TECHNICAL
PAPER
NUMBER 30

APRIL 1959

Biology and Control of the Pine Needle-sheath miner,

Zelleria haimbachi Busck

(Lepidoptera; Hyponomeutidae)

By Robert E. Stevens

PACIFIC SOUTHWEST
FOREST AND RANGE
EXPERIMENT STATION
KEITH ARNOLD
DIRECTOR

BERKELEY, CALIFORNIA

FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

BIOLOGY AND CONTROL OF THE PINE NEEDLE-SHEATH MINER, ZELLERIA HAIMBACHI BUSCK (LEPIDOPTERA; HYPONOMEUTIDAE)

~~By~~ Robert E. Stevens, ~~Entomologist~~
Division of Forest Insect Research

Technical Paper No. 30

April 1959

PACIFIC SOUTHWEST
FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

SUMMARY

In early summer of 1956, a severe infestation of the pine needle-sheath miner, Zelleria haimbachi Busck, occurred at the Institute of Forest Genetics near Placerville, California. Since little was known about the miner, studies on its biology were begun. This report summarizes the first 2 years' work.

The needle-sheath miner is a small moth of the family Hyponomeutidae. The adult measures about 12 mm. in wing expanse. It has a white body. The forewings are golden-yellow, each with a broad white median longitudinal band; the hindwings are white.

The larvae are essentially naked. They are dark orange above and cream-colored below, except toward the end of the final instar, when ingested plant material gives them a bright green color. There are 5 larval instars.

Ponderosa pine, Jeffrey pine, and jack pine are the most common hosts although a number of other hard pines can be infested. The known distribution of the insect is from New Jersey north and west through the Great Lakes region, west to the Pacific Coast, and then southward in the West following the range of ponderosa and Jeffrey pine. Although not widely collected in the West, it does not appear to be especially uncommon.

Eggs are laid singly on the needles in midsummer, and the first-instar larvae overwinter as needle miners in the needle on which the egg was laid. In the spring, larvae start to feed on the tender tissue within the sheaths of newly developing needle fascicles. The needles are severed within the sheath and a considerable amount of webbing is produced around the bases of the needles. Each larva appears to require about 10 fascicles for development, and under high population densities nearly every needle on a tip may be destroyed. Pupation takes place in early summer in the tips where the larvae have been feeding, and lasts about 2 weeks.

Parasitism is an important natural control mechanism. Several parasites have been reared from needle-sheath miner larvae and pupae.

Experimental control in 1957, using an emulsion of malathion applied with a hydraulic sprayer, was 99 percent successful against an epidemic infestation in plantations at the Institute of Forest Genetics.

CONTENTS

BIOLOGY AND CONTROL OF THE PINE NEEDLE-SHEATH MINER, ZELLERIA HAIMBACHI BUSCK (LEPIDOPTERA; HYPONOMEUTIDAE) [1/]

By Robert E. Stevens, Entomologist
Division of Forest Insect Research

In early June 1956, heavy defoliation became evident in pine plantations at the Institute of Forest Genetics, Placerville, California. Investigation revealed a severe infestation of the pine needle-sheath miner, Zelleria haimbachi Busck. This insect had been reported from the Institute and other localities in previous years; in 1952 it was heavy enough on a plantation on the Modoc National Forest to promote consideration of applied control. In 1953, however, the Modoc infestation had dropped below alarming levels, and no control was needed. At Placerville in 1956, the defoliation caused three-way concern for the valuable hybrid pines in the plantations. First, the trees presented an extremely unsightly appearance. Second, continued heavy defoliation might reduce their vigor to the point where the larger trees might be attacked by bark beetles. Finally, differences between the hybrids, all still under test, might be masked by the effects of defoliation.

Little was known of the habits of the needle-sheath miner, and because of its potential importance to the increasing number of pine plantations in the West, research on its biology was started. This report deals with information gathered during the first 2 years of study, and with the results of experimental applied control.

All work was done at the Institute of Forest Genetics, or with material gathered at the Institute. The Institute is the pioneer pine breeding station in the United States, and its plantations contain locally bred hybrids and representative specimens of most of the pines of the world. It is located just outside Placerville, some 40 miles east of Sacramento, in the Sierra Nevada foothills at an elevation of about 2,700 feet. It is a facility of the Division of Forest Genetics Research, Pacific Southwest Forest and Range Experiment Station, which cooperated with the Division of Forest Insect Research throughout the course of this work.

1/ Part of the material in this report was used in a thesis submitted in partial fulfillment for the M. S. degree in entomology, University of California, Berkeley, January 1958.

HISTORY

A literature search in the fall of 1956 disclosed only a limited amount of information about Zelleria haimbachi. The first mention of it occurs in the original description; Busck (1915) remarks that the host was "short-needled pine" and that the adult emerged on July 17. The type locality is Wenonah, New Jersey. The next reference to Z. haimbachi was made by J. F. G. Clarke (1929), who reported it among insects newly found in British Columbia. W. H. Lange (1935) reported the insect widespread throughout California's eastside region in 1935 and also reported rearing adults from ponderosa pine foliage. The adults emerged from July 30 to August 3, having been collected in the pupal stage on July 25. DeLeon (1935) mentions Lange's article, and adds a 1930 record from Placerville. He states that the larvae web needles together and feed at their bases until the needles are completely cut off but hang from the tree by silk webbing produced by the larvae.

A. W. A. Brown (1941) reported the occurrence of Z. haimbachi in the Mississagi region, north of Ironbridge, Ontario. He refers to it as the "jack-pine needle miner," so it is assumed the host was jack pine. The insect is described in a short reference by Keen (1952). Keen's note on its biology probably has its basis in the records made by Lange and DeLeon.

