Introduction

Wood is a biological material. If protected from moisture and insect attack, it can last for centuries. When wood is not properly protected, however, it will succumb to biological processes that decompose wood: insects that eat the wood or fungi that cause rot and decay. The most damaging insects that attack structural wood are termites. Their activity results in damage and control costs that exceed $1.5 billion per year nationally. Beetles are the next important group of insects that attack wood, while bees, wasps and ants are third in importance, depending on geographical location. Wood-inhabiting fungi are another group of organisms that occasionally cause problems in Arkansas.

Termites

Termite control represents a major portion of pest-control work. No other type of pest control involves as many variables that affect the work to be done or the results obtained. Technicians involved in termite control must have a thorough understanding of the biology and unique habits of the termites, including their food, moisture and temperature requirements. Technicians must also have knowledge of building construction as well as the equipment, chemicals and safety precautions involved in termite control.

Termites are primitive insects belonging to an order of insects known as Isoptera, which means equal wings. This refers to the fact that both pairs of wings on the winged forms (called alates or swarmers) are of equal size and shape. Termites are thought by some to be closely related to cockroaches, but they are different from almost all other insects because they can convert the cellulose of wood into starches and sugar and use it for nutrition. They can do this because of a mutually beneficial association with microorganisms in their digestive tracts that convert cellulose into simple substances that termites can digest. In nature, termites help convert dead wood and other materials containing cellulose into humus.

Entomologists have described about 2,200 species of termites for the entire world; however, only 70 of these species infest structures and require control. There are 13 species of termites in the continental United States that require man's attention to a greater or lesser extent.

Termites occur in every state of the United States and parts of Canada. To date, they have not been reported in Alaska (Figure 1). They cause varying

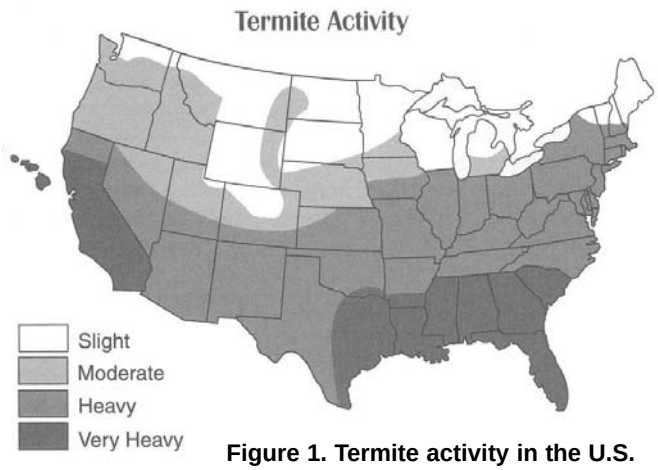


Figure 1. Termite activity in the U.S.

degrees of trouble, depending upon the geographical location. The presence and abundance of termites in an area is determined by several factors including temperature, humidity, soil moisture and soil type. Because subterranean termites rely on soil moisture, they're affected by soil types. In clay soils, moisture is not as readily available because it is tightly bound to the soil particles. Sandy soils have more available moisture. Consequently, subterranean termites are generally more prevalent and more able to survive in sandy soils. Fungi in wood are another source of moisture.

Subterranean termites are the predominant species in Arkansas. Drywood and Dampwood termites have been found in localized areas, however they do not naturally occur in Arkansas. They have been shipped into the state in infested construction materials or furniture from southern and western states. Use of infested materials in construction can establish these pests in structures but it is doubtful if they can survive under Arkansas climatic conditions.

Subterranean Termites

Subterranean termites are native, soil-inhabiting insects that feed on wood, paper and similar cellulose containing materials. The economic importance of subterranean termite attacks on buildings is related to the fact that wood members of a building closest to the soil, such as sills, joists, studs, girders and other important load bearing elements of construction are most likely to be severely damaged by termites. Failure to stop termite attacks can cause loss of support. Other forms of building deterioration, such as sagging walls, leaking surfaces and wood decay can follow. Heated buildings where wood is in direct contact with or in close proximity to the soil offer termites the ideal environment, a favorable year round climate and an abundant sheltered food source.

