

are of no economic importance to forestry. The adults are distinguished by their depressed, oval bodies, their nearly horizontal heads, their slender, depressed legs of almost equal size, and the absence of long ovipositors in the females.

Order Isoptera—Termites

Termites constitute the order Isoptera. They are one of the oldest and most primitive groups of insects. Termites are social insects and live in colonies. In all species there is a definite caste system, with each of the adult castes performing an essential function in the life of the colony. Termites utilize cellulose, which they normally obtain from wood or other plant material, as their main energy source. Cellulose is normally indigestible to most animals; however termites have single-celled protozoa and bacteria within their digestive tracts that break cellulose into digestible units (588). Many species of fungi are associated with termites in a beneficial manner. This association varies from little dependence on fungal activity in wood to a totally symbiotic relationship with fungi (1053). The influence of fungi on the activity of termites is poorly understood but some species, such as *Gloeophyllum trabeum* (Pers. ex Fr.) Murr. (*Lezites trabea* Pers. ex Fr.), are known to produce an attractant and a feeding stimulant (829, 1121).

Only 38 species of termites are believed to be native to the continental United States. Of these, 14 are known to occur in the eastern half of the country, exclusive of western Texas (1267). In addition to these native species, two introduced species, *Cryptotermes brevis* (Walker) and *Coptotermes formosanus* Shiraki, occur in the East. *C. brevis* may have been introduced into southern Florida. *C. formosanus* is believed to have been introduced into the Gulf Coast during World War II.

Termites are small, cylindrical, soft-bodied insects sometimes without eyes. The antennae are moniliform and, in the winged adults, the number of antennal segments varies from 12 to 25 or more. The median ocellus is absent. In certain species it is replaced by a more or less distinct opening of a gland known as the fontanelle. The wings are long and narrow and, when folded on the back, extend well beyond the end of the abdomen. In all North American species, the forewings and hindwings are similar in form and in the general features of their venation. The abdomen is broadly joined to the thorax.

Termites have very few effective natural enemies that attack individuals in the nest. For example, there are no known internal insect parasites, and predacious enemies are largely limited to ants, lizards, and birds. During and after the swarming period the winged adults of many species are eaten by all sorts of animals, particularly other arthropods (scorpions, solpugids, spiders, centipedes, dragonflies, cockroaches, mantids, crickets, beetles, flies, and wasps) and vertebrates (fish, frogs, toads, lizards, snakes, birds, and mammals, including humans) (741). These predators may have some adverse effect on the establishment of new colonies but probably have no effect at all on the parent colony. As yet, there are no studies on the rate of predation and its possible significance in controlling the populations of a single species of termite (941). Fungi, nematodes, and bacteria usually kill a small percentage of the individuals in a colony. Occasionally molds cause much heavier losses.

In many parts of the Eastern United States, particularly the South, termites are almost universally present in stumps, logs, and other woody materials in contact with the ground. Termites are largely beneficial in forested areas because of their value in the decomposition of dead wood and its reincorporation into the soil.

However, when termites infest wooden structures and other useful wood products, they are often extremely destructive. The extent of the monetary losses they cause is not known. Estimates vary, however, from \$100 to more than \$750 million per year in the United States for damage, repairs, and preventive and remedial control (645, 757, 832).

For further information on termites, the reader is referred to the following studies: 365, 366, 536, 566, 617, 645, 686, 695, 696, 720, 1266, 1316.

Family Rhinotermitidae Subterranean Termites

The subterranean termites of the Eastern United States all belong to the family Rhinotermitidae. Because these termites all require a constant supply of moisture, their colonies are found either entirely or partly in the ground. They may, however, feed in wood located some distance from the ground, but they always maintain connection with the ground unless a continuous supply of water is otherwise available. In order to attack wood located away from the ground where a supply of water is not available, they construct covered passageways, commonly called shelter tubes (fig. 13A).

