STUDIES OF LYCTID AND SCOLYTID BEETLES INFESTING SEASONING LUMBER

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STUDIES OF LYCTID AND SCOLYTID BEETLES INFESTING SEASONING LUMBER

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I. INTRODUCTION

In the fall of 1950 investigations were begun on the powder-post beetles of the family Lyctidae.

This topic was suggested as a thesis subject because of the increasing importance of these insects to the hardwood industry. Thousands of board feet of seasoned lumber, and even more important because of the man-hours involved, large quantities of tool handles, gunstocks, and other manufactured items, are lost annually to this pest. A factor increasing their importance is their habit of attacking only the sapwood. Since most of the timber being cut in the northeastern United States is either second or third growth, larger amounts of seasoning hardwood lumber are subject to attack.

At the outset of this project two goals were set: a survey of the insects infesting seasoning lumber, and a determination of the effects of various humidities on the life cycle of the powder-post beetle.

Attempts to secure relatively large populations of powder-post beetles for the humidity control experiment failed. After these failures efforts were directed toward finding a successful

method of rearing these beetles in small chambers suitable for the originally intended humidity experiment.

From the preliminary work on the survey a high incidence of scolytid damage was noted in seasoning lumber at various sawmills. Because of these findings a third problem was investigated. In most cases it was obvious that the infestation had occurred sometime before the logs had been sawed. Many adult beetles were removed from samples checked in the laboratory. Examination of the life cycle of these beetles showed that they overwinter in the adult stage. If infested timber were milled and piled for air-seasoning in late fall or during the winter, the adults would emerge in early spring to seek new locations for their tunnels. With these facts in mind, it seemed possible that the beetles could re-infest the same lumber which would still be of a correct moisture content, or lumber free from scolytid injury that had been cut and stacked at approximately the same time. An experiment was conducted to determine if scolytids would re-enter wood samples of a similar moisture content to those from which they had emerged.

II. REVIEW OF LITERATURE

The Powder-post Beetles, Family Lyctidae

The order Coleoptera has been studied systematically by many workers. Coleopterists have revised the system of classification according to the form of the antennae and tarsi, or based systems on phylogeny or genitalia, or combinations of these characteristics. The revisions of the order made by Le Conte and Horn (1883) listed the lyctids as a subfamily of Ptinidae. Fall (1905) in his revisions of the family Ptinidae raised the subfamily Bostrichinae to family status, and suggested that Lyctinae might be included in the family Cucujidae. Lyctinae was classified as a subfamily of Bostrichidae by Blatchley (1910). According to Leng (1920), Kraus suggested the family standing for the lyctids. Most of the recent publications follow the systematic arrangement of Leng's Catalogue of Coleoptera (Table I).

The work of these insects may be recognized by the numerous minute holes which are made by the emerging adults, and the presence of fine white dust-like borings.

TABLE I

SYNONYMY OF BEETLES COMMONLY CLASSED AS POWDER-POST BEETLES

Author	Classification			
LeConte	Ptinidae	Anobiinae	Bostrichinae	Lyctinae
Fall	Ptinidae	Anobiinae	Bostrichidae	Cucujidae — Lyctinae
Blatchley	Ptinidae	Anobiinae	Bostrichidae	Lyctinae
Leng	Ptinidae	Anobiidae	Bostrichidae	Lyctidae
Dorn et al.	"	"	"	"
Comstock	"	"	"	"
Essig	"	"	"	"
Chamberlin	"	"	"	"
Craighead	"	"	"	"

Because of the talc-like dust made by the larvae, they are popularly known as the powder-post beetles. Some authors restrict this common name to the family Lyctidae (Essig, 1942), while others use it more loosely. Dorn et al. (1936) and Graham (1929) use it for the representatives of four families, Ptinidae, Anobiidae, Bostrichidae, and Lyctidae, of the superfamily Ptinoidea. They refer to the family Lyctidae as being the most typical, and call them the "true powder-post beetles." Comstock (1948) used the common name for the family Bostrichidae, and stated that the members of Lyctidae resemble the powder-post beetles. In the latest publication by Craighead (1950) the common name, powder-post beetles, is used for both the families Bostrichidae and Lyctidae. However, the former is designated as the "large powder-post beetles" and the latter as the "Lyctus powder-post beetles."

Blatchley's (1910) description stated that the adult beetles are elongate and slender and have a prominent head, slightly narrowed behind the eyes, and not covered by the thorax. The latter characteristic immediately separates this family from related ones. The thorax is trapezoidal in shape with a fine lateral margin. The antennae are eleven-segmented, with a

rounded club composed of two segments. The anterior coxae are entirely enclosed and separated by the prosternum; the posterior ones are widely separated. The first ventral segment of the abdomen is much longer than any of the others.