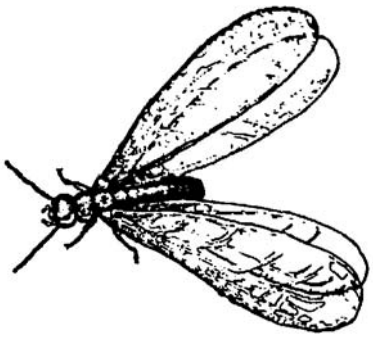


Figure 2. "Swarmer" Termite.

Subterranean termites are social insects that live in colonies. Three castes can be found there – reproductives, workers and soldiers. The winged primary reproductive adult (swarmer, alate, flying termite) is the form most often seen. These **swarmer termites** (Figure 2) are dark colored with bodies about 3/8 of an inch long. They have two pairs of "gauzy" (semi-transparent) wings of identical size and shape that extend beyond the body to twice its length. The antennae or "feelers," like those of all termites, resemble a string of little globular beads.

Large numbers of winged individuals emerge on warm sunny days (usually when temperatures are at least 64°F) after a rain as early as March or April but usually in late April to early May. After taking flight and finding a mate, the termites lose their wings, search out a place to start a nest, mate and begin rearing the first group of workers. The mated female becomes the **"queen"** and the male the **"king"** (Figure 3).

Figure 3. Queen and King Reproductive Termites.

In very large colonies, a **secondary reproductive** (Figure 4) caste may also be seen. These supplemental or secondary reproductives mate and reproduce within the existing colony. These termites are light colored and usually have two pairs of short wing pads. Usually, they exist in addition to the regular **mature queen** (Figure 5) but may become the most important source of eggs in the colony. They are formed as needed and can also take the place of the queen if she is injured or dies. Thus strong colonies have multiple queens. These additional reproductives also give the colony a chance to spread through the process of "budding," where a number of workers or secondary reproductives can be cut off from the main colony and form a new, self-sufficient colony.

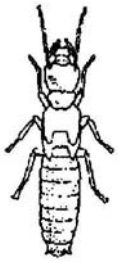


Figure 4. Secondary Reproductive.

Figure 5. Mature Termite Queen.

The **worker** (Figure 6) caste makes up the bulk of the colony and is directly responsible for damage to wood. Workers are about 1/4-inch long, whitish colored and soft-bodied. Recent studies of living colonies suggest there may not be a true worker caste in common North American species. They may actually be late instar nymphs. Termite workers are sterile and dedicate their lives to the upkeep, feeding and sanitation work of the colony. Their need for moist, humid environments requires workers to live within the ground or in mud tubes that are

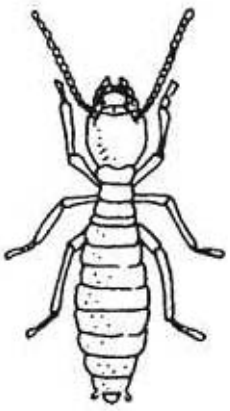


Figure 6. Worker Termite.

constructed up into the wood they are attacking. Workers are rarely seen unless infested wood is examined or the mud tubes are broken open. Because of their thin skin, workers will dry up and die within three to six hours if exposed to the drying conditions outside the nests. The nymphs and adult workers both have thin, bead-like antennae and differ only in size.

The **soldier** (Figure 7) caste is another form found in colonies. Their primary function is defense of the colony. Soldiers are easily recognized by their large, brownish, well-developed heads and jaws/mandibles. Their responsibility is defending the colony from attack by ants or other termites. The sterile soldiers are far less numerous than the workers. They hide within the mud tubes and in the nest, and will not be seen unless the wood or mud tubes are disturbed.