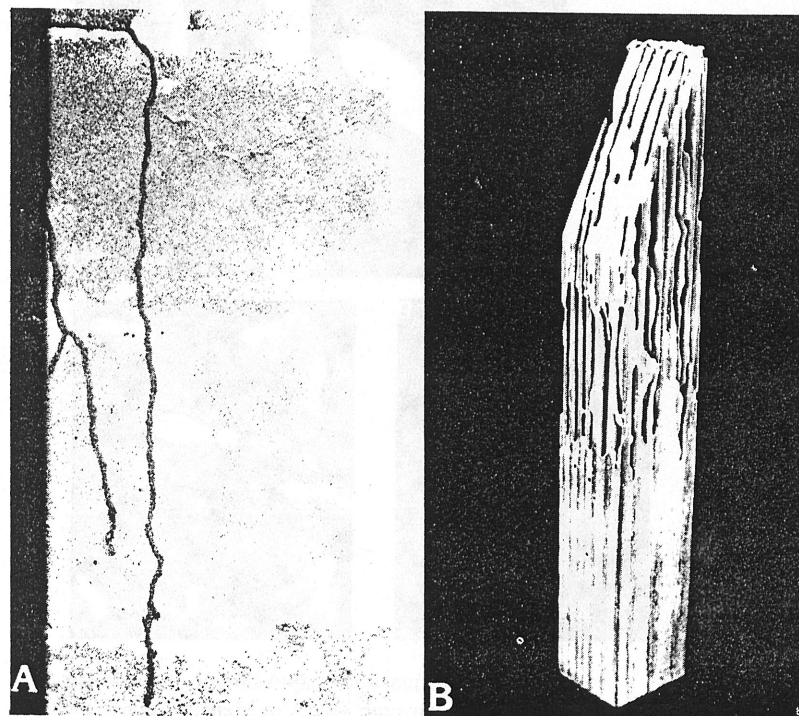


Figure 13.—Subterranean termite: A, shelter tube on foundation wall; B, damage to a pine stake.

Regardless of the extent of damage they cause to the interior of wood (fig. 13B), these termites always leave a covering shell intact. Because of this shell, there usually is no external evidence of infestation, even though the interior of the wood may be destroyed. The first indication of infestation may be the swarming of

winged adults, the presence of shelter tubes over foundation walls, or the sudden collapse of the surface of infested wood.

The principal food of subterranean termites is cellulose, which they obtain from wood and other plant tissues. As a result, these termites are not only destructive to the woodwork of buildings, utility poles, fence posts, and other wood products, but also to paper, fiberboard, and various types of fabrics derived from cotton and other plants. Shrubs, nursery stock, ornamental plants, and many kinds of shade trees are damaged occasionally. Trees killed by other insects, fire, or disease, particularly in the South, are attacked and the timber rendered unmerchantable unless it is utilized shortly after being killed.

In attacking wood, subterranean termites usually feed on the soft springwood only. As a result, their galleries run with the grain. These galleries are characteristically stained on the inside with grayish specks of excrement and earth but are free of pellets like those found in the galleries of nonsubterranean termites.

Subterranean termites occur throughout most of the United States and in southern Canada. They are common in most of the eastern half of the United States and along the Pacific Coast. It is considered likely that the native species have occupied their present ranges for millions of years; however, there seems to be an increase in their destructiveness northward. This increase has probably resulted from the general adoption of central heating plants in structures, from changes in building practices, the wider use of termite-susceptible wood in construction, and from the tremendous expansion of suburban homes into forested areas.

The eastern subterranean termite, *Reticulitermes flavipes* (Kollar), is the predominant species in the Eastern United States. It occurs from the East Coast to the Great Plains and from the Gulf of Mexico north to Ontario. In general, *R. flavipes* occupies regions of high humidity. Dead wood in forested areas is commonly infested with this species. It will attack wood from most of the species of trees in this part of the country. Infestations also occur in the woodwork of buildings, in cellulose materials in storage, and in poles and posts.

