continue to molt, though they experience minimal physical change—except in some cases where they transition into the soldier caste, as seen in *Nasutitermes arborum*. In this species, the soldier's elongated, snout-like head structure is noticeably distinct from the rounded, mandibulate head of the worker from which it develops.

In several termite species, foraging is predominantly carried out by larger, mature workers, while younger workers—though they do not contribute to trail marking—possess enlarged salivary glands and are thought to play a key role in feeding and care within the nest. For instance, in *Macrotermes natalensis*, it has been noted that older workers, identified by their pale appearance resulting from urate-rich fat deposits, are primarily responsible for nest construction.

The Soldier: The soldier termite is identified by its elongated and heavily hardened (sclerotized) head, which projects forward. In many species, this head bears large, prominent mandibles used for defense. However, in the subfamily *Nasutitermitinae*, the mandibles are greatly reduced or nearly absent. Instead, these termites exhibit a remarkable forward extension of the frontal gland, forming a distinctive projection. This specialized adaptation has led to such soldiers being commonly referred to as "nasutes."

Although soldier and worker castes differ in function, they share several morphological traits. In *Nasutitermitinae*, soldiers are typically male, while in *Termitinae* and *Macrotermitinae*, soldiers are generally female. The developmental pathway of soldiers is not entirely understood, though it appears closely linked to that of workers. In some cases, soldiers arise from nymphs that are visually identical to those destined to become workers. Furthermore, it has been observed that fully formed workers can also transform into soldiers. Interestingly, both these developmental routes to soldier formation may occur within the same species.

Replacement Reproductives

Three distinct forms of replacement reproductives have been recognized in termites. The first type, known as *adultoid reproductives*, originates from fully developed, winged adults that later achieve reproductive status within their native colony. This form is considered uncommon and has been observed primarily in the subfamily *Macrotermitinae*, both under natural conditions and in controlled studies. However, it has also been documented in species such as *Nasutitermes arborum* and *Anoplotermes pacificus*.

The second and most frequently encountered category is the *nymphoid reproductive*. These individuals develop from nymphs and are identified by the presence of wing pads—either in early or advanced stages—and pigmented compound eyes. Nymphoid reproductives are often produced in relatively large numbers, with a noticeable predominance of females.

The third type, known as *ergatoid reproductives*, is rarely observed. These reproductives arise from the worker caste

and are characterized by their complete lack of wings, closely resembling workers in appearance. This category demonstrates the rare biological phenomenon of *neoteny*, where reproductive ability emerges during an immature or larval stage.

Intestinal Protozoa

Certain termite species are particularly notable for hosting a diverse and abundant population of symbiotic microorganisms within their hindgut. In more primitive groups—especially drywood and dampwood feeders like *Zootermopsis*—protozoa are the dominant symbionts. Members of families such as *Mastotermitidae*, *Kalotermitidae*, and *Rhinotermitidae*, representing nearly one-third of all termite species, are known to harbor these protozoa. These organisms play a vital role in breaking down cellulose found in the wood particles consumed by termites. After being chewed and ground by the gizzard, the wood is digested chemically with the aid of cellulase enzymes secreted by the protozoa.

All four major classes of protozoa are represented in the intestinal tract of wood-feeding termites. Remarkably, nearly every wood particle within the gut is surrounded by protozoa. However, not all protozoa contribute to cellulose digestion—some feed on other protozoa or other gut microorganisms such as spirochetes and bacteria, while others absorb dissolved nutrients directly from the surrounding gut fluid. During each molt, termites lose most, if not all, of their gut symbionts. These vital organisms are reintroduced through **trophallaxis**, a process in which colony members exchange gut contents. As a result, the social structure of termite colonies is essential for maintaining nutritional symbiosis and overall colony health.

Fungus Gardens

An extraordinary adaptation is seen in the subfamily *Macrotermitinae*, where termites practice fungus cultivation to aid in cellulose and lignin breakdown. Inside their nests, the termites build specialized chambers ranging in size from that of a walnut to a coconut. These spaces house compact but porous nodules known as fungus combs or gardens. These combs contain numerous tunnels that allow termite movement and are composed primarily of processed fecal matter.

