Entomologist

PEST CONTROL, INC.

TERMITE SPECIALISTS — 904-641-4922
FAX 904-641-9853

Pest Control
Lawn Care
Estate Inspection

10256 Beach Blvd. • Jacksonville, FL 32246

A CHARTER A

PEST CONTROL INC.
10256 Beach Blvd.
Jacksonville, Florida 32246-4792

Phone 641-4922

5/20/96 [handwritten initials]

DATE 5/17/96

NUMBER

Nassau County
Maintenance Dept
3163 Bailey Rd
Fernandina Beach FL 32035

TERMS

PLEASE DETACH AND RETURN WITH YOUR REMITTANCE — $ 775.00

DATE		BALANCE
	BALANCE FORWARD ⇒	
	Re: Nassau County Courthouse	
5/15/96	Wood destroying organism inspection and evaluation.	775.00

COPY

APPROVED

DATE 5/21/96

All Accounts are due and payable within 30 days of date of service, accounts over 30 days are past due and subject to a 1 1/2% late fee per month.

Thank You

PAY LAST AMOUNT IN THIS COLUMN

A CHARTER A
PEST CONTROL INC.

10256 BEACH BLVD.
JACKSONVILLE, FLORIDA 32246-4792
(904) 641-4922

PAUL M. McKINIRY
Entomologist

May 17, 1996

Nassau County
Maintenance Dept
3163 Bailey Rd
Fernandina Beach FL 32035

Re: Nassau County Courthouse

Dear Sirs,

The results of my inspection of the courthouse building on May 15, 1996 are detailed on the accompanying wood-destroying organisms report. I am further summarizing herein my opinion and making recommendations.

The size of the building and my lack of familiarity with the titles of the departments and rooms require that I generalize my findings particularly in describing the locations of the wood-destroying organisms evidence.

It is my opinion that the greatest concern should lie in controlling the EASTERN SUBTERRANEAN TERMITE problems. As renovations are being made, roof leaks, and moisture conditions must be eliminated, including weather sealing and waterproofing all exteriors. The sources of the existing moisture conditions must be addressed and repaired, as well as replacement of wood members affected, thereby eliminating a conducive situation for above-ground subterranean termite activity. These areas should then be chemically treated appropriately to reinforce any weakness or chemical breakdown occuring from moisture.

The second concern is DRYWOOD TERMITES: evidence was found in (3) sites, however no live or active termites were observed at the time of inspection, this being not unusual. The swarming season for the drywood termite begins in our area from approximately late May through the end of the summer; the magnitude of the possible infestation may be determined throughout this period by the quantity of swarming termites or lack of. I recommend a follow-up inspection within eight to twelve weeks to check the (3) sites for signs of active, live infestation.

Another concern is the evidence of the wood boring beetle known as the OLD HOUSE BORER; numerous exit holes were found, all of which are located in the front portions of the attic. Again, probing the wood revealed no live insects, but actually splitting the beams is usually required to find the larvae. Conspicuously missing was the large amount of very fine frass which is pushed out of exit holes in areas of active infestation.

The majority of the areas of evidence appear very sound; a structural report can provide more detail on this.

I recommend that the current renovation to the structure continue in progress; further evidence of insect activity may be uncovered, also some of the insect damaged wood that has already been planned for replacement will be removed, eliminating the question of whether the site is active or inactive.

Further monitoring is the most conservative approach, which may likely be accomplished as renovations proceed. Fumigation of the entire structure is the most reliable way to curtail the possibility of further insect activity and damage, and should be considered.

An option for treatment of the Old House Borers is a borate treatment using a product such as TIMBOR; this type of treatment is localized and is an alternative to whole-structure fumigation.

Both Drywood Termites and Old House Borers can be treated by whole-structure fumigation; fumigation can assure that any hidden undetected insect activity is stopped.

I have enclosed information related to TIMBOR treatment and fumigation treatment using Vikane fumigant. I have also included information pertaining to the life cycles of the specific insects.

Please contact me directly for any further information you require.

Sincerely,

A Charter A Pest Control, Inc.
Paul M. McKiniry
Entomologist

WOOD-DESTROYING ORGANISMS INSPECTION REPORT

Section 482.226, Florida Statutes

Licensee name A CHARTER A PEST CONTROL, INC. License number 0000201

Licensee address 10256 Beach Boulevard, Jacksonville, Florida 32246

Inspector Paul M. McKiniry Inspection date 5/16/96 Identification Card No. 2657

Requested by Nassau County Maintenance Department, 3163 Bailey Road, Fernandina Beach, FL 32035
(name) (address)

Property inspected Nassau County Courthouse, Fernandina Beach, Florida 32035
(address)

Specific structures inspected Courthouse and offices

Structures on property NOT inspected Refer to attachment page(s).

Areas of structure(s) NOT inspected Refer to attachment page(s).

Reason NOT inspected Refer to attachment page(s).

SCOPE OF INSPECTION

"Wood-destroying organism" means anthropod or plant life which damages and can reinfest seasoned wood in a structure, namely termites, powder post beetles, oldhouse borers, and wood decaying fungi.

THIS REPORT IS MADE ON THE BASIS OF WHAT WAS VISIBLE AND ACCESSIBLE AT THE TIME OF INSPECTION and is not an opinion covering areas such as, but not necessarily limited to, those that are enclosed or inaccessible, areas concealed by wall coverings, floor coverings, furniture, equipment, stored articles, or any portion of the structure in which inspection would necessitate removing or defacing any part of the structure.

THIS IS NOT A STRUCTURAL DAMAGE REPORT. A wood-destroying organisms inspector is not ordinarily a construction or building trade expert and therefore is not expected to possess any special qualifications which would enable him to attest to the structural soundness of the property. IF VISIBLE DAMAGE OR OTHER EVIDENCE IS NOTED IN THIS REPORT (ITEM NUMBER (3) OF THIS REPORT), FURTHER INVESTIGATION BY QUALIFIED EXPERTS OF THE BUILDING TRADE SHOULD BE MADE TO DETERMINE THE STRUCTURAL SOUNDNESS OF THE PROPERTY.

THIS REPORT SHALL NOT BE CONSTRUED TO CONSTITUTE A GUARANTEE OF THE ABSENCE OF WOOD-DESTROYING ORGANISMS OR DAMAGE OR OTHER EVIDENCE UNLESS THIS REPORT SPECIFICALLY STATES HEREIN THE EXTENT OF SUCH GUARANTEE.

REPORT OF FINDINGS

(1) Visible evidence of wood-destroying organisms observed: ☐ No XX Yes Wood Borer Beetles; Eastern Subterranean Termites; Drywood Termites; Wood Decay/Fungi
(Common name of organisms)

Locations: Refer to attachment page(s).

(2) Live wood-destroying organisms observed: XX No ☐ Yes
(Common name of organisms)

Locations:

(3) Visible damage observed: ☐ No XX Yes Wood Borer Beetles; Eastern Subterranean Termites; Drywood Termites; Wood Decay/Fungi
(Common name of organisms causing damage)

Locations: Same as listed #1; refer to attachment page(s).

(4) Visible evidence of previous treatment was observed: ☐ No XX Yes

Explain: Drill marks

(5) This company has treated the structure(s) at time of inspection: XX No ☐ Yes IF YES: A copy of the contract is attached.

(Organisms treated) (Pesticide used)

(6) This company has treated the structure(s): XX No ☐ Yes IF YES: Date of Treatment:

(Common name of organisms) (Common name of pesticide)

(7) A notice of this inspection: ☐ and/or treatment XX has been affixed to the structure(s)

Crawl
(Location of notice(s))

COMMENTS: Refer to attachment page(s).

Neither the licensee nor the inspector has any financial interest in the property inspected or is associated in any way in the transaction with any party to the transaction other than for inspection purposes.

SEND REPORT TO PERSON WHO REQUESTED THIS INSPECTION AND TO:

Signature of Licensee or Agent Paul M. McKiniry Date 5/16/96

103645 (1145) DACS REV. 11-92 (Obsoletes Previous Editions)

A CHARTER A

PEST CONTROL INC.

10256 BEACH BLVD.
JACKSONVILLE, FLORIDA 32246-4792
(904) 641-4922

PAUL M. McKINIRY
Entomologist

May 16, 1996

Nassau County Maintenance Department
3163 Bailey Road
Fernandina Beach, Florida 32035

RE: Nassau County Courthouse

Attachment to accompany DACS FORM 103645 inspection report for the above-referenced property.

Structures NOT inspected: NONE

Areas of structure(s) NOT inspected:

1. Portions of interior
2. Portions of attic
3. Exterior eaves
4. Portions of flooring
5. Portions of walls
6. Portions of crawl
7. Enclosed and inaccessible areas

Reasons NOT INSPECTED:

1. Furnishings and government business restricting access
2. Some areas inaccessible to inspect
3. Inaccessible
4. Concealed by floor coverings
5. Concealed by wall coverings
6. Inaccessible
7. Areas behind interior and exterior walls, areas concealed by wall coverings, floor coverings, furniture, equipment, stored articles, landscaping, etc.

#1 VISIBLE EVIDENCE:

A. Wood Borer Beetles

1. Scattered signs in attic beams

B. Eastern Subterranean Termites

1. Scattered signs throughout attic with heavier concentrations in areas of water staining and/or leakage
2. Attic window frames, front support beams
3. Arch windows at NW location in judges chambers

PMM 5/16/96

4. Termite and wood decay evidence at truss ends in lower portion of rear utility area at extreme SW corner of building
5. Signs on 2 x 14 under ramp at ladies room, located just inside crawl

C. Drywood Termites

1. Old termite galleries - located in exterior window sill (4th sill from rear) to west side of courtroom
2. Termite pellets in phone/file room on ground floor
3. Evidence on floor joists located approximately 6-10 feet back in extreme western-most crawl

D. Wood Decay/Fungi

1. Exterior window sill of courtroom, third window over on west side
2. Scattered on interior eaves and sheathing in attic

COMMENTS:

Water leakage evident under tower area of attic; also, areas of attic eaves and along several areas of exterior walls on floor below. Some water staining noted in areas of crawl space, confined to limited and various locations.

Signature Paul M. McKiniry Date 5/16/96
A Charter A Pest Control, Inc.
Paul M. McKiniry
President

Wood Protection by Surface Treatment with Borates

Masahiko Tokoro and Nan-Yao Su, University of Florida
An abstract, from a presentation to the Florida Entomological Society
August 10, 1993

Procedures:

Products:

Tim Bor (disodium octaborate tetrahydrate), 10%
Bora Care (40% disodium octoborate tetrahydrate, 60% Ethylene glycol), 20%

Application procedures:

Pine 2 X 4s (wood moisture content 15%) sprayed 2X to the point of runoff, allowed to dry 1 week, then cut into 20cm sections, subjected to bioassay for 6 months. Chemical assays taken at 1 week and 6 months.

Bioassay procedures:

Three colonies each species (native and Formosan)
Three reps per species/compound combination (total 6 reps/species)
Termites were placed in separate protective chamber which was conected to the center of the cut end of each block, allowing the termites to leave the chamber and forage freely through the treated block.