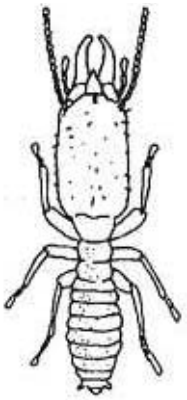
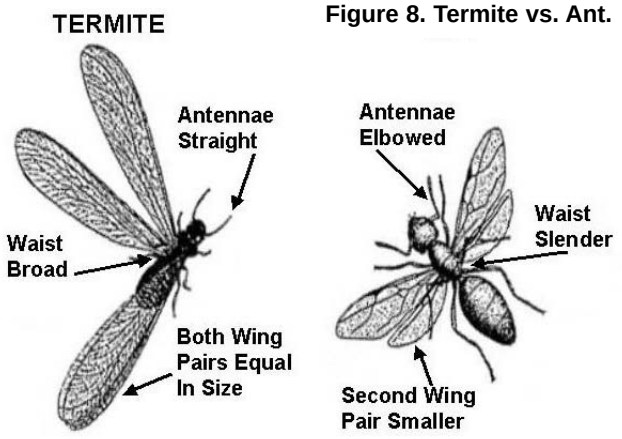


Figure 7. Soldier Termite.

Many people confuse the winged primary reproductive termite with flying ants, which can also be found swarming near structures. Termites can be distinguished from ants by comparing their physical characteristics (Figure 8). Winged termites (alates) have straight antennae, thick waists and four long, fragile wings of equal size and shape. Winged ants have a wasp-like body shape, narrow waists, elbowed antennae and two forewings that are larger than the two rear wings.

Figure 8. Termite vs. Ant.



Biology and Habits

General – A colony, usually between two and six years old, becomes large enough to produce swarmers. At this time, the colony consists of thousands of individuals, both growing and mature. When swarming occurs, both winged males and females emerge from the colony, pair off and fly away to begin new colonies. They lose their wings and construct a small cell in or near wood where they mate, reproduce and rear the first group of workers. The mated female becomes the "queen" and the male the "king." Usually the large numbers of swarmers never survive to establish colonies but are preyed upon by birds, toads and other animals, or they die from adverse environmental conditions. Indoors, their usual fate is to die harmlessly within a few days.

Swarming activity occurs during daylight hours over several days or weeks and usually follows a rain. Environmental conditions such as heat, light and moisture trigger emergence of swarmers. Each species has a definite set of conditions under which swarming occurs. This is why swarming varies according to the time of year and region of the state.

Swarming and mating – Most social insects swarm. This is one means by which certain social invertebrates perpetuate the species. A well-established colony of termites may develop hundreds to thousands of winged kings and queens (primary reproductives), depending on the species. This usually occurs during the time of year best suited to the needs of the termite. Subterranean termites prefer warmth and there must be enough moisture present so that they will not desiccate. Therefore, on the first warm day following the first spring rains, subterranean termites frequently emerge from their swarm tubes in great numbers. However, in Arkansas it is not uncommon to see subterranean termites swarm in other seasons of the year. Our records show swarming has occurred in every month of the year.

The act of swarming is dangerous for termites. Winged termites tend to be weak fliers and are easy prey for hungry birds and predacious insects. Generally, less than three percent of the swarming termites survive. The wind has a strong influence upon the direction and distance traveled by the new kings and queens. Once they have emerged from the nest, the primary reproductives eventually strike the ground

out of exhaustion or by accident. Random pairing commences at once. The queen seeks a suitable location to start another colony. While she is doing this, a king or several kings line up and follow behind her. Before mating takes place (or a first chamber is built) termites break off their wings along a basal suture.

Subterranean termite queens usually locate their original nests in the soil, frequently near buried wood. Drywood termites prefer a crack in almost any kind of wood to locate their nests. Once mating has occurred (hours to one week or more after swarming), the queen produces eggs of the desired caste.

Subterranean termites develop through three growth stages - egg, nymph and adult.