Fisher (1940) described the larvae as curved, wrinkled, yellowish-white, with brown jaws, scarabaeoid in form. The spiracles on the eighth segment are much larger than those on the other segments, appearing as two brown oval spots. They have three pair of minute three-segmented legs.

According to Mallis (1945), Gaham and Laing described the egg as being "white, cylindrical, shiny, granular, and about 0.8 millimeters long. There is a small slender strand at one end, behind which the surface is striated lengthwise."

Fisher (1940) outlined the life history of Lyctus, which is quite typical of the entire family. He stated that under natural conditions the normal period of development from egg to adult is approximately one year. The adults begin to emerge in the spring, first appearing about April. Females lay thirty to fifty eggs, placing them within the pores on the surface of the wood. The larvae, which hatch in eight to ten days, tunnel into the wood. At first they are said to tunnel with the

grain, but later to work through the wood in all directions. When the larvae are full grown, they bore toward the surface of the wood, making a pupal chamber just below it. In emerging, the adults have been known to bore through heartwood, varnish, paint, glue, and even metal coverings, such as lead and silver.

It has been observed (anon., 1939) that Lyctus parallelopipedus (Melsh) develop from egg to adult in approximately three months under ideal southern conditions. Snyder (1926) found that under indoor conditions development may take place more rapidly and eggs may be deposited earlier.

The economic importance of these insects has been increasing constantly during the past three decades. Transportation of hardwood timber or finished hardwood articles has distributed the beetles to all parts of the world. The estimated damage in the United States is approximately eighteen million dollars per year (anon., 1939).

Lumber inspectors have great difficulty detecting all lyctid-infested lumber, especially during the first weeks of an initial infestation when the eggs and young larvae are hidden within the surface pores. Inexperienced observers when

inspecting for powder-post damage often notice the characteristic dust, but fail to find the emergence holes because of the adult's habit of emerging from the underside of the boards.

Any hardwood is liable to lyctid attack. However, they confine their injury to the sapwood, the portion of the tree containing the largest amount of starch which is their principle food. It has been stated that some species of beetles may begin their destruction before the timber is thoroughly seasoned, and that Lyctus parallelopipedus will attack lumber above a moisture content of 15 percent (anon., 1939).

Panshin (1949) stated that well air-seasoned lumber contains from twelve to eighteen percent moisture, while "kiln-dried" lumber implies less than ten percent moisture.

According to Craighead (1950), lumber may be seasoned in the yard or shed nine months or more in the North without fear of Lyctus attack. Kiln-dried or thin-dimensioned air-seasoned hardwood stock is subject to attack in less than three months.

Snyder (1938) recommended: (1) inspection of lumber annually; (2) prevention of accumulation of waste wood; (3) arrangement of sapwood material by species and age for ready

examination; (4) disposal of the oldest stock first since it is the most susceptible to attack; and (5) inspection of all newly arrived stock to prevent introduction.

It was found in 1939 that the immersion of unfinished lumber for ten seconds in a five percent water solution of borax protected it from Lyctus parallelopipedus but not L. planicollis (anon., 1939). In 1940 successful control of lyctid beetles by fumigation with methyl bromide was reported (Christian, 1940).

Snyder and St. George (1924) found that kilns operated by live steam, in which wood up to one inch thick could be heated to a temperature of 130° F. for one and a half hours, killed the insects. This method does not prevent subsequent attack and is not recommended for wood requiring great structural strength or a fine finish, since steaming may weaken and discolor the wood.

It is reported that stock cultures of Lyctus beetles were reared by the hundreds in large tins covered over with cheesecloth and confined in an incubator which was held above 26° C. and at 75 percent relative humidity. The wood contained 10 to 15 percent moisture at 21° to 27° C. A life cycle was completed

in less than six months under these conditions (anon., 1939; Christian, 1940).

Hansens (1944) reported the use of sulfuric acid to maintain constant humidity for experiments on the body louse. The acid was placed in the bottoms of battery jars, and the solution covered with screening. The jars were covered with large petri dishes, and sealed with "Celloseal" or vaseline.

Wilson (1921) found that the moisture content of most materials varies only a small amount with moderate changes in temperature, providing the relative humidity is kept constant. Both Wilson and Hansens gave tables for percentages of sulfuric acid required to give definite humidities.

Buxton and Mellanby (1934) gave a convenient method to make a range of dilutions for different humidities by use of a sulfuric acid stock solution. A table is given for the concentration of stock solution and water to use for various relative humidities.

Saturated solutions of salts may also be used to maintain definite relative humidities. Martin (1939) lists salts and the relative humidities they will give when used as saturated solutions. A similar list may be found in the Chemistry and Physics Handbook.

Peterson (1934) reported that within an insect cage the relative humidity is determined to some extent by the construction or covering of the cage.