The fungus cultivated in these gardens belongs to the basidiomycete genus *Termitomyces*, which includes around nineteen identified species or variants. Interestingly, *Termitomyces* fungi are not found growing independently in nature; they appear to exist solely within termite nests. This exclusivity suggests a highly specialized mutualistic relationship between the termites and the fungi.

Fungus combs are initiated using fungal material collected from the surface, typically from fruiting bodies (sporophores) that emerge from the soil. These sporophores originate from the underground fungus combs and grow upward to the ground surface. This system of external cultivation represents a unique form of symbiosis, where both the termite colony and the fungus benefit through cooperative cellulose processing and nutrient cycling.

Termites as Food and Medicine

Termites are regarded as a delicacy in various regions across Asia and Africa. In countries like Uganda and Zambia, the termite queen is especially valued as a gourmet item and is

often given to children as nourishment. In addition to the queen, soldier termites and reproductive forms are also consumed. Nutritionally, termites are a rich source of protein, fats, carbohydrates, and essential amino acids, benefiting both humans and primates.

The caloric content of winged reproductive forms of *Macrotermes falciger* and *M. subhyalinus* has been estimated at 761 and 613 kcal per 100 grams of dry weight, respectively. These reproductive forms are particularly popular due to their higher nutritional values compared to worker termites. For instance, reproductive termites contain approximately 87% protein, 2.7% carbohydrates, and 6.7% amino acids, whereas workers have slightly lower levels: 82% protein, 1.3% carbohydrates, and 4.7% amino acids. Additionally, the mineral content in the reproductive caste exceeds that found in traditional vegetarian foods, salmon, and broiler chicken.

Beyond their role as a food source, termites are also used in traditional medicine, a practice known as **entomotherapy**—the treatment of human ailments using insect-derived substances. In some cultures, termites are soaked in honey for about three weeks and then consumed as a tonic to boost strength and vitality. Powdered termites mixed with honey are administered to treat respiratory issues such as wheezing and bronchial ailments, as well as for their diuretic properties. Furthermore, soil from termite mounds is traditionally applied to manage various skin conditions. In veterinary medicine, this soil is also employed to treat common livestock ailments, particularly Foot and Mouth Disease.

Damage to Agricultural Crops

Termites are responsible for considerable yield reductions in both annual and perennial crops. They can infest plants at any stage of growth, from seedling emergence to full maturity. The damage typically starts at the root zone and gradually extends upwards. In mature plants, termites often feed on the bark and internal tissues, eventually leaving the plant vulnerable and leading to its death. India is home to around 200 known termite species, out of which approximately 40 have been identified as agricultural pests.

Damage to Seedling Species

Termites construct large mounds that can house several thousand individuals. From these nests, they create shallow underground foraging tunnels that extend outward for distances of up to 50 meters. These primary tunnels branch into a complex network of smaller galleries, which the termites use to feed directly on subterranean plant matter. They often attack seedlings by cutting them either just below or just above the soil surface.

Damage to Maturing and Mature Plants

Damage Caused by *Odontotermes wallonensis* in Various Crops

Damage to mature plants is predominantly caused by *Odontotermes wallonensis*. This species constructs diffuse networks of underground galleries and chambers, allowing termites to invade and feed on root systems. Such feeding either directly kills the plant or weakens it severely. Disruption in water and nutrient translocation due to root damage also increases the plant's vulnerability to pathogens. Additionally, in lodged plants where grain touches the soil, fungal infections—especially by *Aspergillus*—may occur.

1. Maize

In maize, termites target seeds and young seedlings. They typically attack the stem at ground level, covering the base with an earthen sheet extending up to 10 cm. Upon removal of this layer, a tunnel is revealed at the base—extending both upwards and downwards—and filled with soil, while the outer stem remains intact. Roots are generally not attacked until the plant matures. Affected plants may either remain upright or collapse (lodging), often resulting in complete cob destruction.

2. Groundnut

Termites form earthen encrustations up to 5 cm on the main stem, boring into it just above ground level. They create tunnels into the taproot and upwards into the stem. Damage also extends to pegs and mature pods, occasionally penetrating the pod shell. The injury to pegs often causes them to break during harvesting, leaving pods in the soil. Termites remove the soft, non-fibrous parts of the shell, exposing veins and causing scarring. These pods are more prone to mold infestation at harvest. Damage typically results in increased plant mortality and yield loss.

