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PESTICIDE APPLICATOR CERTIFICATION TRAINING

Category 7b Manual

Wood Infesting Organisms Pest Control

VIRGINIA COOPERATIVE EXTENSION SERVICE

EXTENSION DIVISION

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

INDUSTRIAL, INSTITUTIONAL, STRUCTURAL, AND HEALTH RELATED PEST CONTROL

CATEGORY 7b: WOOD-INFESTING ORGANISMS

A Training Program for the Certification
of Pesticide Applicators

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FOREWORD

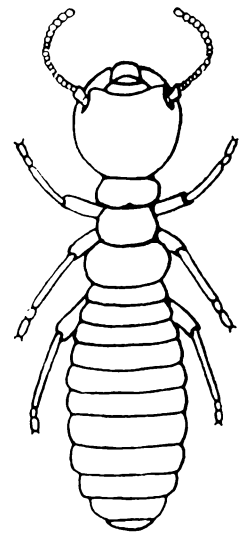
This training manual is intended to provide information that you may need to comply with EPA's Standards for Certification. It will help you prepare for the Certification examination prepared and administered by the Virginia Department of Agriculture and Consumer Services.

The emphasis of these standards and this training is on the principles of applying pesticides safely for man and the environment. It is not intended to provide you with all the knowledge needed. Additional information in the form of publications, short courses, field days, and professional meetings can be obtained from the local Cooperative Extension Service office in your area.

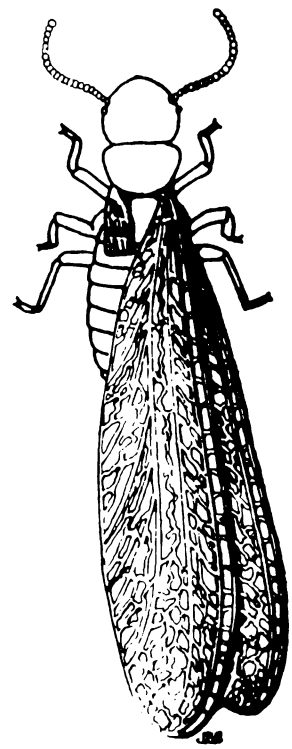
WOOD-DESTROYING PESTS

One of the most important activities of industrial, institutional, structural, and health related pest control operators is protecting buildings from wood-destroying pests. The most damaging pests of man's structures are termites. The beetles are the next most important group of insects which attack wood. There are a variety of beetles, with very distinct habits, that feed on structural wood. Third in importance, depending upon geographical location, are the bees and ants.

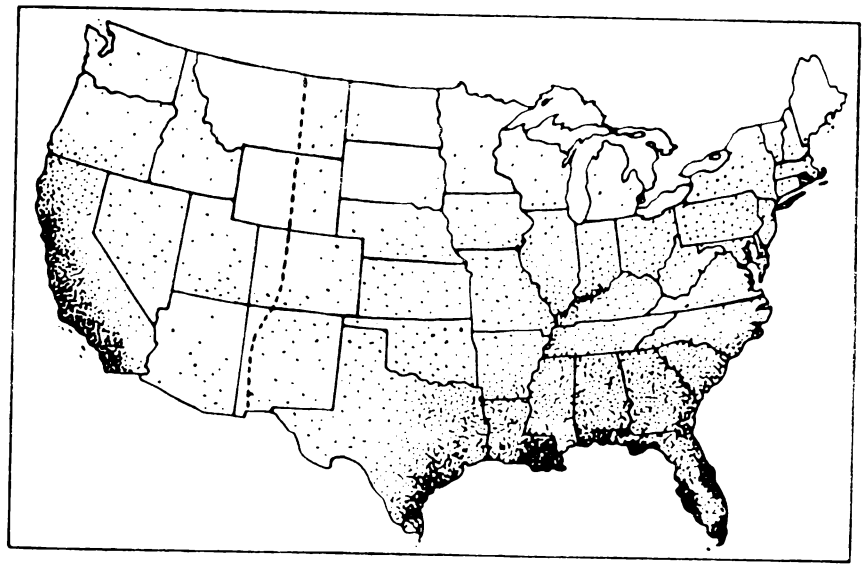
TERMITES



Termites are relatively primitive insects. They are most closely related to the cockroaches and grasshoppers. Entomologists have described about 2,200 species of termites for the world. However, only about 70 species around the world infest buildings and require control. In the U.S., there are only about 15 species of termites that require some control measures.



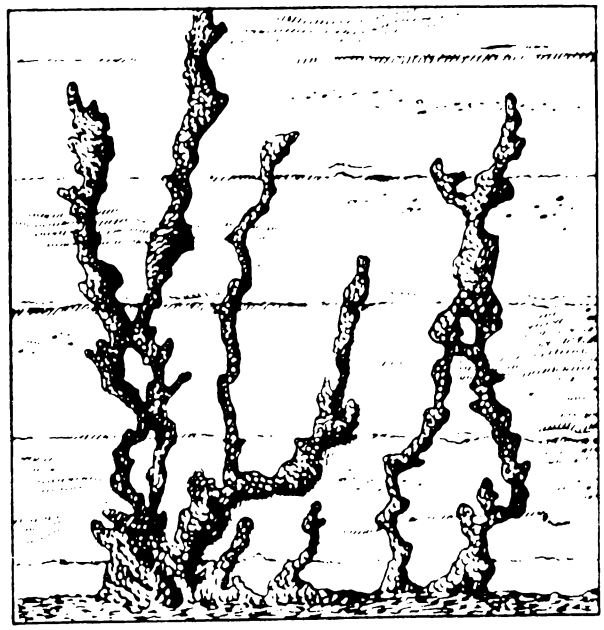
Termites occur in virtually every state of the U.S. Alaska is the only state to escape from these pests. The presence and absence of termites in an area is controlled by their environmental requirements such as temperature, humidity, atmosphere, soil moisture, and soil type. The following map illustrates the known distribution of four species of termites in the contiguous U. S.



Distribution of Four Termite Species in the U. S.

Subterranean Termites

Subterranean termites live closely associated with the soil. They build their nests in the ground and construct channels through the soil and tunnels composed of earth through wood. Termites prefer to have their food -- wood -- in or in-contact with soil. But they will construct earthen tunnels or tubes from the soil to wood to get food. To reach the wood in houses, termites construct earthen tubes through cracks in slabs, through expansion joints, inside masonry walls or in the voids of concrete blocks, or any crack in the foundation or between foundation parts. Termites will also build tubes back from the wood of a house to the soil.



Subterranean Termite Shelter Tubes Attached to Concrete

Termites feed on wood. In addition to wood, termites feed on a variety of cellulose-containing materials, fungi, and dried animal remains. In some termites, the digestion of cellulose is carried out by small (microscopic) animals that live in the gut of the termites.

Termites do not confine their feeding to structural wood. They have been important scavengers of dead wood in the forests for millions of years. Only when man started to build his houses in the natural home of the termite did they start feeding on wooden buildings.

All termites are social insects. A colony's population is initiated and maintained by a queen that may live for many years, as long as 50 years in some species. A termite colony is composed of several different kinds of individuals, and this is called a caste system. Two to several castes may be

present, depending on the species, and all castes are composed of males and females. Castes can be divided into two groups: (1) reproductives; and (2) non-reproductives.

Reproductives. There may be two kinds of reproductives present in a colony: primary reproductives and secondary reproductuves. The primary reproductives are the queen and king. They usually have dark bodies with completely developed wings and eyes. Secondary reproductives occur in a variety of forms, but are not dark colored and are not fully winged.

Non-reproductives. The non-reproductives are the workers and soldiers. The workers are wingless, unpigmented, soft-bodied forms without compound eyes or well-developed mandibles. They function as the labor force of the colony, maintaining and adding to the nest, and feeding members of other castes and immatures. Soldiers usually have compound eyes and generally have large heads with well-developed mandibles. They function as defenders of the colony.

New colonies are formed when winged primary reproductives appear and swarm from the nest. These primary reproductives are usually produced in mature termite colonies, generally in 3-5 year old colonies. Males and females pair off during this swarming, but mating usually occurs on the ground. After mating, their wings drop off and the pair seek out an appropriate site for nest construction. They prefer places which offer a good combination of shelter, food, and moisture.

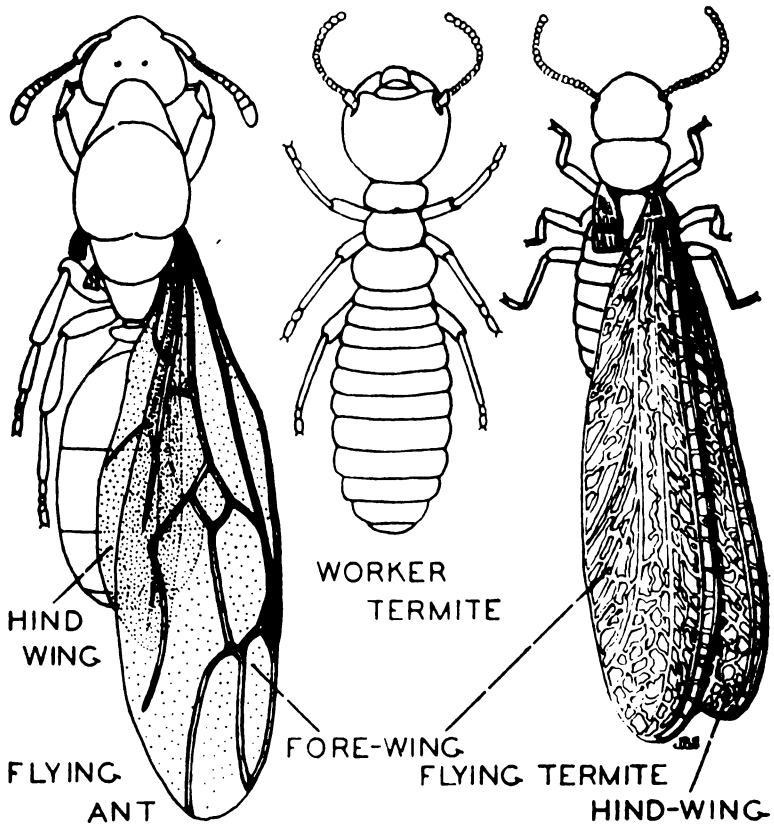
Swarming winged termites are commonly confused with winged ants. However, there are several distinct differences between these two groups of insects.