The Ambrosia Beetles, *Monarthrum mali* and *M. fasciatum*

According to Leng (1920) the classification and synonomy of the genus *Monarthrum* is as follows:

Order Coleoptera

Suborder Rhynchophora

Superfamily Scolytoidea

Family Scolytidae

Ipidae (Swaine)

Subfamily Ipinae

Tribe Corthylini

Genus *Monarthrum* (Kirsch), 1866

Pterocyclon (Eichhoff), 1868

Species *fasciatum* (Say), 1825

Species *mali* (Fitch), 1855

These species belong to a group of scolytids which have been classed together because of similar feeding and living habits, rather than anatomical likenesses, and are popularly

called ambrosia beetles. This common name has been derived from the fungi ambrosia on which the adults and their larvae feed. Other names, such as "timber beetles," "shothole borers," and "pinhole borers," have been given to the group because of the nature of their injury.

Blatchley (1916) characterized the tribe Corthylini to which the Genus Monarthrum belongs as having:

> Pronotum and elytra without scales, commonly glabrous or sparsely pubescent; abdominal sternite seven with posterior margin rarely rounded; anterior tibia broader toward apex or serrate on outer margin; pronotum with anterior dorsal area commonly rugose; head concealed from above; anterior tarsi with joint three simple.

The genus is distinguished by the cylindrical first palpal joint, emarginate elytral apex, and two-jointed funicle. M. fasciatum is slightly larger than M. mali and may be distinguished by a pale yellow band across the middle of the wing covers.

Swaine (1918) described scolytid larvae as, "always legless, whitish in colour, with darker, strongly chitinized head and mandibles, and with the thoracic segments distinctly larger than the others, in the true dark beetles."

No direct information could be found on the life histories of these two species. Scolytids in general transform from the

pupal to the adult stage in the late summer or in the fall. Most species remain in their host throughout the winter, and emerge the following spring (Craighead, 1950).

These species are monogamous. The female starts the gallery which extends into the sapwood. Craighead (1950) referred to the galleries as compound ambrosial burrows. They differ from simple ambrosial burrows in that the parent beetles make niches in the upper and lower sides of the tunnel for the eggs. As the larvae grow they deepen their pits. The parent beetles attend and feed the young by removing debris and putting fungus in the mouth of the larval niches.

Craighead (1950) claimed that bark beetle damage to utilized timber is of much less importance than that by other groups of insects, such as the lyctids and termites.

Snyder (1927) reported that adult ambrosia beetles caused "pinhole" damage in freshly felled green sawed logs (with or without bark), and in any green or partly seasoned lumber. Graham (1929) also stated that ambrosia beetle injury is not always confined to freshly cut or killed trees, but that they will attack green lumber, particularly the slow drying large dimension stock. Experiments conducted in the South

(Christian, 1939) substantiated the statements of Snyder and Graham. This work showed that the adult beetles caused the damage by boring into the wood. The only boring done by the larvae is in the enlarging of their small niches. The adults are attracted to freshly felled logs and green lumber, which under favorable conditions for attack may be severely damaged within a few days time, and in a few weeks reduced in value to the extent of fifty percent or more. Christian also found that the beetles are able to survive in the wood only while the moisture content is high. Consequently the damage ceases before the timber is thoroughly seasoned.

Chamberlin (1949) stated that M. fasciatum and M. mali are reported to be very destructive to gum in Louisiana, attacking green lumber as well as fresh logs.

III. METHODS AND PROCEDURES

Survey of Insects from Sawmills and Lumberyards

The insects for this survey were collected during the fall of 1950 and spring of 1951. Collecting was done at various sawmills in lower Michigan and at retail lumberyards in the Lansing area. Storage sheds and other buildings, as well as the lumber and waste piles, were inspected for infestations. Samples of lumber showing signs of insect damage were brought to the laboratory for a more careful examination.

Attempts were made to rear some of the larval forms found infesting the seasoning or seasoned wood. Infested boards were cut to convenient sizes and placed in one of three types of containers. The cages consisted of glass lamp globes covered with cheesecloth and set on glass terraria, small battery jars covered with cheesecloth, or copper mesh cages enclosed on the ends by screening or terracotta germination dishes. The cages were placed in a constant temperature room (24^{o} C.).

Identification of the insects taken was done by the author, except when the genus and species names of the lyctid or scolytid

beetles were desired. These insects were sent to the United States National Museum. The wood from which insects were removed was identified by a faculty member of the Michigan State College Forestry Department.

The Rearing of *Lyctus* sp.

Two methods, sulfuric acid solutions and saturated salt solutions, were investigated for maintaining constant humidities. The use of salt solutions was decided upon because of the ease with which they may be handled. The beetles were to be raised at a temperature of approximately 24° C. Table II gives the range of humidities to be used and the salts necessary for the given percentages of relative humidity.

It was planned to enclose 15 to 20 beetles in large battery jars with a piece of hickory showing no previous infestation. The salt solutions were to be placed in a glass terrarium and covered with a fine mesh screen. The jars were to be covered with glass and sealed with vaseline.

