M. R. Bedford.

Not for publication

BIOLOGY OF THE SPOTTED PINE SAWYER MONOCHAMUS MACULOSUS (HALDEMAN) (COLEOPTERA: CERAMBYCIDAE)

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Biology of the Spotted Pine Sawyer,

Monochamus maculosus (Haldeman) (Coleoptera : Cerambycidae)

D. A. Ross[1/]

ABSTRACT

Spotted pine sawyer adults emerged near Vernon, B. C. from 30 May to mid-August. At 1300' altitude, 65% emerged at the end of one year; the remainder emerged the second summer. At 3000' altitude, 41% emerged at the end of one year; 58% emerged the second summer; less than 1% emerged the third summer. Adults in captivity fed, mated, and oviposited readily; maximum longevity was 140 days for females, 135 days for males.

Flight speeds into the wind ranged from 2.7 to 4.8 m.p.h. and from 5.3 to 7.8 m.p.h. down or across wind. Long distance flights were downwind. Flight capacity determined on flight mills was extensive.

The preoviposition period ranged from 19 to 38 days after emergence. Females chewed deep niches in the bark on the shaded side of the log where they deposited usually two or three eggs which hatched in 5 to 11 days. The larvae mined under the bark for as little as 30 days and then formed U-shaped galleries averaging 5 cm. deep in the wood. Pupal cells were formed 2 to 13 mm. from the surface. Pupation occurred in the wood, never earlier than the spring of the year following attack. Adults emerged two weeks after pupation.

Fire-killed pine contained larval galleries along the boles at least up to 40 feet. The number of larval entrance holes was lowest in the base of the bole.

Woodpeckers were important predators of *M. maculosus*.

Fewer *Monochamus* galleries were constructed in the wood during the attack year in constantly shaded logs than in logs left exposed to full sunlight. Larvae moderately damaged April fire-killed and June-cut logs in 1962, but did not infest December 1961 and March 1962 felled trees. These observations suggest avenues of logging management practices for reducing damage by this economically important insect.

INTRODUCTION

A sudden increase in the number of requests from personnel of the woods industry and British Columbia Forest Service for information on wood borers led to a study of the biology of the spotted pine sawyer, *Monochamus maculosus* (Haldeman). This insect is an important pest of ponderosa pine, *Pinus ponderosa* Laws., logs left in the forest during the summer and trees killed by fire. Keen (1952) reported that the larvae infest pines and Douglas-fir throughout the western United States. As well as causing damage by burrowing in the wood, this sawyer introduces wood-staining fungi that cause deterioration of the timber.

Stands of ponderosa pine were killed by forest fires at Carr's Landing (3,000') and O'Keefe (1,300') on 7 July 1960 and the trees subsequently became heavily infested by *Monochamus*. A difference of 1,700 feet in

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1/ Officer-in-Charge, Forest Entomology Laboratory, Forest Insect and Disease Survey, Vernon, B. C.

elevation between the two burns and their proximity to the Vernon Laboratory were ideally suited for this study. Some observations were made in the field. However, most of the data were obtained at the Laboratory, from reared or captive material. The investigations were conducted from 1961 to 1963.

LIFE HISTORY

Adult

Four four-foot logs from each of three trees at both Carr's Landing and O'Keefe were cut and caged near the Vernon Laboratory in April 1961. The daily emergence data of adults (Fig. 1) recorded from the time the material was caged until September 1963 are presented in Table I.

The major emergence from logs collected at O'Keefe (65%) occurred in 1961, the year following the fire, whereas the major emergence from Carr's Landing logs (58%) occurred in 1962. Nevertheless, one male and one female took three years to develop in bolts from Carr's Landing. In both localities the first emergents were males and the major emergence of males preceded that of the females. The peak adult emergence from O'Keefe collected material preceded that from Carr's Landing material. Dates of emergence including both areas ranged from 14 June to 24 July in 1961 and from 5 June to 17 July in 1962. Only M. maculosus was reared from Carr's Landing material but two of the emergents from O'Keefe collected material were M. oregonensis Leconte. Both species made circular openings (Fig. 11) with the vertical slightly greater than the horizontal diameter in standing trees. Measurements of 30 openings made by maculosus (range 6 to 10.5 mm. maximum diameter) and 10 by oregonensis (range 6.5 to 9 mm.) from various sources showed no useful specific differences.

Field emergence of Monochamus spp. occurred in 1961 from 30 May to 25 July at O'Keefe, and 13 June to 22 August at Carr's Landing. Peak field emergence (70% of the total) was between 14 and 27 June at O'Keefe whereas the major emergence at Carr's Landing occurred later and was protracted.