3. Sugarcane

Attack by *O. wallonensis* begins soon after planting, hampering germination and resulting in poor crop establishment. As the crop matures, termites bore into the cane through lateral holes, often exploiting previous damage from rodents or stem borers. They tunnel both upwards and downwards inside the shoot, damaging the pith and killing the growing points. This disrupts central leaf growth and significantly reduces juice content and cane weight. Damage continues from early internode development until harvest.

4. Soybean

In soybeans, termite damage occurs below the soil surface, where internal root tissues are consumed, weakening the plant. The root system, particularly root stubble, suffers the most. Termite infestation increases progressively during the crop's growth stages, causing significant losses.

5. Coconut

O. wallonensis poses a serious threat to coconut seedlings, especially in nurseries and during early stages after transplanting. The termites often attack the tender growing points, resulting in stunted growth, central shoot wilting, and sometimes total seedling death. Mud galleries are commonly seen on the trunks, and tender shoots are frequently cut off. The pest causes gradual desiccation and wilting of both roots and shoots in young coconut plants.

6. Wheat

Field surveys have shown that *O. wallonensis* attacks wheat throughout its growth cycle. Among cereal crops, wheat is one of the most susceptible to termite infestation. Damage has been reported even in irrigated *rabi* season fields. Annual yield losses due to termite activity in India have been estimated to range from 6% to 40%, depending on the region and crop conditions.

Termites and Forestry

Tree species such as *Eucalyptus*, *Shorea*, *Tamarix*, *Tectona*, and *Terminalia* are particularly vulnerable to termite attacks during the early stages of growth, especially within the first

three years. Among the termite species, *Odontotermes feae* is known to cause significant damage to these young trees. Additionally, drywood termites are increasingly being recognized as serious pests in forestry across the Indian subcontinent. For instance, *Bifiditermes beesoni* has been reported infesting *Ficus benghalensis* in India, and species such as *Acacia*, *Dalbergia*, *Eriobotrya*, and *Zizyphus* in regions of western Pakistan.

In India, *Neotermes gardneri* is associated with damage to trees including *Artocarpus*, *Litsea*, *Pterospermum*, and *Woodfordia*. Another subterranean species, *Reticulitermes chinensis*, has been observed feeding on the roots of *Pinus longifolia* in plantations located at elevations around 1200 meters (approximately 4000 feet) in Assam. This termite bores through the roots—preferably those less than 15 mm in diameter—creating galleries filled with soil while leaving the bark untouched.

The genus *Coptotermes*, which thrives in warmer climates, includes species like *C. helmi*, which has been recorded damaging a wide variety of trees in India. Similarly, *C. ceylonicus* has been reported in Sri Lanka (formerly Ceylon) with comparable habits. Meanwhile, *Odontotermes* is a well-known genus across the Indian subcontinent for its scavenging behavior, feeding on decaying woody material found on the forest floor.

Termites as Structural Pests

Termites pose a significant concern when they infest and damage structural wood and other components within buildings. Their destructive activity can also affect household furniture, paper-based products, various synthetic materials, and even stored food. However, the risk of such damage can be substantially minimized through well-planned building designs, the implementation of termite control measures during construction, and consistent, routine inspections for signs of termite presence.

Detection and Identification

Adult termites are often mistaken for winged ants, as both insect groups produce winged reproductive forms that leave their colonies in large numbers to initiate new ones. However, termites and ants can be distinguished by three key physical traits: the shape of their antennae, the structure of their wings, and the form of their abdomen. Termite swarming tends to occur seasonally, with timing and intensity varying by species and geographic location. One of the visible signs of a termite infestation is the appearance of darkened or blistered wood, especially in structural components. Wood in affected areas is usually thin and can be easily penetrated using a sharp tool like a knife or screwdriver. In recent years, advanced techniques have been developed to improve termite detection. These include odor sensors, acoustic emission devices that respond to feeding activity, fibre optic tools, microwave-based detectors, and infrared imaging technology.

1. Dampwood Termites

This ecological group includes termite species belonging to the families Termopsidae and Kalotermitidae. Although commonly referred to as “dampwood termites,” the name can be misleading, as certain species within this group actually prefer relatively dry wood. Compared to other termite groups, these termites generally pose a lesser threat as pests. When control measures are necessary, they

typically involve localized chemical treatments, removal of infested wood, or preventive strategies such as using chemically treated lumber and ensuring that structural wood remains dry and well-separated from moisture sources.