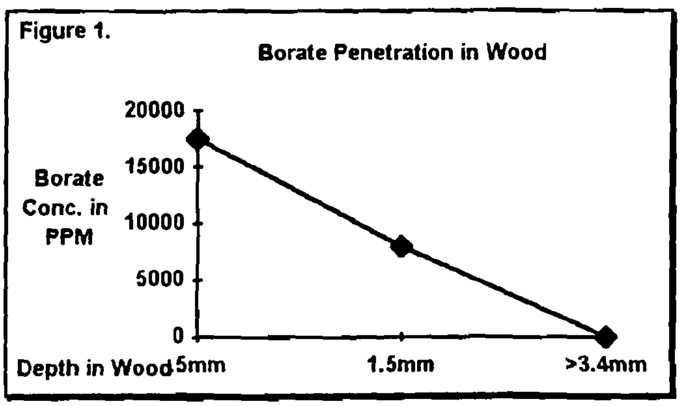
Results:

Bioassay:

Neither product inhibited penetration of termites. Termites penetrated through to the surface of treated blocks in all reps and even made tunnels on the treated, exterior surfaces of the blocks. In no replicate did the borate treatment stop penetration or damage of wood by termites; treatments only slowed the colonies down so that they consumed slightly more than half the wood consumed in the untreated controls. Mortality, though greater than controls, did not eliminate colonies.

Chemical Assay:

Penetration of Borates into wood was extrememly limited--even at 6 months (time of greatest penetration)--resulting in a thin, highly concentrated layer at the surface, dropping off sharply to



non-detectable levels within 3.4 mm (see Fig. 1). Some borate residues were detected in termite galleries, indicating some potential for transfer by termites.

Summary:

Borate treatments did not penetrate much beyond the surface.
Borate treatments did not protect wood from termite attack (penetration, tunnelling and consumption).
Mortality was insufficient to eliminate colonies.
Wood consumption reduced by less than 50% versus controls.

TIMBOR

Date of Introduction:
1983 registered for cockroaches, ants, beetles, fungi, termites

EPA Numbers:
Registration No. 64405-1; Establishment No. 64405-TN-1

License Fee/Process:
Available through normal distribution

Equipment/Costs:
B& G or power sprayer , hand drill,

Treatment Process:
Timbor/Bora Care is an inorganic salt(disodium octaborate tetrahydrate) that is water-soluble. When applied to bare wood penetrates deeply and can remain there for up to 40 years. The diluted Bora-Care must be used within 24 hours after mixing. Depending on the infestation location, the solution can either be applied to the point of runoff or injected into beetle holes/termite galleries.

Time Requirement:
Depends on the location/size of the infestation. Estimate half to one day of labor.

Scientific data/support:
U. S. Borax Research Corporation has a number of laboratory studies which attest to the effectiveness of Timbor for controlling subterranean termites and powderpost beetles. Studies for drywood termite species are not as complete. Current advertising claims that timbor/bora care has a two-fold mode of action. One, it can act a a repellent against termites; and two, as a toxic bait on the wood that termites ingest. Research is still needed to clarify the exact mode of action, depth of penetration in wood, and the ability of subterranean termites to build over or wall of borate-treated areas. Their literature states that it is not a substitute for fumigaton since fumigants treat everthing within the tent. Borates can be used as as a suppliment to fumigation in order to provide long term residual control. No publications or referee journals exist.

HUD/FHA:
Meets requirment as long as a guarantee is offered

Safety:
The use of chemical spalsh goggles and solvent resistant gloves is advised. .Spills and over-spray may be cleaned with a damp cloth or absorbed with appropriate materials. A NIOSH approved respirator is recommended for confined areas. Possible depressive effect on nervous system.

Claimed Benefits:
Naturally occurring product, no color, ordor or surface residue; easy and convenient to use; interior and exterior use; long term residual activity; low toxocity to humans and pets; cost effective

Advertising:
Businesss to business brochures

Costs to Homeowner:
Complete treatment is usually priced 10% less than a fumigation. Spot treatments are 1/2-1/3 the price of a fumigation.

Guarantee:
Depends on customer offering service. Probably one year, only for treated area.

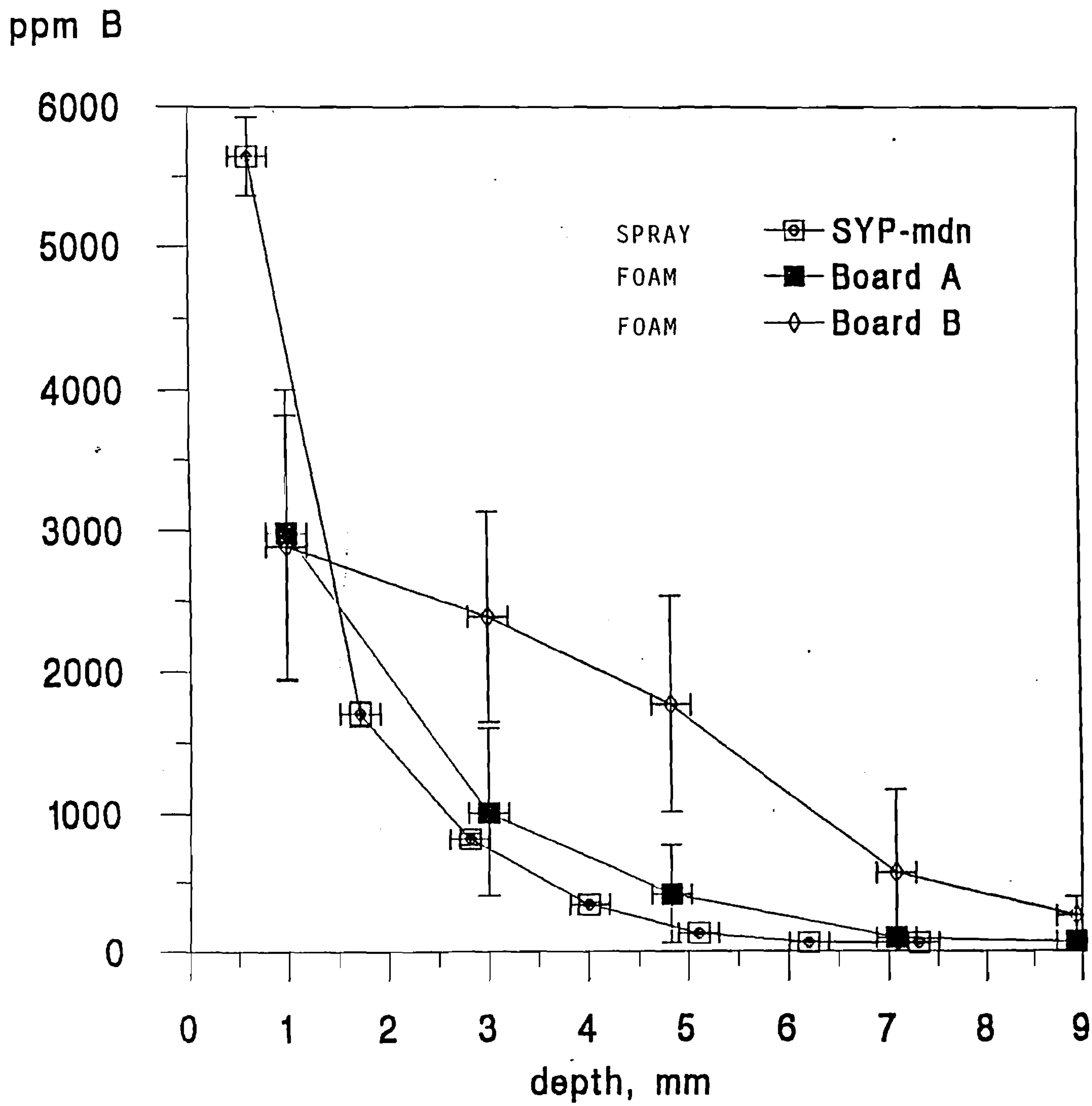
Customers:
Used by many customers as a "tool" in their aresenal of methods to use. Rarely used as a substitite for fumigation or complete treatments.

TIMBOR/BORA-CARE (continued)

Claimed Benefits:
No deadly chemicals, safe & clean, proven effective, no holes drilled in walls, no moving out overnight, no boarding pest, no bagging perishable foods, no removing plants, no roof release required, hassle-free

Concerns:
Cannot penetrate painted or varnished wood. Dr. Rudi Scheffrahn says penetraion of bare wood is very poor.

Foam Treated SYP
15 % TIM-BOR Foam (A & B) vs
2X 10 % TIM-BOR sprays



Courtesy of Dr. Mark D. Noirot and U.S. Borax, Inc.

flights usually begin before sundown and end before midnight. Alates of *Coptotermes formosanus* are strongly attracted to lights. Indigenous subterranean termites (*Reticulitermes* spp.) fly only during the day.

Western Drywood Termite, *Incisitermes minor* (Hagen) (Kalotermitidae)

Drywood termites establish their colony and continue to live in nondecayed wood having little moisture and, unlike subterranean termites, they never require contact with the ground. In some regions, such as southern California and the Caribbean area, they are the most important termite pests.

In California, the western drywood termite is found under natural conditions as far north as Mendocino County and the Sacramento Valley. It is abundant in coastal regions, and extends eastward into Arizona in peripheral desert regions, in mountain canyons, and along streambeds. Colonies of this species have been transported to, and at least temporarily established in, various parts of the United States. Drywood termites are very amenable to accidental distribution because they may infest commonly transported articles, such as boxes, crates, and furniture, can tolerate low moisture conditions for long periods, and the colony is often small, infesting only a small volume of wood, and can therefore be readily transported for long distances.

Unlike the powderpost termite, *Cryptotermes brevis*, the western drywood termite is seldom seen in furniture and other small wooden products. However, an interesting observation on such an infestation was made by R. E. Wagner in October, 1973 (personal communication). In a bookcase having no contact with wooden members of the house structure, he found many predrilled 3-mm holes, 5 of which had been plugged with the typical drywood termite sealoff. A recently established royal pair of drywood termites was found about 10 mm deep in each hole, evidently individuals from the annual flight of alates. The house had been fumigated about 10 years earlier, but had become reinfested.

In newly developed residential tracts in California, some of the orchard trees are retained in the dooryards. The dead limbs on such trees often harbor drywood termites, particularly if the trees are walnut, and these may serve as sources of infestation for the newer houses. In southern California, homes in new residential tracts tend to become infested by drywood termites sooner and in greater numbers than by subterranean termites (Ebeling, 1968). Most often, drywood termites infest these homes as alates originating in older buildings in near-by areas. However, infested telephone poles, posts, and piles of lumber or firewood can also be sources of further infestation.

The lumberman, builder, and homeowner and, in lawsuits, the lawyer, often inquire as to where, in the sequence of events from the planing mill to the finished home, infestations of such insects as drywood termites, woodboring beetles, and woodwasps originate. It is important to know the life histories and habits of such insects.

Description of Drywood Termite Alate. The alate (plate I, 4; figure 82) is dark brown, and has smoky-black wings with black veins. It may be distinguished from the alate of the western subterranean termite by its larger size (about 11 to 12 mm long) and by the fact that it has a reddish-brown head and thorax, while the subterranean termite is black throughout.

Fig. 82. Western drywood termite, *Incisitermes minor*. *Top*, queen, soldier, and nymphs; *center*, alates; *bottom*, soldier and nymphs.

Habits. The first evidences of drywood termite infestation are usually piles of brownish fecal pellets (figure 83) below "kickout" holes or chinks and cracks in the infested wood, particularly where outer walls of the wood member have become excessively thin from prolonged infestation.