Every mature colony of the eastern subterranean termite contains some or all of seven castes during the year: larvae or immatures, nymphs, soldiers, workers (a "true" worker caste is not believed to exist in *Reticulitermes*), alates or winged reproductives, and primary and supplementary (or replacement) reproductives. Larvae hatch from the eggs and are precursors of all the other castes (fig. 14A). Workers (fig. 14B) are soft-bodied, grayish white, and slightly less than 6 mm long. They are the individuals responsible for the maintenance of the colony and the gathering of food. Soldiers (fig. 14C) are similar to the workers except for their much larger heads, their larger and more formidable mandibles, and their slightly greater length. Soldiers cannot feed themselves but contribute to colony labor by defending it. Nymphs (fig. 14D) develop from larvae and eventually molt into reproductives (fig. 14E). These reproductives are soft-bodied and brown to black, have two pairs of long, whitish opaque wings of equal size, and are 10 to 12 mm long. The winged reproductives fly from their colony to form new colonies. Colonizing flights occur during the day, most frequently after the first warm days of spring, often following a warm rain in April or May. They may also occur during the remainder of the warm season and sometimes even in the fall, especially in the South. In heated buildings, flights occasionally occur during the winter. The individuals in these flights are attracted by strong light. When they emerge within buildings, they gather about windows and doors. Here, they soon shed their wings, which may be found in large numbers even after the flights have ended.

Soon after shedding their wings, males and females pair off and search for a place to form a new nest. The great majority of them are usually unsuccessful, but some survive and manage to hollow out small cells in the ground near wood. They enter the cell, seal the opening, and eventually mate.

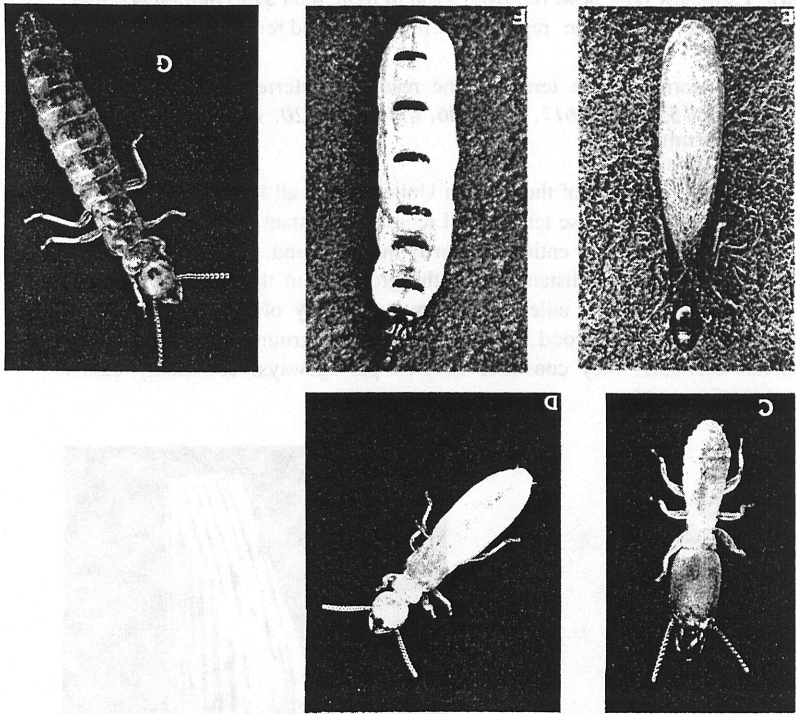
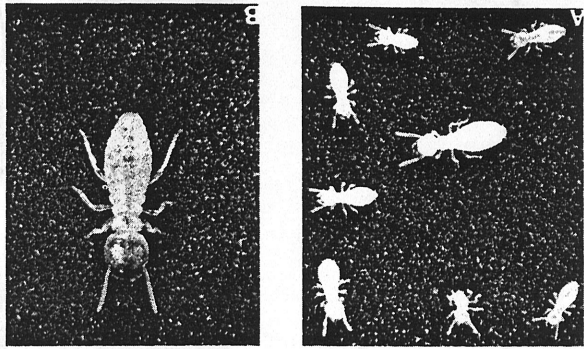


Figure 14.—Eastern subterranean termite, *Reticulitermes flavipes*: A, larvae or immatures; B, soldier; C, nymph; D, winged primary reproductives; E, physiological female primary reproductives; F, female supplementary reproductives.

A,B,E,F: F-531243
D: F-531902
C,G: Courtesy South. For. Exp. Stn., Gulfport, Miss.