Comparing Winged Forms

Ants - the hindwings are smaller than the forewings and have fewer veins; termites - the two pair of wings are similar in size and number of veins.

Comparing Wingless Forms

Ants - have dark, hard-shelled bodies; termites - are pale and soft-bodied.



Drywood Termites

The various species of drywood termites have a caste system and feeding habits similar to subterranean species. However, drywood termites live and feed on sound, dry, seasoned wood. They have no soil connection and need no moisture source. They do not construct the earthen tubes characteristic of subterranean termites.

Drywood termites have been reported in the Norfolk area in eastern Virginia.

WOOD-BORING BEETLES

Beetles belong to the largest order of insects, Coleoptera. This group of insects is characterized by strong chewing mouthparts, front wings which are hard and cover the abdomen, and a development that involves an egg, larva, pupa, and adult stage. The young (larvae or grubs) are usually the damaging stage. The pupa (resting stage preceding the adult) is formed in the wood in which the larvae feed.

Beetles which, as larvae, feed in seasoned wood and thereby produce finely-divided powder-like frass or excrement ("sawdust") are known by the common name "powder-post beetles". Included in this term are the representatives of many different families of beetles, which have different biologies and damage capabilities.

The beetles that commonly attack seasoned wood include:

Lyctidae
Bostrichidae - powder-post beetles
Anobiidae
Cerambycidae - long-horned beetles

Among the beetles that attack seasoned wood, the cerambycids (long-horned beetles) are not often confused with the others. The large size of the larvae and adults distinguishes them. (They may vary in length from 1/2" to 4".)

Lyctid Powder-Post Beetles

Among the many different kinds of insects that attack wood and wood products, the destruction caused by lyctids is probably second only to that of termites.

Lyctids are a pest of hardwood and are more commonly found in recently dried rather than old wood. They are known to infest flooring and timbers, plywood, crating, furniture, tool handles, gun stocks, and other articles made of hardwoods. They do not attach softwoods.

Life Cycle. The female lays eggs in the open pores of unfinished hardwood. The eggs hatch, and the larvae tunnel through the wood, reducing it to powder. After a period of time, the larvae form cavities near the surface of the wood and the pupae are formed. When the adults emerge from the pupal stage, they cut their way to the wood surface, leaving small round holes where they emerge. The adults mate soon after emergence. About one year is required to complete the life cycle.

Factors Affecting Lyctid Attack. Three major factors influence the attack and subsequent development of lyctid beetles: (1) moisture content of the wood; (2) starch content of the wood; and (3) pore size of the wood.

1.) Moisture Content -- Lyctids seem to be most active in wood with a moisture content of from 10% to 20%. Noticeable activity is not found in wood with a moisture content above 32% or below 8%.

2.) Starch Content -- The larvae of lyctid powder-post beetles utilize the sugar and starch content of the wood for food. This food is only present in the sapwood portion of the tree.

3.) Pore Size -- Female beetles place their eggs into the exposed pores in the ends or along the sides of the wood. Woods with very large pores are the ones most often infested. These include ash, elm, oak, pecan, and walnut. Woods with smaller pores such as birch, maple, sycamore, and willow are attacked, but not nearly as heavily. Woods with very fine pores, such as apple and beech are relatively immune to lyctid powder-post beetles.

Softwoods (pine, fir) are usually safe from lyctid attack. They do not have pores and generally have a low starch content.

Anobiidae Powder-Post Beetles

The wood-infesting anobiids breed in old dry wood. They will feed on girders, beams, foundation timbers, as well as hardwood timbers; however, they seem to prefer softwoods.

Most adults emerge from April through July, but emergence may continue into September in the South. The adults live several weeks or more, during which they mate and lay eggs. When inactive, the adults rest on the wood surface or in exit holes.

A female anobiid lays up to 100 eggs, depositing them individually on the wood surface, into cracks or crevices in the wood, or occasionally in the mouth of an old exit hole. Most of the eggs are laid during the first three weeks of a female's adult life. The eggs hatch in one to two weeks. The relative humidity must be 45% or higher for hatching indicating that correcting moisture conditions may aid in control.

Upon hatching, the young larvae bore immediately into the wood. The larvae spend their entire life feeding and tunneling through the wood. They usually mature within one year, but some evidence suggests that, if the wood continues

to dry out and has less than 15 percent moisture, the larval stage may last for two or three years.

The larvae pupate within the wood, with the pupal stage lasting two or three weeks.

Bostrichid Powder-Post Beetles

Several members of this family may infest furniture and other wooden structures in the home. For the most part, bostrichids are more common in the warmer areas of the world.

The eggs of bostrichids are not laid in the surface pores of wood as in the case of lyctids, nor are the eggs laid in surface cracks or crevices as in the case of anobiid beetles. Female bostrichids bore into the wood and lay eggs in the tunnels. After hatching, the larvae produce tunnels in the wood. Since both the adults and the larvae bore into the wood, the tunnels formed vary in size and shape.

Old House Borer

The name, old house borer, gives the impression that the insect is primarily a pest in old buildings. While it may attack ancient structures and a building may be many years' old before attack is discovered, the "old house borer" most often attacks new structures. This is particularly true in the United States. Since the old house borer had a very long life cycle and can infest the same piece of wood again and again, it may be several decades before serious structural damage is recognized.

Distribution, Importance and Spread. In the United States, the old house borer has become well established in most of the states along the Atlantic Coast. Infestations seem to occur most frequently in Maryland, Virginia, and

North Carolina. One or more infestations have been reported from many other states as far West as Louisiana and Minnesota.

Once the beetle has become established in a favorable area, it seems to spread both by movement of infested lumber and by direct movement of the adults from house to house.

Food. The old house borer lives and reproduces in dry, barkless softwoods which also provide the insects' food. These woods are from needle-bearing trees such as pines, spruces, and firs. The pines seem to be preferred.

Occasionally, the emerging adults may tunnel through hardwood panelling, plaster, lead, and a variety of other materials which may cover the softwood in which they develop.

The larva of the old house borer is the feeding stage; the adult does little, if any, feeding. Wood with large annual rings and coming from the outer part of the tree seems to be preferred. Probably this is because wood near the bark tends to be richer in nitrogen than wood near the heart of the tree.

While the larvae consume and digest the cell walls of the wood, it is the nutritional value of the cell contents that influence their rate of growth and consequently their ability to do damage. The food value of the wood is reduced when it is kiln-dried at very high temperatures, or if it is infested by blue-stain fungi. The latter develop on the residural cell contents and on the food materials in the sapwood but do not significantly attack the wood structure itself.

Decayed wood is not attacked.

Life History and Habits. The preferred site for egg laying seems to be a joint between two pieces of wood, a narrow crack, or a check mark that develops in shrinkage of wood during drying. Stacked piles of susceptible lumber provide many excellent oviposition sites. If such a

place is found, the female may begin laying eggs at once, but she can wait several days to do so. Eggs are deposited singly or in small clusters. Usually 150 to 200 eggs are laid, but over 500 may be laid by a single female. The egg stage lasts only a few weeks, tending to be shorter at higher temperatures and humidities.

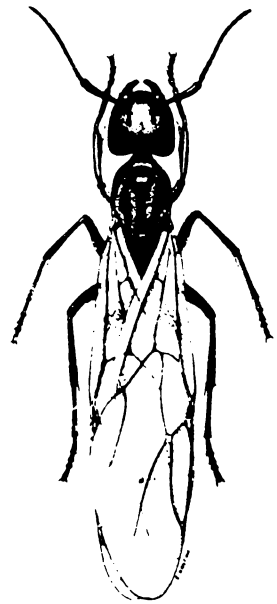
The young larvae bore into the wood adjacent to where they hatch from their eggs. They prefer to tunnel across the grain of spring wood. The young larvae are so small that their presence is seldom seen or recognized. As the larvae become larger they tend to work along the grain. The larvae almost never break the surface of the wood with their tunnels.

The feeding period may be as short as one year if the larvae have an ample supply of wood rich in food value which is in a warm, moist place. In structures, the larvae usually feed for several years before becoming fully grown and ready to pupate. The pupal period lasts only two or three weeks and usually occurs in the spring. Constant temperature is not favorable. Some period or periods of low temperature are needed for pupation. Even a few days at or below freezing are not so favorable as the prolonged cold of a winter.

Emergence of the adults occurs during warm weather, ordinarily in late spring or summer. They are said to be strong fliers. The adults do little, if any, feeding but are capable of chewing or biting exit holes through hardwood, plaster, and other hard materials.

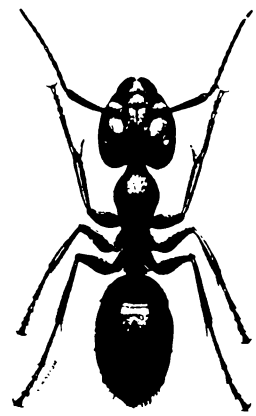
The complete life cycle may be as short as one year and as long as thirty-two years, but three to ten years is the typical range.

Carpenter Ants



Carpenter ants occur widely in the United States and are the largest of our common ants. The adults very in lengths from about 1/4" for a worker up to 3/4" for a queen. They are either entirely black or black and red. A number of different ants utilize cavities in wood as nesting sites; however, only those of the genus Camponotus are correctly termed carpenter ants.