A scarcity of emergents from sample trees in the field during 1962 and 1963 was presumed to be the result of woodpecker predation during the winter. However the fact that the sample trees were more severely burned than the caged material, coupled with their greater exposure to sun and wind, may have resulted in a shorter attack period and accelerated larval development. Although the fires occurred in both areas on the same day and the trees were susceptible to Monochamus attack at the same time, the 1,700 foot difference in elevation may explain the earlier emergence from the O'Keefe logs and trees. The lower minimum and more protracted periods of cooler temperatures overnight at the higher altitude undoubtedly slowed larval development resulting in later emergence at Carr's Landing.

The speed, direction, and duration of flight of reared adults was determined in free-flight trials out-of-doors, or on flight mills in the insectary. Beetles that had fed and mated were released singly in the field and their flight between two points was timed with a stop watch.

The tests were done at temperatures above 27°C. Wind gust speeds ranged up to 2.5 m.p.h. in the 1962 tests and up to 5.5 m.p.h. during the 1963 tests.

Data in Table II are based on 19 low level flights. These indicated no pronounced difference in flight speed between the sexes. Flights ranged from 2.7 to 4.8 m.p.h. into the wind and from 5.3 to 7.8 m.p.h. down or across wind. The beetles took off voluntarily against the wind generally when the gusts were less than 2.5 m.p.h.

Fed males and females released in treeless fields flew downwind about 20 to 80 feet above, and more or less parallel to, the ground until out of sight. During hot calm weather a few individuals climbed steeply out of sight. When the wind speed was greater than 2 to 3 m.p.h. the adults flew downwind, although a half or three-quarter circle into and across the current was made sometimes while gaining altitude.

Since flight occurrs most frequently at high temperatures, particularly when the weather is calm or only slightly windy, strong winds probably play an insignificant part in the dispersal or transportation of the spotted pine sawyer. On the other hand, convection currents may be important.

A few tests on the duration of free flight of freshly emerged M. maculosus adults were obtained under optimum conditions. Ten unfed vigorous males and females tossed into the air all flew less than 100 feet.

In 1963, flight mill trials with four fed females were carried out on Tuesdays and Thursdays (only days convenient) from 9 July to 15 August. Four mills were used and all beetles were given an opportunity to fly each time. There was a variation from day to day in the length of flight, but it did not appear to be related to temperature (range 22 to 30°C.) or to individual beetles. Two of the females were mated on 25 July. The mated individuals flew a total of 541 and 550 minutes; the unmated females flew a total of 356 and 359 minutes. The maximum continuous flight for one beetle (mated) was 104 minutes on 1 August. After the mating date the average flight duration was greater for the mated than for the unmated females. The inference is that mating may have increased the urge to find a niche for oviposition.

Based on aforementioned data some fed females theoretically were capable of travelling 10 miles in a single flight downwind. Data also indicated that during five weeks of repeated flights some fed, mated females were capable of travelling a total of 60 miles. Under optimum conditions it is likely that they could have flown even farther.

Observations of feeding, mating, oviposition and longevity of adults were made on caged material. M. maculosus that emerged in cages were placed in pairs in a shaded location in glass-fronted cloth-covered cages 25 x 25 x 30 cm. as follows: 24 pairs in 1961, 35 pairs in 1962 and 50 pairs in 1963. They were given freshly-cut foliated ponderosa pine twigs every second or third day. Both sexes fed voraciously on the bark and cambium, generally on the current and previous year's growth. Occasionally they also chewed on the new needles, particularly at the base, but seldom severed them.

When a freshly-cut log section and twigs were placed together in a cage the adults fed on the twigs only (Fig. 2). When the twigs were removed the adults fed on the inner bark of the bolt. Feeding continued throughout the day at temperatures at least as low as 12°C.

Caged adults were observed several times a day. In most instances the males were the same age as or older than the mated females but a few were one to three weeks younger. When not feeding or quiescent, the male attended the female as long as the male lived. All pairs mated at least once and at least seven times in one case. The first observed copulation of the last mentioned pair occurred on 29 June 1961 and the seventh on 21 July. Duration of copula for all pairs was one to five minutes. All matings observed occurred between 0830 and 1830 hours at temperatures over 15°C. Frequency of copulation increased greatly at temperatures over 20°C. Viable eggs were produced except in a few instances where the females died prematurely.