2. Drywood Termites

As was mentioned when using the common name “dampwood termite,” the same applies to the use of the common name “drywood termite.” Although some ecological and biological differences exist among species, drywood termites are generally known for infesting dry, intact wood. This includes structural timber, dead branches of native trees, shade and orchard trees, utility poles, wooden posts, and stored lumber. These termites have minimal moisture requirements and are capable of surviving in arid conditions for extended periods. Unlike other groups, they do not maintain any connection between their nests and the soil. One of the telltale signs of an infestation is the presence of distinctive fecal pellets. These droppings are small (less than a millimeter in length), elongated with rounded ends, and feature six flattened or slightly concave surfaces separated by longitudinal ridges. While their color and texture can vary, they typically resemble coarse, multicolored sand.

3. Subterranean Termites

Subterranean termites rely on environmental moisture for survival. To meet this requirement, they typically establish their nests in or near the soil and access food sources by traveling from the ground. They maintain a continuous link to the soil by building tunnels within wood or constructing protective mud tubes, also known as shelter tubes. These termites can easily penetrate a variety of materials, including drywall (plasterboard) and certain plastics. However, their most severe damage is often seen in foundational timbers and structural support beams.

The winged reproductive caste, which develops from nymphs with wing buds, exhibits a range of colors from pale brown to black, with wings that can appear gray, translucent, or even dark charcoal. Soldiers are distinguished by larger, more pigmented heads, which lack eyes and are equipped with long, narrow mandibles or other specialized defensive features. Workers make up the majority of the colony—around 80%—and are smaller in size than reproductives. They are wingless and have less prominent heads compared to soldiers.

4. Arboreal Nesters

Certain arboreal termite species are considered significant structural pests across tropical and subtropical regions, including areas from northern Argentina to Mexico, as well as parts of Asia and Australia. These termites typically construct carton nests on trees, utility poles, fences, and beneath the roofs of older buildings. While some species create a single, centralized nest, others develop multiple nests that are interconnected.

Their soldiers, known as nasutes, are characterized by a brown to black-colored head and a distinctive conical projection or “nose,” which they use to spray a defensive secretion. The worker caste is noticeably larger than the soldiers. These termites access buildings by traveling through easily recognizable carton tunnels built along walls

and wooden structures. In some cases, nests may also be located within the building itself—either under the roof or concealed inside walls.

Termite Management in Buildings

1. Design of a Building

Certain building designs and construction practices can increase the risk of termite infestation. To reduce this risk, it is essential to avoid using wooden or other cellulose-based forms, spacers, and fill materials during construction—unless these materials are completely removed before the project is finished. Structural wood components such as subflooring, siding, and door frames should be installed at least 30 centimeters above ground level. Additionally, exterior cladding materials like cement, stucco, stone, or wooden fascia should not come into direct contact with the soil near the foundation. Maintaining a gap helps prevent termites from gaining concealed access to the structure behind these surfaces.

2. Preservative-treated Timber Products

A variety of structural lumber and panel products are available on the market that have been infused with insecticides as a means of termite management. Wood that is naturally vulnerable to termite attack can be made resistant by applying chemical preservatives that not only deter termite feeding but also often inhibit the growth of fungi and other wood-decomposing organisms.

Traditionally, wood preservatives included active compounds such as creosote and pentachlorophenol. More recent formulations feature ingredients like chromated copper arsenate (CCA), ammoniacal copper quaternary (ACQ), and disodium octaborate tetrahydrate (DOT). CCA-treated wood typically has a green tint, while wood treated with ACQ appears brown. These preservatives are most effective against termites when the treated wood is consumed. In the case of drywood termites, the use of such treated timber can also help prevent the establishment of new colonies by deterring the reproductive alates from settling.

3. Physical Barriers

Physical termite barriers are constructed using various inert materials and may also incorporate adhesives or sealants to securely attach sheet products or mesh to structural components like bricks and concrete. These additions enhance the strength and longevity of the barrier system. Broadly, physical barriers are classified into two main types: graded particle barriers and sheet material barriers. Particle-based systems are typically composed of carefully sized grains of sand, crushed stone (such as granite or basalt), or even crushed glass. These particles are selected for their specific size, which prevents termites from tunneling through when installed beneath or around foundation structures, as well as around service conduits and piping.