A few days after mating, the female lays from 6 to 12 eggs. Hatching occurs in about 50 to 60 days, and the young larvae grow to maturity in less than 1 year. Later, both soldiers and reproductive nymphs appear in the colony and reach maturity within 1 and 2 years, respectively. Mating continues at irregular intervals, and the colony continues to increase in size. The original pair of reproductives lives together for life, sometimes for many years. The female increases greatly in size (fig. 14F) and produces literally thousands of eggs in her lifetime. In well-established colonies, there may be hundreds of thousands of individuals. In very large colonies, supplementary reproductives (fig. 14G) will develop in a colony to produce eggs if the primary reproductives die. These large colonies may be so widely spread out that it is difficult or impossible to estimate their size or to locate their main parts.

Reticulitermes tibialis Banks is the most widely distributed species of *Reticulitermes* in North America. It is largely confined to the arid areas of the western half of the United States but also occurs eastward in the North Central States as far as the Chicago area. To the east, *R. tibialis* overlaps a portion of the ranges of *R. flavipes*, *R. hageni* Banks, and *R. virginicus* (Banks). Along the southern shores of Lake Michigan, *R. tibialis* coexists with *R. arenicola* Goellner among sand dunes, where it infests small pieces of wood partly buried in the sand. Farther to the southwest, in Kansas and Texas, it occurs in heavily sodded prairies and in hard-packed and often alkali soil.

While *R. tibialis* is fully capable of damaging buildings, it is not as economically important as *R. flavipes* because of the thinly populated regions in which it occurs. Flights of this species occur over a large part of the year during the fall, winter, or spring, depending on the locality. Winged adults, in general, are almost entirely shiny black and about 10 mm long. The tibiae are also blackened and the pronotum is broad.

Reticulitermes virginicus occurs in the southeastern and central portions of the United States. Its range coincides closely with that of *R. hageni* in the east, although it does not appear to extend as far to the west. It is often mistaken for *R. flavipes* but is smaller. Throughout its range, *R. virginicus* overlaps the region occupied by *R. flavipes*, but it does not extend into the northern regions occupied by this latter species. In general, the line of northward extension of *R. virginicus* coincides with the regions where the average annual minimum temperature does not fall below -23°C . Westward, this species extends through southern Illinois and Missouri, south to the coast of the Gulf of Mexico, as far west as Houston, Tex., and eastward to the southern tip of Florida (1267).

Reticulitermes hageni is a small yellow-brown species and is the most distinctive of the *Reticulitermes*. It occupies about the same territory as *R. virginicus*. These two species are reported to occur more commonly in drier forested areas than does *R. flavipes*.

Reticulitermes arenicola was described from collections from the sand dunes along the southern shore of Lake Michigan in Indiana and Michigan. Little has been detailed regarding the field biology of this species. It inhabits sandy areas, and its flights occur toward the end of May.

Flights of *R. virginicus* tend to occur later in the spring than those of *R. flavipes*, although some overlap occurs between these two species. Flights of *R. hageni* tend to occur later than those of *R. virginicus*, although, again, there is some overlap between species. Flights of *R. virginicus* in the southern portion of its range occur

earlier than flights in the northern portion, even within buildings. This is not the case with in-building flights of *R. flavipes* (1267).

All species of *Reticulitermes* that occur in the Eastern United States are economically important with the possible exception of *R. arenicola*. The taxonomy of the genus is not well established. Although there can be little doubt that there are physiological, behavioral, and ecological differences among species, there is no evidence to suggest that control methods for one should be different from control methods for another. One should be certain of the genus but, except as a matter of interest, the particular species cannot now be considered critical from the standpoint of control.

The **Formosan subterranean termite**, *Coptotermes formosanus* Shiraki, is an introduced species. Active colonies were first recorded in North America in a shipyard warehouse in Houston, Tex., in 1965. Since then additional colonies have been discovered in Houston and Galveston, Tex.; Charleston, S.C.; and New Orleans and Lake Charles, La. The species was described from individuals collected in Formosa in 1909. Since then it has been reported from Ceylon, China, Guam, Hawaii, Japan, and South Africa. Incipient colonies generally start in or near the soil where moisture and damp wood are available. Nests are normally built in soil near the base of tree stumps, utility poles, or other underground food sources, but they may be found almost anywhere if conditions are favorable. Colonies have been observed on boats, ships, barges, dredges, water tanks, piers, floating drydocks, in living and dead trees, and in buildings.