A fertilized female or "queen" produces eggs. The young termites hatching from the eggs are called nymphs and are white or pale cream colored, soft-bodied and blind. They have three pairs of legs and, though capable of moving about, must first be cared for by other termites. Later, the nymphs can feed on wood and take care of themselves.

In a colony, some nymphs develop large heads with a hard, brown skin and large jaws or mandibles. These individuals are soldier termites. Other nymphs develop two pairs of wing pads on their backs, and at the final molt to the adult, emerge as dark colored, winged, reproductives with fully developed eyes. In very large colonies, some of the developing potential reproductives become reproductively mature males and females but with arrested wing development. These supplemental reproductives may mate within the colony and never leave it. Reproductive needs of such colonies are often taken over entirely by supplemental reproductives.

Colony history – During the spring or summer months, a mated pair of winged termites establishes a new colony beginning with the young hatching from the small number of eggs first produced by the female. These nymphs become workers, more young are produced and thus the colony grows. However, a "budding-off" process in which a number of workers and some supplemental reproductives become physically isolated from the original colony can also produce new colonies. Man's activities, as in digging a cellar, laying a foundation or even applying soil insecticides, can bring this about. Thus, when a building becomes infested with termites, there may be no sure indication of whether the infestation began as a completely new colony, an isolated fragment of another colony, or whether a colony located nearby, as for example in a fence post, simply "moved in" to take advantage of the year-round warmth of the building.

Critical Needs

Subterranean termite specialization requires that they live almost constantly in a high relative humidity environment. Because of this, they need access to the earth. Because of soil moisture, the air spaces between soil particles are almost always very humid, and this humid atmosphere is important to the termite colony. Cutting off this "ground contact" with soil moisture is therefore the main principle in termite control. Other sources of moisture such as roof or gutter leaks, defective plumbing, etc., also serve the termites' needs but only if sustained over long periods.

Maintaining humidity in the feeding cavities is a problem for the termite. Masonry and wood absorb moisture. To reduce such losses, termites line their tunnels with salivary secretions that harden to form a moisture impervious layer. Although masonry and wood absorb moisture, termites are often unable to feed in wall studs at distances of more than a few feet from the floor because they are too far from their humidity source. Floor joists also represent an increasing linear distance from the moisture source. To provide more moisture to the joists, termites often construct earthen-lined shelter tubes upward to and downward from the joist. Subterranean termites construct tube-like structures from the soil to the wood they are infesting. The tubes are formed from a mixture of soil, wood particles, fecal material and a saliva-like substance. They are simply an extension of the nest above ground serving as protection and means to regulate moisture. Poorly ventilated crawl spaces often provide an atmosphere of high relative humidity that permits the joists to absorb moisture and thus facilitate termite damage.

A second critical need of subterranean termites is a constant source of wood or cellulose-containing material from which they derive their nutrition. Paper, cotton, burlap or other plant products are often actively attacked and consumed by subterranean termites. Unlike the carpenter ant, termites cannot hibernate and

must continue to feed and be active throughout the winter. Severe winter cold prevents termites in the woodland from feeding in stumps above ground during much of the winter. However, wood in close contact with heated soil, common in house design beginning in the 1920s provides a favorable habitat during winter.

Wood is made up of three dominant ingredients, those being cellulose, lignocellulose and lignin. All plants have varying amounts or proportions of each of these organic substances. The more cellulose in a plant or plant product, the more attractive it is to a termite. Some woods have chemical substances that confer variable susceptibility to termite attack. There are also woods that are somewhat immune to termite attack especially their heartwood (e.g., cypress, redwood and cedar). Wood products such as paper are favorite foods since they are nearly pure wood pulp and cotton fiber. The lignin, a substance avoided by these pests, is removed during the paper manufacturing process.

Subterranean termites cannot digest cellulose themselves, and are among the species dependent on large numbers of one-celled microorganisms (protozoa) that exist in the termite gut. These protozoa break down the cellulose, a complex sugar, to simpler compounds that termites can further digest as food. Worker termites and older nymphs consume wood and share their nourishment with the developing young, other workers, soldiers and reproductives.