Fig. 83. Fecal pellets of the western drywood termite, *Incisitermes minor*. *Left*, typical pile of pellets on a ceiling plate; *right*, enlarged view of pellets. (From Ebeling, 1968.)

The pellets are elongate, averaging about 0.85 mm in length, with rounded ends, and with 6 flattened or roundly depressed surfaces. Longitudinal ridges occur at the angles between the 6 surfaces. The shape of the fecal pellet is the result of pressure exerted by 6 plates of rectal epithelium and 6 rectal grooves (Child, 1934). Another indication of the insects' presence may be the flight of alates during warm, sunny days in the fall months.

Besides infesting the dead branches of common native trees and shade and orchard trees, drywood termites also infest utility poles, posts, and piles of lumber (particularly sapwood of redwood) in lumberyards. They generally enter houses through attic vents or shingled roofs but, particularly in hot, dry localities, they are often found in the substructure, where they may have entered via the foundation vents. They attack rafters, ridgepoles, and sheathing in the attic, windowframes and sills, door and window jambs, doorsills and, in the substructure, mainly the floor joists and adjoining structural timbers. They may also infest wooden furniture or other wooden materials within the home.

Pence (1956*b*) found that under extremely dry conditions, individuals of *Incisitermes minor* in a wood cavity sealed themselves in thoroughly with carton and huddled together to conserve moisture. One individual in such a group survived in kiln-dried wood placed in a silica gel desiccator for 245 days. Its abdomen was then completely flat from loss of water. When given access to water, the termite drank until it became turgid and then continued its life normally. Because most kalotermitids can live in dry wood and do not require shelter tubes leading to the ground, they can damage wooden furniture, even if it is moved about frequently. This, plus the ability of a colony to exist in a very small piece of wood, results in kalotermitids and another nonsubterranean termite species being easily dispersed from one area to another. They often appear in areas far removed from regions in which they are indigenous, and it is then urgent that such localized infestations be eradicated.

The Royal Pair

After a flight of winged reproductives and subsequent breaking off of their wings, a mated pair of drywood termites will select a place to enter wood. Pairs work together to make a hole (figure 84), and then seal themselves in (Harvey, 1934). The hole serves as the entrance to the "royal cells," and is about 10 cm deep. The "royal pair" enlarge the hole, and the queen lays her first eggs. Generally, 2 to 5 nymphs hatch from the first eggs and begin an enlargement of the burrow. The nymphs (plate I, 5; figure 82) perform the duties of the worker caste of the higher termites. The queen then lays more eggs in the advanced part of the main passage of the burrow.

Colony Composition

Toward the end of the second year, after the colonizing pair has entered the wood, the colony generally consists of the primary king and queen, one soldier, and a dozen or more nymphs

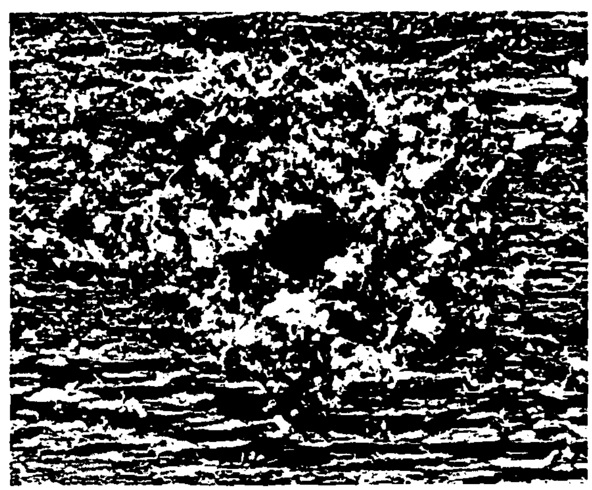


Fig. 84. Entrance hole of the "royal pair" of the western drywood termite.

(Harvey, 1934). By this time, the abdomen of the queen has become broader and longer, and she can lay a greater number of eggs (figure 85). From late spring to late fall, the primary queen lays from 1 to 12 eggs each day for 7 to 10 days, ceases egg-laying for a month or more, and then resumes at the same rate as before. Harvey (1934) found that at a temperature of 80° F (27° C) and a relative humidity of 83%, the eggs in 1- and 2-year-old colonies were hatched in an average of 77 days. He believed that maximum egg-laying capacity is reached when the queen is 10 to 12 years old, and then declines rapidly. A secondary queen then takes over her functions.

The time required for *Incisitermes minor* to develop from egg to alate or soldier is believed to be more than 1 year. It has been estimated that a colony 15 years old might contain a primary king and queen, 1 or more supplementary reproductives, 120 soldiers, and 2,600 nymphs. Thus, the colonies are small compared with those of the subterranean termites, which may contain millions of individuals.

The relatively small colonies result in correspondingly less rapid and less severe damage to buildings than that which is caused by most subterranean termites, but proliferation of colonies in a building can result in extensive infestation.

Fig. 85. Primary queen of the western drywood termite and a clutch of eggs.

Southeastern Drywood Termite, *Incisitermes snyderi* (Light)

This species ranges from South Carolina to Florida and west to eastern Texas. It is lighter in color than *I. minor,* and is not so severe a pest, but does similar damage. Its flights occur in May or June at nightfall.

Desert Drywood Termite, *Marginitermes hubbardi* (Banks)

These termites replace *Incisitermes minor* at lower elevations and in more arid regions of the deserts of southeastern California, in Arizona, and in northwestern Mexico. The alates are yellow to light brown and, including wings, are about 13 mm long. They may be distinguished from the alates of most other drywood termites of the areas by their very pale coloration, round ocelli, and by the third antennal segment, which is not longer than the second or fourth. In the soldier, the third antennal segment is clublike and is almost as long as all the succeeding segments combined, making identification easy. The alates emerge at night, usually just after a rain, and tend to collect at lights by the thousands. This species readily invades buildings, and is sometimes very abundant in favorable locations. Its damaging potential may increase as cities and suburbs extend into desert regions where it can exist in large cacti and in trees (Weesner, 1965). It is very destructive to poles, posts, floors, ceilings, window and door frames and sills, furniture, boxcars, and other wooden objects in coastal or low-lying towns of the west coast of Mexico. It is much more common in wooden structures than in wood occurring in nature (Light, 1933).

Powderpost Termite, *Cryptotermes brevis* (Walker)

This species (plate I, 6) was accidentally introduced into the United States, and is well established in Hawaii, Florida, and parts of Louisiana. It has not been recorded in any natural habitat, but only in man-made structures. It is widely disand extent of woodborer infestations in finished lumber could be determined. It may be desirable to use this technique before investing in an expensive control measure, such as fumigation. Fumigation with methyl bromide gas has been successful in the United States and Europe for the control of the oldhouse borer, *Hylotrupes bajulus*, which has habits similar to those of the newhouse borer and does similar damage. Therefore, it is reasonable to suppose that methyl bromide can be successfully used against the latter species.

Infestation of a building by newhouse borers is seldom, if ever, sufficiently severe to justify the great expense of fumigation. Filling of exit holes or repair of damaged areas after the adults have emerged is the most economical solution. In any case, by the time the infestation has been detected it is often too late for any measures aimed at the destruction of the insects themselves.

Oldhouse Borer, *Hylotrupes bajulus* (L.)

The oldhouse borer apparently originated in northern Europe, where it has been found in 40 to 50% of the houses in some surveys. It has spread from there to many parts of the world, including most of the states of the Atlantic seaboard and in various other areas as far west as Minnesota and Texas. An August mean temperature of about 73° F (23° C) is an important factor favoring the development of the oldhouse borer, and might be a useful criterion in predicting the future distribution of the beetle in North America (Anonymous, 1967*c*). There are well-documented records of the oldhouse borer having been transported to new areas in infested wooden boxes and packing cases. From France, the insect was transported to England in pine flooring, and to Australia, in the pine framing of prefabricated houses (NPCA, 1965). Thus, while this serious pest has not yet been established in the western United States, there is no reason to believe it could not be accidentally introduced.

Unlike the newhouse borer, the oldhouse borer can be present in old houses as well as new ones and, most importantly, can reinfest timbers from which it emerges. It can thus cause great structural damage.

Korting (1962) stated that lumber in houses 60 years and more of age was less subject to infestation than in new houses. Moreover, adult female beetles in the older houses are smaller and have fewer progeny. Patton (1931) reported that, in Denmark, roofs of timber covered with metals more than 20 years were most subject to attack. Houghton (1939) stated that in the United States, *H. bajulus* was most likely to attack attic and roof timbers, but infested framing and flooring also. In Norway, *H. bajulus* was found mainly in attics, and only in districts of the highest mean temperatures and the longest periods of relatively high temperatures during the summer (Knudsen, 1967). In Massachusetts, houses that are centuries old, some of historic interest, are being infested. Sometimes the infestations are so severe that the occupants of infested houses hear "gnawing" or "clicking" sounds that are caused by the beetles (Becker, 1954). Like the newhouse borer, the oldhouse borer attacks only softwoods, feeding mainly on the sapwood, but the adults may bore through other types of wood or plaster in order to emerge.

Whereas both *Arhopalus productus* and *Hylotrupes bajulus* can be introduced into a building in infested lumber at the time of construction, of the 2 beetles only *H. bajulus* can infest the building after construction. At least in the United States, it is strictly a structural pest, and has not been found in logs and stumps (Snyder, 1955*a*), presumably because it is an introduced species that has not yet become established in nature. [Another species, *H. ligneus* (F.), has been found

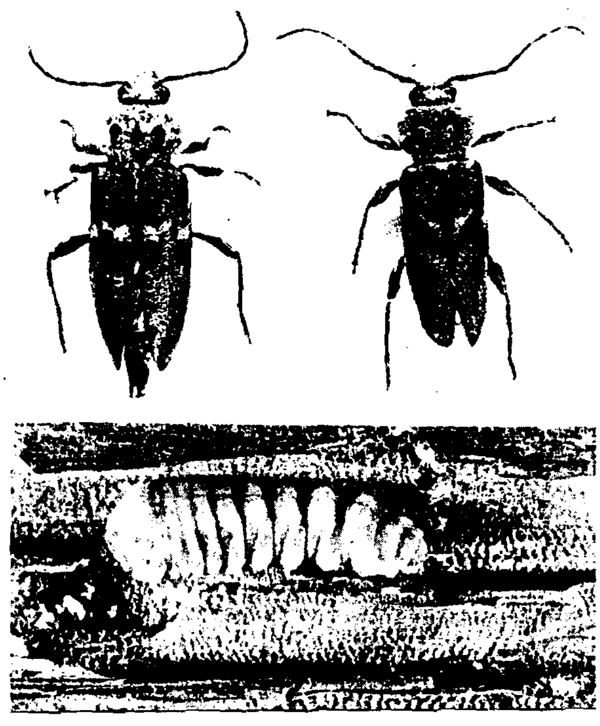


Fig. 122. Oldhouse borer, *Hylotrupes bajulus*. *Top*, female (*left*) and male; *bottom*, larva *in situ*. (Courtesy United States Forest Service.)

damaging rustic furniture in cabins (Thompson, 1932).] Although infestation by *H. bajulus* can occur wherever susceptible wood is present, in the United States the majority of infestations are said to be in attic framing in the northeastern area and in the substructure along the mid-Atlantic Coast (NPCA, 1965).