A few adults were dissected when they died; others were killed and dissected later to note egg development. Ovarioles were counted in two females only; one had 12 ovarioles in each ovary; the other contained 12 in one, and an undetermined number in the other ovary. Seven young females aged one (2 specimens), three (1), four (2), five (1) and 15 (1) days old were dissected; none contained developed eggs. In 10 cage-reared mated females more than 20 days old, the number of fully developed eggs ranged from 3 to 21. The pre-oviposition period, which was determined precisely for only four individuals kept in cages containing suitable host material, ranged from 19 to 38 days after emergence. Records were kept also of two individuals that did not have access to suitable oviposition material. One that emerged and mated 1 August 1964 oviposited on a twig 24 days later, after chewing pieces from the bottom of the cage. An unmated female that emerged a few days earlier first dropped eggs on the cage floor 44 days after emergence.

The adult females chewed a slot-like niche for oviposition (Fig. 4) in the bark almost to the cambial layer. On thin bark the egg niches were narrow and many were 2.5 to 4.0 mm. long. On thick bark they tapered inward from an oval which averaged 7 x 10 mm. on boles about 18 cm. in diameter. Egg slots were observed on boles 7.5 to 30 cm. in diameter.

Most of the egg slots on standing burned trees and standing caged log sections 18 to 25 cm. in diameter were cut horizontally. For example, of 162 egg slots on nine 3 foot-long sections of tree boles from Carr's Landing, 80% were horizontal, 18% were oblique and 2% vertical. In fire-killed trees, the majority of niches were cut in the charred portions of the bark. Charred bark is easily removed and the females chewed through it quickly.

M. maculosus adults observed ovipositing on logs in the field appeared to prefer the shaded portion. This was tested by analyzing the position of egg slots on 40 lineal feet of ponderosa pine logs lying east-west on the ground. Of 52 egg slots, 67% were on the lower half of the log and 82% of those on the top half, were on the north side. Possibly such preference is evident only when the temperature is above an undetermined threshold.

The number of egg slots or niches cut in 15 to 20 cm. diameter logs was determined for three females. To prevent oviposition under the bark on the log ends, a cardboard disc was fastened to each end with masking

tape. The total number of niches cut by each beetle was 35, 53, and 70. The number of slots cut daily from 17 to 21 July averaged 2.2 and ranged from 1 to 4. The first slot, cut by the female that cut 70, was on 17 July and the last was on 30 August. One caged female was observed cutting a slot as late as 6 September.

After cutting out an egg niche with its mandibles, the female found the opening with the tip of the abdomen and worked her ovipositor into the moist inner bark, sometimes to the cambium. One female spent eight minutes with its ovipositor in the egg niche; another remained in situ for nine and a half minutes. Oviposition was observed between 1015 and 1700 hours.

One fertilized female was placed in a cage with a log cut from a living tree four days previously; on the ensuing day it cut two slots and deposited two eggs in one slot. Slot cutting and oviposition in the bolt continued daily for at least a week. This and other observations indicated that freshly-felled trees were immediately acceptable for oviposition.

The longest-lived female died at the age of 140 days, the oldest male at the age of 135 days. Average longevity for the 10 oldest caged 1962 males and females reared from Carr's Landing logs (caged April 1961) was 105 and 100 days, respectively. The majority of these had mated and the females had deposited eggs in logs.

Egg

From one to nine eggs (Figs. 3 & 5) were found on a single plane in each niche in the caged logs; two or three eggs was most frequent. The only niche examined in the field contained three eggs. Generally the eggs were placed parallel to the wood grain, although a few were diagonal. Eggs inserted through the same opening were spaced up to 10 mm. apart. The phloem about the eggs was brown, probably due to oxidation, which made the location of the egg obvious when the bark was stripped from an infested log.

Twenty-seven eggs averaged 4.3 x 1.3 mm. and ranged from 3.9 to 4.5 x 1.1 to 1.7 mm.

In mid-July 1962, eggs adhering to the inner bark, and kept in petri dishes in the insectary, hatched in 5-7 days. Under similar conditions in the latter half of August 1963 the incubation period ranged from 7-11 days (average 8 days). The increase in incubation time in August was undoubtedly related to lower temperature.

Larva and gallery

Analysis of head capsule measurements of 175 insectary-reared larvae indicated four instars. Head capsule widths of first instar larvae incubated from eggs ranged from 0.48 to 0.78 mm. Other instars were: second - 1.17 to 1.69 mm.; third - 1.82 to 2.93 mm.; fourth - 2.95 to 4.29 mm. First instar larvae measured 3 mm., and last instar larvae up to 6 cm. in length.