Miller [2/] commented that the insect had been bothersome for 3 years at Placerville.

Entomologists of the Canada Department of Agriculture (Anon. 1952) noted the decline of Z. haimbachi in the Okanogan Valley area. There is no previous record of this infestation. They reported that the infestation status changed from medium and heavy to very light. Damage to ponderosa pine was reported in 1952 and 1953 from the Sugar Hill plantation on the Modoc National Forest, and a light infestation was also reported on pines at the Institute of Forest Genetics in 1953 (Anon. 1954).

First observations on the biology of the insect at Placerville were made in 1956 by R. H. Smith (1957). His observations, along with those by DeLeon and Lange, represent the only biological information available before this study.

2/ Miller, J. M. Status of forest insect conditions, Institute of Forest Genetics, 1948 and 1949. U. S. Dept. Agr. Bur. Ent. and Plant Quar., Forest Insect Div., Berkeley, Calif. 8 pp., (typed) 1949.

The insect has been given several common names: the jack-pine needle miner (Brown 1941, Keen 1952), the pine needle cutter (Anon. 1957), and the pine needle-sheath miner (Smith 1957). The latter name is the most desirable of the three, as it best describes the work of the insect and does not imply a single host.

Although not solely pertinent to Z. haimbachi, one point about nomenclature merits some explanation. The family name Hyponomeutidae is oftentimes found written Yponomeutidae. According to P. W. Oman,[3] Director of the Insect Identification and Parasite Introduction Laboratories, Agricultural Research Service, U.S. Dept. Agr., this difference of spelling results from differences of opinion regarding the correct transliteration of the stem word from the Greek. Inasmuch as Hyponomeutidae is the form used by Agr. Res. Serv. taxonomists, it is so used here.

DISTRIBUTION AND HOSTS

The known range of the pine needle-sheath miner is shown in figure 1. In addition to the references found in literature, distribution data were obtained from the Agr. Res. Serv., the Canada Department of Agriculture, and the California Insect Survey. The Agr. Res. Serv. records included material listed in the Hopkins notes of Forest Insect Research divisions of the various U.S. Forest Service experiment stations.

Following is the list of locations where identified specimens of Z. haimbachi have been found:

In Canada--from records furnished by the Canada Department of Agriculture:

British Columbia.—Sosoyoos, Oliver, Penticton, Westbank, Whiteman's Creek at the north end of Okanogan Lake, Chase and Montie Creek, all on ponderosa pine, and from Salmon Arm, Chase and Enderby on lodgepole pine; also Vancouver, host unknown.

Alberta.—No records.

Saskatchewan.—Hudson Bay, Green Lake and Holbein, all on jack pine.

Manitoba.—Sandilands F. R., Ashern, Rennie, Red Rock Lake, Cowan, Spruce Woods F. R., Pointe du Bois, Whiteshell F. R., Piney, Molson, St. Duens, Whitemouth, Darwin, Seddon's Corner, Horseshoe Lake, Oiseau Lake, Lac du Bonnet, and Spruce Woods F. R. All hosts were jack pine.

3/ Personal communication.