Life History and Habits. To establish their nests, carpenter ants seek soft, generally moist wood, particularly wood that has weathered and begun to decay. Although the nest is often begun in the soft wood, later excavations frequently are made into perfectly sound and dry lumber. They may be found in porch columns and roofs, window sills, wood scraps in dirt-filled slab porches, and wood in contact with dirt.



These ants do not eat wood but excavate galleries in it to rear their young. Carpenter ants eject the wood in the form of coarse shavings. They feed on honeydew from aphids, other insects, animal remains, and household food scraps.

The work of carpenter ants is easily distinguished from that of termites. Their galleries are excavated with the grain and follow the softer portions of the wood. The galleries are kept smooth and clean, having a sandpapered appearance.

When carpenter ants are found in a structure, either the colony is nesting within the building proper, or they are nesting somewhere outside the building and merely entering to forage for food.

Wood Decay Fungi

Decay will occur only in wood having a moisture content greater than 20 percent. Most decay or rot fungi grow only on wood which is subject to wetting by contact with moist soil, rain, plumbing leaks, or condensation. Two rare species, however, can conduct water directly to wood. Decay fungi, which are living plants that take their food from the wood as they grow, reduce the strength of wood, often making it brown and crumbly or white and stringy. Discoloration and powdery growth on wood should not be confused with decay. If the moisture content of the wood is not obvious, it must be measure with a moisture meter to determine accurately the need for treatment.

The use of fungicides or insecticides alone will not stop wood decay once it has started, though it will slow its progress in some cases. The key to the complete control of wood decay is to eliminate the source of moisture, if possible, through proper drainage, breaking wood-soil contact, ventilation, the use of vapor barriers, and other good construction practices. If moisture is a chronic problem, construction lumber should be commercially pressure-treated with preservative chemicals.

WOOD DECAY AND BIOLOGICAL REQUIREMENTS*

Decay is the decomposition of wood by non-green plants known as fungi. Fungi are composed of millions of microscopic thread-like structures called hyphae. Initially, individual hyphae spread throughout the wood causing no change in appearance except a possible discoloration. As decay progresses, large groups of hyphae grow together to form mycelia. The mycelia secrete enzymes, which attack the cell walls of the wood and finally cause the wood to disintegrate or rot.

Several types of fungi infect wood. For convenience these will be divided into categories. The fungi referred to as "white rots" and "brown rots" cause serious damage to wooden members under proper conditions. The white rot fungi feed on the lignin, the material that helps hold individual wood cells together. They leave behind a fibrous, cellulose mass, which turns white. The brown rot fungi feed on the cellulose and leave behind the lignin, which turns brownish. In advanced stages of brown rot, the wood disintegrates into cubicals. Hence the name "brown cubical rot" is sometimes used.

Some fungi, such as sap stains, surface molds and mildew, feed on food substances stored in the wood. They make wood unsightly but do not greatly affect its strength. Surface molds and mildews occur only on the surface, while sap stains deeply penetrate the wood. These fungi may be gray, green, blue, pink, orange or black.

The term "dry rot" refers to wood which is rotted but appears very dry. Actually, the wood was moist when decay

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*Adapted from Department of Forestry and Natural Resources, Purdue University (Daniel L. Cassens)

occurred but has since dried out. Wood never decays when it is dry.

One fungus, Poria incrassata, is sometimes referred to as dry rot. This fungus attacks and decays moist wood and then, by thick root like strands (rhizomorphs) 1/4 to 1/2 inch or more wide, conducts moisture to normally dry wood which may be several feet from any moisture source. This is a very rapid form of decay which can destroy buildings within 2 years. Fortunately it is not common in the United States, but cases of it have been reported.

Requirements for Decay

Air - All fungi affecting wood in buildings need oxygen. Wood stored under water or deep in the soil will not decay because of the lack of oxygen.

Spread of Decay - Fungi are spread from area to area by microscopic spores of "seeds". These spores are produced by fruiting bodies, often referred to as "mushrooms" or "toadstools" and are scattered everywhere. A large number of spores are even located in the soil. Once wood is infected, decay is further spread by hyphae.

Temperature - The best temperature for wood decay fungi is 75-90°F. At other temperatures, decay continues at a reduced rate or is even dormant at freezing or extremely high temperatures.

Food - Since fungi are non-green plants, they require a food source. Therefore, an effective way to control wood decay is to poison the food supply by the use of wood preservatives such as creosote, pentachlorophenol ("penta" for short), or certain water-borne salts such as copper, zinc, and arsenic. Durable woods such as redwood and the cedars naturally deposit extractives in their heartwood which act as poisons to fungi.

Moisture - All wood contains a certain amount of moisture unless it is specially dried. Lumber cut from freshly harvested

trees may have a moisture content of 100 percent (based on oven-dry weight of the wood). Lumber properly installed in homes has a moisture content of 8-15 percent. For most fungi to destroy wood, it must have a moisture content of 20-30 percent or higher. At 20 percent or less moisture content, decay stops. Thus, another effective way to control wood decay is to keep the moisture content of wood below 20 percent.

Structural Components Damaged

The house parts most often damaged are the floors, sills or joists, windows or doors, roof trim, and porches, steps or decks. These wood members are usually close to the soil or exposed to the weather.

Causes of Moisture

The most common causes of moisture are rainwater splash, roof leaks, and plumbing leaks. In many cases, these problems can be corrected by structural changes (addition of gutters) or routine maintenance.

Decay is Economically Significant

In spite of the relatively simple methods available to prevent wood decay, little attention has been paid to its economic importance and control in residential construction. The reasons for this are several. In the past, naturally-durable woods were commonly available and hence prevented much of the decay that is occurring in the non-durable woods being used today. Also, wood decay can take from two to several years to develop before extensive damage occurs and, therefore, often goes unnoticed. Unlike termite or other insect damage, most people do not recognize the early warning signs of decay nor do they "see" any form of life, such as insects. Then too, the cost of materials and labor to replace decayed wood were relatively insignificant in the past as compared to current costs.

Pest control operators are in a unique position to assist homeowners with wood decay problems. PCO's already routinely inspect millions of homes for termite infestations and other household pests. While these routine inspections are being made, any signs of wood decay or the conditions which lead to decay should be noted. Wood decay inspection services could be offered to existing customers to develop a long-lasting and better working relationship between the PCO and client, or the service could be offered as an additional benefit in a package deal to attract new business.

Control of wood decay frequently calls for increased ventilation (particularly in crawl-space homes), increased drainage, correction of faulty plumbing, gutter systems, and repaired roofing. Application of chemical sprays to the wood surface has little or no effect on wood decay. As a result, many PCO's will not be able to carry out all possible control measures unless they add additional work crews or sub-contract jobs. Therefore, most PCO's will likely be selling a service and professional information to the public and not necessarily carrying out the corrective measures.

Checklist for Decay Inspection of Houses

Wood is a very popular building material and will continue to remain so. When properly used, it will last for centuries as proven by many American homes well over 200 years old. Wood properly installed has a moisture content between 8 and 15 percent. However, if it is improperly used or if wooden structures are poorly maintained, the moisture content of wood can easily rise above 20 percent and wood decay will follow.

Wood is constantly absorbing and releasing moisture depending on the temperature and humidity of the surrounding air. However, if the moisture content of wood is to rise much over 20 percent, free moisture such as that from

excessive soil moisture, rain seepage, leaking plumbing, or condensation is usually present. The wood absorbs this moisture by direct contact or by condensation of the water directly onto the wood.

The following is a checklist for the inspection and control of wood decay in houses. It is not intended to be all-inclusive but will give an indication of the most common areas to inspect.

Outside the House

1. The lot should be graded so that water drains away from the house on all sides. Ditching or installation of subsurface drainage will sometimes help if grading is impractical. The foundation walls should be waterproofed and the footings equipped with perforated plastic drain tile and covered with gravel to allow rapid drainage of any water which accumulates.
2. If gutters and downspouts are present, they should be free of debris and well maintained. The downspouts should be arranged so that all water runs away from the house. Splashblocks or drain tile are sometimes helpful.
3. If the house has an enclosed crawl space, adequate ventilation is usually required. At least 1 square foot of clear vent space per 150 square feet of crawl space is recommended when soil covers are not present. If screening is used, increase the vent area by 1/3. If a polyethylene cover has been placed over the soil, at least two foundation ventilators should be installed and one square foot of clear ventilating area is recommended for each 1500 square feet of crawl space area. If the crawl space is heated and used as a plenum chamber, it is seldom ventilated and vapor barriers are installed along perimeter walls and soil covers are also used. The ventilators should provide cross circulation, be as near corners as possible, and free from obstructions such as shrubbery, etc. Mechanical vents should be set completely open except in the coldest weather.

4. Decay is also commonly seen along roof lines of houses where porches, additions, etc. are added on the original structure or where chimneys intersect the roof line. Roof decking and facia boards may be wetted by water curling around the leading edges of the shingles. Shingles must be in good repair and should extend 1-1/2 inches beyond the roof decking or a T-shaped strip should be inserted under the shingles for added protection. Proper flashing and adequate roof slope to drain water away is required wherever portions of buildings join together or chimneys, vents, etc., pass through the roof.

5. Peeling paint may also be a sign of excessive moisture. If excessive moisture is present in the house, it will eventually be absorbed by the exterior wood siding. The siding will shrink and swell thus causing paint to peel. Sometimes rainwater moves up the back side of wood siding by capillary action. Again, the wood swells as it absorbs the moisture and shrinks as it begins to dry. As a result, the paint may peel.

Paint may also fail because of low-quality material or improper application. Plywood and Southern Pine Lumber are two different wood products to paint. Paint in these cases often fails without any moisture problems.

6. Earth-filled porches or planters should not be attached directly to wooden members. Ideally there should be 8 inches of clearance between the soil and any wood. In porches, the fill may be tunneled to give 8 inches of clearance.