Description. The adult females of *Hylotrupes bajulus* may reach a length of 2.5 cm, but the males are only about half as long. The adults are slightly flattened, grayish black to very dark brownish black, with many gray or yellowish-gray hairs on the head and anterior part of the body. However, these may be rubbed off on older specimens. Two elevated black, shiny knobs on the prothorax give the dorsum an appearance like a face with a pair of eyes (figure 122). About a third of the way posterior on the elytra, and centrally located, there are 2 grayish, transverse marks.

The full-grown larva (figure 122) is grayish white, from 2 to 4 cm long, has a broad thorax, and tapers posteriorly. There are deep folds between the abdominal segments, and there is a deep groove running lengthwise in the center of the prothorax. There are 3 black ocelli in a row on each side of the very small head, but a hand lens is required to see them. The stout, very dark jaws are relatively prominent. The pupa is about the size of the adult, and is at first creamy-white and then becomes light brown.

About 150 to 200 white to grayish-white, spindleshaped eggs about 2 mm long are laid in checks, cracks, crevices, or irregularities of the wood. Stacks of lumber are said to be excellent oviposition sites. It takes 2 or 3 weeks for the eggs to hatch. The larvae feed in the dry sapwood from 2 to 10 years (usually 3 to 5) until the sapwood is completely destroyed. They fill their mines loosely with frass composed of tiny pellets and fine, powdery material. The frass occupies a greater volume than the wood from which it was produced, and this causes the surface of the infested wood to have a blistered or rippled appearance (Hickin, 1963*a*). A rhythmic rasping or chewing sound made by the larvae may be the first indication of their presence, for their tunnels seldom break through to the surface, even though the interior may be severely mined.

Life Cycle. The adults may remain in the tunnels prepared by the larvae for 7 to 10 months before emerging, but then live for only a brief period. They appear in the summer, and oviposition takes place at that time. In the United States, the period required for the life cycle of the old-house borer may be from 3 to 5 years in the ern states, whereas northward from the la of Washington, D.C., an additional 2 to : may be required. Most of the period is sp the larval stage, for the egg and pupal stag last only about 2 weeks, and the adults li 16 days. The majority of adults fly in Ju July. Adult beetles often emerge from atti bers a year or two earlier than from bas wood in the same building, because of the l attic temperatures (Patton, 1931; Crai 1950; St. George *et al.*, 1957; Hickin, McIntyre and St. George, 1961).

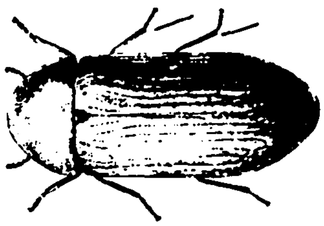
Signs of Infestation

There are a number of indications whe house borers are active in a building. In th stages of an infestation, the rasping or t sounds made by the larvae while boring m heard, or a blistering of the wood when the works close to the surface may be seen. I wood surface is probed where tunneling i pected, the larvae or their powdery boring be located. Only after the buildings are at 3 to 5 years old in the southern states, or more years old northward from the latitu Washington, D.C., will the emerging adul their 7-mm, broadly oval emergence hole evident (McIntyre and St. George, 1961).

Relation of Protein Content to Susceptibility of Wood to Attack

Becker (1963) determined that a minimu 0.2% of protein was required, in the softw investigated, to support an oldhouse borer ulation. From that point, larval developme creased in direct proportion to an increa protein content. The suitability of the woo the development of larvae decreased as it probably because of a change in the nut value of proteins during storage, a decrea vitamin content, and other chemical or struc changes in the wood. The suitability of the for larval development could be fully rest by the addition of protein and vitamin B. N theless, as just stated, some very old building being severely attacked. The older the build the greater the chance that it may have an i tation, despite the decreasing nutritional val the wood.

During the first stages of decay, wood infe by wood-destroying fungi, such as *Lenzites*, sh an increase in protein content and becomes n favorable for larval development. Likewise, |



(6x actual size)

Figure 8-P. ***Xyletinus peltatus*** (Harris). This is a brown to reddish brown beetle clothed with fine yellow hairs. (From "Recognition of Structural Pests and Their Damage" by H. L. Sweetman, by permission of Wm. C. Brown Co., Inc.)

poorly ventilated areas where moisture tends to collect. Its common name is derived from the ticking sound that the adult makes inside infested wood that is audible in the hush and stillness of night. The sound is actually a mating call.

Xyletinus peltatus is a serious pest in the Southeast United States of crawlspace timbers. (See Figure 8-P). Infestations tend to build to such proportions that serious loss of structural strength to sills, joists, and subflooring areas occurs.

LONG-HORNED BEETLES OR ROUNDHEADED BORERS
Family *Cerambycidae*

The beetles of this family lay their eggs in cracks or crevices in bark or on the surface of rough-sawed timbers. The larvae are wood borers.

Mature larvae are large, varying from ½ to 3 or 4 inches long. The body is long and narrow and a light cream color. The rear portion of the head is partly drawn into the body so that only the mandibles and other mouthparts are easily seen.

Adults are large, conspicuous beetles varying in length from ½ to 3 inches long. They can be easily distinguished from other beetles by their long, thin antennae which may be longer than the body. Many species have conspicuous markings on the wing covers.

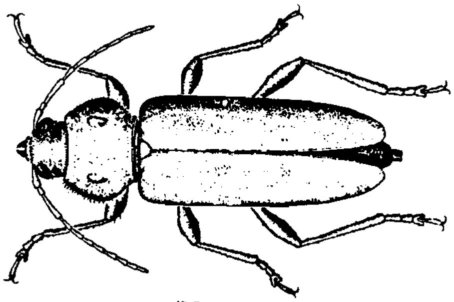
The most common structural pest of this family, and the only one which occurs with any degree of regularity in houses and other structures, is *Hylotrupes bajulus* (Linnaeus), the old house borer. It is a fairly common pest, and its larvae hollow out extensive galleries in seasoned softwood.

The old house borer is mainly a pest of newer structures, although it is found in older buildings. It is well established along the Atlantic Coast, but infestations have been reported as far west as Louisiana and Minnesota.

Adults are greyish-brown to black with the dorsal surface densely covered with light-colored hairs. They are about ¾ inch in length with two white patches on the elytra. On the pronotum there are two black, shiny bumps. When these bumps are surrounded by the long grey hairs, the result is an owl-like appearance. (See Figure 8-Q).

The life cycle usually is three to twelve years, although it can be considerably longer if environmental and nutritional conditions are not favorable. Since the beetle has a very long life cycle and can infest the same piece of wood again and again, it may be many years before serious structural damage is recognized. The exit holes do not occur in very large numbers until the infestation has been established for several years. This, along with the fact that larvae will do extensive feeding without breaking through the surface of the wood, make it necessary to inspect infested wood very carefully to detect old house borer damage. Rough wood being examined should be probed or struck to detect weakness or the presence of boring dust. If exit holes are present, they will be broadly oval and about ¼ to ⅜ inch in diameter.

Like a number of other members of this family, the old house borer is able to digest cellulose. Since



(2.5x actual size)

Figure 8-Q. The old-house borer, ***Hylotrupes bajulus*** (Linnaeus). This large beetle is quite destructive to seasoned softwoods where the larval stages construct extensive galleries which are packed with powder-like frass. It is one of the long-horned beetles of the family Cerambycidae. (A. Provonosha)

carbohydrates are readily available to this insect, the limiting nutritional factor appears to be the supply of protein. Larval development is more rapid in wood which is infested with fungi.

BARK AND TIMBER BEETLES
Family *Scolytidae*

There are a number of species of the family Scolytidae which may be of concern to the pest control specialist. The bark beetles excavate extensive galleries immediately beneath the bark. Certain patterns of tunnels are characteristic of certain groups within the family. The timber beetles excavate tunnels in solid wood. Some of them derive nourishment directly from the wood. Others feed upon fungi which they cultivate within the galleries. The eggs are deposited within the galleries. These beetles are often (but not always) associated with wood from trees which are either dead or dying.

The bark beetles may create problems in log cabins, park shelters and similar structures made of roughhewn wood in which the bark is left intact or in which small areas of bark are left in place. Other common sources of bark beetles are rustic lawn and porch furniture and firewood brought indoors during winter.

Timber beetles are sometimes troublesome when they emerge from improperly seasoned wood used in hardwood floors or in decorative paneling. Although the emerged beetles may be a nuisance for a short

other wood destroyers

TERMITES other than subterranean termites are divided into three groups: dry-wood, damp-wood, and powder-post termites. Of these, dry-wood termites are the most common, although damp-wood termites may be found frequently in some limited areas. The classification followed herein is that of F. M. Weesner.

NON-SUBTERANEAN TERMITES

DRY-WOOD TERMITES

Family *Kalotermitidae*

Dry-wood termites generally live in undecayed wood which has a very low moisture content. They do not require any contact with the soil in order to live. In the United States, they are found in a narrow strip from Cape Henry, Virginia, on the Atlantic, south to Florida, along the Gulf of Mexico, and from Mexico to northern California on the Pacific coast. (See Figure 8-A).

These termites bore directly into wood and make their nests in the wood itself. Because they do not require any contact with the ground, they can seriously damage movable wooden objects such as furniture.

A male and female pair work their way into the wood chosen for the nest. The opening through which they enter the wood is sealed with a plug of brown cement about ⅛ inch in diameter. Behind this plug they excavate a chamber where the queen lays the first eggs. The nymphs which hatch from these eggs perform the work of the colony. Soldiers and reproductives develop from these nymphs. There is no worker caste.

During the swarming season, nymphs make round holes 1/16 to ⅛ inch in diameter through which the reproductive forms leave the wood. When swarming is completed, these holes are plugged in the same way as the entrance holes.

Damage done by dry-wood termites is entirely different from that caused by subterranean termites. These termites cut across the grain of wood, excavating large chambers which are connected by small tunnels. (See Figure 8-B).* The chambers and tunnels being used by the colony are kept clean. Excreta and other debris are stored in unused chambers or cast out through small openings in the wood.

Excretal pellets are a distinguishing characteristic of non-subterranean termites. These pellets are hard and have 6 distinct concave surfaces on the sides; only the ends are rounded. (See Figure 8-C).* Certain anobiid beetles also eject pellets from wood on which they feed. These can easily be distinguished from those of termites because they have rounded, convex surfaces.