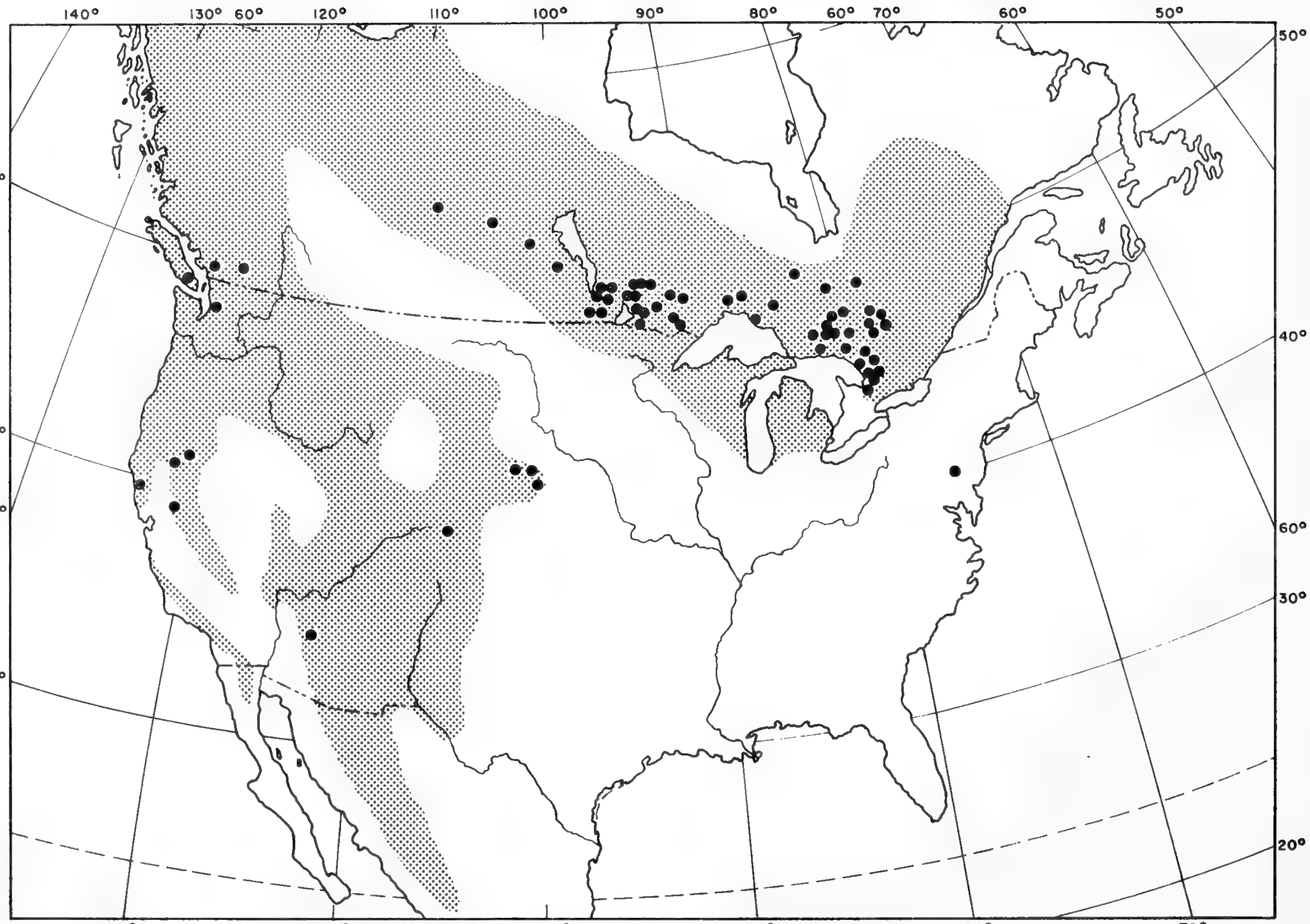

Figure 1. --Zelleria haimbachi collection points (dots) and generalized range of its principal hosts.

Quebec. —Laniel.

Ontario. —East Hawk Lake, Constance Bay, Biscotasing, and Grenville and Simcoe Counties. The East Hawk Lake record is from jack pine; hosts in the other instances are not known.

There are also 118 additional records from Canada, not specifically located. Dr. B. M. McGugan, co-ordinator of the Canadian Forest Insect and Disease Survey, from whom most of the Canadian information was obtained, feels that the lack of records from Alberta may or may not be meaningful, because collections have been relatively few there. He also feels that the lack of records from Quebec might not necessarily mean that the insect does not exist there.

In the United States--from records of Agricultural Research Service:

New Jersey.—Wenonah.

Colorado. —Boulder, from ponderosa pine.

Nebraska. —Valentine, Nenzell and Halsey, on ponderosa pine.

Arizona. —Prescott and Senalor, on ponderosa pine.

California. —Placerville and the Lassen National Forest, both from ponderosa pine.

Washington. —Vashon, from shore pine.

The original specimens from New Jersey are listed as being "bred from short-needle pine" (Busck 1915). Three pines—Virginia pine, pitch pine, and shortleaf pine—occur in the locality, and all have relatively short needles. This host designation, being the only one from the eastern United States, complicates speculation regarding the southeastern limit of the miner's range. It is entirely possible that it occurs somewhat farther south.

The scarcity of collections from the Western United States should not be taken as an indication that the needle-sheath miner is a rare insect. Recent observations by entomologists at the Station indicate that it is present in California nearly every place where ponderosa or Jeffrey pines occur. Although the insects themselves have not been collected, empty puparia, overwintering larvae, and damage characteristic of *Z. haimbachi* have been widely observed throughout the State. Since no other insect is known to have similar habits, it is felt that the evidence is indeed of the needle-sheath miner. Except under conditions of high population density such as currently prevail at the Institute of Forest Genetics, though, the miner is an inconspicuous insect, and is rarely obtained in the course of casual collecting.

R. H. Smith (1957) compiled a host list of natural and hybrid pines at the Institute, and rated these hosts by ocular estimate as to their relative degree of defoliation (table 1).

Elsewhere, the needle-sheath miner has been collected primarily from ponderosa pine, Jeffrey pine, lodgepole pine, and jack pine. There are isolated records from Canada of its occurrence in spruce and balsam fir, and a single record from California of its being reared from cones of knobcone pine, but in these cases the insects were probably only casual inhabitants.

Several items in Smith's host list are worth considering. First, specimens of different tree species in the plantation have varying space and distance relationships with one another. Heavy infestation of a particularly susceptible species adjacent to a less susceptible one might have made differences in the observed effect. Nevertheless, the observations are felt to be of enough value to furnish the basis for some generalizations. Most significant, no soft pines have ever been listed among the hosts, either in Smith's list or in any records from the field. Soft pines grow interspersed with the hard pines at the Institute, and it is reasonable to assume that some of them would have become infested if they were susceptible. A logical explanation for this immunity might be found in the character of the needle sheaths in the two groups of pines. Generally speaking, soft pines have deciduous needle sheaths and hard pines have persistent sheaths (Shaw 1914). The needle sheath plays an important role in the larval habitat, and its absence might make the needle bundle an unsuitable environment.

Smith's list also shows that the more heavily attacked species are those with the longer needles. The ponderosa-Jeffrey pine group has needles often measuring upwards of eight inches long; the lodgepole-jack pine group (Pinus contorta, P. banksiana), rating somewhat lower on the damage scale, generally has needles under three-inches long.

The insect seems to prefer young trees 3 to 30 feet in height. At Placerville in 1956 and 1957, 1- and 2-year-old trees were not found to be infested, and 3-year-old trees were only rarely attacked. By the fourth year, however, the tree is acceptable and heavy defoliation may take place. Under the epidemic conditions at Placerville, several trees up to 60 feet high were heavily infested.