Workers are grayish white overall. The head is pale yellow, with a white mark in the center and a dark-brownish spot on each side of the clypeus. The pronotum is nearly twice as broad as it is long, and the legs are slender and hairy. Soldiers (fig. 15) have oval heads and slender bodies. The pronotum is short, elliptical, and notched at the middle of the frontal margin. A small, short tubelike process extends from the frontal gland and exudes a milky, acidulous secretion. The abdomen is slender, entirely pubescent, and bears a pair of three-segmented caudal appendages (cerci). Alates have large, hyaline wings, 10.6 mm long, about three times as long as the abdomen, and about three times as long as they are broad. The head is hexagonal and brown; the frons is irregularly concave at the center where a globular projection occurs; the pronotum is semicircular and as broad as the head; the legs are short, heavy, and yellowish brown; and the abdomen is short, elliptical, and yellowish brown. The bodies are marked with minute spots, and the wings are 12 to 14 mm long.

Nests of Formosan subterranean termites are constructed of a friable material called carton. It consists of a mixture of masticated wood, saliva, and excrement. A nest may be several cubic feet in volume. Tunnels radiate from nests constructed in the soil. They can be found at depths of 3 m in the earth and extend horizontally up to 60 m (665). Their walls are lined with essentially the same materials used in constructing the nest and are nearly impervious to water. Primary queens can lay up to 1,000 eggs per day, and a single colony may contain many hundreds of thousands of individuals. Winged reproductives swarm during May and June. They are poor fliers, and the majority drop to the ground within 90 m of the nests unless carried farther by the wind. First evidence of a colony's presence may be the appearance of these winged adults at swarming time.

Large colonies can cause severe damage in a short time (fig. 16A). In Hawaii, walls of new buildings have been hollowed out in 3 months' time. Living trees are

are the Chinese elm, several species of oak, hackberry, and velvet ash. Dead trees are highly susceptible. Extensive damage all the way to the top of 20-m-tall baldcypress snags has been observed in Louisiana (77).

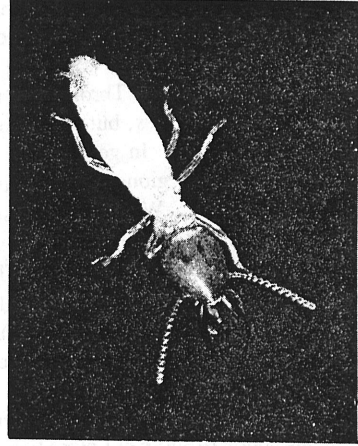


Figure 15.—Soldier of the Formosan subterranean termite, *Coptotermes formosanus*.

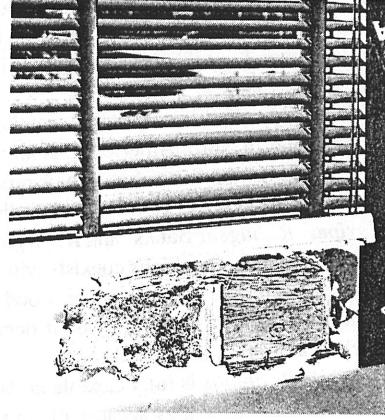


Figure 16.—Formosan subterranean termite colony and damage: A, carton nest and damaged wood above a window inside a building; B, colony of workers in a cypress log.

Families Kalotermitidae and Rhinotermitidae Nonsubterranean Termites

Many species of nonsubterranean termites occur in the Eastern States. They are found throughout Florida, also in a narrow strip along the Atlantic Coast as far north as southeastern Virginia, and westward along the Gulf Coast to Mexico. Infestations are found in structural timber and other woodwork in buildings, furniture, utility poles, wooden derricks, piles of lumber, wood pulp or fiber

insulation boards, in other products containing cellulose, and in trees and other plants. Because of their ability to live in wood that is frequently moved, nonsubterranean termites are often found in regions far removed from their normal range, including Canada. None of these termites is able to establish permanent infestations if transported out of its normal range (366, 1124). Nonsubterranean termites usually are less injurious than subterranean species in the Eastern United States. However, many years ago, large buildings in the South were seriously damaged (1122). Nonsubterranean termites fly directly to and enter untreated and unpainted wood at swarming time. They cut across the grain of the wood and excavate broad pockets or chambers connected by tunnels of small diameter. They feed on both the soft springwood and the harder summerwood. Their cavities contain compressed fecal pellets which often have six darkened grooves along their length (fig. 17). Some of these pellets are pushed to the exterior through small holes and are found in piles on the floors of infested buildings.