Entrance into wood is usually made from a crack or crevice which the termites can enter before boring into the wood. This may be a crack in the wood itself or may be the joint between two pieces of wood or

*See color section in center of book

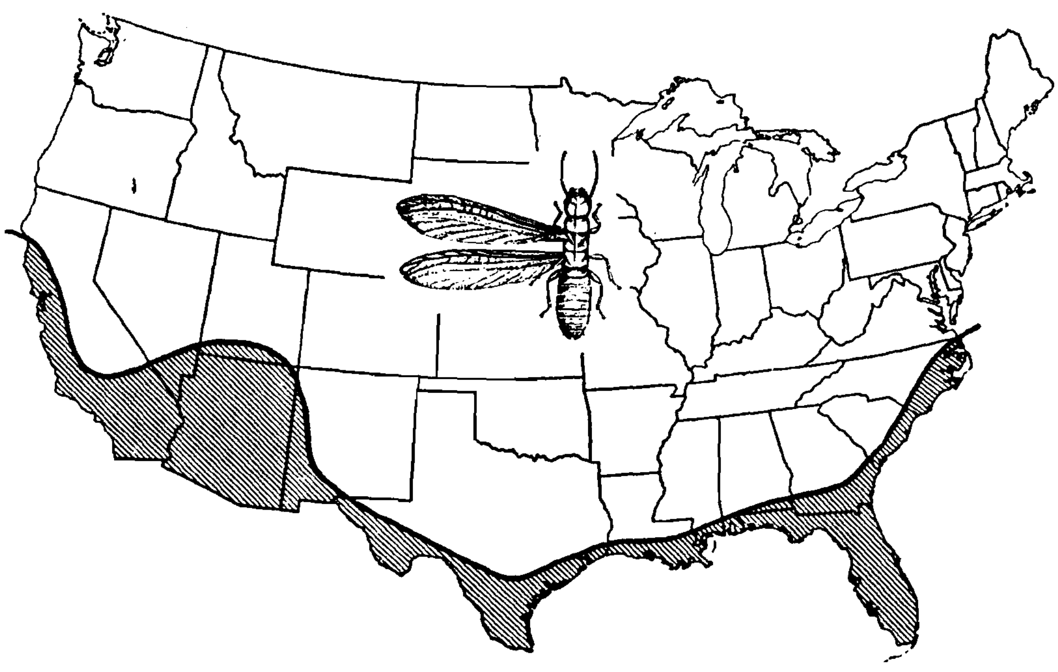


Figure 8-A. A winged adult dry-wood termite and the areas where found (shaded) in the United States. (Redrawn from a plate by T. E. Snyder, 1950, provided by the National Pest Control Association.)

even the space underneath the roofing paper or sheathing paper.

Because of their ability to live in wood without contact with soil, non-subterranean termites are frequently carried in infested furniture and other wooden objects into geographical areas where they are not normally found. For this reason, pest control specialists should be aware of their habits so as to recognize them when they appear.

Dry-wood termites may attack wood products of all kinds. Structural timbers and woodwork in buildings, as well as furniture and other wooden objects, may be damaged. Although serious damage is done to buildings and other wood products in some areas of the U.S., these termites are usually less injurious than Subterranean termites, simply because they are less widespread.

The dark, western dry-wood termite, *Incisitermes minor* (Hagen), is found from California east to Arizona and Utah. In this area, it causes extensive damage to structures as well as to wooden derricks, piled lumber, furniture and telephone poles. It may infest any dry wood portions of a structure from foundation plates to the roof, and it is the most destructive dry-wood termite in this country.

Small flights occur during April through July, frequently after rains. Winged adults are dark brown and about ½ inch long. The white, soft-bodied nymphs remain in the galleries and are not seen unless the wood is broken open.

The light, western dry-wood termite, *Marginitermes hubbardi* (Banks), is found from California to Arizona. It is also referred to as the southern dry-wood termite. This termite is very similar in habits to the western dry-wood termite but prefers drier conditions and higher temperatures.

The light, southeastern dry-wood termite, *Incisitermes snyderi* (Light), is found from South Carolina to Florida and west to Texas. It is the most injurious species of dry-wood termites in that area.

Another southern dry-wood termite, *Incisitermes schwartzi* (Banks), is a common species in southern Florida occurring as far north as Pensacola.

The dark, southeastern dry-wood termite, *Kalotermes approximatus* Snyder, occurs along the Gulf Coast west to New Orleans and on the Atlantic Coast north to southern Virginia. It attacks both timbers in structures and in posts and utility poles.

ROTTEN-WOOD, DAMP-WOOD TERMITES: *Kalotermitidae, Hodotermitidae, and Rhinotermitidae*

The group contains some of our largest termites with bodies as much as one-inch long and with wings of alates twice that length. Although damp-wood termites do not require contact with the soil in order to obtain moisture, they cannot live in dry wood, but require wood with a high degree of moisture content. They are also usually associated with wood decay.

They plug openings into the wood and excavate large galleries, as do dry-wood termites. They do not, however, keep the galleries clean. Their pellets can be found throughout their tunnels in infested wood, although many of the six-sided pellets are discarded from the galleries through small openings in the surface of the wood.

The rotten-wood termite, *Zootermopsis angusticollis* (Hagen), is the largest of our native termites and is the most important termite of this group from an economic viewpoint. Since moist but sound wood is attacked, this species perhaps should be called more properly a damp-wood termite. There is no worker caste. The work of the colony is carried on by the nymphs of the soldiers and reproductives. It occurs most commonly in the cool and humid coastal areas. Sporadic infestations are found at lower altitudes in southern California. It occurs commonly at higher elevations in the coastal ranges of mountains. As one moves north along the West Coast, the frequency and severity of occurrence at lower elevations becomes more pronounced. The rotten-wood termite is a major problem at low altitudes along the coastal areas of Washington and Oregon. According to Snyder, although termed a rotten- or damp-wood termite, this species continues to live in dry, sound wood. Occasional colonies of this termite are carried to other parts of the country in shipments of lumber, but it has been unable to establish in these areas.

Winged forms are light brown with dark-brown leathery wings. Nymphs are white to cream-colored with a darker abdomen. These termites swarm in relatively small numbers, 50 to 60, from a single colony. Swarmers are attracted to light and are common about street lights at night.

The desert damp-wood termite, *Paraneotermes simplicicornis* (Banks), which is found in the Southwestern states from Texas to California, differs from other damp-wood termites in being subterranean in habit. It attacks only moist wood. This termite is of horticultural importance since it frequently attacks the underground parts of shrubs and young trees and is particularly troublesome in residential areas and citrus groves. It is also found in fence posts and in baseboards and door frames of buildings. Flights occur in July and August in evenings after rains.

The Florida damp-wood termite, *Prorhinotermes simplex* (Hagen), is found in the extreme southeastern counties of Florida and in the Keys. It lives naturally in damp but solid logs near salt water, and is a common pest of buildings in the limited area where it is found. It is not earth-inhabiting although it may enter logs beneath the soil.

There are several other damp-wood termites which may be found occasionally in buildings. These, however, are not very common. More complete information on them can be found in the selected references at the end of the chapter.

POWDER-POST TERMITES Family *Kalotermitidae*

Powder-post termites live in dry wood, damaging structural timbers as well as furniture. They enter wood through tiny openings and excavate galleries as do dry-wood termites. The galleries are not kept clean but are frequently filled with the fine powder to which the wood is reduced by the termites.

Powder-post termites are easily distinguished from dry-wood termites by their much smaller size

subterranean termites[1]

CONTROL OF TERMITES is a major portion of pest control work over a large part of the country. Many specialists do no other kind of work, while most of those who control other household pests also do termite control. In no other aspect of pest control do so many variables affect the type of work to be done and the results of the control operation. Termite control specialists must know building construction, understand the proper and safe use of chemicals, maintain equipment, recognize safety hazards, and use considerable judgment in the performance of every job.

The order Isoptera consists entirely of termites which are primitive insects closely related to cockroaches. In nature they help to convert dead wood and other materials containing cellulose to humus. From this standpoint, termites are very beneficial animals. Only when man started to build in the natural home of the termite did they start feeding on his buildings. Termites harbor certain one-celled organisms in their digestive tracts, and these organisms convert cellulose into simple substances which the termites can digest. Termites are social insects in which there is a division of labor between different types of individuals (castes). Nearly all termite species have reproductive and soldier castes. In many termite societies there is a distinct worker caste,* but in many of the more primitive species the typical duties of the workers (nest building, food gathering, and feeding of reproductives and soldiers) are handled entirely by the nymphs. Even in species with workers, the older nymphs usually do much of the work. These individuals are referred to as functional workers.

**The literature concerning subterranean termites contains many references to the worker caste. Recent investigations of living colonies indicate that there may not be a true worker caste in our common North American species, and that what we have long considered to be workers are actually late instar nymphs.*

Workers and nymphs of subterranean termites perform all of the work of the colony and are the forms which do all of the damage to structures which are of concern to the pest control specialist. Soldiers serve only to defend the colony against its enemies and cannot eat wood. They, together with the reproductives, are fed by the workers. Both workers and soldiers are blind.

Winged adults are referred to as the primary reproductives. They emerge from the colonies on colonizing flights at certain seasons of the year. After these flights, they lose their wings and construct a small cell in which they mate, reproduce, and rear the first group of workers. Where these primary forms are not present, supplemental or secondary reproductives without pigmentation or functional wings occur, often in large numbers.

Each termite colony is self-supporting and essentially independent of other colonies.

LIFE HISTORY

The stages in the life history of subterranean termites are essentially the same for the various species of concern to the pest control specialist. Refer frequently to Figure 7-A as you read the following paragraphs.

Termites develop from eggs which are laid by the primary or secondary reproductives.

Nymphs hatch from the eggs and undergo several molts through which different individuals develop into various forms. (See Figure 7-B).* Four different castes can develop from nymphs: workers, soldiers, winged, or primary reproductives, and supplementary reproductives. (See Figures 7-C and 7-D).*

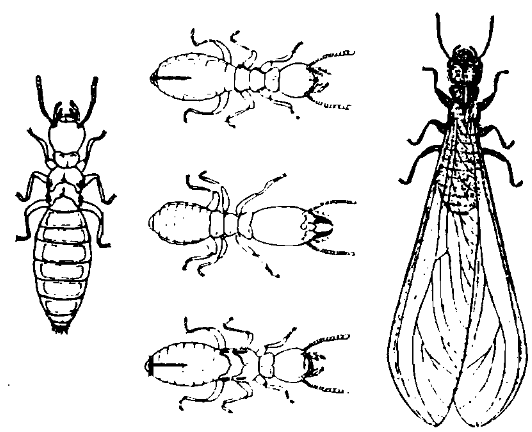


Figure 7-A. Representatives of the castes of the eastern subterranean termite, ***Reticulitermes flavipes*** (Kollar). Right: The winged (alate) primary reproductive. These alate forms are the familiar "swarmers" which often give the first indication that a structure is infested. Middle row, top: The sexually undeveloped worker. The members of this caste are the individuals which do the actual damage. Note the complete lack of wing pads. Middle row, center: The soldier is greatly modified in head structure and serves a completely specialized function in the division of labor within the colony. It works solely in the defense of the colony and cannot feed itself. Middle row, bottom: A developing supplementary reproductive. Note the lengthened wing pads which are usually the first indication of the development of these reproductives. Left: A functional supplementary reproductive. Female supplementary reproductives are thought to be the most important of the reproductive individuals in the subterranean termite society.

[1]Order Isoptera, Family Rhinotermitidae

*See color section in center of book

In new colonies, nymphs from the first small batch of eggs usually all become workers. Other forms are not normally produced until later egg laying.

In species in which workers occur, they are the most numerous individuals in a termite colony. They perform all of the work of the colony — feeding the other forms, grooming the queen, excavating the nest, and making the tunnels. In the process of making nests and tunnels and ingesting food, they chew and eat cellulose, thus causing the destruction which makes them of economic importance. Worker termites are usually light colored and do not have wings or other specialized structures.

Soldier termites serve the specific function of protection of the colony from its enemies. Their heads are large, quite hard and have much larger jaws than are found in the other forms. When openings are made into termite workings, the soldiers gather, with their large heads and strong mandibles facing outward, to protect the colony from invaders.