Table 1.--Pine needle-sheath miner hosts at Placerville, California, 1956, listed in order of decreasing damage [1]

Species of *Pinus*	Average percent defoliation
1. *Pinus ponderosa* x *scopulorum*	88
2. *P. jeffreyi* x (*jeffreyi* x *coulteri*)	86
3. *P. ponderosa* x *arizonica*	86
4. *P. attenuata* x *radiata*	85
5. *P. ponderosa* x *montezumae*	75
6. *P. ponderosa*	73
7. *P. murrayana*	72
8. *P. jeffreyi*	68
9. *P. apacheca*	63
10. *P. jeffreyi* x *coulteri*	61
11. *P. ponderosa* x *apacheca*	60
12. *P. attenuata*	59
13. *P. washoensis*	59
14. *P. ponderosa* x *washoensis*	58
15. *P. arizonica*	48
16. *P. rigida* x *taeda*	47
17. *P. ponderosa* x *jeffreyi*	45
18. *P. washingtoniana* x *ponderosa*	45
19. *P. coulteri*	40
20. *P. murraybanksiana*	32
21. *P. murrayana* x *murraybanksiana*	29
22. *P. radiata*	20
23. *P. rigida* x (*rigida* x *taeda*)	15
24. *P. cervennes*	10
25. *P. cervennes* x *nigra*	10
26. *P. banksiana*	10
27. *P. taeda*	9
28. *P. echinata*	2
29. *P. calabrica*	1
30. *P. calabrica* x *nigra*	1
31. *P. nigra* x *densiflora*	1
32. *P. contorta*	trace
33. *P. contorta* x *murrayana*	trace
34. *P. muricata*	trace

1/ Compiled by R. H. Smith, Pacific Southwest Forest and Range Experiment Station.

DESCRIPTION

Figure 2 shows an adult needle-sheath miner in resting position. The original description of the adult (Busck 1915) is adequate, and is quoted:

> Zelleria haimbachi n. sp. Labial palpi, face and head pure white. Antennae white with ill-defined light brown annulations. Thorax white, edged posteriorly and laterally with golden yellow; patagia golden yellow. Forewings light golden yellow with a broad central longitudinal white streak from base to apex; outer half of costal edge, apical part of the wing and cilia slightly dusted with black; cilia black. Hindwings silvery, whitish fuscous, cilia white. Abdomen silvery white mixed with light yellow, anal tufts pure white, legs silvery white. Alar expanse; 12 mm.

Figure 2. --Adult pine needle sheath miner resting on a ponderosa pine needle.

The eggs are whitish, semi-transparent, strongly flattened, and measure about 0.6 mm. by 0.3 mm. Several days before hatching, the tiny larvae can be seen curled horseshoe-fashion within.

Newly hatched larvae are naked, about 1.5 mm. long, bright orange in color, and have glossy black head capsules. As the body is no wider than the head capsule, only slightly over 0.10 mm., these first instar larvae present an exceedingly slim, threadlike appearance. There is a general progressive lightening of color as the larvae pass through the successive instars. By the time the later instars are reached, the body color has faded to tan, with a broad, dull orange stripe running the length of the body on either side of the dorsal line. In some specimens these stripes are contiguous, rendering the entire dorsum a dull orange. Head capsules of the later instars are tan, and the body is adorned with a moderate complement of inconspicuous setae. Shortly before pupation, the larvae turn green, being engorged with fresh plant material. Fully developed larvae are commonly 14 mm. long before the prepupal length reduction.

Figure 3 shows larvae feeding in a ponderosa pine tip.

Figure 3. --Larvae of the pine needle-sheath miner (arrows), feeding in new foliage. Note holes in needle sheaths. X2.

Pupae are illustrated in figure 4. Newly formed pupae are bright green in color, but turn brown within two days. They average about 7 mm. long.

Figure 4. --Pine needle-sheath miner pupae in place, X2, and fascicles of needles killed by larval feeding. Some silk has been pulled away so that the pupae can be seen clearly.

The general life history of the pine needle-sheath miner at Placerville is pictured in figure 5. Records are from ponderosa and Jeffrey pines and their interspecific hybrids. Because observations on the life history and habits of Z. haimbachi were carried out on the Placerville population, this section of the report applies specifically to the Placerville area. However, since the life cycle of the needle-sheath miner is geared to the annual appearance of new shoot growth in the host, a universal phenomenon, it seems unreasonable to expect any major differences in its activities elsewhere.

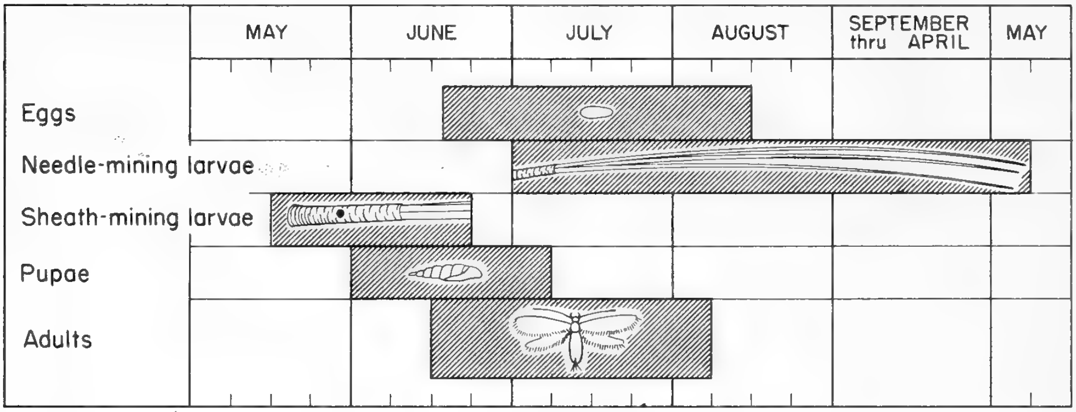

Figure 5. --Generalized life-history pattern of Z. haimbachi at Placerville, California.

In 1957, initial emergence of specimens reared in the Placerville insectary occurred on June 18. While field emergence might have preceded this by a day or so, it was not observed. The peak of emergence (again of reared specimens), occurred on June 23, and the latest individual emerged on July 5. Smith (1957) reports that in 1956 initial emergence was noticed in early July, and Keen (1952) states that adults emerge about the end of July.