In an attempt to secure the number of beetles needed for the experiment a rearing method similar to that described by Christian (1940) was used. Infested pieces of hickory were

TABLE II

SALTS AND THE RELATIVE HUMIDITIES GIVEN WHEN USED IN SATURATED SOLUTIONS

Percent Relative Humidity	Salt		
9	$H_3PO_4 \cdot (1/2)H_2O$	Saturated	Solution
31	$CaCl_2 \cdot 6H_2O$	"	"
43	$K_2CO_3 \cdot 2H_2O$	"	"
51	$Ca(NO_3)_2 \cdot 4H_2O$	"	"
71.2	NH_4Cl and KNO_3	"	"
81.1	$(NH_4)_2SO_4$	"	"
93	$NH_4H_2PO_4$	"	"

placed in glass lamp globes, set in glass terraria, and covered with cheesecloth. A small bottle of water with a cloth wick was enclosed to raise the humidity inside the cage. Three cages were placed in a constant temperature room, which was held at approximately 24° C. and at a relative humidity of

about 60 to 65 percent. One cage was left at room temperature without a water bottle for moisture, that is, at conditions similar to those the insects would be exposed to in an average home or heated building. Occasional checks were made of all wood samples to determine the condition of the larvae.

Working on the assumption that if smaller pieces of wood were used, the internal environment of the wood might be closer to the external environment, infested wood was chopped into small irregular pieces and placed in two 750 ml. jars. Two test tubes of water were enclosed in each for moisture. One jar was covered with cheesecloth, the other with an inverted petri dish.

Approximately three weeks after the chips had been enclosed, it was noted that mold had developed on the chips in the jar covered by the petri dish. This growth of fungi within this closed container raised the question: Could the method described above for rearing beetles at various percentages of relative humidity be done in small enclosed containers? In an attempt to answer this question new stocks of wood infested with Lyctus beetles were obtained. The wood was examined to determine the stage of development of the insects.

Figure 1. Large battery jar type cage; water; hickory.

The method used in this rearing attempt was as originally described. Four rearing containers were used (Table IV). Water was used in three for humidity control. In one of these three cages a small coil operated humidity gauge was enclosed. In the fourth cage a saturated solution of potassium nitrate and ammonium chloride was used to give a relative humidity of 71.2 percent.

Infestation Experiments with Monarthrum mali (Fitch) and M. fasciatum (Say)

The object of these tests was to find if M. fasciatum and M. mali would enter partially seasoned, milled lumber. The containers used were glass lamp globes set on glass terraria and covered with cheesecloth. The containers with enclosed wood were placed in a constant temperature room (24° C.). Under these conditions the wood would dry more rapidly than in the natural outdoor environment. Two methods were used to increase the moisture within the jars. In three containers small bottles with cloth wicks were used, and moist sand was used in three others. The sand was sterilized and moistened with copper sulfate solution to prevent fungi spores from germinating. The enclosed wood was placed on inverted

petri dishes to keep it from absorbing moisture from the sand.

The following is an outline of the type of cages used, kind of wood enclosed, and the species of scolytid beetle involved.

Containers with moist sand:

Cage 1. Two 2" x 4" x 5" pieces of non-infested soft maple were enclosed with ten adult beetles, M. mali, taken from the same stock.

Cage 2. A 2" x 4" x 10" piece of soft maple infested with M. mali was enclosed. The beetles were allowed to emerge and remain in the container.

Cage 3. A 2" x 4" x 10" piece of American beech infested with M. fasciatum was enclosed. As in the above cage the adults were allowed to emerge and remain in the container.

Containers with water bottles:

Cage 1. A non-infested 2" x 4" x 9" piece of soft maple was enclosed with ten adult beetles, M. mali, previously taken from soft maple.

Cage 2. Two 2" x 4" x 9" pieces of soft maple infested with M. mali were enclosed. The beetles were allowed to emerge and remain in the container.

Cage 3. Two 2" x 4" x 6" pieces of American beech infested with M. fasciatum were enclosed. The beetles were allowed to emerge and remain in the cage.

When the moisture content of wood samples was desired the following method of determination was used.

This method involves cutting of a small sample, about 1/4 to 1/2 inch thick and the width of the board, weighting and then drying in an oven (generally electrically heated) at a constant temperature of 212° to 221° F. The sample is re-weighed periodically until it reaches a constant weight, which indicates that all the moisture has been removed from it. The moisture content of the sample, expressed in percentage, is then determined by subtracting the last weight (oven dry) from the original (green) weight, dividing the difference by the oven dry weight and multiplying the result by 100.

Figure 2. Lamp globe cage with moist sand.