After hatching, the white legless larva fed on the inner bark and cam-

bium, usually working downward in a standing tree. It excavated an irregular sometimes J-shaped broad mine, (Fig. 8) scoring the inner bark and sapwood increasingly deeper. Grindings of bark, shreds of wood (up to 22 mm. long, Fig. 10), and frass were packed tightly behind the larva as it progressed.

The shortest time (one of 12 larvae observed during 23 June to 25 July 1963) that elapsed between egg hatch and penetration of larvae into wood of freshly cut bolts in a sunny location was 30 days.

The proportion of sawyer larvae in the wood and under the bark was determined at two week intervals by examining samples from a 30 cm. d.b.h. ponderosa pine tree felled 22 June 1961 and sawn into six 8-foot logs. The tree was alive at the time of falling. On each date a two-foot section from each of five of the logs was debarked and the numbers of larvae in the wood and between the bark and wood determined. Results from the combined samples, each totalling 10 lineal feet, and from a sixth log cut from the upper crown, are shown in Table III.

Within a month of felling of the tree, some of the larvae had entered the wood; by winter the proportion was close to 50%. Two factors that might have influenced the proportion in the wood were continued oviposition and predation. There was no woodpecker predation. However, insects, noteably Cleridae, killed many larvae under the bark. The continued oviposition would have tended to decrease the proportion in the wood while differential insect predation would have increased the proportion of larvae in the wood.

The entrance holes to the gallery (Fig. 9) and cross section of galleries made by M. maculosus were elongate oval with the axis of the greatest diameter parallel to the wood grain. The average size of 20 entrance holes in a log from the tree felled on 22 June 1961 was 4.5 x 9.2 mm. with a range from 4 to 6.5 x 8.5 to 11.5 mm.

In a standing tree the larva worked in the gallery on its side, its mandibles operating with the wood grain as it cut toward the center of the bole. The wood was engraved strongly on the mine side of the entrance hole. The gallery entered the wood tangentially at an obtuse angle, then at a depth of 12 to 18 mm. (average 15 mm. for 20 galleries) it curved abruptly toward the heart of the bole. A second broader bend in the gallery made a lower curve completing a flattened S. This S-shaped entrance may have some protective value for the larva against the elements, parasites and predators. The general shape of the completed gallery was a U with the base parallel to the wood grain.

Larvae penetrated the wood at varying rates in relation to temperature and possibly the moisture content of the wood. The following is an example of rapid penetration. Four larvae that had hatched from eggs about 30 June in an 18 cm. diameter bolt cut from a living tree on 3 June 1963, and kept in a sunny location, tunneled to depths of 5, 6, 7 and 7.5 cm. by 22 August of the same year.

In completed galleries the maximum penetration of larvae in fire-killed ponderosa pine trees 25-30 cm. d.b.h. at O'Keefe was 11.5 cm. with an average of 5 cm. Of those that penetrated 4 cm. or more, 16% were deeper than 6.5 cm.

The average gallery length from entrance to exit in charred logs in the O'Keefe burn was 15 cm. for those made by seven males, and 15.4 cm. for 15 females. Shreds of wood up to 26 mm. x 0.5 to 1 mm. and frass were packed in the gallery behind the larva. The end of the gallery was enlarged into a pupal chamber oval in cross section; the range in greatest cross-section diameters of 10 pupal chambers was 9 x 14 to 10 x 22 mm. The end of the chamber was close to the surface of the bole, therefore the adult would have had little cutting to do to emerge. The distance from the surface of 15 pupal chambers in the tree felled 22 June 1961 averaged 7.5 mm. and ranged from 2 to 13 mm.

Larval feeding continued late into fall, ceased in winter, and began again early in the spring. In 1961 larvae could be heard feeding in standing fire-killed trees on the mid-afternoon of 7 April (14°C.) at O'Keefe.

Pupa

Pupation occurred in the pupal chamber, almost invariably in the gallery in the wood. In only one instance was a pupa found under the bark; no gallery had been constructed in the wood although the wood had been broadly scored. Pupation did not occur earlier than the spring of the year following attack. Late in May or early in June, the stage may last for two weeks.