Under or Inside the House

1.It is commonly accepted that if the moisture content of wood is over 20 percent, steps should be taken to correct the moisture problem. Wood is a variable substance and moisture content consistently changes and can even vary with location in the same piece of wood. Use a moisture meter to determine

if the moisture content of several randomly selected wood members is over 20 percent. Be sure to check wherever wood contacts masonry structures or is close to sources of free water or soil contact. If moisture content is over 20 percent, initiate steps to reduce it.

2. Excessive moisture may also be indicated by obvious signs of decay in the advanced stages. These include the presence of fruiting bodies (mushrooms), white to brown cottony growths, root-like strands of fungi, crumbly dark brown wood with cubical checks or soft bleached and fibrous wood, or structural weakening of wood members. Make certain the decay has not occurred at a previous date and is no longer active. If sound wood has a moisture content of 20 percent or more (use moisture meter), eliminate the moisture problem and replace decayed and weakened wood. If the moisture problem cannot be corrected, replace the rotted wood with wood pressure-treated with a preservative. Weakened wood will give a brash failure when "picked at" with a screwdriver or other heavy pointed instrument. Sound wood will be hard and give a splintery break.

The presence of surface molds, stains, and mildew on wood, particularly in the crawl space, indicates that at least the wood surface was wet enough for decay to occur at one time. It does not necessarily mean it is still wet. Again, use the moisture meter. If the moisture content is below 20 percent, the molds and stains can be ignored.

3. The presence of very wet soil or even standing water in the crawl space under the house indicates excessive moisture. If the ventilation is poor and the house built low to the ground, the wood will absorb moisture from the humid atmosphere or water vapor may condense on the wood. Steps should be taken to drain the water away from the house. Properly installed gutters and downspouts, change in drainage patterns, plumbing repairs, use of sump pumps, etc., may all be potential solutions.

Crawl space ventilation should be increased. A 4-6 mil polyethylene soil cover may also be used. The polyethylene should be applied over the soil and care must be exercised so that water does not accumulate on the top of the soil cover.

4. Any exterior wood such as siding should be at least 8 inches above the finished grade. In crawl-space houses, interior girders should be at least 12 inches above the interior soil line and joists 18 inches. If a moisture problem occurs, the clearance should be increased if it is less than the minimum specified above. The wood members in question should be carefully inspected for decay and corrections made as appropriate. A soil cover may be useful in controlling moisture movement from the soil to the above wood structure.

5. Condensation on wood may occur in very humid crawl spaces. Since wood absorbs moisture rapidly, the condensate may not always be visible. Therefore, it is important to check the moisture content with the meter. Again, control dictates elimination of all moisture sources, increased ventilation, and the use of a soil cover.

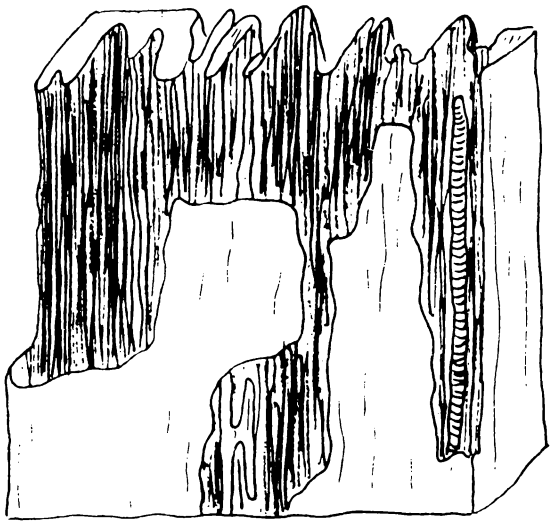
6. Excessive moisture can also result from clothes dryers discharging warm humid air into the crawl space on house proper. Vent the dryer to the outside. If moisture condenses on pipes and then drips to the wood below, they should be insulated. Defective plumbing should also be repaired. Defective grouting around plumbing fixtures may result in seepage to wooden members beneath.

7. Buckled flooring results when dry wood is installed and later absorbs moisture and swells. This is an indication that the wood has picked up moisture but it or the subfloor may still not be above the 20 percent danger point.

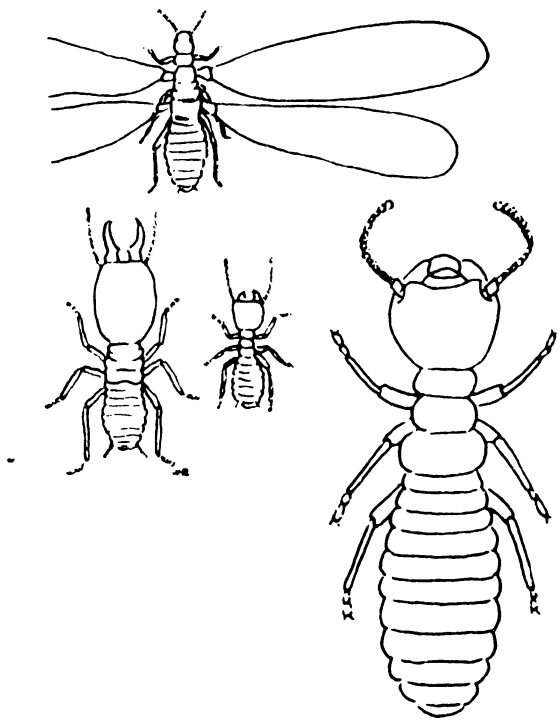
8. Attics should also be inspected. Look for water stains, especially near roof edges, in roof valleys, where adjacent roofs join together, or where chimneys intersect the roof line. Attic ventilation is also important. In gable roofs, vents are usually provided at the gable ends and should be about 1/300 of the ceiling area. Hip roofs should have air inlet openings in the soffit area of the eaves and outlet openings at or near the peak.

9. Increased emphasis on insulating, particularly in the North where average January temperatures are 35°F or below, may lead to condensation and wood decay problems. In winter months, warm, moist air will move from inside the house towards the outside colder wall. As the warm, moist air moves into this cooler region, condensation may occur. Therefore, a vapor barrier (4-6 mil polyethylene) is installed on the inside wall of new houses. In attics, it should be installed on the downward side of any insulation and when installed in a floor system, it should be on the upward side. If vapor barriers have not been installed when a house has been insulated, paint on vapor barriers such as aluminum primer have been reported effective.

TERMITES

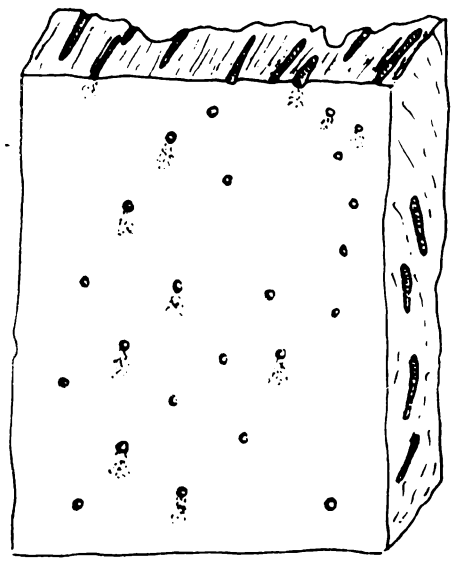


DAMAGE. INTERCONNECTED, IRREGULAR CAVITIES AND TUNNELS ARE LINED OR PARTLY FILLED WITH CLAY-LIKE MATERIAL. THE TUNNELS OFTEN FOLLOW SOFT PARTS OF ANNUAL RINGS. DAMAGE IS MOST COMMON NEAR GROUND OR FOUNDATION. IT IS USUALLY NOT EVIDENT ON UNBROKEN SURFACES. HOLLOW MUD TUBES MAY EXTEND FROM THE GROUND TO NEARBY WOOD SURFACES. ALMOST ANY KIND OF WOOD IS ATTACKED.



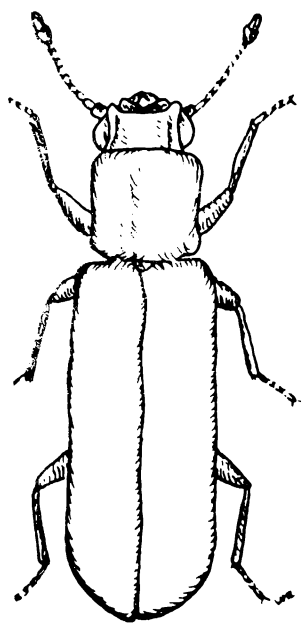
TERMITES ARE SMALL, YELLOWISH-WHITE TO BROWN INSECTS THAT LIVE IN LARGE COLONIES IN THE SOIL. COLONIES CONSIST OF MANY INDIVIDUALS, INCLUDING A KING, QUEEN, WORKERS, AND SOLDIERS. THE COLONY PRODUCES SWARMS IN THE SPRING.

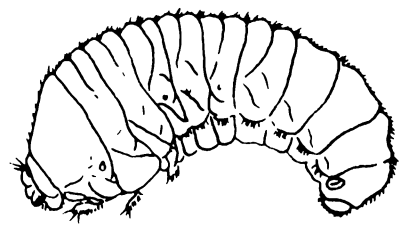
POWDER-POST BEETLES



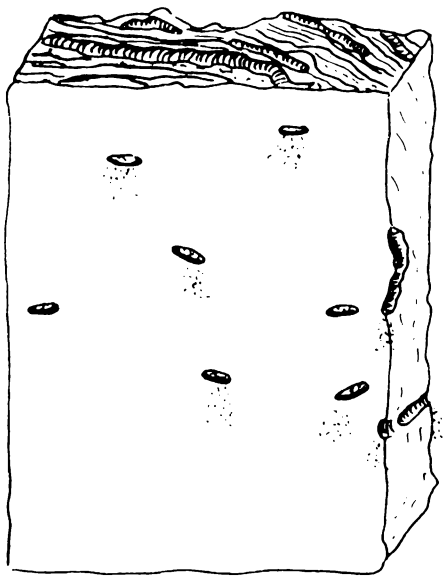
DAMAGE. SMALL ROUND HOLES AT SAWED OR ROUND-EDGE SURFACES. MAY BE NUMEROUS, ESPECIALLY ON SAPWOOD PORTIONS. HOLES ARE CONNECTED TO TUNNELS FILLED WITH COARSE TO POWDERY SAWDUST. SAWDUST MAY FALL FROM HOLES IF WOOD IS JARRED, OR MAY BE PUSHED OUT BY ADULTS WHEN THEY EMERGE.