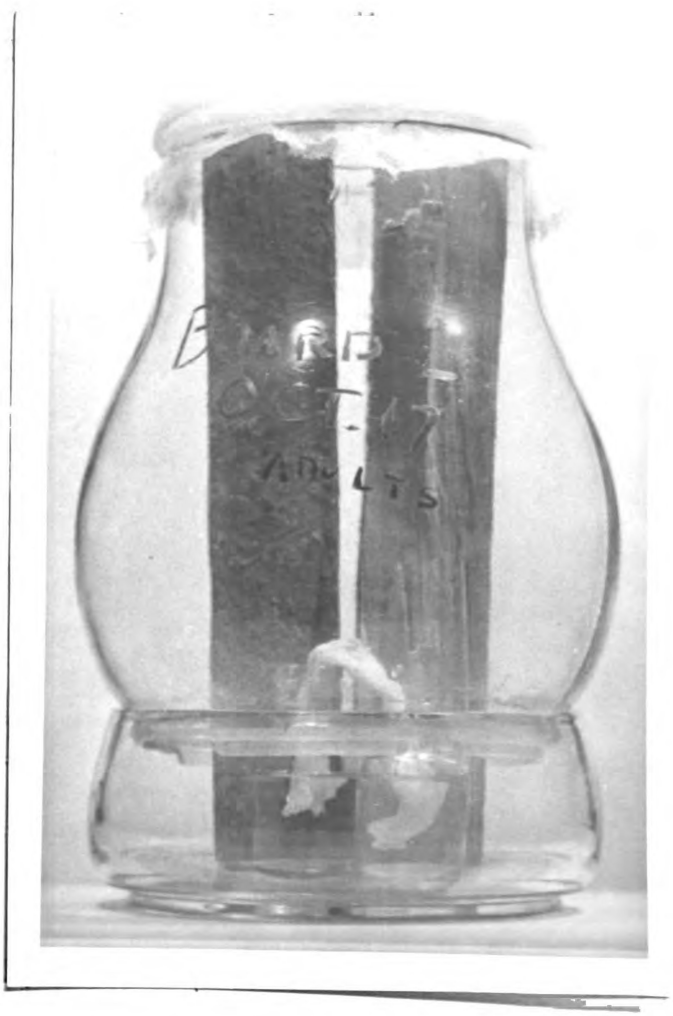

Figure 3. Lamp globe cage
with water bottles.

This operation may be expressed as,

$MC = [(W - D) \div D] \times 100$ (Panshin, 1949).

IV. PRESENTATION AND DISCUSSION OF DATA

Survey of Insects from Sawmills and Lumberyards

Collembola, springtails

Entomobryidae. In both fall and spring many of these insects were found between boards which had been piled without an air space, thus causing moisture to form, giving the springtails an ideal habitat. They are easily recognized by their ability to jump and the spring-like appendage on the underside of the abdomen. The springtails feed primarily on decayed vegetable matter or fungi. Therefore, they may be considered slightly beneficial.

Thysanura, silverfish

Lepismidae. They were found in the spring crawling about wood which had been stacked inside sheds, lathe rooms, and like places. The silvery scales covering the body and the three long posterior appendages usually serve to distinguish this group. They are chiefly nocturnal, feeding upon dry

vegetation, plant products, paste, or other articles having a rather high starch content. About sawmills and lumber sheds they are of little economic importance.

Corrodentia, booklice

Trogiidae. These insects were abundant in habitats similar to those of the silverfish. The members of the order found were minute, wingless forms; the heads and hind legs are relatively large in proportion to the rest of the body. While they can cause great damage in granaries, libraries, and museums, they are of no importance in locations where lumber is stored. Their diet consists mainly of vegetable and animal debris, paste, fungi, and other organic substances.

Coleoptera, beetles

Cucujidae. Two species, Silvanus surinamensis and S. bidentatus, were found crawling about the surface of boards piled both in sheds and outdoors. The former, commonly known as the sawtoothed grain beetle, is characterized by the row of marginal teeth on each side of the prothorax. It causes considerable destruction to cereals, dried fruits, and seeds.

TABLE III

RESULTS OF SURVEY

Order and Family Genus and Species if of Importance	Locations Where Taken			
	Between Boards	Surface of Wood	In the Sapwood	In the Heartwood
Collembola				
Entomobryidae	-			
Thysanura				
Lepismidae	-	-		
Corrodentia				
Trogiidae	-	-		
Coleoptera				
Cucujidae				
Silvanus surinamensis		-		
Silvanus bidentatus		-		
Lyctidae			-	
Lyctus sp.		-		
Cerambycidae			-	-
Megacyllene robiniae				-
Chrysomelidae		-		
Scolytidae				
Monarthrum fasciatum			-	-
Monarthrum mali		-	-	-
Xyleboris affinus				-
Hymenoptera				
Formicidae				-
Camponotus sp.			-	
Braconidae				

S. bidentatus is usually taken from beneath bark, and probably feeds on fungi. At first glance these insects resemble the powder-post beetles. However, they may be distinguished readily by the characteristics of their antennae. The last three segments of the antennae of the Cucujids are slightly enlarged giving the appearance in most species of a three segmented club, while the lyctids have only two segments enlarged.