GALLERIES IN LOGS IN SHADE VERSUS SUNLIGHT

An attempt was made to find out if a smaller proportion of galleries would be constructed in the wood during the attack year if the logs were kept completely shaded. Twenty-six bolts from living ponderosa pine trees felled on 4 July were exposed to mated M. maculosus, one pair per bolt, until about eight egg slots had been cut into the bark of each. Thirteen bolts with egg slots were stood on end in a shaded location on the ground and an equal number were placed on the ground in full sunlight. Cheesecloth was wrapped around each bolt to prevent attacks by other insects. The 23 cm. long bolts ranged in diameter from 12 to 16 cm. d.i.b., the bark thickness from 6 to 20 cm.

During October the bark of each bolt was removed and the disposition of the sawyer larvae noted. The bark on the sun-exposed bolts was dry, light, and tight; the bark on the shaded bolts was wet, heavy, and loose. Data from these observations are recorded in Table IV. Eleven of 13 sun-exposed bolts had some M. maculosus larvae in the wood, whereas in the shaded location one of 13 bolts had a single larva in the wood. The larva in the shaded bolt had entered the wood one inch from the top dry end. Of the total larvae, 1.5% in the shaded bolts and 59% in the unshaded bolts had burrowed into the wood. Head capsule measurements indicated that about 75% of the larvae in the sun-exposed logs were in the third instar whereas 60% in the shaded logs were in the third instar; the remaining larvae were in the second instar.

The observations were repeated in 1963 with an added comparison between an equal number of bolts from freshly felled trees and from a tree killed by fire in April 1963. Two groups of 20 bolts each were infested, the first groups between 14 June and 3 July, the second between 9 and 26

July. They were debarked in the fall of 1963.

The number of living larvae in the fall was too small for more than tentative conclusions. In the first group, 11 of 12 larvae in fire-killed bolts kept in the sun were in the wood, and 4 of 15 larvae in the shaded burned bolts were in the wood. Thirteen of 14 larvae in bolts from a freshly cut tree kept in the sun were in the wood, and 7 of 29 larvae in the shaded bolts were in the wood.

In the second and later group a smaller percentage of larvae had penetrated the wood, otherwise results were similar to those of the first group. In both groups there was no significant difference between the proportions of larvae in the wood of bolts from fire-killed and freshly cut trees.

These trials indicated that formation of galleries was numerically reduced when the bolts were shaded from direct sunlight. The earlier construction of galleries in the wood was less when the bolts were shaded from direct sunlight. The earlier construction of galleries in the wood of logs exposed to direct sunlight probably was the result of a slightly more rapid development attributable to higher temperatures. Possibly the larvae bored into the wood when the bark became too dry or when the temperature under the bark rose beyond the level of tolerence for third instar larvae.

Results of these trials suggest that artificial shading and decking of freshly cut logs during the flight period of sawyer beetles would be a good management practise.

MONOCHAMUS DAMAGE IN LOGS OF DIFFERENT AGES

An attempt was made to relate time of felling of ponderosa pine to the amount of damage caused by Monochamus spp. as indicated by the number of larval entrance holes in the wood of sample logs. Logs used in the trial were cut from living ponderosa pine trees felled on 15 December 1961, 15 March, and 15 June 1962. Additional logs were cut from trees killed by fire in April 1962. Three, six-foot logs in each category were set out lying east-west in each of three replications spaced about 80 feet apart. One replication of logs was unaccountably removed, leaving only six logs of each of the four categories.

In November 1962 the logs were peeled and the numbers of Monochamus entrance holes and larvae under the bark of each log was determined. No Monochamus larvae were found in the logs of trees felled in December or March. Five of six of the June-felled and five of six of the logs from the fire-killed trees contained larvae. The surface area of the logs was not calculated. However, the size variation among the logs was not great for all were six feet long and ranged in diameter from 8 to 11 inches at the larger end. The average number of entrance holes was 6 (range 0-13) per June log and 7 (range 0-15) per log from the fire-killed trees. The number of larvae under the bark ranged from 0 to 20 and averaged 10 in the June-felled material, and ranged from 0 to 5 with an average of 3 per log in fire-killed material.

This demonstrated that the logs from the trees felled in June and

the logs from the April fire-killed trees were moderately damaged by Monochamus and that no Monochamus galleries were constructed in the wood of the trees felled in December or March. The December and March cut logs were moderately to severely infested with Ips and buprestids before adult Monochamus emerged in the field. The June cut and fire-killed material was lightly attacked by Ips, buprestids and some Dendroctonus.

It is reasonable to assume that the preempting attacks by bark beetles and some buprestids early in the season, and subsequent rapid larval development may have made the bark of the December and March cut material unsuitable for Monochamus. Apparently, Monochamus and bark beetles attacked the June and fire-killed logs more or less simultaneously and were able to compete successfully.