THE TERM "POWDER-POST BEETLES" COVERS THREE KINDS OF BEETLES: 1) ANOBIID BEETLES: 2) BOSTRICHID BEETLES: AND 3) LYCTID BEETLES. ANOBIIDS ATTACK ALMOST ANY KIND OF WOOD, BUT SEEM TO PREFER OLD WOOD. BOSTRICHIDS PREFER TO INFEST THE SAPWOOD OF MOST HARDWOODS. THE SAWDUST IN THE TUNNELS IS CAKED TOGETHER, RATHER THAN LOOSE AND POWDERY. LICTIDS INFEST THE SAPWOOD OF HARDWOODS. NEWLY SEASONED WOOD, SUCH AS LUMBER IN YARDS, NEW HARDWOOD FLOORS, TOOL HANDLES, ETC.

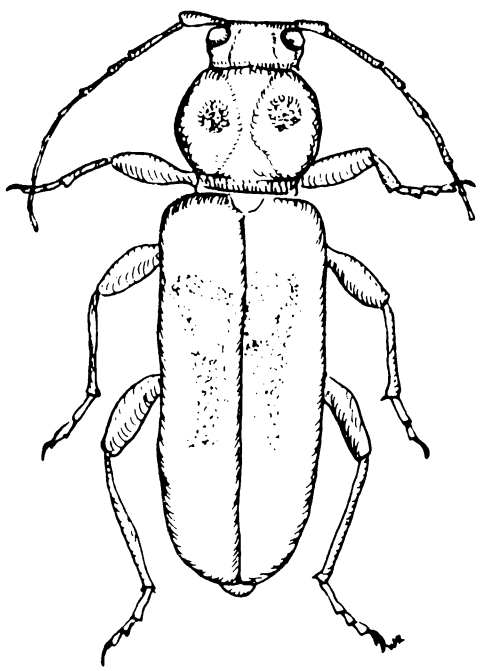




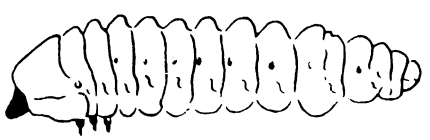
OLD HOUSE BORER



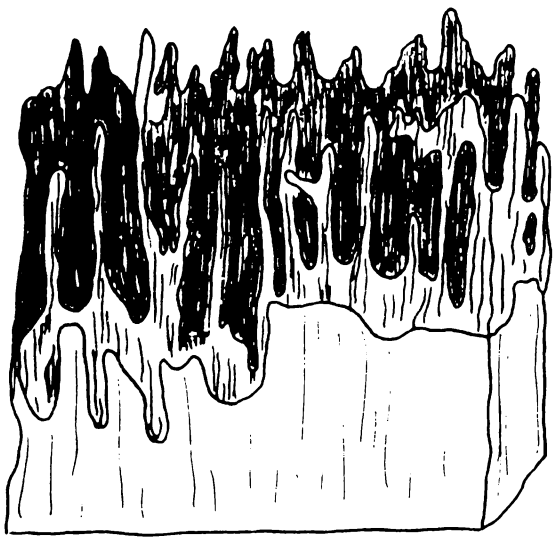
DAMAGE. LARGE OVAL HOLES THAT CONNECT TO TUNNELS THAT DEEPLY RIDDLE CONIFEROUS SAPWOOD. THE TUNNELS ARE FILLED WITH FINE, LOOSE POWDER THAT MAY FALL FROM HOLES AT THE SURFACE. THE HOLES ARE USUALLY NOT NUMEROUS.



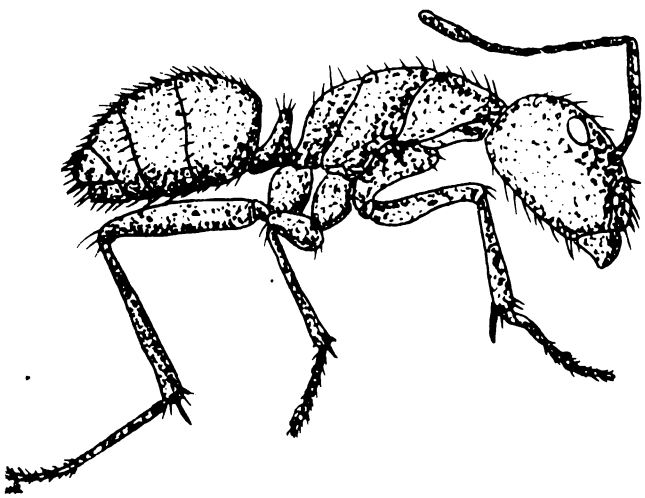
OLD HOUSE BORERS ARE IN THE LARGE FAMILY OF LONG-HORNED BEETLES. THE ADULT IS ELONGATE (1/2 TO 1 INCH LONG) AND BLACK. THERE ARE GRAYISH HAIRS AND MARKINGS ON THE THORAX AND WING COVERS. THE LARVA IS ELONGATE (ABOUT 1 INCH WHEN MATURE), AND SLIGHTLY FLATTENED.



CARPENTER ANTS



DAMAGE. THE WOOD HAS INTERCONNECTED IRREGULAR CAVITIES AND TUNNELS. THE CAVITIES HAVE CLEAN, SMOOTH WALLS, WITHOUT SAWDUST. DAMAGE IS SELDOM EVIDENT ON UNBROKEN SURFACE. LOOSE, COARSE, FIBROUS SAWDUST MAY BE PILED NEARBY. DAMAGE MAY BE IN ANY PART OF THE BUILDING, COMMONLY IN DECAYED, MOIST, OR NATURALLY SOFT KINDS OF WOOD.



CARPENTER ANTS (CAMPANOTUS SPP.) ARE LARGE (1/4 TO 3/4 INCH LONG), AND USUALLY BLACK. THE WINGED FORMS HAVE LARGE BROWNISH WINGS WITH DISTINCTLY DARKER COLORED VEINS. THE WINGED AND WINGLESS FORMS MAY APPEAR IN LARGE NUMBERS INSIDE THE BUILDINGS. THEY USUALLY SWARM IN THE FALL.

BASICS OF INSECTICIDES, RODENTICIDES, AND AVICIDES

Pesticide applicators conducting health, industrial, and institutional, structural, and health-related pest control should have a basic understanding of the commonly used pesticides. The paragraphs that follow will present information on: 1) chemical structure; 2) common commercial products; 3) toxicology; and 4) frequent symptoms of poisoning.

Insecticides

A large number of the pesticides used today are for the control of insects. Most of the insecticides produced are "contact poisons"; that is, they must actually come in contact with the insect to exert their toxic action. The toxic action most important for insecticides is acute toxicity. Insecticides that kill insects rapidly display the property of chronic toxicity

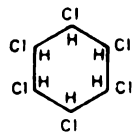
Insecticides are often classified into groups according to their chemical structure. The groups of insecticides important to most commercial pesticide applicators include:

1. ORGANOCHLORINE PESTICIDES
2. ORGANOPHOSPHATE PESTICIDES
3. CARBAMATE PESTICIDES
4. PENTACHLOROPHENOL
5. BOTANICAL PESTICIDES
6. BIOLOGICAL PESTICIDES
7. FUMIGANTS

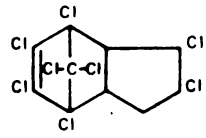
In some cases, the chemical structures of pesticides in the groups will be presented. These structures will help show similarity between different compounds; it is not necessary for the reader to commit them to memory.

ORGANOCHLORINE PESTICIDES

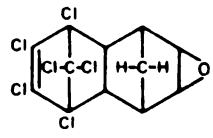
CHEMICAL STRUCTURE



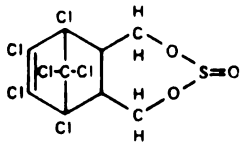
LINDANE



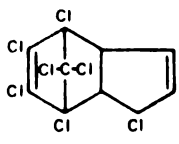
CHLORDANE



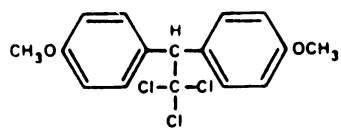
DIELDRIN



ENDOSULFAN



HEPTACHLOR



METHOXYCHLOR

COMMON COMMERCIAL PRODUCTS

Highly toxic: endrin (Hexadrin), a stereoisomer of dieldrin. Moderately toxic: aldrin (Aldrite, Drinox), lindane (Isotox, Gammexane), chlordane (Chlordan).

TOXICOLOGY

In adequate dosage, these chemicals interfere with axonic transmission of nerve impulses and, therefore, disrupt the function of the nervous system, principally that of the brain. This results in behavior changes, sensory and equilibrium disturbances, involuntary muscle activity, and depression of vital centers, particularly that controlling respiration.

SYMPTOMS OF HUMAN POISONING

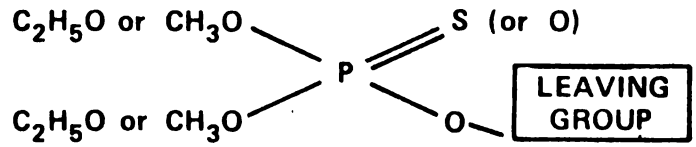
APPREHENSION, excitability, dizziness, HEADACHE, DISORIENTATION, weakness, PARESTHESIAE, muscle twitching, tremor, tonic and clonic CONVULSIONS (often epileptiform), coma. Soon after ingestion, nausea and vomiting are prominent. When chemicals are absorbed by parenteral routes, apprehension, twitching, tremors, and convulsions may be the first symptoms. Respiratory depression is caused by the pesticide and by the petroleum solvents in which these pesticides are usually dissolved.