Supplementary reproductives of both sexes are wingless or have only very short wings. These forms are developed as needed and quickly take the place of a queen who is injured or dies. They usually develop in addition to the regular queen and become the most important source of eggs in the colony. Others, with a group of males and workers, may become isolated from the colony and establish a new one, thus spreading the original infestation without being visible above ground at any time.

Primary reproductives (swarmer termites) are the forms most often seen by householders. The winged adults are usually much darker than the other members of the colony. All 4 wings are the same length and extend more than the length of the body beyond the tip of the abdomen. Both male and female reproductives leave the colony in great numbers, usually in the spring or fall, in swarms which are often the first visible indication that termites are present. Environmental conditions have to meet certain requirements before termites will swarm. The temperature, moisture both within and outside the colony, light conditions and even barometric pressure influence swarming activities. As a general rule, swarmers emerge on warm sunny days when the humidity is high.

After a brief flight, the wings are broken off and males and females pair and attempt to establish a new colony. They are particularly defenseless at this time, and many die or are killed by their natural enemies. Each surviving pair will make a small cell in which they will mate and lay eggs. Although this is the classical cycle of termite reproduction, there is an unfortunate tendency to overemphasize the importance of the primary queen. Supplementary reproductives are responsible for the production of most of the eggs within a colony after it has become established. In a colony of one million individuals, the queen may have laid as few as 10,000 of the eggs from which individuals develop, with supplementary reproductives responsible for the remainder.

Swarmer termites are often confused with flying or swarmer ants. Since ants are often seen swarming around buildings, it is important to be able to distinguish the two so appropriate control recommendations can be made. Ants have a very thin waist between the thorax and the abdomen while termites are broad waisted. Termite wings are all about the same size and shape, whereas the forewings of the ant are larger, longer and of a different shape than the hindwings. A third difference involves the antennae with termite antennae being straight and ant antennae being elbowed.

THE TERMITE AND ITS ENVIRONMENT

Subterranean termites are very closely dependent upon a complex of environmental factors which normally restrict the colony to the soil. Contact with the soil as a source of moisture has been mentioned previously, and although this is the fundamental need involved, the simple statement that moisture is essential tends to make the relationship seem more simple than it really is.

The workers, soldiers, supplementary reproductives, and nymphs are soft-bodied insects which tend to lose water very rapidly upon exposure to dry air. This fact illustrates one of the important functions of an available moisture source, and it is reflected in the habit of construction of tubing when the termites pass over exposed areas. While these tubes serve as a means of concealment and also to some extent as a mechanical barrier against intrusion of ants, it is probable that retention of moisture and preservation of a high humidity in the air surrounding the termite is the most important function. The negative response to light which termites exhibit is intimately involved with keeping the termite in a concealed environment and may have come about as a result of response to the great problem of water loss.

The mere retention of moisture is not the only important factor of the life of the termite which is associated with water. The warm, moist conditions which prevail within the closed system of the nest provide an ideal site for the growth of microorganisms, particularly fungi, which apparently provide the necessary source of protein and vitamins which are essential to the termite. The accumulation of fecal material, in turn, adds to the material available to promote the growth fo the fungi.

The most striking facet of this intricately interdependent system is the delicacy with which it is balanced. It is not rare to discover the remains of a termite colony which is slowly being crowded out by the growth of fungi which has for some reason progressed at a rate such that the termites could not "keep up with it." If sudden temperature shifts or other factors result in the accumulation of liquid water within the galleries, a condition exists which is most unfavorable to the termites, and they may literally drown. Each autumn the termites in the temperate zone normally respond to more gradual temperature changes by moving downward in the soil where the necessary stable conditions of temperature and humidity can be maintained. In the following spring, the colony then seems to respond to increased temperatures and moisture in the soil above and again moves upward.

SUBTERRANEAN TERMITES OF NORTH AMERICA

The large majority of termite damage which occurs in the United States is caused by subterranean termites although, in certain specific areas, others may be the principal problem. Several species of the genus *Reticulitermes* comprise our most important and widespread group of subterranean termites.

Subterranean termites differ from the dry-wood and damp-wood termites in that colonies usually need to maintain contact with the soil in order to acquire enough water to survive. In a few cases, where structural timbers are sufficiently moist, colonies are able to survive without ground contact. This, however, is not common. The underground colony lives in a series of chambers and galleries from which they construct mud tubes to the wood which they use as food.

The eastern subterranean termite, *Reticulitermes flavipes* (Kollar), is thought to be the most common and widely distributed termite in North America. It is found from Ontario, Canada, south to Florida and west to Arizona and Utah.

This very destructive termite damages building timbers and contents, fence posts and utility poles, and occasionally living plants.

Swarming begins as early as February in the southern states and as late as May or June in the colder areas. In addition, late fall swarming from September to November may also occur. Swarms have occurred every month of the year where associated with heated slabs.

The light southeastern subterranean termite, *Reticulitermes hageni* Banks, occurs from the District of Columbia south to Florida and west to Texas and Kansas. Swarming occurs from August to October in the northern part of its range and from October to February in Florida.

The southeastern subterranean termite, *Reticulitermes virginicus* Banks, is found from Philadelphia south to Florida and west to eastern Texas and Oklahoma. Swarming flights occur in May or June with some fall flights in October and November.

The Pacific Coast subterranean termite, *Reticulitermes hesperus* Banks, is the most destructive subterranean termite on the West Coast. This termite excavates galleries in wood similar to those of the eastern subterranean termite, spotting the wood with dirty, yellowish-brown fecal spots. Shelter tubes are built but less commonly than by the eastern termites. This termite is found from British Columbia south to western Mexico and east to Idaho and Nevada. It is a slowly developing species with the flight of reproductives not usually occurring from new colonies until after the fourth year.

The arid land subterranean termite, *Reticulitermes tibialis* Banks, is found from Oregon and Montana south to Western Mexico, east to Indiana, and south to Missouri, Arkansas and Texas. Much of this distribution overlaps that of the Pacific Coast subterranean termite; however, the arid land subterranean termite is the species found in the dryer portion of the area.

Another subterranean termite that has been found in the continental United States as well as Hawaii is the Formosan subterranean termite *Coptotermes formosanus* Shiraki. Since 1965 this termite has been found in several cities along the coast lines. The number of infestations already located, the evidence of large widely dispersed swarms and the fact that some infestations appear to have been active for years suggest that this termite is now firmly established on this continent. It is one of the world's most aggressive and economically important species of termite, and has been reported to cause more damage to structures in Hawaii than any other insect. They represent an extreme economic hazard in all areas where they become established. Although subterranean in nature, the termite is quite active when free of soil contact as long as enough moisture is present to support the colony. Although this termite is found mainly in tropical regions, it has moved into more temperate areas by way of the shipment of infested wood and wood products. The control of this termite is often more difficult than other subterranean species. However, the principles of control, application technique and recommended chemicals are the same as those discussed later in the chapter. Additional steps may be necessary, such as removing moisture sources above ground and injecting chemicals, removing the secondary nest from wall areas, or fumigating in extreme cases, the above-ground portions of well-established colonies.

In addition to the members of the genera *Reticulitermes*, and *Coptotermes*, the soldierless, nasutiform and desert termites are subterranean in habit. Of these, only the desert termite, *Amitermes wheeleri* (Desneux), damages buildings. This species is distributed from southwestern Texas through Arizona and Nevada to California. In nature, they live in dead trees, stumps and cactus plants. They are strong fliers and invade buildings built in desert areas.

INSPECTIONS FOR SUBTERRANEAN TERMITES

When called to a building in which a subterranean termite infestation is suspected, a pest control specialist must be able to determine whether or not termites are actually present. This is often a difficult problem requiring a great deal of effort and the use of specialized techniques and information to reach the correct solution.

The termite inspector must know which species are present in his locality. He must know the habits of each of them in order not to miss any possible sign of infestation. He must be able to recognize the signs of damage in order to know whether or not termites are present and to evaluate the extent of an infestation when it occurs.

In making the inspection, a good bright flash-

Becker and Kerner-Gang, 1964; Kovoor, 1964; Becker, 1965; Smythe and Coppel, 1966*a*). For rearing termites in the laboratory, Becker (1969*b*) suggested the use of wood blocks with about 3 to 10% weight loss owing to attacks by brown-rot Basidiomycetes, such as *Coniophora puteana*, *Lenzites* spp., *Polyporus* spp., or *Merulius lacrymans*. The mycelium of certain nontoxic fungi can be added with additional benefit.

Workers of the eastern subterranean termite, *Reticulitermes flavipes*, when exposed to both decayed and sound wood of 6 wood species, ate 1.4 to 2 times more decayed than nondecayed wood. During an 8-week test, survival of termites was highest on wood decayed by *Daedalea quercina* and *Poria oleracea*. Termite survival was better on ovendried decayed wood than on less dry sound wood for all wood species except a walnut (*Juglans nigra*), on which there was no survival (Smythe *et al.*, 1971).

The question is sometimes asked whether subterranean termites will feed on sound wood that is not infected by fungi. To obtain information on this subject, Pence (1957) collected *Reticulitermes hesperus* from sound, white Douglas-fir lumber and placed the insects on sterilized and ovendried strips of the same wood, dyed with India ink. Within a few hours, their intestinal tracts were filled with the dyed wood. When given a choice, they fed on black wood exclusively in the presence of light, but fed on either black or white (undyed) wood indiscriminately when placed in darkness. There is no doubt that termites attack and destroy perfectly sound timber, but the galleries they form in the wood are soon infected with fungi, which probably are a useful amendment to their diet.

The eastern subterranean termite was attracted by aqueous extracts of 6 species of wood decayed by the fungus *Lenzites trabea*, to 3 species decayed by *Poria cocos*, and to 1 each decayed by *Lentinus lepideus* and *Daedalea quercina* (Smythe *et al.*, 1971). Attractancy of wood decayed by *L. trabea* should not be construed to imply usefulness of the fungus to termites under natural conditions; in fact, Smythe *et al.* (1971) found it to be associated with generally decreased termite survival. However, there has been much recent investigation on the subject of attractant fungi because of the possibility that their extracts, combined with suitable insecticides, may provide specific control, or that fungal parasites and pathogens may be used in biological control (Esenther and Gray, 1968; Sands, 1969).

Unique genera and species of oxymonad, trichomonad, and hypermastigote flagellates (protozoa) that occur in the intestinal tracts of termites are found only in the 4 most primitive termite families: Mastotermitidae, Hodotermitidae, Kalotermitidae, and Rhinotermitidae. The great majority of these flagellates ingest wood particles, and appear to be indispensable for the survival of the termites. Although there appears to be no doubt that the flagellates are responsible for cellulase activity in the hindgut of the lower termites, it seems that they do not contribute substantially to the nitrogen (for protein) requirements of the insects. Possibly, the bulk of the nitrogen is supplied by fungi present in the wood (Honigberg, 1970). The higher termites (Termitidae) possess protozoa such as found in other insects and in other invertebrates, and even in the large intestines of some vertebrates, but they do not depend on them for the digestion of wood. In fact, as a rule they do not feed solely on wood or cellulosic material, and what wood they do eat is usually much more decayed than the wood eaten by the lower termites.