This suggests that ponderosa pine trees cut before April may not be susceptable to infestation by Monochamus and may be left in the woods dur- the oviposition period. Presumably trees cut just before or during the oviposition period should be utilized within a short time or removed to water storage.

DISTRIBUTION OF MONOCHAMUS SPP. WITHIN THE TREE

A measure of the distribution of M. maculosus was obtained in the winter of 1960-61 by counting the number of larval entrance holes in sample sections from standing burned trees at O'Keefe and Carr's Landing.

Ten trees were taken at random at each of the two localities. They ranged from 9 to 13 inches d.b.h., from 50 to 76 feet in height, and from 43 to 76 years of age. The trees were felled and, beginning at breast height, 8 one-foot sections were cut out at five foot intervals, the bark removed, and the number of entrance holes on each section counted. No part of the bole of standing fire-killed ponderosa pine in the sampled trees was free of Monochamus attack, at least up to 40 feet above the ground.

The number of entrance holes per square foot, by trees, averaged 2.07 for the O'Keefe samples, and 2.64 for the Carr's Landing samples. Data for the samples were combined according to height above ground for each locality (Table V).

The number of entrance holes at both locations was lower in the basal blocks than the central and upper blocks. This distribution demonstrated that samples should be taken at least from the basal, central and upper portions of the bole when assessing larval populations, or in assessing damage to timber by sawyer beetles.

PREDATION BY WOODPECKERS ON LARVAE AND PUPAE IN THE WOOD

There was much evidence at O'Keefe and Carr's Landing of woodpecker feeding on sawyer larvae in the burned trees. The charred bark had been scaled off at varying heights on numerous trees but most debarking was at least 10 to 15 feet above ground level. Black-backed, three-toed and hairy woodpeckers apparently did most of this work. A preliminary measure of woodpecker predation was obtained at O'Keefe on 6 April, 1961. Of 140 pupal chambers in one-foot-long blocks from the basal, central and upper

bole of five fire-killed trees, 76% had been opened by woodpeckers.

Between 15 and 18 May, 1961, the 3-foot-long portions of the sample trees at O'Keefe and Carr's Landing burns used in the adult emergence study were examined for well-established galleries. Based on 410 entrance holes in the samples at O'Keefe and 175 at Carr's Landing, larval predation by woodpeckers was 45% and 25% respectively.

These data demonstrate that woodpeckers are important predators of Monochamus larvae in the galleries of small infestations.

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REFERENCES

Keen, F.P. 1952. Insect enemies of western forests. Misc. Pub. 273 U. S. D. A. 280 pp.

Morgan, C. V. G. 1948. The biology of Monochamus notatus morgani (Coleoptera : Cerambycidae). Ent. Soc. B. C. Proc. (1947) 44: 28-30.

TABLE I

Emergence of Monochamus maculosus from 12 4-foot sections of fire-killed ponderosa pine from O'Keefe and Carr's Landing, caged near Vernon, B. C.

Source	O'Keefe (1300')[a]			Carr's Landing (3000')[a]		
Year	1961	1962	1963	1961	1962	1963
No. adults	35	19	0	44	64	2
% females	54	38	-	61	40	50

a. Elevation in feet.

TABLE II

Average flight speed in m.p.h. of mated and fed Monochamus maculosus July 1962, and August 1963 (in brackets) at Vernon, B. C.

Wind speed m.p.h.	Males			Females			
	1.0	1.5	2.0	1.0	1.5	2.0	2.5
Flight into wind	-	4.7[a]	2.9[a]	-	4.4[a]	3.5[a]	-
Flight down wind	-	-	5.3[a]	6.5	7.4[a]	(7.0)	-
Flight across wind	-	(3.0)	(5.0)	-	(4.4)	4.2	(7.8)

a. Average speed in two trials.

TABLE III

Percentage of living Monochamus larvae by date that had tunneled into the wood of a ponderosa pine felled 22 June, 1961

Date, 1961	No. of 2-ft. bolts	No. of Monochamus larvae	Per cent in wood
July 26	5	76	8
Aug. 11	5	63	38
22	5	79	33
Sept. 12	5	66	48
19	1[a]	121	48

a. Eight feet long.