Lyctidae, powder-post beetles. These beetles were found in varied locations. No infestations were observed on inspection of the stocks of wholesale or retail lumber distributors. However, these lumberyards were inspected in late fall and early spring, so it is possible that infestations may have been present in lumber which had been on hand for a short time but which could have contained dormant larvae causing no characteristic dust.

In a lathe room of one sawmill, a heavy infestation was found in hickory material that had been allowed to stand undisturbed for six or seven years.

Dead adult beetles were taken from the bases of the pillars and joist of a lumber storage shed. These structures were covered with adult emergence holes, demonstrating that

the infestation had been present for many years. Such infestations are reservoirs where populations may build up, constituting a constant threat to any hardwood material stored in such a building. When the beetles are established indoors, the life cycle is shortened, causing the period of attack to be lengthened.

Outdoors lyctids were found in air-seasoning hickory. The area of infestation was limited to the boards just above ground level.

The work of the lyctids is sometimes confused with that of termites. As described earlier, the adult powder-post beetles make small, round holes from the interior to the surface of the wood for emergence, and their galleries, running in all directions, are packed with powder. The termite galleries usually run with the wood grain, are always void of refuse, and these insects do not push wood particles to the outside (Bur. Ent. and Pl. Quar., 1949). The surfaces of termite-infested wood never have the characteristic emergence holes of the lyctids.

Infested wood collected in the fall contained only very young larvae. Wood from a partially heated structure examined

on April tenth contained much larger larvae than those from the fall sample. No pupae or adults were found.

Cerambycidae, long-horned wood borers. In the fall survey many larvae of this family were taken from soft maple, and in the spring several Megacyllene robiniae adults were found in a mill yard.

The cerambycid beetles may be distinguished from other beetles found in similar situations by their larger size and very long antennae. The antennae are as long as the head and thorax, and usually as long as or much longer than the body.

Primarily these insects feed in dead wood, but some of the roundheaded borers cause reduction in grade of lumber because of serious damage resulting from attacks on recently felled or living trees. Injury which is often classed as powder-post damage may result from the larval work of several species of cerambycids. Some forms attack only recently cut wood, but if the wood, after being attacked, is placed in buildings or stored in drier situations, the larval period is prolonged for several years (Craighead, 1950). One species Hylotrupes bajulus is an enemy of seasoned, dry, coniferous woods, often attacking rafters, joists, stacked dry lumber, and flooring.

The damage of the latter beetles may be distinguished from lyctid injury by the larger size of the galleries and the coarseness of the borings filling them.

Chrysomelidae, leaf beetles. Two species were taken from the surface of piled lumber. Although anatomically similar, they may be separated from the cerambycids by their shorter antennae, seldom longer than the head and thorax, and their smaller size. Beetles of this group are mostly leaf feeders and of no importance about lumber.

Scolytidae, Bark or timber beetles. In the fall the adults of three species of timber beetles were taken, two, Monarthrum mali (Fitch) and Xyleborus affinis (Eich), from soft maple, and Monarthrum fasciatum (Say) from American beech. The habits and importance of M. mali and M. fasciatum have been discussed in the review of literature.

No reference could be found of X. affinis having been taken before in Michigan. Swaine (1918) stated that he had not recognized this species from Canada or the northern states. Blatchley and Leng (1916) and Leng (1920) record this insect as having been taken in New Jersey and West Virginia.

Chamberlin (1949) stated that it is common along the Atlantic coast from New Jersey to Florida, and around the Gulf of Mexico. Craighead (1950) reported that X. affinis was originally described from Cuba, and it breeds from New Jersey southward to Florida and Mississippi.

Chamberlin (1949) lists as hosts of this beetle oak, hickory, gum, and other hardwoods, and he stated that it attacks logs and green lumber. Blatchley (1916) stated that they succeed in establishing colonies only in the sapwood of dying timber, but that they may be driven by hunger to attack healthy trees. The damage from these attacks is of two types, that from the construction of the burrows, and that of causing "blue stain." The latter is caused from the introduction of fungus spores by the parent beetles. Discoloration results from the penetration of the hyphae of the fungi into the sapwood.

Five or six galleries are started, and an egg produced in each, by a single female. The young, like those of other ambrosia beetles, feed on the fungus introduced by the female (Blatchley, 1916). In a period of less than a month the eggs can develop into adults. Usually there is an unequal sex

distribution in favor of the females, this aiding in the propagation of the species.

Hymenoptera; bees, wasps, and ants

Formicidae, carpenter ants. Members of the genus Camponotus were found in logs before milling and in the heartwood of seasoning lumber. They may attack the dead heartwood of living trees, logs, house timbers, or almost any wood materials. Their work is distinguished from powder-post injury by galleries void of powder and from termite damage by the random method in which the galleries are made.