The function of the fungus in the fungus combs of the Termitidae "appears to be mainly the breakdown of lignin, but it probably also supplies nitrogenous materials and possibly other factors, such as vitamins" (Sands, 1969).

TERMITES

Termites are social insects of the order Isoptera. They live in colonies comprising winged and wingless reproductive forms and numerous wingless sterile workers, nymphs, and soldiers. Despite the fact that social insects account for only a small percentage of the structural pests, 2 groups of social insects, termites and ants, are among the first 3 in importance. The other group, the cockroaches, comprises ancient insects from which the termites are believed to have descended.

Termites feed on wood, and throughout a large area of the world they are the most destructive insects to wood structures. This is a measure of the importance of their natural role in nature—breaking down and returning to the soil and atmosphere the enormous tonnage of dead and fallen trees and other cellulosic material that is continuously accumulating on the earth's surface. They are important pests of agricultural crops, forest nursery seedlings, and range grasses, and also damage an enormous amount of stored food and household furniture and commodities, including even most plastics (Snyder, 1935, 1955*b;* Harris, 1961; Ebeling, 1968). Damage from termites plus the cost of controlling them probably amounts to approximately a half billion dollars per year in the United States alone (Ebeling, 1968). Our knowledge of the history of South America would probably have been much more complete if it had not been for termites, for they are said to have eaten most of the books more than a century old (Howse, 1970).

Termites are found in tropical, subtropical, and in most temperate climatic zones. They are increasing their range and density northward, being favored by the accelerated urbanization incident to the "population explosion," particularly in areas where central heating of buildings affords them a particularly favorable environment for the establishment of colonies.

Much has been written about termites, yet until recently the largest and most comprehensive work, particularly on termite biology, was a book titled *Termites and Termite Control.* It was edited by C. A. Kofoid, and published by the University of California Press in 1934 (partially revised in 1965), and includes the contributions of 35 experts on termite biology, taxonomy, and control. In 1969 and 1970, a treatise of 2 volumes, titled *Biology of Termites* and edited by Kumar Krishna and Frances M. Weesner, was published. Twenty-five scientists contributed to this exhaustive treatise, which covered many aspects of termite biology, systematics, distribution, behavior, social organization, and control. *Termites—Their Recognition and Control,* by Harris, published in 1961; and *Termites—A World Problem,* by Hickin, published in 1971, are books on the distribution, classification, economic importance, and control of termites, as well as wood-preservation procedures, written from a world standpoint. An excellent popular book on termites was written by Howse (1970).

The lower termites (e.g., drywood and dampwood termites) can be easily collected and then cultured and observed under glass. The higher termites are more difficult to culture, but successful techniques for culturing have been developed for certain species in all families, and have been described by Becker (1969*a*). An observable termite colony should be a fascinating subject for classroom demonstration.

Climatic Limitations

Although termites were able to extend their range to approximately the 50° F (10° C) annual mean isotherm north and south of the equator, only time will tell how much farther they may be able to go because of the improved microclimate afforded them by heated buildings.

In Wisconsin, the approximate northern limit for the eastern subterranean termite, *Reticulitermes flavipes,* coincides with an annual minimum isotherm of –30° C (–22° F). Upward movements of termites from the soil cease near zero C, and they overwinter primarily at a soil depth of from 3 to over 4 ft (1 to 1.5 m). In this way, the insects can escape adverse weather conditions, such as dryness or low temperature. It appears that the most adverse effect of winter is to confine them to a zone below an adequate source of food, which is usually near the ground surface. The survival of termites in cold climates depends on their ability to repopulate during the warm season (Esenther, 1969).

The situation in Wisconsin is probably typical of all areas in which subterranean termites are extending their range into colder regions. Esenther (1969) points out that only "man-oriented" colonies have been found in Wisconsin. He believes that they were introduced originally on infested lumber and spread mainly through new colony formation facilitated by their subterranean tunneling. Unlike the situation in the warmer southern parts of the range of the species, dissemination by flight must be relatively insignificant in the north. The rate of development of an incipient colony in the north is too slow, and therefore the termites are not likely to survive the rigors of the first winter to form alates. Thus, reproduction is by neotenic individuals, those which attain sexual maturity without attaining the alate (winged) form.

Becker (1970*a, b*) has observed differences between *Reticulitermes flavipes* in Wisconsin and Hamburg, Germany, when compared with what he considers to be bioecological races of that species in South Carolina and Hallein, Austria. The northern forms were the most active gallery builders, and demonstrated daily rhythms of activity that were lacking in the southern forms.

Biology and Colony Formation

Termites are relatively primitive from an evolutionary standpoint, but their social organization is the most complex among the insects. Along with the ants and the more highly organized bees and wasps, they belong to the truly social or *eusocial* insects. The common traits of eusocial insects are: (1) cooperative caring for the young, (2) a division of labor in which more or less sterile individuals work on behalf of fecund individuals, and (3) an overlap of at least 2 generations in life stages so that during some period of their life, the offspring can assist their parents. Species of insects lacking all these traits are called *solitary*. There are also many species among the wasps and bees that are in various stages of sociality between solitary and eusocial (Wilson, 1971).

A society can be developed only if its members are long-lived. This in turn depends on an adequate and continuous food supply. Termites solved this problem by acquiring the ability to use wood-cellulose as food. The principal termite pests in the United States are in the families Rhinotermitidae and Kalotermitidae, the members of which depend on protozoa (mastigophoran flagellates) in their hindguts to break down cellulose. Termites do not possess these protozoa when they are born; they must obtain them by proctodeal feeding, that is, feeding upon liquid intestinal content taken from the anal aperture of an older termite. Every time the termite molts, the lining of the hindgut is shed, along with the entire body cuticle, and the protozoa are lost. Refaunation takes place by proctodeal feeding (Andrew, 1930; Honigberg, 1970).

In some areas of the world, termites belong primarily to the family Termitidae. The termitids are responsible for most of the earthen termite mounds, some as much as 10 meters in height, which form a characteristic feature of many landscapes of the African and Asian tropics. These termites have no intestinal fauna of the types that can aid in digestion. They may consume grass, leaves, humus, the manure of herbivorous animals, and decaying wood. The Macrotermitinae have spongelike fungus combs in their nests. They are constructed of chewed wood and feces, and are built up to fit the chambers of the nest. These termites feed on fungus (*Termitomyces*) in the combs. The function of the fungus in digestion appears to be mainly the breakdown of lignin, but probably other factors are supplied, such as nitrogenous materials and vitamins (Sands, 1969). Thus, termites have an abundant, continuous food supply, and this, coupled with their longevity, the potential immortality of the colony, and their ability to care for their eggs and young and protect the colony against natural enemies and the elements, allows for the development of enormous numbers of individuals. For example, in a large colony of the moundbuilding termite *Nasutitermes exitiosus* (Hill) in Australia, 11.05 kg of termites were removed, representing 2.5 million insects, of which about 87% were of the wood-destroying worker caste (Gay and Wetherly, 1970). Such enormous numbers of termites result in a great capacity for destruction of wood structures, with no seasonal letup in tropical areas. Most of the foregoing factors also favor another social insect, the ant, as a successful and persistent pest of man. Ants may not have as constant a food supply, at least not in nature, but they can store foods in their well-protected nests.

Termites live what is known as a "cryptobiotic" mode of life. They live in enclosed passageways, either entirely in the wood in which they feed or partly within the wood and partly within soil. At certain times of the year, depending on the species, a certain percentage of the colony develops wings and changes from the whitish color of the nymphs to the distinctive dark or black color of the winged reproductives (alates). The latter fly off to form new colonies.

The alates are the members of the colony most likely to be seen by the homeowner. They are the potential kings and queens. The homeowner often confuses alates with "winged ants." The abdomen of the termite is broadly joined to the thorax, while the thorax and abdomen of the ant are joined by a narrow petiole or "waist" (figure 66). The termite has straight, beadlike antennae, while those of the ant are elbowed. Unlike the castes they left behind, the termite alates are heavily pigmented. The fore- and hindwings of the alate termite are approximately equal in

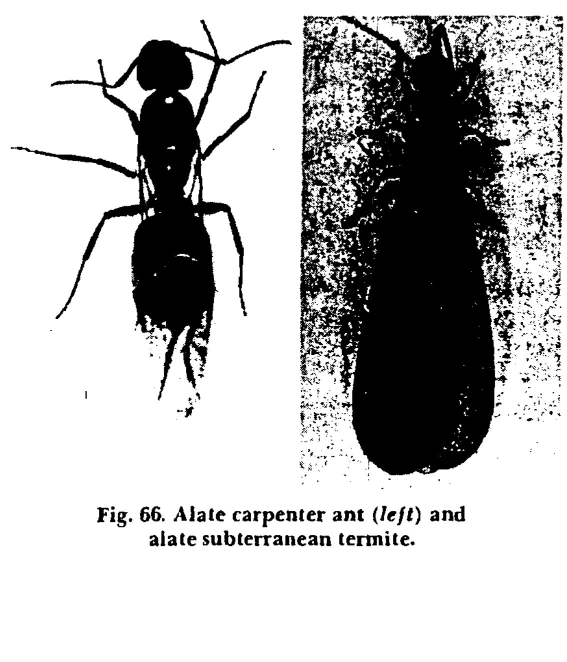


Fig. 66. Alate carpenter ant (*left*) and alate subterranean termite.

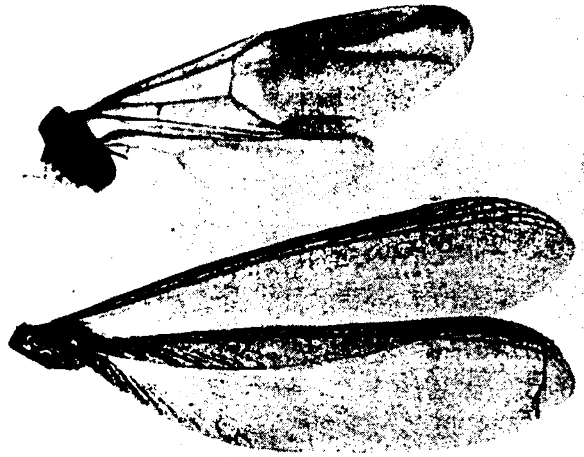


Fig. 67. Wings of a carpenter ant (*top*), and of a dampwood termite.

length, and usually extend from 25 to 33% of their length beyond the end of the abdomen when folded. The hindwings of the alate ant are much shorter than the forewings, and the folded wings rarely extend beyond the end of the abdomen (figure 67).

After the flight of the alates, their wings break off near the base. Males and females pair off and begin a small excavation for a new nest. Subterranean termites (Rhinotermitidae), for example, may excavate their nest in wood found after digging into the ground, or between a piece of wood and damp ground, or in a crevice in wood on damp ground. (Galleries eventually extend deeply into the ground.) The pair then mate, and the first eggs are laid. The egg-laying capacity of the queen increases as she grows older. Queens of some moundbuilding tropical termites can lay as many as a thousand eggs per day for as long as 25 years.

Several years may pass before all castes are present in a new colony. The complete colony consists of the primary pair of reproductives (royal pair) and three castes: (1) the workers, which feed on wood or fungi and, by regurgitation and excretion, provide food for the young and the other castes; (2) the soldiers, which in the United States are usually large-headed individuals with massive jaws that guard the nest entrances and the royal pair; and (3) usually 2 kinds of supplementary or substitute reproductives known as *neotenics*. These may be either lightly pigmented and with short wing pads (brachypterous) or very lightly pigmented and without wing pads (Krishna, 1969).