TABLE IV

Situation of Monochamus maculosus larvae, October 1962, in bolts exposed for oviposition, July 1962

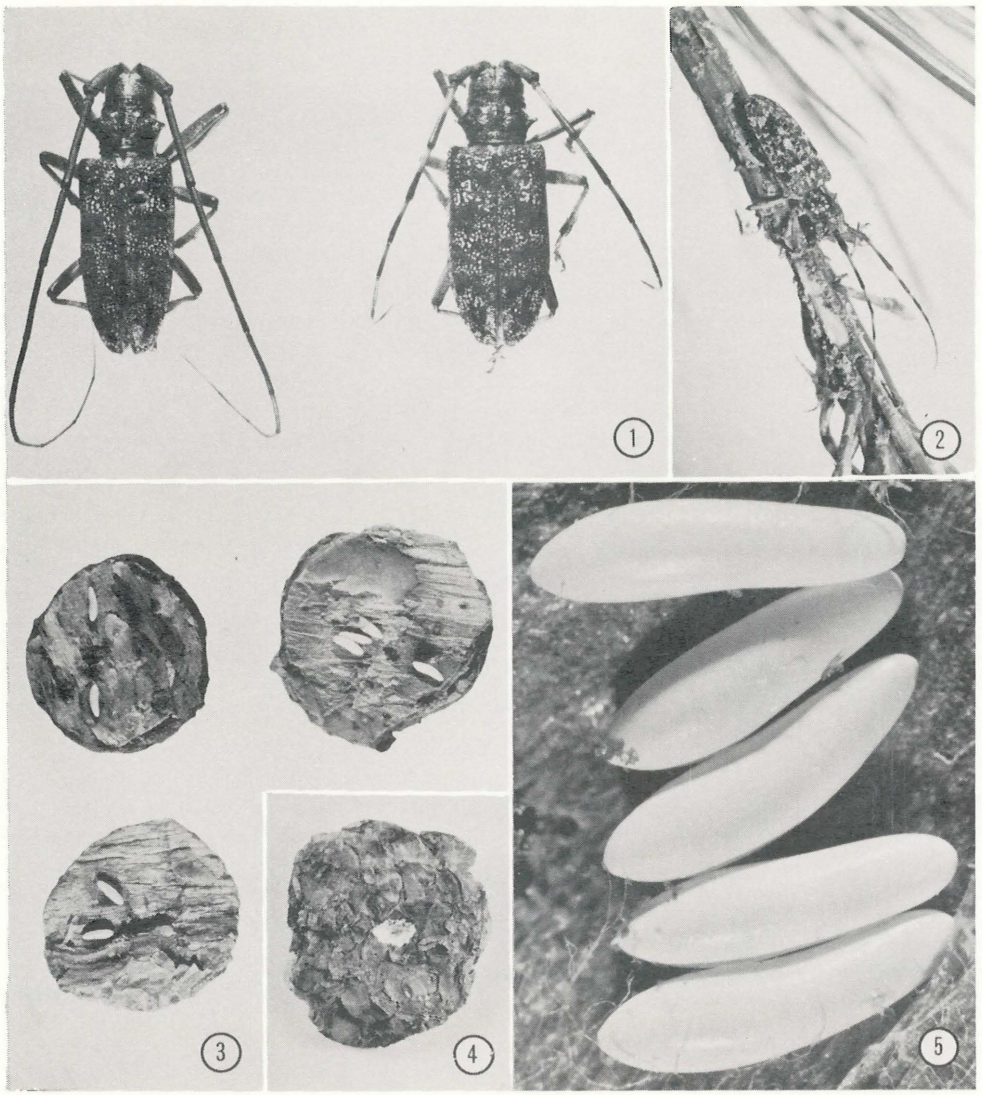
Date bolt removed from cage	Bolt shaded		Bolt exposed to sun	
	No. larvae		No. larvae	
	Under bark	In wood	Under bark	In wood
July 9	1	0		
	6	0		
	3	0		
			0	4
			1	2
16	10	1[a]		
			0	1
			0	4
			0	2
17			2	1
19			0	1
23	7	0		
	6	0		
	4	0		
	7	0		
	3	0	3	3
			1	2
			1	1
27	3	0		
	5	0		
			1	1
			3	0
			3	0
30	7	0		
	4	0		
No. of bolts	66	1	15	22

a. Gallery entrance one inch from dried top end of bolt.