Sheet-based barriers may include corrosion-resistant solid metal sheets or fine stainless-steel mesh. In addition, well-constructed concrete slabs—known as *engineered slabs*—that are designed to reduce shrinkage cracks can also function effectively as physical barriers against termite intrusion.

4. Termiticide Applications to Soil and Non-soil Substrates

The application of termiticides to soil and/or wood has long been a standard approach for managing subterranean, arboreal, and drywood termites across many parts of the world. These treatments typically involve liquid, dust, or foam formulations that are applied to the soil, wooden structures, or directly to aerial or arboreal nests. The primary goal is to establish a chemically treated zone in the soil that acts as a protective barrier between the termite colony and structural wood.

Termiticides are generally categorized based on their mode of action into repellent and non-repellent types. Pyrethroids and synthetic pyrethroids, which are widely available under various brand names, fall under the repellent category. When termites encounter these substances, they tend to avoid the treated areas. However, if there are untreated gaps or weaknesses in the chemical barrier, termites may continue to forage until they locate an entry point and tunnel into the structure through it.

5. Space Fumigation

Space fumigation is a method that involves introducing a toxic gas into a sealed structure—often enclosed with tarpaulins—or into a confined area or object that is infested with drywood termites, subterranean termite aerial colonies, or arboreal nests. This technique presents several challenges, including the complexity of securely sealing the structure with tarps to prevent gas leakage, accurately calculating the correct dosage, safeguarding food items and sensitive furnishings, and the absence of long-term (residual) protection after treatment.

Other important considerations include the requirement for building occupants to vacate the premises for two to three days to allow for fumigation and proper ventilation. Additionally, there's potential for structural damage, particularly to roofs, caused by the placement of tarpaulins or the movement of workers during setup. Among the fumigants commonly used, methyl bromide remains a widely applied chemical for this purpose.

6. Thermal Control

There are four thermal options available for termite management, although mostly for drywood termites. They include electricity, heat from propane heaters, excessive cold from liquid nitrogen, and excessive heat from microwaves. All of these thermal techniques have limited availability.

Bait Technology

Baiting represents the most recent advancement in termite control strategies. This method targets entire colonies using either toxic or non-toxic baits. Typically, the bait consists of wood or a cellulose-based material that termites prefer, combined with a slow-acting toxicant or a biological agent such as fungal spores, mycelium, or infective nematode stages that carry toxin-producing bacteria lethal to termites. Termite workers consume the bait placed within bait stations and are exposed to a lethal dose of the treated food. These bait stations are strategically installed in the soil at regular intervals around structures. As workers feed on the bait, they share it with other colony members through grooming or trophallaxis, gradually leading to a decline or complete collapse of the colony.

Several commercial bait formulations are available, containing active ingredients such as diflubenuron, chlorfluazuron, hexaflumuron, triflumuron (Bayer–Alsystin 480 SC), sulfluramid, noviflumuron, disodium octaborate tetrahydrate, arsenic trioxide, fipronil, and hydramethylnon.

Conclusion

Termites are highly polyphagous and rank among the most destructive pests, causing severe damage to a broad spectrum of agricultural and horticultural crops, forest species, and even stored products. When infestations occur during the early stages of crop growth, they can result in total yield loss. Farmers predominantly rely on chemical pesticides as the primary control method. However, this approach is often unsustainable, economically burdensome, and environmentally detrimental.

Completely eradicating or preventing termites in cultivated fields is neither practical nor recommended. Although several indigenous and traditional methods are available, their effectiveness tends to be region-specific and limited when used in isolation. As such, these practices should be integrated into a well-designed Integrated Pest Management (IPM) strategy to reduce dependency on synthetic chemicals and mitigate environmental impact.

Researchers have developed eco-friendly, farmer-oriented approaches—such as cultural, mechanical, physical, and biological control measures. Biological methods include the use of entomopathogenic fungi, bacteria, nematodes, and botanical extracts, all of which offer significant potential for termite management. Incorporating these bio-control agents into IPM programs can yield more effective and sustainable results. Despite their promise, biological solutions have not yet been widely adopted for large-scale field use.

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