Certain types of fungi play an important role in a termite's life. Termites are highly attracted to odors produced by wood decaying fungi that, through the decaying process, make the wood easier to penetrate. In some instances, the fungus provides a source of nitrogen in the termite diet.

Termite colonies are remarkably non-combative. It is entirely possible for ants and termites to infest the same building, each producing its winged adults at the appropriate time. There is interaction only if the ant colony finds it expedient to feed upon individuals of the termite colony.

Signs of Infestation

Generally the first readily noticeable sign of infestation is the presence of swarming reproductives on windowsills or near indoor lights. If swarmers are found inside, it is usually an indication that an active infestation exists somewhere within the structure. Presence of swarmers outdoors is a naturally occurring phenomenon but should be a warning that termites are in the vicinity and are possibly attacking a nearby building.

Another indication is the presence of wings, discarded by the swarmers as a normal part of their behavior, found near emergence sites, on window sills, in cobwebs or inside 'in floor' heat/air ducts.

Also, any sub slab ductwork, for venting a heating unit or cook-top range ventilator, can develop cracks that allow termites to enter below grade. If any of these conditions exist, they should be carefully inspected and, if possible, corrected.

Damaged wood often is not noticed unless the exterior surface is removed. However, galleries can be detected by tapping the wood every few inches with a screwdriver. Damaged wood will sound hollow and the screwdriver may even break through into the galleries. Subterranean termite feeding follows the grain of the wood and usually only the soft springwood is eaten. The galleries will contain soil and fecal particles. Subterranean termites do not push wood particles or pellets (fecal material) outside the galleries, as do other wood-boring insects, but rather use them in the construction of their tunnels.

Termites can detect vibrations through their legs. They are unable to hear noises near their nests, but are immediately alerted when their nest is tapped. When alarmed, the soldier termites butt their heads against the gallery walls to initiate the vibrations that will warn the colony. Under certain circumstances it is possible to hear this "ticking" sound.

Other signs of infestation are the presence of flattened, earthen shelter tubes that the termites build over the surface of the foundation to reach the wood (Figure 9). These tubes are usually 1/4-1/2-inch wide. Termites perish rapidly under dry conditions, so they build these mud tubes

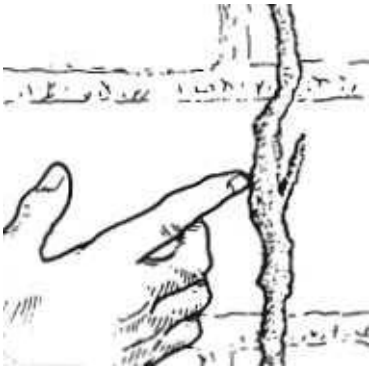


Figure 9. Termite shelter tube.

to maintain correct humidity throughout the colony. Buildings should be inspected at least once a year for evidence of tubes. In concrete slab construction, closely examine the expansion joints and cracks where pipes and ducts go through the slab. Particular attention must be given to bath plumbing traps and exposed soil beneath heating and air conditioning systems.

When looking for signs of termite activity, the inspector must also be alert for those conditions that favor termite infestations. The most critical condition is wood-to-soil contact. The U.S. Forest Service has identified 15 conditions that frequently lead to termite infestations:

1. Cracks in concrete foundations and open voids in concrete foundations are hidden avenues of entry.
2. Any wooden posts or supports set in concrete may be in contact with the soil underneath.
3. Concrete porches with earth fill may provide wood-to-soil contact.
4. Form boards left in place contribute to the termite food supply.
5. Leaking pipes and dripping faucets in the crawl space keep the soil under the structure moist.
6. Blocking crawl space vents with shrubbery will cause the air under the structure to remain damp and warm.
7. Construction debris in the backfill beside the structure will contribute to the termites' food supply.
8. Low foundation walls and footings will provide wood-to-soil contact.
9. Stucco or brick veneer carried down over the concrete foundation allows for hidden access to the structure.
10. Soil-filled planters built up against the side of the structure allow direct access into foundation cracks.
11. Forms left in slabs, where plumbing drains enter the structure, provide access.
12. Wooden porch steps in contact with the soil are entry points.
13. Heating units in crawl spaces maintain warm soil temperatures for termite colonies year-round.
14. Paper is a wood product. Paper collars around pipes and ducts also provide access to the structure.
15. Wooden fences, trellises and other wooden adornments up against the side of the structure may provide access.