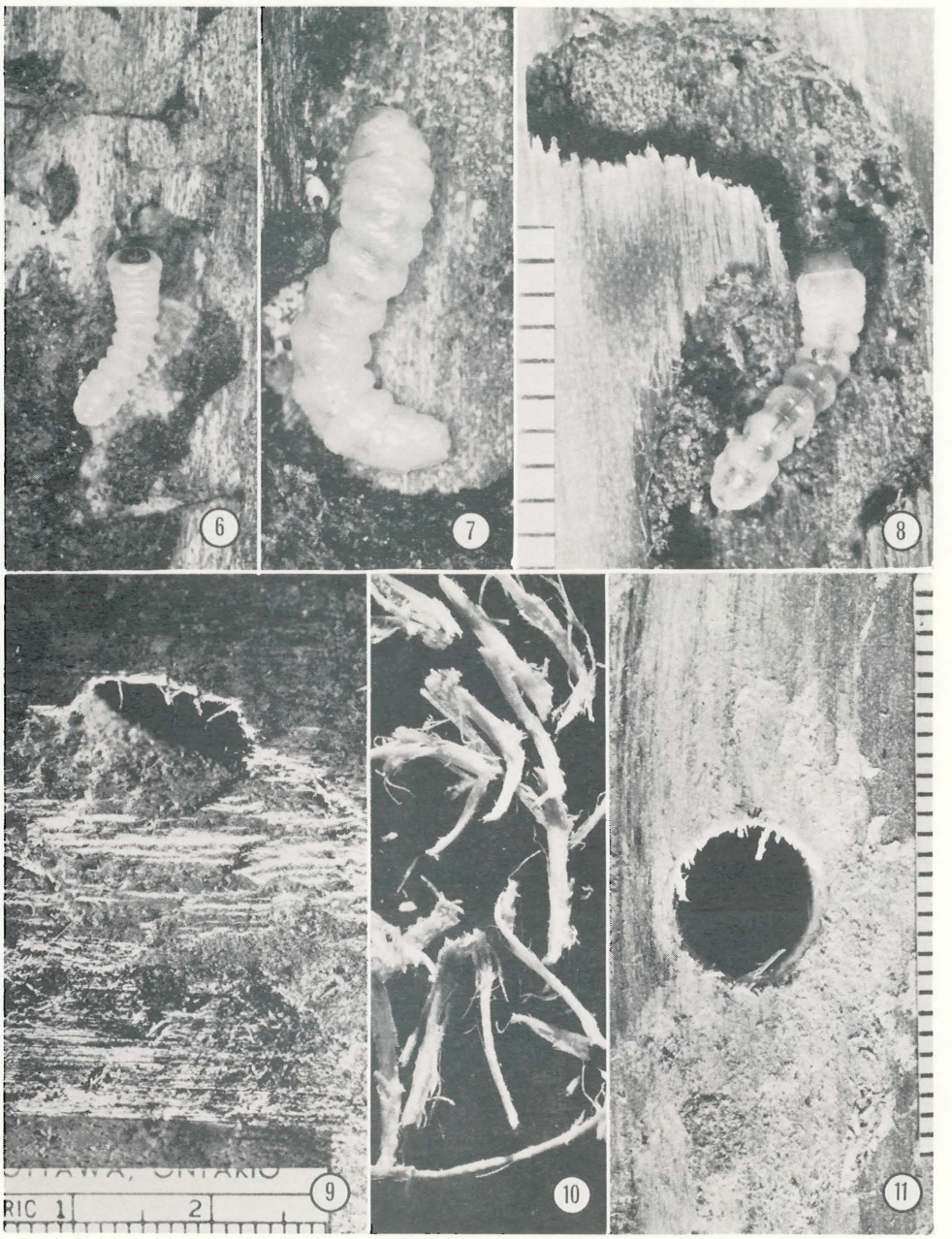
TABLE V

Monochamus entrance holes at five-foot intervals along fire-killed (7 July 1960) ponderosa pine stems, winter 1960-61

Height of sample in feet	Average no. holes per square foot	
	O'Keefe	Carr's Landing
40	3.96	3.22
35	3.61	4.13
30	3.20	3.44
25	2.84	3.54
20	1.80	3.20
15	2.02	2.87
10	0.61	1.20
5	0.18	0.59



Figs. 1 - 5. Monochamus maculosus (Hald.). 1, Adults, male (left) and female; 2, feeding damage on twig; 3, plugs of Pinus ponderosa bark with eggs in situ; 4, egg slot in bark (whitened); 5, eggs X 13, 25 July 1963.



Figs. 6 - 11, Monochamus maculosus (Hald.). 6 - 8, larvae on mined inner bark 25 July 1963; 9, scored wood and elliptical gallery entrance; 10, shreds of wood from gallery; 11, gallery exit made by adult.