Adult moths were observed to be inactive during the daytime, resting on the needles as shown in figure 2. The moths fly in the daytime only when disturbed. Activity picks up at dusk, however, and on into the night, as the moths flit from branch to branch and tree to tree.

Genitalia examination of 158 adults disclosed that 78 were males and 80 were females, in effect a 1:1 sex ratio. Eggs are deposited singly on the needles, lightly cemented down, and mostly about midway between the base and the tip. They are mostly placed adjacent to a corner of the needle and have the long axis parallel with the long axis of the needle. Smith (1957) observed that the current year's foliage is preferred for oviposition by a 4:1 ratio.

The eggs hatch in about 10 days, and the abandoned shells persist on the needles only a week or two thereafter. In 1957 at Placerville, eggs began to hatch about July 1.

The first-instar larvae bore directly through the undersurface of the egg into the needle, and begin mining along the needle edge toward the tip. Infrequently, a larva begins mining toward the needle base, but soon becomes oriented and reverses its direction. Larvae hatching from the occasional eggs laid on the flat needle surface away from the edge also mine directly to the edge and continue outward in the usual manner.

The insects overwinter in this first-instar larva stage, feeding slowly. Progressive lengthening of the overwintering mine (table 2) indicates that the larvae do not cease feeding for any appreciable length of time during the winter.

Table 2. --Progressive lengthening of needle-sheath miner overwintering mines at Placerville, California, 1956-57

Collection date	Number of mines measured	Range of measurements	Mean mine length	Percent of total length
Aug. 10, 1956	9	1-6 mm.	3 mm.	4
Aug. 17	24	1-7	3	4
Aug. 24	20	2-9	4	6
Aug. 31	18	1-7	5	8
Oct. 1	15	3-13	7	10
Oct. 24	68	5-25	9	12
Nov. 23	63	7-32	14	19
Jan. 29, 1957	58	11-35	18	25
Feb. 22	77	19-45	31	43
Apr. 9	100	28-68	41	57
Apr. 24	76	17-62	34	44
May 9	13	38-62	47	65
After abandonment 1/	20	60-83	72	100

1/ From measurements of abandoned mines in June 1957.

Frass is packed behind the larva as the mine is lengthened; as the frass dries it becomes straw-colored and shows up as a threadlike yellowish band under the epidermal cells of the needle. This is about the only way that an overwintering larva within a needle can be detected--by its telltale track of drying frass.

In the spring the new pine shoots begin to elongate. Up to this point, the larvae have been feeding slowly, constructing the mine no wider than their own width and, except under close scrutiny, showing very little outward signs of life. Now, however, a distinct change in the larval habit takes place.

Activity quickens; the larvae increase the size of the mine to twice their width and move away from the needle edge. Where before they have been sluggish, the larvae now become very responsive; the change to the second instar is made within the needle at this time. After constructing about 5 mm. of this widened gallery away from the edge of the needle, the larva abruptly bores a hole through the upper surface of the mine and abandons the needle. In 1957 at Placerville, nearly all mines had been abandoned by mid-May.

The moving of the larvae away from the needle edge, which began in about mid-April at Placerville in 1957, might be a significant event when applied control is being considered. After the shift away from the needle edge takes place, the remaining time within the needle is not over 3 weeks, and preparation to spray newly emerged larvae could well be made during this period.

In ponderosa pine at Placerville, the shift from the needle took place while the shoot elongation was going on but needle elongation had not yet started.

Inasmuch as measurements of the head capsules during the winter showed no evidence of instar changes from time of hatching, collections then were infrequent. The frequency of collection was increased in the spring, however, and collections were made biweekly starting in late April and increased to daily in late May. No set number of larvae were taken each time, but 50 was used as an approximate goal. Collections were continued until June 23, at which time larvae were becoming scarce.

Head capsule width was measured with a standard binocular microscope reticule. These measurements (table 3 and figure 6) indicate 5 larval instars. Though the second instar is poorly represented in the collecting, the evidence seems strong enough to indicate it as a separate instar. This is the instar that abandons the overwintering needle, and persists for only a short time.

Table 3. --Needle-sheath miner larval progress

Date	Number specimens tallied	Percent in instar					
		I	II	III	IV	V	Pupa
August 1, 1956	26	100					
February 22, 1957	24	100					
April 9	100	99	1				
April 24	76	79	21				
May 9	13		54	40	6		
May 14	81		11	73	16		
May 27	94		3	68	22	7	
May 29	77		3	70	14	3	
June 6	74			22	66	12	
June 7	67			43	30	27	
June 14	71			2	58	19	21
June 17	54				46	24	30
June 19	52				50	27	33
June 21	41			9	24	18	49
June 23	26			4	8	4	84