REMARKS

Chemically, organochlorine pesticides are very stable compounds. They persist in the environment and are sometimes considered pollutants. Organochlorine compounds have a long residual activity and are broad-spectrum insecticides--they kill many types of insects.

ORGANOPHOSPHATE PESTICIDES

GENERAL CHEMICAL STRUCTURE



COMMON COMMERCIAL PRODUCTS

Highly toxic: TEPP, phorate (Thimet), mevinphos (Phosdrin), and ethyl parathion (Parathion, Thiophos).

Moderately toxic: dichlorvos (DDVP, Vapona), chlorpyrifos (Dursban), diazinon (Spectracide), trichlorfon (Dylor, Dipterex, Neguvon), and malathion (Cythion).

TOXICOLOGY

Toxicants of this group phosphorylate almost irreversibly varying amounts of the acetycholinesterase enzyme of tissues, allowing accumulation of acetylchloline at cholinergic neuro-effector junctions (muscarinic effects), and at skeletal muscle myoneural junctions and in autonomic ganglia (nicotinic effects). Poison also impairs central nervous system function. Toxicants can be absorbed by inhalation, ingestion, and skin penetration.

SYMPTONS OF HUMAN POISONING

Symptoms of acute poisoning develop during exposure or within 12 hours after contact. HEADACHE, DIZZINESS, EXTREME WEAKNESS, ATAXIA, TINY PUPILS, blurred or dark vision, muscle TWITCHING, TREMOR, sometimes convulsions, mental confusion, incontinence, unconsciousness, NAUSEA, vomiting, abdominal cramps, diarrhea. Tightness of chest, SLOW HEARTBEAT, wheezing, productive cough, sometimes PULMONARY EDEMA (up to 12 hours after poisoning). SWEATING, rhinorrhea, tearing, salivation. Severe poisoning may cause sudden unconsciousness or TOXIC PSYCHOSIS resembling acute alcoholism.

REMARKS

This is a very large group of poisons. A conservative estimate is that at least 100 organic phosphate insecticides have reached the commercial market. Some examples include diazinon, malathion, parathion, and methyl parathion.

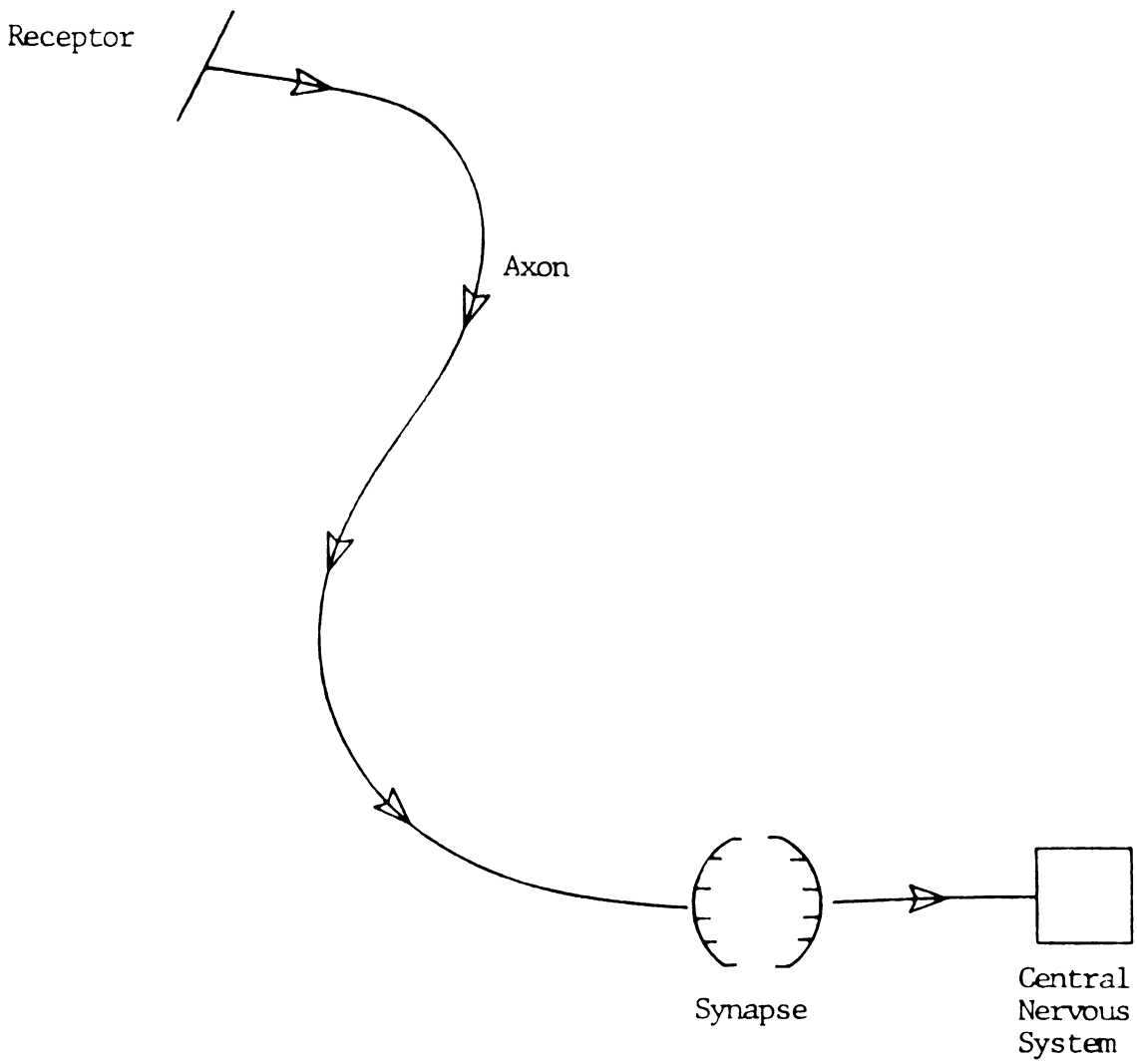
The chemicals in this group have several properties which we need to know something about. An important property is that they are easily broken down under alkaline conditions. This means that they are not particularly stable chemicals and are often short-lived as insecticides. They do not persist in the environment and, from a practical point of view, they often have to be applied repeatedly to bring about insect control.

Organic phosphate insecticides have a wide variability in their toxicity to mammals. Malathion, for example, is quite safe for use around mammals while others, such as parathion and methyl parathion, are very toxic to mammals. The organic phosphate chemicals are only slightly soluble in water, but are completely soluble in organic solvents. They are used for a variety of purposes including insecticides, acaracides, plant systemics, and others.

The mode of action of the organic phosphates is fairly well understood. These chemicals act upon the insect's nervous system to cause death.

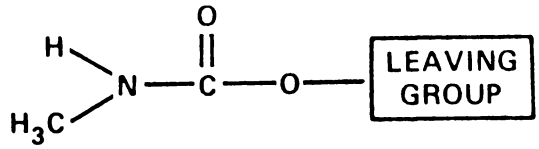
The nervous system works much like an electric light and an on/off switch. When you flip the switch on, the electricity travels rapidly to the light bulb and it lights. Similarly, when an insect is touched or stimulated in some way, the message is received at the receptor and travels along the nerve wires (axon) to the central nervous system (CNS). Before the message reaches the CNS, it must pass over a break in the axon. This break is called a synapse. The message is carried across the synapse by the help of a chemical called acetycholine. This

chemical is produced for a very short time -- just long enough to transfer the message from one side to the other. After this, another chemical is produced to break down acetycholine so the axon is ready for another message. When an organic phosphate insecticide is introduced into this nervous system, the effect is to prevent the production of the chemical that breaks down acetycholine. Under these conditions, the chemical acetycholine accumulates at the synapse. It is toxic to the synapse. The insect nervous system is damaged and is not capable of carrying out its normal function. As a result of this, the insect dies.



CARBAMATE PESTICIDES

GENERAL CHEMICAL STRUCTURE



COMMON COMMERCIAL PRODUCTS

Highly toxic: aldicarb (Temik), carbofuran (Furadan).

Moderately toxic: propoxur (Baygon), carbaryl (Sevin).

Some chemicals of this class are "systemic," i.e., they are taken up by the plant and translocated into foliage and sometimes into the fruit.

TOXICOLOGY

Toxicants of this group cause reversible carbamylation of the acetylcholinesterase enzyme of tissues, allowing accumulation of the acetylcholine at cholinergic neuroeffector junctions (muscarinic effects), and at skeletal muscle myoneural junctions and autonomic ganglia (nicotine effects). Poisons also impairs central nervous system function.

A few of the carbamate insecticides are formulated in methyl (wood) alcohol. In cases of ingestion of these formulations, the toxicology of the methanol must be taken fully into consideration: severe gastroenteric irritation, acidosis, and central nervous system injury.

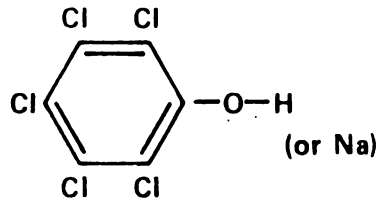
SYMPTOMS OF HUMAN POISONING

Symptoms of acute poisoning develop during exposure or within 12 hours after contact. HEADACHE, DIZZINESS, WEAKNESS, ATAXIA, TINY PUPILS, blurred or "dark" vision, muscle TWITCHING, TREMOR, sometimes convulsions, mental confusion, incontinence, unconsciousness. NAUSEA, vomiting, abdominal cramps, diarrhea.