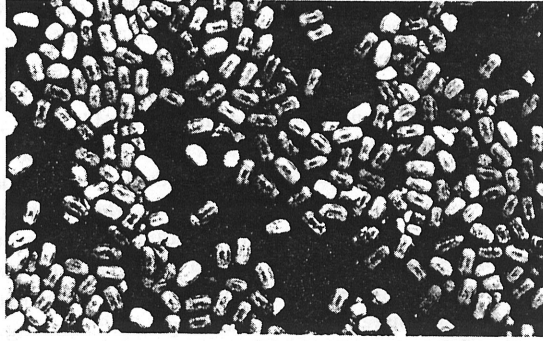


Figure 17.—Fecal pellets of nonsubterranean termites.

Nonsubterranean termites have a caste system similar to that of *Reticulitermes*. However, few of the species, except *Prothiotermes*, contain individuals that could be considered workers. Most of the termites present are larvae or nymphs, and most of the work of the colony is performed by the nymphs. Winged adults usually swarm during the early evening or morning hours in late winter or spring. Unless carried by the wind, they fly for only short distances in search of places to start a new colony. Once they have succeeded, they shed their wings and bore directly into the wood. Then they plug the opening, and seal themselves in. Colonies grow very slowly, are seldom confined to a single chamber, and rarely contain more than a few thousand individuals. Piles of pellets on the floor may be the first evidence of infestations. Other telltale evidence consists of pitted and roughened surfaces of infested floors, doorframes, and other wood.

Cryptotermes brevis (Walker) (Family Kalotermitidae) occurs commonly in southern Florida and is fairly widespread (although not abundant) on the coast of the Gulf of Mexico as far west as Brownsville, Tex. Isolated infestations have also been found elsewhere, including Tennessee, Maryland, Ohio, and New York. In most cases these infestations have been directly linked to transport of furniture from the Southern United States, particularly Florida and Hawaii, and from the Orient. Quarantine officials commonly intercept this species in cargo entering the United States from tropical and semitropical areas of the world. *C. brevis* has not been

recorded in any natural habitat, but only in fabricated structures. It can attack buildings but is particularly noted for severe damage to floors, woodwork, and especially furniture.

Cryptotermes cavifrons Banks (Family Kalotermitidae) occurs in southern Florida in dead trees, logs, stumps, and branches. Unlike *C. brevis*, which seems to be confined to structures, *C. cavifrons* has rarely been associated with buildings or furniture. The usual habitat of this species is in dry, sound, hardwoods in the hammock areas in southern Florida (1267).

Incisitermes snyderi (Light) (Family Kalotermitidae) is the common dry-wood termite of the Southeastern United States. It occurs from South Carolina to Florida and west to Brownsville, Tex., mainly along the coast, but as far north as Alexandria, La. Infestations occur in the woodwork of buildings, in untreated utility poles, and in dead trees, logs, and branches. It does not appear to have the wide ecological range of *I. minor* (Hagen) (Family Kalotermitidae), which occurs in western North America. Collection records suggest that this species is not as subject to transport and survival in new localities as are *I. minor* and *C. brevis*. It does not seem to be as great an economic problem, generally, as is *I. minor* on the West Coast.

Incisitermes schwarzi (Banks) (Family Kalotermitidae) is the common dry-wood termite in southern Florida, occurring also in the northern portion of the State. It is common in coastal and everglade hammocks, and has a fairly high moisture requirement. Infestations are found in the woodwork of buildings and in dead trees, logs, and stumps. Two rather distinctive forms of soldiers ("longheaded" and "shortheaded") occur in colonies of this species (1267).

Incisitermes milleri (Emerson) (Family Kalotermitidae) is a very small termite that occurs on the southern Florida Keys. It is encountered in very dry wood (1267).