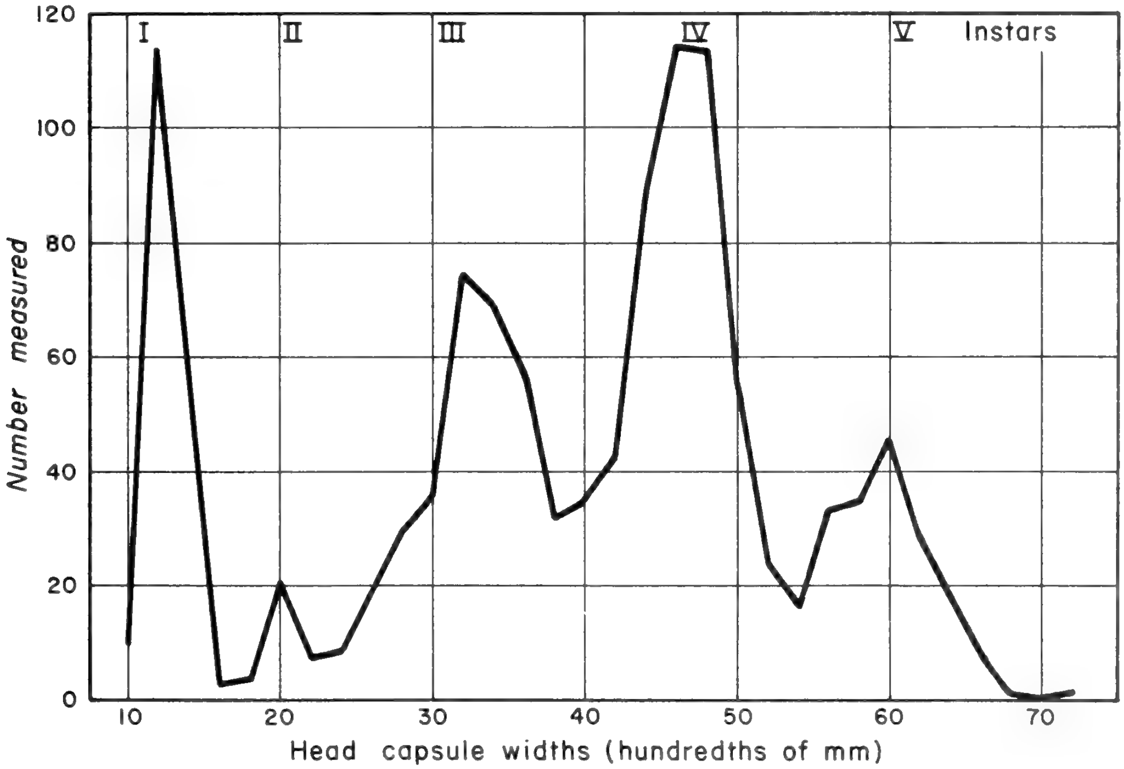

Figure 6. --Pine needle-sheath miner larval instars as indicated by head-capsule width measurements.

Leaving the mine, the second-instar larvae migrate outward to the new growth. Reaching the new shoots, each individual constructs a thin silken tube across the bases of several needles. From the protection of this silken tube, the larva chews a small hole through the needle sheath and begins feeding on the tender tissue of the elongating needles within. (These feeding holes are readily seen in figure 3.) Only part of the needle tissue within the sheath is devoured; it is never completely eaten out. While a larva is still small, it wholly enters the sheath, but as it grows feeding is accomplished with only the head and first few segments inserted.

The final three instars are passed in this manner. Toward the end of the larval period, the insects become freer in movement, abandoning the silken tubes. When disturbed, they readily drop from the tip in which they are feeding and web down to a lower one. A general mass of silken webbing is produced around the needle bases as the larvae move about, and by the time pupae are formed they are well protected by the silk, though not enclosed in individual cocoons.

Larvae pupate in the tips, bound in place by the silken mass (figure 4). A single larva on a potted tree indoors at Berkeley ceased feeding May 23, 1957, remained quiescent for 2 more days, and pupated on the 26th. The pupal stage of this individual lasted 7 days. A sample of 55 specimens, reared in the insectary at Placerville, averaged 10.6 days in the pupal stage.

DAMAGE

As might be assumed from the life history and habits of the miner, the significant amount of damage is caused by the free-feeding, later-instar larvae mining out the needle sheaths. As the needles are in the process of elongating during the larval feeding period, their length when destroyed varies considerably. Some are lost when barely out of the needle sheath, and some grow to a length of several inches. These longer needles, when cut off at the base, often droop sharply at their junction with the fascicle, and until they are blown away by the wind, the presence of these sharply drooping dead needles is an easily seen indication of *Zelleria* damage.

Although the mine of the overwintering larva is probably not large enough to harm the needle, no information on specific effects was obtained.

The number of fascicles destroyed by each larva was investigated briefly, and indications are that this figure is determined by competition. A single larva on a potted seedling, emerging from the overwintering mine, totally destroyed 13 fascicles and damaged one. A heavily infested tip in the field, collected on June 13, 1957, originally bore a total of 222 fascicles. Of these, 148 had been totally destroyed, 54 were damaged, and 20 had escaped injury. From the tip were collected 1 larva, 4 pupae, and 17 parasite cocoons. Discounting predation and assuming that 1 parasite accounts for 1 Zelleria larva and that all larvae had fed normally, we would come up with a figure of 6 fascicles destroyed and 2 damaged per larva. We can infer from these observations that about 6 to 10 fascicles of needles are destroyed by each insect.

The infested tip changes in appearance through early summer (figure 7). The needles that escape damage continue to elongate and the mined-out needles drop off, so that by midsummer, unless the population has been exceedingly high, the infestation becomes inconspicuous. When few needles escape, the resultant thinned tip remains obvious throughout the following year.

PARASITES AND PREDATORS

Smith (1956) indicated that parasitism played an important role in reducing the 1957 population, and he collected six associated species thought to be parasites. Table 4 shows associates collected or reared and relationships observed during the 1957 season. Determinations were made by the Insect Identification Section, Agr. Res. Serv.

The relative importance of the various parasitic species was not studied in detail, but some indications may be gained from the numbers of specimens shown in table 4. Chelonus sp., Herpestomus? sp. and Spilochalcis leptis Burks were the most numerous parasites in 1957. All 11 Tritneptis sp. specimens emerged from a single needle-sheath miner pupa. All parasites designated Type 2 emerged by making a large hole in the head region of the host pupa. Type 1 parasite larvae emerged from host larvae and formed silky cocoons in the needles.