Tightness in chest, SLOW HEARTBEAT, wheezing, productive cough, occasionally pulmonary edema. Sweating, rhinorrhea, tearing, SALIVATION. Severe poisoning may cause sudden unconsciousness, or a toxic psychosis. RESPIRATION DEPRESSION may result from actions of the toxicant and solvent.

PENTACHLOROPHENOL

CHEMICAL STRUCTURE



COMMON COMMERCIAL PRODUCTS

PCP, Dowicide-7 Penchlorol, Pentacon, Penwar, Weedone, Veg-I-Kill, Wood Preserver, Wood Tox 140, Purina Insect Oil Concentrate, Gordon Termi Tox, Usol Cabin Oil, Certified Kiltrol-74 Weed Killer, Ciba-Geigy Ontrack OS 3, 4, or 5, Ortho Triox Liquid Vegetation Killer, Black Leaf Grass, Weed and Vegetation Killer Spray.

Pentachlorophenol has many uses as a weed killer, defoliant, wood preservative, germicide, fungicide, and mulluscicide. It is an ingredient of many other formulated mixtures sold for one or more of these purposes.

TOXICOLOGY

Pentachlorophenol irritates the skin, eyes, and upper respiratory mucous membranes. It is efficiently absorbed through the skin, the lungs, and the gastrointestinal lining. It stimulates oxidative metabolism of tissue cells by uncoupling oxidative processes from the normal stepwise phosphorylation reactions. In common with other phenols, it is toxic to the liver, kidney, and central nervous system.

The majority of severe poisonings have occurred in workers exposed when in hot environments.

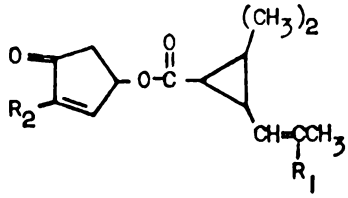
SYMPTOMS OF HUMAN POISONING

IRRITATION of nose, throat, eyes, and skin is the most common symptom of exposure to PCP. Severe or protracted

exposure may result in a CONTACT DERMATITIS. Intensive occupational exposure has resulted in chloracne.

PROFUSE SWEATING, HEADACHE, WEAKNESS, AND NAUSEA are the most consistent symptoms of systemic poisoning by absorbed PCP. FEVER is usually present but may be minimal or absent.

CHEMICAL STRUCTURE



Pyrethrin I: $C_{21}H_{28}O_3$
$R_1 = -CH_3$
$R_2 = -CH_2CH{=}CHCH{=}CH_2$

Pyrethrin II: $C_{22}H_{28}O_5$
$R_1 = -C(=O)-OCH_3$
$R_2 = -CH_2CH{=}CHCH{=}CH_2$

Cinerin I: $C_{20}H_{28}O_3$
$R_1 = -CH_3$
$R_2 = -CH_2CH{=}CHCH_3$

Cinerin II: $C_{21}H_{28}O_5$
$R_1 = -C(=O)-OCH_3$
$R_2 = -CH_2CH{=}CHCH_3$

COMMON COMMERCIAL PRODUCTS

The natural pyrethrins which include Pyrethrins I and II, Cinerins I and II, and Jasmolins I and II.

Synthetic pyrethrin-line (pyrethroid) compounds that duplicate the activity of natural pyrethrin compounds include allethrin, barthrin, cyclethrin, dimethrin, furethrin, Neopynamin, phytholthrin, resmethrin.

TOXICOLOGY

Pyrethrum and allethrin may be absorbed through the gastro-intestinal and respiratory organs. They are not absorbed to a significant degree through the skin; however, allergic reactions may result from dermal exposure.

The nervous systems produced by pyrethrum and allethrin poisoning resemble those of veratrin intoxication, proceeding from excitation to convulsions to tetanic paralysis, except the pyrethrins cause muscular fibrillation as well. Death is due to respiratory failure. If recovery occurs, it is usually complete. Injury to man from pyrethrum has most frequently resulted from the allergenic properties of the material rather than its direct toxicity.

Under practical conditions, pyrethrum and allethrin are probably the least toxic to mammals of all the insecticides currently in use.

SYMPTOMS OF POISONING

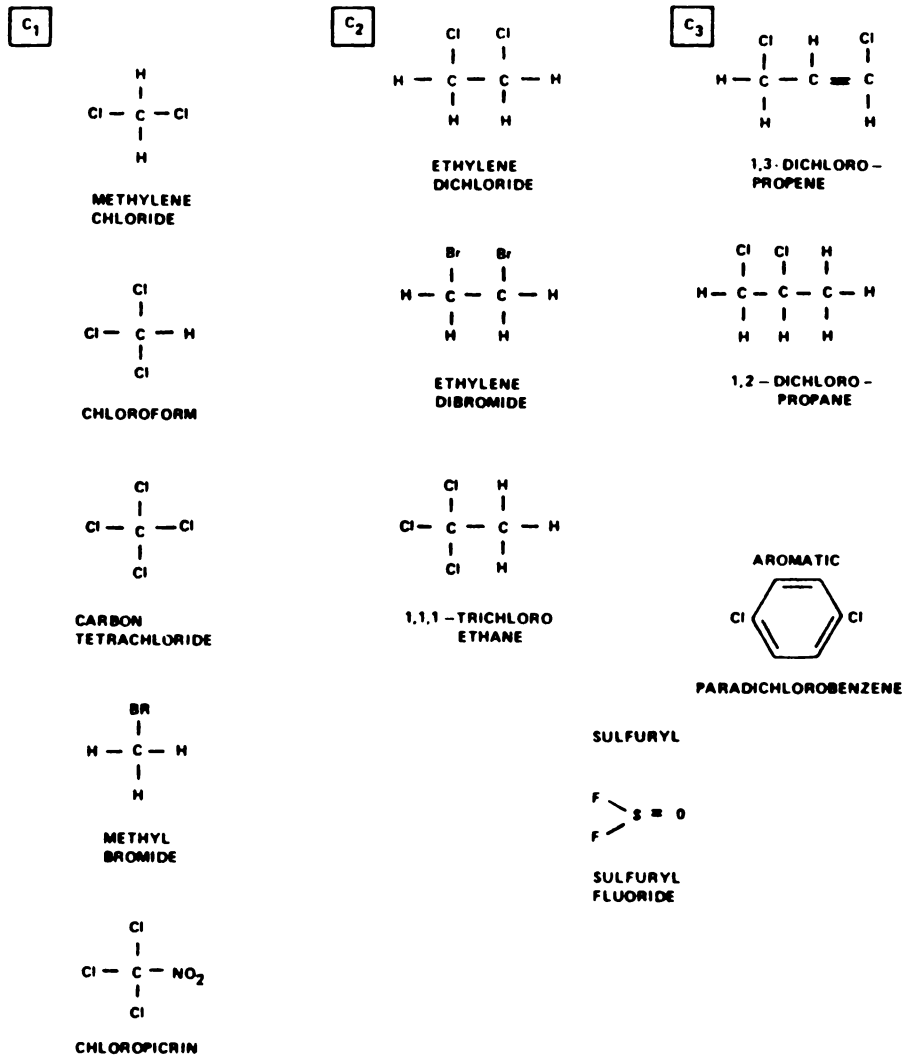
Pyrethrum toxicity may manifest itself in several forms in man. Contact dermatitis is by far the most common. The usual picture is a mild erythematous, vesicular dermatitis with papules in moist areas, and intense pruritus. A bullous dermatitis may develop. Some individuals show manifestations of pyrethrum sensitivity similar to those seen in pollinosis, including sneezing, serious nasal discharge, and nasal stuffiness.

BIOLOGICAL PESTICIDES

The materials in this group are toxins of bacterial origin, most commonly from Bacillus thuringiensis. These materials are probably composed of proteins and must be eaten by the insect. They are often quite specific and work on only one species or one group of insects. Apparently, they have to be eaten in fairly large quantities in order to be effective. Their mode of action seems to be an interference with insect gut membrane. Once this has happended, a variety of secondary effects probably set-in which eventually cause the death of the insect. Use of this kind of an insecticide represents a form of biological control of insects. Because the pathogens or their toxins seem to be specific for insects, they probably do not constitute an environmental pollution hazard.

FUMIGANTS

CHEMICAL STRUCTURES



COMMON COMMERCIAL PRODUCTS

ALIPHATIC - Carbon tetrachloride, methyl bromide; Chloropicrin (Acquinite, Chlor-O-Pic, Pic-Clor, Picfume, Trichlor); ethylene dichloride (EDC); ethylene dibromide (EDB, Bromofume, Celmide, Dowfume W-85, Kip-Fume, Nephis, Pestmaster EDB-85, Soilbrom).

AROMATIC - Paradichlorobenzene (PDB, Paracide, Paradow)

SULFURYL - Sulfuryl fluoride (Vikane)

TOXICOLOGY

Except for the solid paradichlorobenzene moth chrystals, these chemicals are gases or highly volatile liquids at room temperature. As fumigants, they have a remarkable capacity for penetration. Some, especially the bromine compounds, pass readily through human skin and rubber protective gear, thus complicating the protection of exposed workers. In varying degrees, they irritate the skin, eyes, and respiratory tract. When held on the skin by an occluding cover, such as contaminated gloves, these chemicals not only irritate, but cause acute dermatitis and vesiculation. Repeated contact with the liquid halocarbons defats the skin, leading to chronic dermatitis. All are capable of producing pulmonary edema and/or hemorrhage in persons heavily exposed by inhalation, ingestion, or dermal absorption. Death following exposure to the halocarbon fumigants is usually due either to pulmonary edema or to respiratory depression.

Inhalation of pyrolysis products of these fumigants has caused massive necrosis of respiratory tract linings in exposed firemen.