Kalotermes approximatus Snyder (Family Kalotermitidae) occurs primarily in northern and central Florida. Other scattered collection records of this species suggest it may have a much wider range than generally believed and perhaps is not frequently collected because it does not frequent houses as much as some of the other dry-wood termites. It has been reported to occur in dead wood of oak, sweetgum, and magnolia in Florida. Apparently it occurs in dead wood and in dead areas of living trees. There are few flight records for this species. It is reportedly a diurnal flier, as its deep pigmentation suggests, which is not the normal case for dry-wood termites (1267).

Neotermes castaneus (Burmeister) (Family Kalotermitidae) is a very large species that occurs in the southern portion of Florida and on the eastern Keys. It has not been found in woodwork in buildings. Infestations have been limited to dead wood of trees, logs, stumps, and branches, and to living citrus trees. *N. jouteli* (Banks) (Family Kalotermitidae) occurs in the coastal areas of southern Florida, including the Keys. It is occasionally found in moist foundation timbers of buildings, but in nature it lives in dead trees and in logs and branches lying on the ground. Both of these species have a fairly high moisture requirement. Their workings are often situated in fairly damp wood or in dead wood adjacent to the living wood in living trees.

Calcaritermes nearcticus (Snyder) (Family Kalotermitidae) is also known only from Florida. It is similar to *Cryptotermes*; however, it occurs in damper wood and lines some of its galleries with brownish material.

Prorhinotermes simplex (Hagen) (Family Rhinotermitidae) is found only in Florida in the United States. It has a very limited distribution on some of the southeastern Keys and on the mainland occurs only in Dade County. It occurs in mangrove swamps on the coast and in pine forest areas in the lower Everglades. It is fairly common in the Miami area but is not found north of Fort Lauderdale. It has not been collected more than 10 km from the coast. This coastal distribution is typical of this genus throughout the world (1267).

Order Hemiptera—True Bugs

The order Hemiptera consists of a large and widely distributed group of insects. The majority of species are terrestrial in habit, but several are aquatic. Many of the terrestrial forms are phytophagous and feed on a wide variety of trees and smaller plants. Trees, fortunately, are seriously damaged by only a few species. The order also contains a large number of predatory species, many of which feed on other insects and their eggs. A number of others feed on blood of humans and other animals and are decidedly obnoxious or harmful, especially those that transmit disease-causing organisms.

The majority of the Hemiptera have the basal portion of the forewing thickened and leathery, and only the apical portion is membranous. It is from this "half-wing" appearance that the order gets its name. The hindwings are entirely membranous and usually slightly shorter than the forewings. Both pairs of wings lie flat over the abdomen with the membranous distal portion of the front ones overlapping. The mouth parts consist of a bundle of stylets inside a segmented sheath. This slender beak arises from the front part of the head and usually extends backward along the underside of the body, sometimes to the base of the hind pair of legs. Feeding is accomplished by inserting the stylets into the tissues of the plant or animal host and sucking up the juices or blood. The beak sheath folds back beneath the insect as the stylets pierce deeper into the tissues. The antennae are fairly long and consist of four or five segments. Many species have scent glands which give off offensive odors when the insect is disturbed. Comprehensive studies have been made of the Hemiptera of eastern North America (130, 157).

Family Pentatomidae

Stink Bugs

Pentatomids are commonly called "stink bugs" because of the disagreeable odor they emit when disturbed. The adult is usually a broad, short, slightly convex insect. The antennae are five-segmented, and the head and thorax sometimes form a triangle. Many species are brightly colored or conspicuously marked. Green ones may be difficult to detect on leaves. Dark-gray ones are also difficult to see when they rest on the bark of limbs and trunks of trees. Most species are plant feeders, but some feed on other insects, and some feed on both.

The shieldbacked pine seed bug, *Tetyra bipunctata* (Herrich-Schäffer), occurs on loblolly, slash, shortleaf, longleaf, Virginia, eastern white, red, jack, and sand pines and is an important pest in southern pine seed orchards (286, 360). The adults and nymphs are oval and have a humpbacked appearance. The adults are about 15 mm in length. Their color varies from gray-brown in the early stages to a dark reddish-brown with black markings as adults. Their shape and color provide concealment while they feed on nearly mature cones. When motionless, they are not readily noticeable. The eggs are small, green spheres 1.5 mm in diameter. About a dozen eggs are laid in two alternate rows along a single needle or in a group