Of the predators, both the ants and the beetle (larva) fed on Z. haimbachi larvae. Their significance was not evaluated, but the ants probably accounted for a number of larvae. One other larval specimen of the beetle was collected, but it failed to mature.

Of the 394 needle-sheath miner pupae put in rearing, 36 failed to produce adults or parasites. Dissection of these 36 revealed that 17 appeared to be fully developed moths but failed to emerge, 15 had failed to develop fully, and 4 contained partially developed parasites.

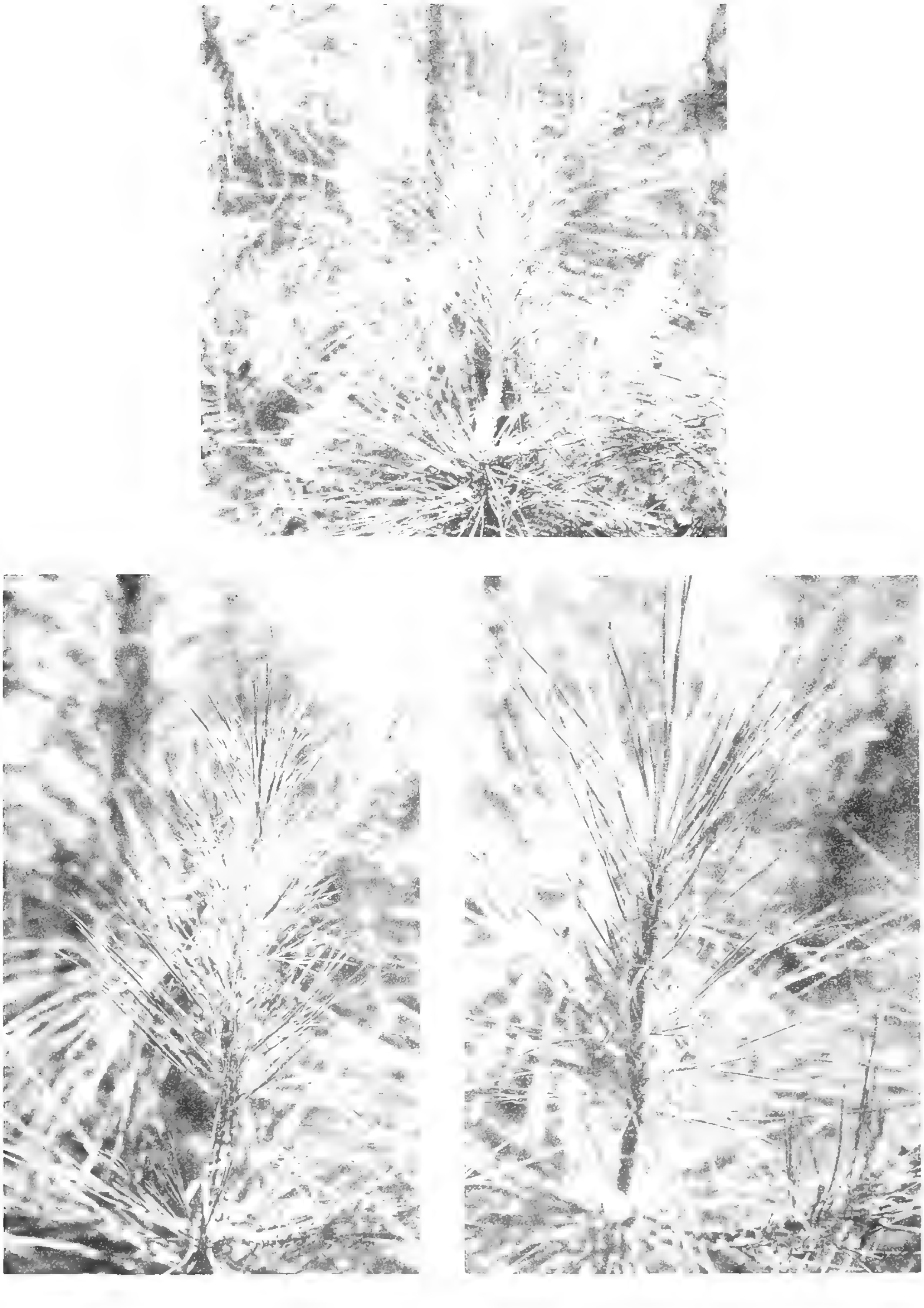

Figure 7. --Seasonal change of appearance of a ponderosa pine tip infested with the pine needle-sheath miner. The top picture was taken on June 11, 1957, the lower left one on June 24, and the lower right one on August 1.

Table 4. --Insects associated with the pine needle-sheath miner

Order	Family	Genus and species	Determined by 1/	Specimens	Relationship
Hymenoptera	Braconidae	Chelonus new species	C. F. W. Muesebeck	48	Parasite, type 1 [2/]
"	"	Bracon gelechiae Ashm.	C. F. W. Muesebeck	1	" "
"	"	Apanteles sp.	C. F. W. Muesebeck	1	Unknown
"	Ichneumonidae	Herpestomus ? sp.	L. M. Walkley	32	Parasite, type 2
"	"	Itoplectus conquisitor Say	L. M. Walkley	4	" "
"	"	Horogenes sp.	L. M. Walkley	1	Presumably hyperparasite
"	Chalcididae	Spilochalcis leptis Burks	B. D. Burks	35	Parasite, type 2
"	Pteromalidae	Catolaccus aenaeoviridis (Grlt.)	B. D. Burks	24	Hyperparasite
"	"	C. kanensis (Grlt.)	B. D. Burks	1	Unknown
"	"	Habrocytus sp.	B. D. Burks	1	Presumably hyperparasite
"	"	Hypopteromalis sp.	B. D. Burks	1	" "
"	"	Tritneptis sp.	B. D. Burks	11	Parasite, type 2, superparasite
"	Formicidae	Crematogaster coarctata Mayr	M. R. Smith	Many	Predator
Diptera	Larvaevoridae	Anachaetopsis tortricis (Coq.)	C. W. Sabrosky	2	Parasite, type 2
Coleoptera	Cleridae	Phyllobaenus (Hydnocera) sp.	G. B. Vogt	1	Predator

1/ Taxonomists of the Insect Identification and Parasite Introduction Laboratories, Entomology Research Division, ARS, USDA.