Braconidae. These minute to small parasitic wasps were taken in large numbers from material infested with powder-post beetles. The adults resemble small, winged, black ants. Their larvae are believed to live as endoparasites of the immature lyctid forms. Pupation takes place in a cocoon near the surface of the wood. When present in large numbers, they may greatly reduce a population, but before they begin their parasitism, a lyctid infestation is well established.

Miscellaneous

Polyporaceae, Fomes pini (Trametes pini), white spot. This fungus, which causes white spotting of wood, is commonly thought to be the result of insect damage. The disease occurs mostly on conifers, with the characteristic white spotting of the wood varying with the species of tree attacked (Von Schrenk, 1900). It may be distinguished from insect damage by the fact that there is no dust or tunneling present.

Rearing of Lyctus sp.

The results from the various methods used in the attempted propagation of lyctids are as follows:

Glass lamp globe type cage. From these cages fifteen powder-post beetles emerged. Thirteen of these were from the two cages kept in the constant temperature room. The other two emerged from the sample held at room temperature. Many environmental factors could have acted upon the larvae, but the most probable factor causing the low emergence rate was the heavy parasitism. From these three cages a total of 81 hymenopterous parasites were taken.

TABLE IV

EMERGENCE IN VARIOUS ENVIRONMENTS

Type of Cage	Percent Relative Humidity	Temp. C.	Sample Enclosed	Moisture Content Sample Not Enclosed	Moisture Content Enclosed Sample	First Lyctid Emerged	Number Lyctids Taken	First Parasite Taken	Number Parasites Taken
Glass lamp globe 1	60-65	24	Oct. 17	-	-	Mar. 8	7	Nov. 8	39
Glass lamp globe 2	60-65	24	Oct. 17	-	-	Mar. 5	6	Nov. 18	26
Glass lamp globe 3	-	21	Oct. 17	-	-	Apr. 6	2	Nov. 11	16
750 ml. jar, cloth cover	60-65	24	Jan.	-	-	-	6	-	0
750 ml. jar, glass cover	-	24	Jan.	-	-	-	0	-	0
Large battery jar; water; hickory	*	24	Apr. 10	9.1%	22.8%	-	0	-	0
Large battery jar; water; black ash	-	24	Apr. 10	-	-	-	0	-	0
Large battery jar; salts; hickory	71.2	24	Apr. 10	9.1%	19.3%	-	0	-	0

* Humidity gauge used found inaccurate.

750 ml. jar with cloth cover. Six adult beetles emerged within one month after enclosure of the infested chips. No parasites were taken. The small number of beetles obtained from this container may be due to injury of some larvae in cutting the chips or to the fact that only a few larvae were present, as the sample was small.

The six beetles were all considerably smaller in size than those emerging from the larger pieces of wood. The chips used were taken from the hickory samples in the lamp globe cages, making the diet of the two groups approximately the same. From this it may be assumed that possibly the growth of these six beetles was retarded by the difference in the external environment of the chips. The temperature (24° C.) at which the wood samples were kept would cause more rapid reduction of moisture content in the small pieces.

750 ml. jar with glass cover. Three weeks after the chips were enclosed, mold was noted. No adults or parasites were taken from this jar.

Large battery jar; water; hickory. Results similar to those from the small glass covered container were obtained.

Within a month mold was formed, and soon afterwards it was noted that the production of powder had ceased. No adults or parasites were taken. On examination of the galleries, they were found to have mold running through them. The moisture content of a sample from the same piece used in this jar, but that had been kept at room temperature, was 9.1 percent. After two months and twenty-six days the moisture content of the enclosed sample had raised to 22.8 percent. The beetles seldom attack wood with a moisture content greater than 15 percent.

Large battery jar; water; black ash. No mold was noted on the enclosed wood until late June. On July eighteenth only a small amount was present, all of this protruding from the emergence holes.

Large battery jar; salts; hickory. The results here were identical to those obtained in the large battery jar containing hickory with water. The moisture content of this sample after enclosure raised to 19.3 percent.

Although it was impossible to conduct the experiment as planned because large numbers of adults were unobtainable, some conclusions may be drawn from the work.

There would be little direct effect of changes in humidity on the development of organisms enclosed within a block of wood. It seems that the relative humidity of an environment would have to remain constant long enough to change the moisture content of the wood before it would affect the organism. Humidity would undoubtedly have the greatest effect on development of the egg, either lengthening or shortening the period between oviposition and hatching, or making them non-viable. It may also be a factor in the length of pupation, since this takes place near the surface.

Infestation Experiments with *Monarthrum mali* (Fitch) and *M. fasciatum* (Say)

From Table V, it can be seen that only one of the species tested, *M. mali*, made an attempt to establish new burrows in the partially seasoned samples. The results from the individual cages are as follows.