Toxic action on the central nervous system is generally depressant, causing unconsciousness, seizures, and general muscle weakness, including weakened respiratory effort. The neurotoxic action of methyl bromide apparently include the basal ganglia as well as the cerebrum, causing not only sensory and motor impairments but also behavioral and emotional disturbances. These may or may not progress to epileptiform seizures and coma. In some cases, behavioral and neurologic manifestations have first appeared several hours or even days after exposure, then they have persisted for days to months.

The chlorocarbons, notably chloroform, increase myocardial irritability and impair contractile strength. Large inhalation dosages may cause death by inducing ventricular fibrillation.

In varying degrees, these fumigants damage the liver and kidneys. In laboratory animals, and in autopsy specimens from fatal human cases, this is commonly manifest as fatty degeneration. More severe poisoning causes centrilobular necrosis of the liver and acute tubular necrosis of the kidney. Fatty degeneration of the myocardium and corneal opacities have been observed in dogs following systemic absorption of ethylene dichloride.

Methyl bromide and ethylene dichloride (and possibly other chemicals of this series, by analogy) are alkylating agents in mammalian tissues; they can inhibit multiple enzyme systems, including the sulfhydryl enzymes and hexokinases in multiple tissues. This may be a major mechanism of toxicity of this series of chemicals.

Paradichlorobenzene is substantially less toxic to humans than are the gaseous and liquid fumigants. It has neither the hemolytic nor the cataractogenic properties of naphthalene fumigant, which it has largely displaced. Given at extreme dosage to laboratory animals, it causes liver injury and neurologic disturbances.

RODENTICIDES AND AVICIDES

Rat and bird control are important aspects of industrial, institutional, structural, and health-related pest control. There are a variety of factors that influence the effectiveness of rodenticides and avicides. Such factors include: 1) toxicity; 2) dosage levels; 3) acceptance and reacceptance; and 4) the development of tolerances. Odor and taste must be considered in some instances. Safety precautions are an essential part of any procedure. An understanding of the mode of action will enable you to use rodenticides and avicides more effectively and safely.

RODENTICIDES

Rodenticides are pesticides used to control rodents such as rats, mice, and squirrels. They are normally employed in solid baits, liquid forms, as dusts, or as volatile chemicals used as fumigants. The most effective rodenticides are those with a high toxicity and palatibility, and with one or more safety features. Rodenticides used in solid baits or liquid forms can be divided into two groups based on the mode of action: 1) the acute rodenticides; 2) the chronic rodenticides.

The acute rodenticides are those in which a lethal quantity of poison is ingested in a single dose with the food or drink of a rodent. They cause death by heart paralysis, gastrointestinal and liver damage, or by attacking the central nervous system. The target animal must consume a lethal dose before the onset of poisoning symptoms. A sub-lethal dose may produce side effects which will make the rodent "bait shy". Pre-baiting is recommended before applying acute rodenticides so the animal will be conditioned to the bait. The unpoisoned bait is first presented to the rodents until they freely feed regularly and then it is replaced by bait containing the poison.

Chronic rodenticides bring about death of an animal only after the poisoned bait or liquid has been consumed on a number

of occasions. Because the poison is consumed over a period of time, a low dosage is lethal. For example, a brown rat can survive a single 50 MG/KG dose, but succumbs to 5 consecutive doses of 1 MG/KG taken on successive days. The symptoms of poison are so delayed that the animal never learns to associate discomfort with the bait consumption, and continues to feed until a lethal dose has been ingested. The main components possessing chronic poisoning action are the anti-coagulants, which interrupt the systhesis of blood-clotting factors so the poisoned animals die from internal bleeding. Chronic rodenticides are relatively nontoxic to domestic animals and man; however, there is no such thing as a "safe rodenticide".

However toxic a chemical poison might be, it will not be lethal unless a rodent, of its own volition, consumes a lethal dose. Additives are sometimes included in the bait to improve performance. Attractants such as flavoring or oils are sometimes added to bait to make it more appealing by enhancing the taste or masking disagreeable odors. Anticoagulants may be made more lethal by adding potentiating agent that accentuate the action of the anticoagulants. Preservatives and binders are used in baits to keep them from deteriorating over time. To guard against accidental consumption of the poisoned bait by nontarget animals, safety additives may be incorporated. Since rodents are unable to vomit, it is often the practice to incorporate an emetic agent in the bait. The emetic agent will induce vomiting and provide a safety factor for the non-target animals.

Secondary poisoning to animals which feed on dead or dying rodents should be anticipated. The danger may be reduced by removing rodent carcasses whenever possible.

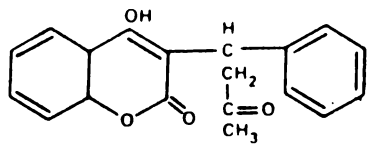
Acute or chronic poisons may be used in dust formulations. A poisoned dust is placed in the holes and burrows of rodents where it adheres to their feet and fur and is transferred to

the mouth during normal cleaning and grooming activities. This method requires a high concentration of poison since the animal can only be expected to consume small amounts. The advantage of contact dusts is that rodents do not suspect the source of illness.

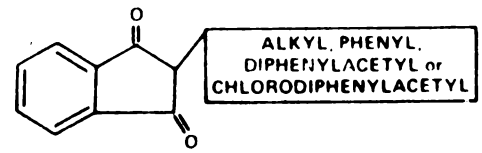
In situations where rodents do not respond to poisoned baits or dusts, a fumigation technique can be used. Rodents breathe the volatile substances and gases which cause death.

ANTICOAGULANT RODENTICIDES

STRUCTURES OF PRINCIPAL CLASSES



WARFARIN (COUMARIN TYPE)



1,3 INDANDIONE TYPE

COMMON COMMERCIAL PRODUCTS

Coumarin type: warfarin (Kypfarin, Warf-42, D-Con, Warficide, Prolin), coumafuryl (Fumarin), Dethmor, Rax.

1,3-indandione type: diphacinone, or diphenadione (Ramik), chlorophacinone (Drat, Caid, Liphadione, Microzul, Ramucide, Rotomet, Raviac, Topitox), pindone (Pivalyn, Pivacin, Tri-ban, Pival), valone, (PMP).

TOXICOLOGY

Gastrointestinal absorption of these toxicants is efficient, beginning within minutes of ingestion and continuing 2-3 days. Apparently, warfarin can be absorbed through the skin, although the circumstances under which this has occurred are extraordinary.

Both types of anticoagulant depress and hepatic systhesis of substances essential to normal blood clotting.

Unlike the coumarin anticoagulants, the indandiones cause symptoms and signs of neurologic and cardiopulmonary injury in laboratory rats; these injuries often lead to death before hemorrhage occurs. These actions may account for the somewhat greater toxicity of this class of anticoagulants.

SYMPTOMS OF POISONING

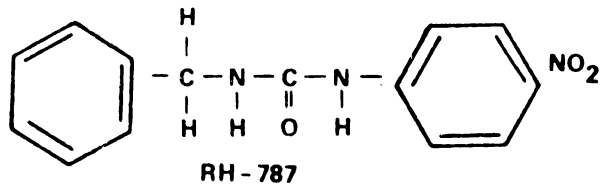
In most instances of accidental ingestion by man of anti-coagulant baits, victims have remained asymptomatic, due to the small dosage taken. Even in cases involving ingestion of sub-

stantial doses, hypoprothrombinemia occurs without symptoms of poisoning. Hemorrhage appears only when extraordinary amounts have been absorbed. In these cases, the anticoagulants were either taken deliberately, were absorbed over long periods out of neglect of elementary hygienic standards, or were injested by starving indigents who used quantities of rodent bait for food.

Victims of large doses exhibit HEMATURIA, NOSEBLEED, HETATOMATA, BLEEDING GUMS, AND MELENA. ABDOMINAL PAIN AND BACK PAIN PROBABLY REFLECT HEMORRHAGE IN THE ABDOMINAL AND RETROPERITONEAL TISSUES.

VACOR AND DLP-787

CHEMICAL STRUCTURE



RH-787

COMMON COMMERCIAL PRODUCTS

Vacor Rat Killer (2% RH-787 in vehicle resembling corn meal); DLP-787 Bait (2% RH-787 in vehicle resembling corn meal); DLP-787 House Mouse Tracking Powder (10% RH-787 in a light green powder vehicle). Compound RH-787 is the active ingredient of both formulations.

TOXICOLOGY

The exact mechanism of RH-787 toxicity is not know. It has no anticoagulant action, and is, therefore, entirely different from the coumarin or indandione rodenticides.

FREQUENT SYMPTOMS OF POISONING

Human poisonings of a significant nature have occurred only after deliberate ingestions of RH-787. Symptoms vary, depending on dose and individual susceptibility.

Symptoms may not appear until 4-48 hours after ingestion of the formulated rodenticide. EARLY symptoms include NAUSEA, VOMITING, ABDOMINAL CRAMPS, CHILLS, AND MENTAL CONFUSION.

AVICIDES

Avicides are pesticides used to control birds in pest situations. Some common avicides include compound DRC 1339 and avitrol. Most avicides are acute poisons which act on the central nervous system. The reaction time required to kill a bird varies with the type of poison. Strychnine used as an avicide will kill birds shortly after the bait is consumed while the avicide containing the compound DRC 1339 does not kill the birds for several hours, generally after they go to roost. This difference in mode of action is important in reducing the effects of secondary poisoning to animals that consume dead birds. Birds dying at the roost sites can be easily picked up and disposed of.

No avicide has been found that is specific for a given bird; thus, there is always a danger that non-target birds will be affected. A poison such as strychnine is lethal to all animals while DRC 1339 is more lethal to starlings and blackbirds, but will also kill smaller birds. Avitrol is an avicide which is used to control blackbirds. Birds ingesting avitrol react with distress symptoms and calls which frighten away the remainder of its flock from feeding area with a minimum of mortality. The advantage of avitrol is that only few birds need to ingest the bait, thus a relatively small amount of bait needs to be put out.

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