2/ Type 1 parasites emerge from the host larva, type 2 from the host pupa.

SAMPLING

Stevens and Hall[4/] did some limited-scale sampling of the over-wintering 1956-1957 larval population at the Institute of Forest Genetics, and studied sample-size efficiency. The sampling unit used was the single fascicle of needles, and sample sizes of 5, 10, 20, 50, and 100 fascicles were tested. A total of 320 five-unit samples were collected, 80 from each of 4 trees, and these were lumped to form the larger sized samples.

The results showed an average of 0.13 larvae per fascicle, and a fairly uniform distribution among the 4 trees checked. There were some indications of higher populations on the north and east sides of the trees. Of the several sample sizes investigated, 5 fascicles appeared to be the most efficient in terms of numbers of fascicles needed to achieve a desired sampling error.

CONTROL

On May 22 and 23, 1957, R. H. Smith and T. W. Koerber conducted experimental chemical control against the needle-sheath miner at the Institute of Forest Genetics. Smith's report was added to the work plan for the job, [5/] and most of the following material is taken from it:

A 2-acre block of the plantation was sprayed with "Ortho #5 malathion," an emulsifiable concentrate containing 5 lbs. of technical malathion per gallon, at a concentration of 1 pound of the insecticide in 100 gallons of water. The material was applied to the point of dripping, with an orchard-type hydraulic sprayer, and the resultant dosage after complete coverage of each tree was 2-1/2 pounds of insecticide per acre. It was estimated that essentially all the foliage was covered.

At the time of spraying about 75 percent of the larvae had abandoned the overwintering needles, and feeding on the new growth was negligible.

4/ Stevens, Robert E. and Ralph C. Hall. Sampling needle-sheath miner populations, U. S. Forest Serv. Calif. Forest and Range Expt. Sta., Berkeley, Calif., 3 pp. (typed).

5/ Smith, Richard H. Experimental control of the needle-sheath miner. Work plan. U. S. Forest Serv. Calif. Forest and Range Exp. Sta., Berkeley, Calif., 8 pp. (typed) 1957.

The results were assessed by random observations immediately after spraying, and counts of larval mortality on comparable sprayed and unsprayed areas the day after spraying (table 5). Larvae began dying shortly after being hit by the insecticide.

Table 5.--Mortality of pine needle-sheath miner 48 hours after spraying with malathion

Area	Tips			Larvae		Percent control
	Inspected	Infested		Dead	Alive	
	No.	No.	Percent	No.	No.	
Sprayed	130	110	85	141	1	99.3
Unsprayed	90	82	90	11	247	

An incidental observation was that dead larvae, because of their exceedingly small size, were more easily detected at 24 than at 48 hours after spraying.

The calculated percentage of control was 99 percent, and occasional checks throughout the summer confirmed the feeling that larval mortality in the sprayed area was indeed almost complete. Signs of feeding and the occurrence of later stage larvae were negligible.

Should control become necessary over wider areas, such as field plantations, the insect may prove to be susceptible to standard large-scale aerial spray treatment. The larva is very active and is fairly well exposed in the last 3 instars so its availability to the spray should be adequate. Many lepidopterous defoliators are quite sensitive to low concentrations and dosages of insecticide, and the pine needle-sheath miner should not be an exception.

LITERATURE CITED

(1) Anonymous.
1952. Annual report of the Forest Insect and Disease Survey, Can. Dept. Agr., Sci. Serv., Div. Forest Biol., 154 pp., illus.

(2) ________________
1954. Forest insect conditions in California - 1953. Calif. Forest Pest Control Action Council, Sacramento, Calif., 13 pp., illus.

(3) ________________
1957. Tentative common names for western forest insects not yet approved by the western forest insect work conference. Report of the West. Forest Insect Work Conf. Com. on Common Names., 14 pp. (Processed.)

(4) Brown, A. W. A.
1941. Annual report of the Forest Insect Survey. Can. Dept. Agr., Sci. Serv., Div. Ent., 23 pp., illus.

(5) Busck, August.
1915. Descriptions of new North American microlepidoptera. Proc. Ent. Soc. Wash., 17:91.

(6) Clarke, J. F. G.
1929. Report of the provincial museum of natural history, Victoria, B. C., 35 pp., illus.

(7) DeLeon, Donald.
1935. Forest insects of the California national parks, part I. Insects affecting ponderosa and sugar pine. U. S. Dept. Int. Natl. Park Serv., San Francisco, Calif., 80 pp., illus. (Processed.)

(8) Keen, F. P.
1952. Insect enemies of western forests. U. S. Dept. Agr. Misc. Pub. 273, revised. 380 pp., illus.

(9) Lange, W. H. Jr.
1935. A new locality record for California. Pan-Pac. Ent. 11:82.

(10) Shaw, George R.
1914. The genus Pinus. Publication of the Arnold Arboretum No. 5. 96 pp., illus.

(11) Smith, Richard H.
1957. Observations on the biology of the pine needle-sheath miner, Zelleria haimbachi Busck. U. S. Forest Serv., Calif. Forest and Range Exp. Sta. Progress report., 7 pp., illus. (Processed.)