Chemicals that are secreted to the outside of the bodies of insects for caste regulation, attraction, communication, trail-marking, etc., are called *pheromones*. A colony of social insects (termites, ants, wasps, or bees) maintains its social cohesiveness primarily through the utilization of such chemicals. They are produced in specialized tissues known as *exocrine glands*. In response to specific stimuli, these glands evacuate their contents into the environment (Blum, 1970).

Termites continually groom one another by means of their mouthparts to obtain desired secretions or exudates containing pheromones. Among the pheromones they obtain in this manner are some that are believed to inhibit the formation of additional members of the sex or caste from which the hormones are obtained, thus serving as a regulatory mechanism to prevent a disproportionate ratio of males, females, and soldiers in a colony (Lüscher, 1956*a*, *b*, 1961; Weesner, 1956). Lüscher (1961) stated that the queen can inhibit sexual development of other potential reproductives, even if her abdomen is covered with varnish, thus covering all integumental glands and the genital opening, but that inhibition is no longer possible if the anus is blocked. He concluded that the inhibitor substance must be given off with the excrement.

There is considerable evidence that the "royal pheromone" that prevents *Kalotermes flavicollis* (F.) from undergoing the final molt is produced by the mandibular glands of the sexual forms. In 20 trials, when one of these glands from a primary sexual female was implanted in the abdominal cavity of a nymph shortly before the final molt, adult differentiation was blocked or inhibited, depending on how close to the final molt the nymph was at the time of implant (Lebrun, 1972).

Reproductives can also stimulate the development of a caste. For example, when a group of nymphs of *Kalotermes flavicollis* is separated from soldiers, some will differentiate into soldiers. The number of soldiers produced is much greater when reproductives are present. The effect of reproductives on soldier production was graded as follows: pair of reproductives (king and queen) > 2 queens = 1 queen = 2 kings > 1 king (Springhetti, 1970). Miller (1969) pointed out that, among the lower termites (all families but Termitidae), there is no evidence that the various castes are genetically different; their caste destinies are the expression of social and environmental factors. Even "workers" can become sexuals, and in laboratory colonies have been able to reconstitute all castes of the colony when they were sufficiently numerous.

The role of pheromones in the structure and formation of termite colonies, particularly when the order Isoptera as a whole is considered, is extremely varied and complex. The amazing extent to which an understanding of the role of pheromones has already developed from the pooled results of world-wide investigations is concisely discussed by Howse (1970). No doubt an even broader understanding will result from current investigations.

Supplementary reproductives (neotenics) are required for rapid increase in numbers of termites in a colony. When groups of workers and nymphs of the western subterranean termite, *Reticulitermes hesperus*, were separated from the mother colony, they formed a new colony in 6 to 8 weeks, utilizing supplementary queens developed from some of the short-winged nymphs found in every large colony (in addition to the nymphs that develop into the alates that leave the colony). A supplementary queen can produce more eggs (60 to 80) in a day at the height of egg-laying than the primary queen in the first 2 years of the colony's development (Pickens, 1934*a*).

Trail-Marking Substances

It has long been known that termites follow "odor trails." The odor trails may serve varied purposes. It has been observed, for example, that breaks in the nest structure of *Zootermopsis* stimulate the laying of trails to the breaks so as to recruit workers for repair work. The intensity of the stimulus the workers receive from the odor trails determines the number recruited (Stuart, 1967). This primitive trail-laying mechanism was apparently adapted secondarily for foraging purposes. The trail-marking pheromone may at the same time be a food attractant (Smythe *et al.*, 1967*a*, *b;* Ritter and Coenen-Saraber, 1969), and in this capacity it offers some potential as a possible means of termite control. The pheromone is secreted by the sternal glands of the workers and soldiers of all termite families (Lüscher and Müller, 1960; Stuart, 1961, 1963, 1964, 1969; Noirot and Noirot-Timothée, 1965; Mosconi-Bernardini and Vecchi, 1966; Smythe and Coppel, 1966*b;* Stuart and Satir, 1968; Moore, 1969; Noirot, 1969; Howse, 1970; Mertins *et al.*, 1971). One such gland is situated on each of the third, fourth, and fifth sternites in the primitive *Mastotermes* of Australia's Northern Territory, on the fourth sternite of *Stolotermes, Porotermes,* and *Hodotermes,* and at the base of the fifth sternite (figure 68) on all other termites. In the sternal gland, there appears to be no duct associated with the glandular cells. The pheromone is probably secreted by the cells, and passes through the fine pores of the cuticle, collecting in a reservoir

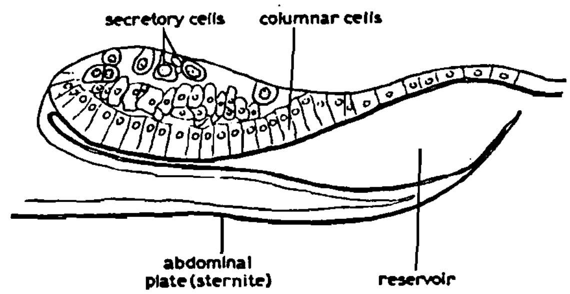


Fig. 68. Longitudinal section through the sternal gland of *Zootermopsis nevadensis*. [From Howse (1970), after Stuart (1964), with permission of Hutchinson and Company, London.]

formed by the overlapping sternal plate of the preceding segment (figure 68). Possibly, the extent to which the aperture at the posterior end of this reservoir is opened is regulated by the pressure exerted by the abdomen as it is pressed against the ground (Stuart, 1969).

Extracts of the trail-marking pheromone from either *Reticulitermes flavipes* or *R. virginicus* were attractive to both these species and to *R. hesperus*, but not to the dampwood termite, *Zootermopsis angusticollis* (Smythe and Coppel, 1966*b*). Several synthetic analogs of the trail-marking pheromone of *R. virginicus* have been prepared, and the molecular structures to which these compounds owe their pheromone-mimicking characteristic have been identified (Tai *et al.*, 1971).

Insect pheromones are generally rather species-specific. Therefore, it is of special interest that 6 subterranean termite species (*Reticulitermes flavipes, R. virginicus, R. hesperus, R. tibialis, Coptotermes formosanus,* and *Leucotermes speratus* [the latter from Japan]) all responded to 4 trail-marking pheromone analogs (Matsumura *et al.*, 1972). The nonspecificity of these compounds would be advantageous in any attempt to use them as lures for trapping purposes in a control program. Two of the pheromone analogs have been found to be easily synthesized (Tai *et al.*, 1971).

There are many other nonpheromone substances, some found in nature and some artificially produced, that have effects similar to those caused by pheromones. For example, wood rotted by the fungus *Lenzites trabea* produces an attractant for *Reticulitermes flavipes* as well as other species of *Reticulitermes* and *Coptotermes*. The fungus induces trail-following by termites similar to that induced by the trail-marking pheromone secreted by the sternal glands of these insects (Esenther *et al.*, 1961; Esenther and Coppel, 1964; Allen *et al.*, 1964*b;* Smythe *et al.*, 1965, 1967*a*, 1967*b;* Esenther, 1969). Column chromatography of the unsaponifiable lipids from pine wood on which *L. trabea* was cultured yielded 2 well-separated fractions that were highly active in choice tests and in a trail-following test with *Reticulitermes lucifugus* (Rossi). The unsaponifiable lipids of the workers yielded only a single active fraction, but it corresponded to one of the fractions obtained from the wood (Ritter and Coenen-Saraber, 1969).

The attractance of 8 compounds formed in wood by wood-rotting fungi (Basidiomycetes) was tested, using 5 termite species as test insects. Five compounds were generally attractive, and 3 deterred termites or had no attraction. Acids were usually attractive, but aldehydes were attractive in only a few cases (Becker, 1964). Many organic compounds have been found to be attractive to *R. flavipes* (Watanabe and Casida, 1963).

A trail-marking scent for *Nasutitermes exitiosus* (Hill) was isolated and identified by B. P. Moore in Australia (Anonymous, 1967*d*), and was found to be an unsaturated diterpenoid hydrocarbon; only 10^{-8} gram was required to lay 10 m of trail. Other species of *Nasutitermes* followed the trail, but distantly related species did not. Because diterpenoid compounds occur in certain essential oils, Moore searched for possible attractants in vegetation. He found a substance in the oil from the Western Australian sandalwood, *Eucarya spicata*, which attracted *Nasutitermes*.

At the United States Forest Service's Wood Products Insect Laboratory in Gulfport, Mississippi, it was observed that *Reticulitermes flavipes* followed marks made by a certain ballpoint pen with blue ink, but other available ballpoint pens did not have this effect. This phenomenon was thoroughly investigated by Becker and Mannesmann (1968). In their investigation, they used 55 termite species from 21 genera of 4 families. They found 3 ballpoint inks that served as trail-markers for many termite species, and 3 others that attracted fewer species. Figure 69 shows workers of *R. lucifugus* following a spiral line made with a ballpoint pen with ink containing a glycol compound. The termites tend to follow a tangent to the curve, and must make repeated corrections in their direction of movement. The inks were less effective for *Mastotermes* and species of Kalotermitidae than for species of Rhinotermitidae and Termitidae. Nine glycol compounds, including some used in ink for ballpoint pens, proved to be trail-marking substances of varying degrees of efficacy. Diethylene glycol monoethylether and diethylene glycol monobutylether were very effective for almost all termite species, including Kalotermitidae. Also, some of the decomposition products (aldehydes and acids) produced when wood was attacked by Basidiomycetes were found to be attractants and trail-markers. *Reticulitermes lucifugus* is unable to react to scent trails if its antennae are partially amputated unless at least 8 segments are retained.

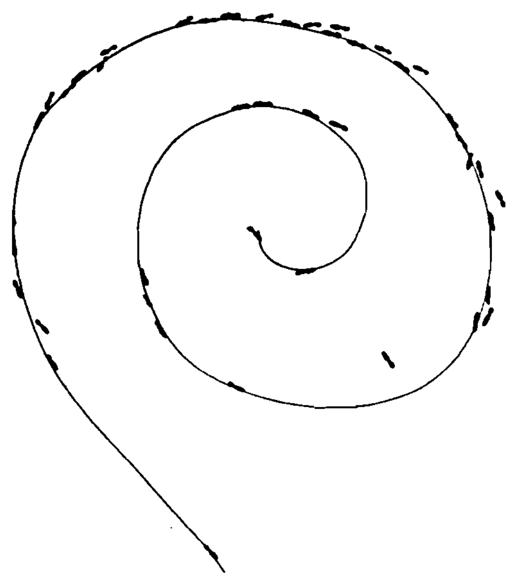


Fig 69. Worker termites (*Reticulitermes lucifugus*) follow a spiral line made with a ballpoint pen, the ink containing an attractant glycol compound. (From Becker and Mannesmann, 1968.)

The possibility of practical utilization of termite attractants in wood baits is discussed under "Termite Baits" later in this chapter.

Western Subterranean Termite, *Reticulitermes hesperus* Banks (Rhinotermitidae)

This is the principal subterranean termite in California. It ranges from British Columbia south to western Mexico and east to Idaho and Nevada. Winged reproductives (alates) are dark brown to brownish black, and have brownish-gray