Estimates of damage caused by subterranean termites have been calculated by Dr. Mike Haverty, 1976 Southern Forest Experiment Station - USDA, Gulfport, MS, and are indicated below:

Estimates of wood consumption are by a theoretical colony of eastern subterranean termites:

1) Wood consumption rate (mg wood/gram of termite/day) = 33.2
2) Weight of worker (mg) = 2.5
3) Wood consumption/termite/day (mg) = 0.083
4) Estimated number of workers/colony = 60,000
5) Wood consumption/colony/day (gm [grams]) = 4.98
6) Days to consume one board foot of pine (where pine weighs an average of 0.5 gm/cc with 2359.7 cc/board foot or 1179.9 gm/board foot) = 236 days

In other words, an average, mature colony of eastern subterranean termites would contain about 60,000 workers. Under ideal conditions, such a colony would consume about 5 grams of wood each day. This is less than 1/5 of an ounce of wood. At this rate it would take this colony about 157 days to totally consume a one-foot length of a pine 2x4.

Drywood Termites

This termite is not commonly found in Arkansas however, a brief discussion is provided for reference.

Drywood termites live and feed in dry, sound wood and can cause structural damage. Usually significant damage requires a longer period (as compared to subterranean termites) to occur since drywood termite colonies develop at a slower rate. Also, since these termites live and feed inside sound

wood, external damage signs may go undetected for years. Infestations may be found in structural timber and woodwork in buildings, furniture, telephone poles, lumber stacked in lumberyards, paper, cloth, fiber insulation boards and in other products containing cellulose.

Identification

Drywood and subterranean termites are similar in general shape and conformation but differ slightly in size and colorations. They are found in colonies consisting of three castes – reproductives, workers and soldiers. Drywood winged reproductives (primary reproductives, swarmers or alates) generally are larger than subterranean termites with dark brown, smoky gray or almost clear wings. The body color may vary from dark brown to light yellowish-tan. The drywood termite worker and soldier castes closely resemble those of subterranean termites. In most drywood termite species, there is no true worker caste as this function is taken over by nymphs.

Biology and Habits

Nymphs hatch from the eggs within several weeks and are cared for by the new king and queen. After two molts nymphs assume the role of workers and begin to feed and care for the original pair. Eggs are not deposited continuously; in fact, very few are deposited during the first year. In subsequent years, the young queen matures and begins to lay more eggs. Eventually, the colony stabilizes when the queen reaches maximum egg production. At that point the colony contains eggs, nymphs, workers, soldiers and reproductives. If the queen dies, secondary reproductives take over the queen's duties. Maximum size of a colony depends on several factors such as location, food availability and environmental conditions. Some colonies remain small, but adjacent, multiple colonies may contain up to ten thousand individuals. The colony grows through the queen's increased egg production and the accumulation of long-lived individuals.

Colony history – After a drywood termite colony has matured, usually requiring several years, swarmers are produced. The swarming activity occurs at dusk or in the evening, and the swarmers fly towards areas of greatest light intensity, gathering around lights or illuminated windows. Emergence is not often associated with a definite season of the year; most drywood termites emerge during the summer. Certain environmental conditions, such as heat, light and moisture trigger the emergence of swarmers, and each species has a definite set of conditions under which swarming occurs. The number of swarmers is in proportion to the age and size of the colony while environmental conditions regulate the numbers coming forth from the colony.