TABLE V

DATA FROM SCOLYTID EXPERIMENT

Containers	Sample and Beetles Enclosed	Number of Beetles Enclosed	Number of Beetles Emerged	Date Emergence Began	Date Entrance Noted
With Sand					
Cage 1					
M. mali	Oct. 18	10	-	-	Oct. 29
Cage 2					
M. mali	Oct. 18	-	8	Oct. 20	Oct. 29
Cage 3					
M. fasciatum	Oct. 18	-	0	-	-
With Water					
Cage 1					
M. mali	Oct. 18	10	-	-	-
Cage 2					
M. mali	Oct. 18	-	0	-	-
Cage 3					
M. fasciatum	Oct. 18	-	6	Oct. 21	-

Containers with moist sand:

Cage 1. One burrow was begun on the bottom of the sample of wood, the surface nearest the moisture. Two adults appeared to be working together at beginning the burrow. The other beetles in the cage simply crawled about on the wood, and within two weeks all appeared dead except those in the new burrow from which fresh dust was being pushed. After four weeks of enclosure the dust production ceased, probably indicating that the enclosed beetles could not survive as the moisture content of the wood was lowered. The moisture content of the sample after enclosure at 24° C. was 10.3 percent, while that of a sample from the same stock kept at room temperature was 14.2 percent, a loss of 3.9 percent during the time of the experiment. This loss could possibly have brought the moisture content below the threshold of the beetles.

On examination of the burrow, it was found to be 1.9 cm. long, with no dead adults inside.

Because of the small number of beetles used and the fact that they were selected without examination for sex, the sex ratio may not have been even. Since this species is reported to be monogamous, other burrows may not have been started because of a lack of mates.

Cage 2. Eight adult beetles emerged about the twentieth of October. Most of them died within a few days. New boring dust showed where one beetle had attempted to enter. When the wood was cut open for inspection the new burrow was found to be 4.5 ml. long. Many dead adults were found in the old galleries.

The new entrance hole was formed in the center of a patch of fungus on the bottom surface of the wood just above the moist sand.

Cage 3. Nothing emerged in this cage. When the wood was examined many dead adults were found in the niches where the eggs had been placed.

Containers with water:

Cage 1. For the first few days after the insects were enclosed, they crawled actively about, but after approximately three weeks all were dead.

Cage 2. No scolytids emerged in this cage. Dead adults were recovered from the galleries when the sample was cut open and examined.

Cage 3. Six adults emerged about the twenty-first of October; after crawling about the surface of the wood for a few days all died.

Although this experiment was not carried out under the conditions present in mill yards, it is evident that the adults of M. mali will attack partially seasoned lumber in Michigan, and that under more favorable conditions M. fasciatum may still be a threat to seasoning lumber.

V. SUMMARY AND CONCLUSIONS

During the fall of 1950 two problems were undertaken: (1) a survey of insects infesting seasoning lumber, and (2) the effects of different humidities on lyctid powder-post beetles.

Early in the survey much lumber was found damaged by scolytid beetles. Because of this a third problem was investigated, i.e., the possible re-infestation of partially seasoned lumber by mature ambrosia beetles.

Of the insects collected, those causing a reduction in grade to lumber were members of the following families: Lyctidae, Cerambycidae, Scolytidae, and Formicidae. The most important pests to seasoned or seasoning lumber were the lyctids. The other three families appeared to cause their greatest damage before the logs reach the sawmills.

One species of Scolytidae, Xyleboris affinis, was taken from soft maple. No record could be found of this insect having been taken before in Michigan.

Attempts at rearing lyctids did not produce a sufficient number of beetles for the planned investigations. Heavy

parasitism by a minute braconid wasp was thought to be the reason for the low number emerging.

Several types of containers were tried for rearing lyctids. From the results it is impossible to state which was the most satisfactory. Cutting infested wood into small pieces, instead of introducing large ones, showed the greatest possibilities.

When lyctid infested wood was placed in small closed containers at high humidities, the wood samples took on much moisture. This brought the moisture content of the wood above that which lyctid beetles could survive, and made conditions advantageous for mold formation. It has been reported that powder-post beetles seldom attack wood with a moisture content above fifteen percent. The high humidities used in the experiment caused the moisture content to rise above twenty percent.

It seems possible to make the assumption from the results, that slight variation of air humidity, such as occurs in nature, would have little effect on lyctid forms. To display marked effects on development, a given percentage of relative

humidity would have to remain constant long enough to alter the moisture content of the infested wood.

In two instances Monarthrum mali re-entered partially seasoned wood samples. M. fasciatum did not enter but may be capable of doing so under more suitable conditions. It appears possible to predict that whenever infestations of M. mali or M. fasciatum are present undamaged lumber is in danger of attack.

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