Critical Needs

Drywood termites derive their nutrition from wood and other material containing cellulose. In fact, the greater the cellulose content of a plant or plant product, the more attractive it is to drywood termites. Drywood termites often actively consume paper, cotton, burlap or other plant products. These termites are dependent on large numbers of one-celled microorganisms (protozoa) that exist in the termite gut for cellulose digestion. The protozoa serve to break down wood particles to simpler compounds that termites can absorb as food. Functional older nymphs consume wood and share their nourishment with the developing young, soldiers and reproductives.

Moisture is not as important to drywood termites as it is to the existence of subterranean termites. They require no contact with the soil or with any source of moisture. Drywood termites extract water from the wood on which they feed and from water formed internally by digestive processes. They require as little as 2 1/2 to 3 percent moisture, but prefer wood with 10 percent moisture content.

Signs of Infestation

Generally the first sign of infestation is the presence of swarming reproductives found on windowsills or near lights. Swarmers found inside are usually a clear indication of an active infestation somewhere within the structure if doors and windows have been closed. Another indication is the presence of discarded wings found near the emergence sites, on windowsills or in cobwebs.

Probably the best evidence of a drywood termite infestation is the presence of fecal pellets. Drywood termites construct "kick holes" in infested wood

through which the pellets are eliminated from galleries or tunnels. These pellets accumulate in small piles below the kick holes or are scattered if the distance between the kick hole and surface below is too great. Fecal pellets also may be found caught in spider webs.

Fecal pellets are distinctive and are used for identification. Drywood fecal pellets are hard, elongated, less than 1/25-inch long, with rounded ends and six flattened or concaved depressed sides with ridges at angles between the six surfaces. The characteristic shape results when the termite exerts pressure on the fecal material in the hindgut to extract and conserve moisture.

The wood interior of drywood termite-damaged wood contains chamber-like structures connected by galleries or tunnels that cut across the wood grain including both soft spring wood and harder summer growth. Galleries have almost sandpaper smooth surfaces containing few or no fecal pellets.

Dampwood Termites

Dampwood termites are not native to Arkansas and are of minor importance from a world standpoint, but they make up a distinct habitat group. Dampwood termites locate their colonies in damp, often decaying wood; but once established, they can extend their activities into sound and even relatively dry wood. They enter wood directly at the time of swarming and always confine their work to wood. They are occasionally responsible for serious damage to wooden structures, usually in conjunction with fungus attack, since the moisture requirements of both are similar.

Flights (swarming) of the dampwood termites usually occur at dusk. Some flights occur throughout the entire year; however, peak annual swarming takes place in late summer and fall.

The winged reproductive of dampwood termites may be an inch or more long, including the wings; the wings are from 7/8 to an inch long. The body is light cinnamon-brown; the wings are light to dark brown, heavily veined, and leathery in appearance. The soldiers are 3/8- to 3/4-inch long, depending upon the instar in which they assumed their typical soldier characteristics. This varies with the age of the colony, which is somewhat true of many species of termites. As with other members of this family, there is no worker class. The nymphs are about 1/2-inch long.

Formosan Termites

There are no records of formosan termites in Arkansas. However, as with dampwood and drywood termites, a brief discussion is provided for reference. This is an important species that is classified as a subterranean termite. Its habits are similar to our native species. The most obvious characteristics that distinguish the formosan termite from native subterranean termites are their larger size, pale yellow body color, oval shape of the head of the soldier in comparison with the oblong head of native subterranean species and hairy wings. The formosan termite also establishes larger colonies, is more aggressive and can do damage much more rapidly. Formosan termites make nests of hardened paper-like materials in wood in or on the ground, in hollows they have excavated from the tree stumps, or in hollow spaces in walls, floors or attics of building. Like the native subterranean termites, the formosan termite builds earthen shelter tubes over objects it cannot penetrate. To date the only areas close to Arkansas reporting established infestations of formosan termites are regions of Louisiana and Texas. However, this species is occasionally transported in wood to other areas of the country and is gradually moving inland from these areas.